

Reconstructive REVIEW

ABSTRACT SUPPLEMENT:
PAN PACIFIC ORTHOPAEDIC CONGRESS
July 16 - 19, 2014 • Hilton Waikoloa, HI

OFFICIAL JOURNAL OF THE



Joint Implant Surgery and Research Foundation

Strategic Alliance with



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Joint Replacement
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Joint Preservation
of the Hip, Knee, and Shoulder



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Editor-in-Chief, Pacific Rim, Reconstructive Review

&

Timothy McTighe, Dr. H.S. (hc)

Executive Director, JISRF,
& Editor-in-Chief, Reconstructive Review

We are pleased to announce that JISRF's journal Reconstructive Review will become the official journal for APAS. We welcome its Members to open free access to all publications and encourage its Members to submit manuscripts for publication in one of four quarterly issues.

We also welcome interested Members to become reviewers for the Reconstructive Review.

**Reconstructive Review Editor-in-Chiefs Role
has been Expanded Providing Global Outreach**

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Please visit our websites for more information:

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Strategic Alliance Announcement



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is Pleased to Announce a Strategic Alliance with the



Donaldson Arthritis Research Foundation

DARF, founded in 2005 by Dr. Thomas K. Donaldson, has a focus on outcome studies and basic science with major emphasis on implant retrievals. His ongoing collaboration with Ian Clarke, PhD provides a synergy between the laboratory and clinical surgical science. Both men are Board Members of JISRF and have a significant working relationship with its Executive Director Timothy McTighe Dr. HS (hc).

JISRF, founded in 1971, has had significant experience with continuing medical education, product development, and clinical surgical evaluation of total joint implant devices.

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In Memory of

Tony N. Aram MD

October 7, 1963 - June 17, 2014

Dr. Tony Aram will be remembered not only as a great surgeon, but a great friend and colleague to many. He lived an exemplary life of devotion, honor, humbleness and dedication to his family, friends and his profession.

Dr. Aram unexpectedly passed away Tuesday morning, June 17, 2014 of natural causes at his home. Tony Aram touched the lives of countless patients and friends over several years in practice.

He devoted his life to the betterment of everyone else and for that so many are grateful.

Tony Aram, M.D. built a culture of radically caring for patients while utilizing the most advanced medical technology. In his pursuit, he became known community-wide for pushing the limits in Orthopaedics to achieve radical results.

We will forever remember his smile and lively personality that would bring light to any situation. He will be sorely missed.

The legacy of Dr. Tony Aram will live on, as the practice he built, Advanced Orthopaedics and Sports Medicine Institute (AOSMI), will continue to serve and treat patients in the Washington, D.C./metro area. After several years of searching for a Doctor to join the practice, and prior to his passing, Dr. Aram hand selected Dr. Asheesh Gupta to join the practice. Dr. Gupta will carry on the mission and vision that AOSMI was so diligently founded on many years ago.

Tony was a significant part of the Joint Implant Surgery & Research Foundation (JISRF) and participated in both our Tissue Sparing Implant (TSI™) Study Group and was part of our Editorial Board for JISRF's journal Reconstructive Review. He will be fondly remembered and we will miss the passion he had for both orthopaedics and his personal and professional friendships. You were a good man Tony and you will always be remembered and missed.

Timothy McTighe, Dr. H.S. (hc)
Executive Director, JISRF

Reconstructive Review

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Chagrin Falls, OH, USA
tmct@jisrf.org

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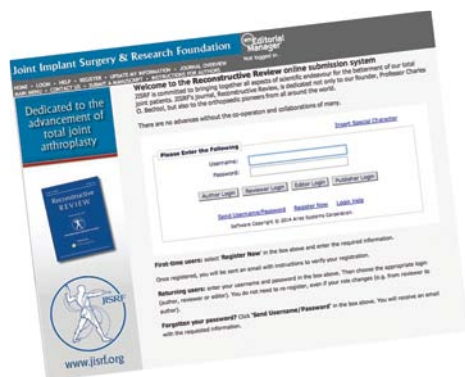


Charles Bechtol, MD was internationally known in the fields of biomechanics and orthopedic surgery. His engineering and biomechanical research resulted in the development of numerous joint replacement implants and internal fracture fixation devices – instruments that are familiar to orthopedic surgeons the world over. His innovations included shoulder and knee prostheses, the Bechtol Total Hip system, the Bechtol “fluted” bone screw, and the Bechtol “continuous strength” bone plate.

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If you would like to become a reviewer on Reconstructive Review please visit
<http://JISRFRR.edmgr.com>
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If you require any assistance please contact David Faroo, Managing Editor at dfaroo@jisrf.org.

Reconstructive REVIEW

Now with its own website to facilitate a more user friendly platform for viewing and searching all past and current articles. The website is based on open source software called Open Journal Systems (OJS) created by the Public Knowledge Project.

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In addition to having Reconstructive Review articles being available on its own website, articles will also be available for viewing at the site of the International Congress on Joint Reconstruction (ICJR), as well as JISRF.





The Reconstructive Review (ISSN 2331-2262 print, ISSN 2331-2270 online) will be published initially once a year working towards four times a year in 2014 by the Joint Implant Surgery & Research Foundation (JISRF), 46 Chagrin Plaza #117, Chagrin Falls, Ohio 44023.

Editorial Correspondence

Please direct any requests for inclusion, editorial comments or questions to Timothy McTighe, Dr. HS (hc), Executive Director, JISRF, 46 Chagrin Plaza #117, Chagrin Falls, Ohio 44023, tmct@jisrf.org.

Correspondence

Direct any questions regarding the submission process, or requests for reprints to David Faroo, Director of Communications, JISRF, 46 Chagrin Plaza #117, Chagrin Falls, Ohio 44023, dfaroo@jisrf.org.

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- Clinical/Surgical
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- Historical Reviews
- Letters to the Editor
- Surveys

The emphasis for these subjects is to address real life orthopaedics in a timely fashion and to encourage the participation from a broad range of professionals in the orthopaedic health care field.

We will strive to be responsible and reactive to the needs expressed to our editors and all members of JISRF. We anticipate our format will evolve as we move forward and gain more experience with this activity. Your opinion is a critical step to our motivation and overall success, please do not hesitate to communicate with us.

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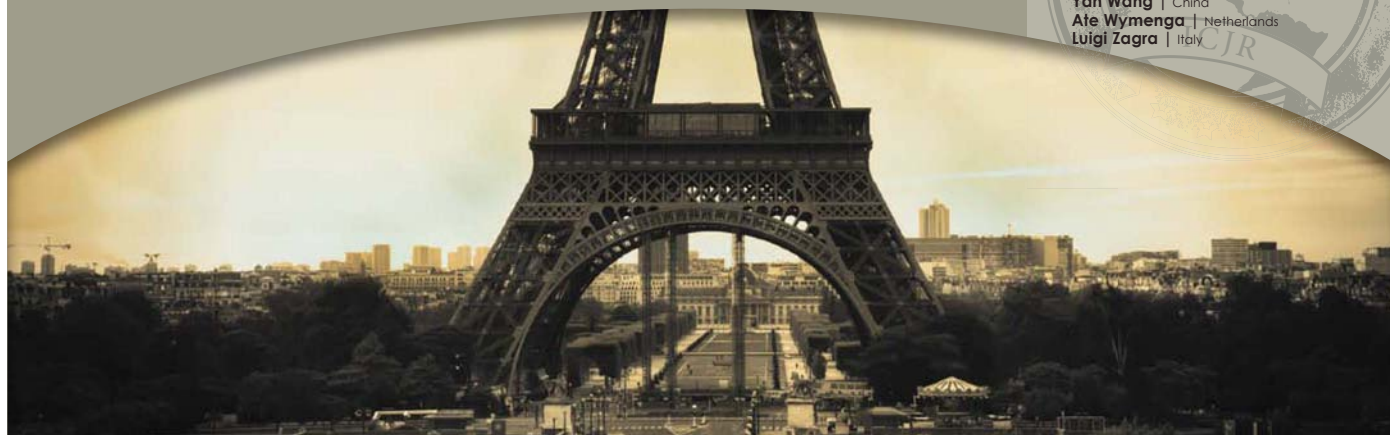
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- Purpose clearly stated
- Methods defined
- Results adequately described
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Podium Presentation Abstracts

State of Arthroplasty in the World

O1A1

State of Hip Arthroplasty in North America

Guest Faculty: Daniel J. Berry, MD

Institution: Mayo Clinic, Rochester, MN, USA

I. Introduction

- A. About 400,000 THA per year
- B. About 2.5 million Americans living with THA
- C. A remarkable testament to the success of this operation

II. Current Practice

- A. Uncemented implants: acetabulum and femur; with limited use of “hybrid fixation”
- B. Cross-linked polyethylene bearing surface
- C. Larger diameter femoral heads 32-36mm
- D. Increased use of ceramic heads

III. Current Trends

- A. Interest/Marketing related to operative approach
 - 1. Current U.S. usage: anterior 20%; anterolateral 20%; posterior 60%
- B. Optimized perioperative management:
 - 1. Pain management—blocks and local injection
 - 2. Rapid rehab protocols—early dismissal
 - 3. Tranexamic acid to reduce transfusion rates

IV. Current Concerns/Unsolved Problems

- A. Trunion/taper tribocorrosion with metal heads
- B. Early postoperative fractures after uncemented femoral components
- C. Infection—stubbornly persistent rate
- D. Instability—decreased but not gone

O1A2

The State of Total Hip Arthroplasty in Asia

Guest Faculty: S.K.S. Marya, MS, DNB, MCH, FRCS, FICS

Institution: Max Institute of Knee & Hip Replacement Surgery, New Delhi, India

Asian spectrum spreads from bullock carts to Boeing jets and from very basic to the most advanced technology. While sections of the continent may lack in research and design, there is no lack of manpower, willingness to learn and innovate within available means.

PRIMARY VS SECONDARY OSTEOARTHRITIS:

In contrast to primary osteoarthritis being the commonest indication for hip arthroplasty in the west, in most Asian populations secondary osteoarthritis takes the patient to the operating table as a sequel of Avascular Necrosis of femoral head, inflammatory arthritis, and post traumatic situations.

BONE MORPHOLOGY AND SIZES:

Asian sizes can vary from XXL to XXS. Innovations have been considered and Asian hip designs have been thought of. At times narrow femoral canals and small acetabulae have to be approached by unconventional methods.

SOCIAL HABITS:

Many social, religious and cultural needs require the joint to accord extremes of movements viz. squatting and sitting cross legged. This has popularised the use of large femoral head sizes but issues with metal on metal surfaces has deflated the enthusiasm.

FACILITY, IMPLANTS AND EQUIPMENTS:

At times the operating conditions may be suboptimal. The complete set of instrumentations may not be available and a trimmed set of trays with sheer innovative ideas is put to use. There is a clear shift of preference for use of cement less implants.

EDUCATION AND TRAINING:

Asians have been keen and gritty learners. There are no 48 hours working weeks. Fellowships and frequent visitations to and from experienced international surgeons and speakers, teaching aids, live surgeries and increasing numbers of patients willing to get operated has certainly helped in evolution.

COST CONSIDERATIONS AND NEWER TECH-

NOLOGIES: While costs are a worldwide concern, Asia has its own obvious difficulties in most pockets. From paying in cash the trend is shifting to Insurances, government support and protection from employers. However we are seeing many administrators and insurance companies emphasising the need to cut costs at times to maximise profits. On the one hands surgeons are looking at ceramics and computers and on the other many are happy with results of Austin Moore and Thompson prosthesis in young patients.

REGISTRIES: As an explosion of such surgeries is expected in Asia there is a great need for proper documentation and research. Perhaps this is where we are lacking the most. Level 5 evidence may not stand the test of time.

LEGAL ISSUES: If Mc Donald's and KFC have arrived in Asia so has the delicious concept of medical negligence and legal recourse. Today the blind trust in the profession is increasingly being challenged. Here internet has served as a dual edged sword.

SUMMARY: While we lack in research and design in most parts of Asia, we benefit from tried and tested concepts from the more developed nations. In this endeavour we at times miss the point e.g. tropicalised refrigerators.

O1A3 State of Knee Arthroplasty in North America

Guest Faculty: Norman W. Scott, MD, FACS
Institution: Insall Scott Kelly Institute for Orthopedics and Sports Medicine, New York, NY, USA

In the late 1960's and early 1970's the goal of knee arthroplasty was to give the badly deformed patient, suffering from either an inflammatory or non-inflammatory arthritis, a better alternative than a resection arthroplasty or arthrodysis, or braxial hinge replacement. Today, we are trying to recreate a more normal biomechanical, high performance, partial or complete knee replacement with a much less complicated and easier peri-operative experience for the patient. In these past 6 decades (1960's-2014), engineers and surgeons have flirted with these ideas of converting a painful arthritic knee into a more functionally normal knee.

The progress has been rather spectacular but the success has not been without an overzealous approach, sometimes not learning from our past mistakes. In today's discus-

sion, we will highlight the "why and how" of our progress and the significance of our gains with an understanding of where we are and of what is possible for the future state of knee arthroplasty.

O1A4 State of Knee Arthroplasty in Asia

Guest Faculty: Shuichi Matsuda, MD, PhD
Institution: Kyoto University, Kyoto, Japan

The first total knee arthroplasty in Japan was performed in 1970. Since then the number of procedure has increased year by year, and more than 75,000 total knee arthroplasty was done last year in Japan. In Korea, approximately 71,000 total knee arthroplasty were performed in 2012, but increase rate was less than 10% in these two countries. On the other hand, China and India are increasing the number by around 25% every year. In 2012, 76,000 and 69,000 total knee arthroplasty were done in China and India, respectively. Considering the large population of these two countries, the number of the procedure is expected to continuously increase. These numbers are mainly based on the investigation by private research company, because in Asian countries, national registry of joint arthroplasty has not well developed compared to European countries or Australia and New Zealand.

Since surgical indication has been limited to considerably advanced osteoarthritis and rheumatoid arthritis, Asian surgeons frequently treat the patients with severe deformities. Due to high success rate of total knee arthroplasty, however, the indication is recently changing to include less advanced osteoarthritis. Currently, the age of the patients are slightly higher than in the United States, so the patients do not seriously hope postoperative sports activities. Instead, the patients would like to have high flexion due to their life style or religious reason.

Research interest has grown up in Asian countries. In searching with Scopus, Asian countries significantly increased the number of the published papers regarding total knee arthroplasty from 51 (year of 2003) to 255 (2013) in total of Japan, Korea, China, and India. During the same period, the number increased from 255 (2003) to 504 (2013) in United States. Also, many papers are recently coming from Singapore, Taiwan, Malaysia, Thailand, etc. Research topics are different among Asian countries. For

example, Japanese surgeons focus more on gap measurement and kinematic analysis than the other countries, and more RCTs have been done in Korea.

Catering surgeries to ethnic difference is another important issue. We need to understand that type of deformity is different among the ethnic groups. For example, the tibia has more torsion in Asian people than Caucasian people. In coronal plane, the tibia has greater deformity of the proximal tibia in Asian people although the mid-shaft of the tibia is almost straight. Also, there is a study reported ethnicity difference of knee joint laxity. Of course, we should recognize differences of individuals, not only due to ethnicity. More personalized surgery will be required for the patient.

Technical Tips for Total Knee Arthroplasty

O2A3

Reliability of a Gap Control Technique With the Tensor/balancer During PS-TKA

Primary Author: Ryuji Nagamine

Institution: Bone and Joint Center, Sugioka Memorial Hospital

Coauthors: Keiichi Kondo (Bone and Joint Center, Sugioka Memorial Hospital), Yuika Chen (Bone and Joint Center, Sugioka Memorial Hospital), Koichiro Tanaka (Bone and Joint Center, Sugioka Memorial Hospital), Yoshinori Yo (Bone and Joint Center, Sugioka Memorial Hospital)

PURPOSE: Kinematics of the knees after TKA was analyzed by means of fluoroscopic images, and the reliability of a modified gap control technique with the tensor/balancer was assessed.

MATERIALS AND METHOD: Thirty-one knees in 30 cases were assessed. The mean age was 73.0 years old. They gave informed consent and agreed to participate in this study. The NRG PS System (Stryker® Orthopaedics, Mahwah, NJ, USA) was used in all patients. TKA was

performed with the modified gap control technique. Thirty inch-pounds were applied to expand the joint. Only the trial femoral component was inserted. The joint gap angle and distance between the tangent to the condyles of the trial femoral component and tibial cut surface in full extension and at 90° flexion were measured.

One month after TKA, the fluoroscopic images of the prostheses were taken during knee extension/flexion. Then, a torque of about 5Nm was applied to the lower leg in order to assess the varus/valgus flexibility at each flexion angle. The pattern matching method was used to measure the 3D movements of the prostheses from the fluoroscopic images.

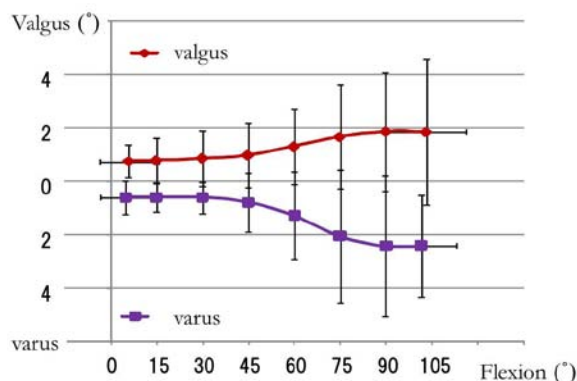
RESULT: Gap angle during TKA was $0.9^\circ \pm 1.4^\circ$ varus (mean \pm SD) in extension and was $0.3^\circ \pm 3.2^\circ$ valgus in flexion. Gap distance difference between extension and flexion with 30 inch-pounds expansion strength was 2.3 ± 1.8 mm. Gap angle after TKA was $0.1^\circ \pm 0.6^\circ$ varus in extension and was $0.6^\circ \pm 2.4^\circ$ varus in flexion. The mean joint gap in full extension and at 90° flexion was less than 1° both during TKA and after TKA. Varus/valgus flexibility after TKA was $1.6^\circ \pm 1.3^\circ$ in extension and was $3.9^\circ \pm 3.3^\circ$ in flexion (Fig. 1). The varus range was about 2° and the valgus range was also about 2° in flexion.

DISCUSSION AND CONCLUSION: The tensor/balancer is popular during TKA because the joint gap distance and angle can be assessed quantitatively. However, the joint gap angle and distance are influenced by many factors such as patellar eversion, force to expand the joint gap and the tensor/balancer itself. Therefore, the reliability of the PS-TKA by means of the tensor/ balancer is still obscure. In this study, the modified gap control technique was used during PS-TKA using the tensor/balancer, and relatively high force of 30 inch-pounds was applied to expand the joint gap. The foot was placed on the operative table when the joint gap at 90° knee flexion.

The results of this study showed that the joint gap during TKA was almost rectangular both in extension and flexion. The joint gap was also almost rectangular both in extension and flexion after TKA. The implanted knees were stable from full extension to knee flexion. The flexibility was larger in flexion compared with extension because of the mechanism of the post and cam.

These results showed that the tensor/balancer, with a load

of 30 inch-pounds, was reliable even though the patella was everted and the foot was placed on the operative table during TKA.



O2A4

Could Total Knee Replacement Design and Surgical Technique Affect In-Vivo Knee Kinematics and Clinical Outcomes?

Primary Author: Fabio Catani

Institution: University of Modena and Reggio Emilia

Coauthors: Francesco Fiacchi (University of Modena and Reggio Emilia), Francesco Zambianchi (University of Modena and Reggio Emilia), Vitantonio Digennaro (University of Modena and Reggio Emilia)

Orthopaedic surgeons and their patients continue to seek better functional outcomes after total knee replacement, but Total Knee Arthroplasty (TKA) designs claim characteristic kinematic performance that is rarely assessed in patients.

The objectives of this investigation is to compare in-vivo kinematics during daily living activities of two different TKA designs (15 patients with Scorpio NRG - Stryker Orthopedics and 16 with Journey Bi-Cruciate Stabilized knee system - Smith&Nephew) and to determine the in-vivo kinematics in knees with Cruciate Retaining (CR) TKA (8 patients with Triathlon CR – Stryker Orthopedics) Kinetically Aligned (KA) with Patient Specific Technology (PSI) and to compare them with findings of previous studies of kinematics of the same CR TKA design Mechanically Aligned (MA) with conventional surgery.

Both Scorpio NRG TKA and Journey BCS TKA reported a different posterior translation (Journey BCS 10-18mm,

NRG Scorpio 2-3mm) of the medial and lateral contact points between femur and tibia in all the analyzed motor tasks during knee flexion. Both the prosthetic designs reported progressive external rotation of the femoral component relative to the tibia during flexion. Journey BCS group reported also statistically significant better KOOS results. Regarding complication occurrence, stiffness was more frequently reported in the Journey group (5.2% vs 1.2%), whereas anterior knee pain was observed only in the Scorpio NRG group (1.9%).

Triathlon CR kinematically aligned with PSI showed an average external rotation of the femur on the tibial base-plate of 7.6° during chair-rising, 9.5° during step up and 11.6° during leg extension. The corresponding mean antero-posterior translations between femoral and tibial components during the three motor tasks were +4.7, +6.4 and +8.4 mm on the medial compartment, and -2.5, -3.6, -2.6 mm on the lateral compartment, respectively, with the medial condyle moving progressively anteriorly with flexion, and the lateral condyle moving progressively posteriorly with flexion.

We compared Triathlon CR KA TKA results from this study with Triathlon CR TKA mechanically aligned with conventional surgery. The results of this study shows no screw home mechanism. The internal rotation of the tibia with knee flexion is close to healthy knee, better than Triathlon CR TKA operated with standard surgery.

The medial condyle is characterized by the same pattern of the implant operated with mechanical alignment, with a paradoxical anterior translation of 5mm. The lateral condyle shows a posterior rollback better than Triathlon CR operated with standard surgery.

In conclusion, the higher posterior femoral rollback observed in the kinematic assessment of Journey BCS, associated with a better patello-femoral design, could be the reason for better clinical outcomes. Instead, cases of stiffness and antero-lateral pain with joint can be attributed to excessive medial and lateral tibiofemoral posterior translation. The NRG group demonstrated good axial rotational but this was not coupled to physiological kinematics patterns. Patello-femoral pain can be explained by less friendly femoral groove design.

In this study we demonstrated that TKA clinical-functional outcome and complications are highly influenced by the

bearing geometry and kinematic pattern of prosthetic designs, which can be influenced also by the surgical technique.

O2A5

The Importance of 2mm and 2 Degrees in Total Knee Balancing

Primary Author: Patrick A. Meere

Institution: NYU Hospital for Joint Diseases

Coauthors: Peter S. Walker (NYU Hospital for Joint Diseases), Christopher P. Bell (NYU Hospital for Joint)

The purpose of balancing in total knee surgery is to achieve smooth tracking of the knee over a full range of flexion without excessive looseness or tightness on either the lateral or medial sides. Balancing is controlled by the alignment of the bone cuts, the soft tissue envelope, and the constraint of the total knee. Recently, Instrumented Tibial Trials which measure and display the location and magnitude of the forces on the lateral and medial condyles, have been introduced, offering the possibility of predictive and quantitative balancing. This paper presents the results of experiments on 10 lower limb specimens, where the effects of altering the bone cuts or the femoral component size were measured.

A special leg mounting rig was fixed to a standard operating table. A boot was strapped to the foot, and the boot tracked along a horizontal rail to allow flexion-extension. The initial bone cuts were carried out by measured resection using a navigation system. The trial femoral component and the instrumented tibial trial were inserted, and the following tests carried out: Sag Test; foot lifted up, the trial thickness chosen to produce zero flexion. Heel Push Test; heel moved towards body to maximum flexion.

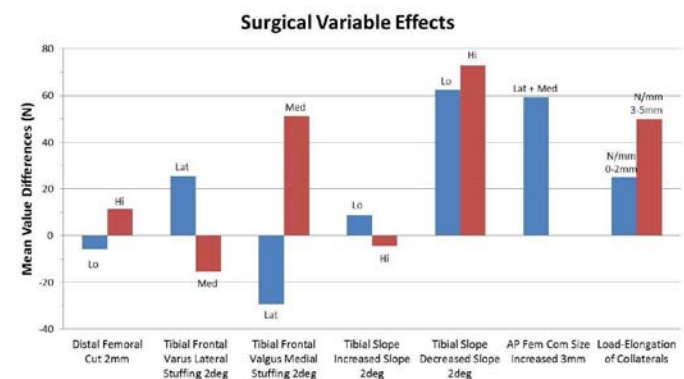
Varus-Valgus Test, AP and IXR Tests were also carried out, but not discussed here. For an initial state of the knee, close to balanced, the lateral and medial contact forces were recorded for the full flexion range. The mean value of the contact forces per condyle was 77.4N, the mean in early flexion (0-60 deg) was 94.2N, and the mean in late flexion (60-120 deg) was 55.7N. The difference was due to the effect of the weight of the leg. One of the following Surgical Variables was then implemented, and the contact forces again recorded.

1. Distal femoral cut; 2mm resection (2mm increase in insert thickness to preserve extension)
2. Tibial frontal varus, 2mm lateral stuffing
3. Tibial frontal valgus, 2mm medial stuffing
4. Tibial slope angle increase (5 deg baseline); +2 degrees
5. Tibial slope angle decrease (5 deg baseline); - 2 degrees
6. Increase in AP size of femoral component (3mm)

The differences between the condyle force readings before and after the Surgical Variable were calculated for low and high angular ranges. The mean values for the 10 knees of the differences of the above Surgical Variables from the initial balanced state are shown in the chart.

From literature data, the mean tension increase in one collateral ligament is close to 25N/mm up to the toe of the load-elongation graph, and 50N/mm after the toe. Hence in the initial balanced state, the collateral ligaments were elongated by 2-4mm producing pretension. From the Surgical Variables data, up to 2mm/2deg change in bone cuts (or 3mm femcom change), and collateral ligament releases up to 2mm, would correct from any unbalanced state to a balanced state.

This data provides useful guidelines for the use of the Instrumented Tibial Trials at surgery, in terms of bone cut adjustments and ligament releases.



O2A6

Gap Balancing in TKA

Guest Faculty: Raymond H. Kim, MD

Institution: Colorado Joint Replacement, Denver, CO, USA

Multiple studies demonstrate total knee instability is one of the major causes of failure leading to revision surgery. Often the etiology of knee instability is attributed to technical

errors of inadequately balancing the flexion and extension gaps. Various techniques have been utilized to establish proper femoral component rotation such as the trans-epi-condylar axis, the femoral anteroposterior axis, 3 degrees external rotation relative to the posterior femoral condyles, or the gap-balancing methodology in which the femoral component is positioned parallel to the resected proximal tibia with the medial and lateral collateral ligaments and soft tissues equally tensioned. Utilization of bone or anatomic landmarks to establish femoral component rotation can lead to frequent error due to anatomic variability. Current data suggests use of measured resection techniques often results in flexion gap asymmetry and increased incidence of femoral condylar lift-off compared to utilization of the gap balancing technique.

O2A7

Clinical Benefit of Bony Island Resection in Posterior Cruciate Ligament Retaining Total Knee Arthroplasty

Primary Author: Yoshio Onishi

Institution: Department of Bone and Joint Surgery, Ehime University Graduate School of Medicine

Coauthors: Kazunori Hino (Department of Bone and Joint Surgery, Ehime University Graduate School of Medicine), Masami Ishimaru (Department of Bone and Joint Surgery, Ehime University Graduate School of Medicine), Yasutake Iseki (Department of Bone and Joint Surgery, Ehime University Graduate School of Medicine)

INTRODUCTION: In posterior cruciate ligament–retaining total knee arthroplasty (CR-TKA), a small bone block (bony island) is often preserved to protect the posterior cruciate ligament (PCL) during tibial resection, but this procedure is troublesome. In contrast, we prefer to resect the tibial plateau completely. However, since it has been reported that resecting the PCL results in an increase of the flexion gap, there is concern over a potential increase of the flexion gap in our procedure due to partial detachment of the PCL. The purpose of the present study is to evaluate the influence of bony island resection on the joint gap.

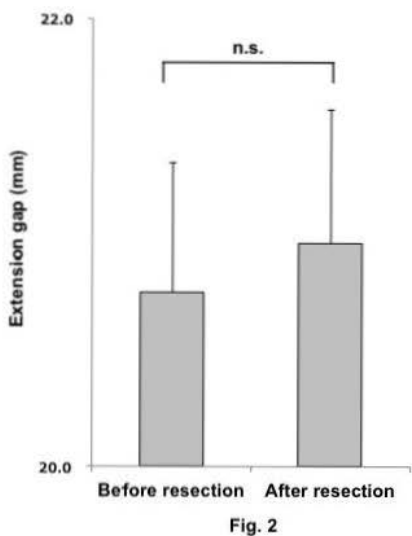
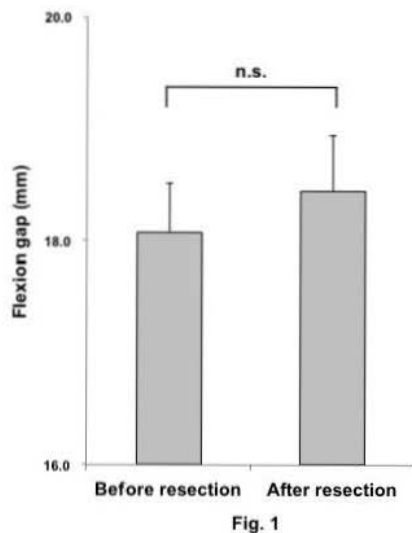
METHODS: The subjects were 20 consecutive patients who underwent CR-TKA for varus osteoarthritis. There were 18 women and two men with a mean age of 71.8 years (range, 62–82 years). All operations were performed

using a posterior cruciate ligament–retaining prosthesis (MERA Quest Knee System, Senko Medical Instrument Manufacturing, Tokyo) with a measured resection technique. The distal femur was cut and the tibial plateau resection was made with preserving the bony island. The central joint gaps in 90° flexion and full extension were measured using a tensioning device (Offset Repo-Tensor, Zimmer, Warsaw, IN) at a 40-lb distracting force. After the resection of the bony island, the central joint gaps were measured by the same method. In addition, the posterior tilt of the tibial resection and the depth of the lateral tibial cut were measured.

RESULTS: The flexion gaps before and after the resection were 18.1 ± 0.4 and 18.4 ± 0.5 mm, respectively, and there was no statistical difference ($p = 0.07$) (Fig. 1). Similarly, the extension gap did not increase significantly before and after the resection (20.8 ± 0.6 and 21.0 ± 0.6 mm; $p = 0.81$) (Fig. 2). The posterior tilt was $6.0 \pm 1.4^\circ$, and the depth was 10.4 ± 1.2 mm.

DISCUSSION: The PCL is the largest and strongest ligament in the knee. It mainly works as the first stabilizer against posterior laxity and performs as the second stabilizer against valgus laxity in mid-flexion. Accordingly, we think that preserving the PCL leads to postoperative joint stability in total knee arthroplasty. Our procedure is comparatively easy, but we cannot avoid the problem of partial detachment of the PCL. The PCL is comprised of two bundles: the anterolateral bundle (ALB) and the posteromedial bundle (PMB). As for the attachments of the bundles, an anatomical study has reported that the locations of the centers of the ALB and PMB were 1.5 ± 0.8 and 6.0 ± 2.0 mm, respectively from the tibial plane. Therefore, considering our tibial resection, which is 10.4 ± 1.2 mm from the lateral plateau and extends obliquely from the lateral side to the medial side in the frontal plane, these data suggest that the distal part of the ALB attachment and the majority of the PMB attachment are preserved. This is supported by the results of our study.

CONCLUSIONS: Bony island resection can facilitate the surgical procedure and preserves the PCL function.



most common but serious complications and has a significant impact on morbidity and costs due to revision surgery and / or intensified rehabilitation required. Numerous factors have been associated with an unstable hip including patient and surgical factors (such as surgical approach, failure to restore soft tissue tensioning and hip biomechanics) and implant design. Occasionally the etiology of the dislocation is multifactorial or unknown.

When dislocation occurs, a thorough medical history, physical examination, and radiograph assessment are recommended. An understanding of the mechanism, timing and direction of dislocation is mandatory in formulating the appropriate treatment. Restoration of limb length and offset and careful assessment of radiographs and CT scans to study component orientation is vital. Non-surgical intervention usually is possible. When this fails, then revision surgery usually involves correction of malpositioning; improvement of head to neck ratio; usage of constrained cup / dual mobility cups; or augmentation of soft tissues to prevent further instabilities.

To minimize the frequency of early dislocation, patients, nursing staff and physiotherapists, and the doctors responsible for following up, must be given precise instruction. Surgeon's experience also plays a role in minimizing instability. As large studies change the common wisdom within the community so that more surgeons are doing better surgeries, the rates of dislocation may decrease.

O2B2

Indications for Constrained Liners

Guest Faculty: Adolph V. Lombardi Jr., MD, FACS

Institution: Joint Implant Surgeons, Inc., The Ohio State University, and Mount Carmel Health System, New Albany, OH, USA

THA Dislocation

O2B1

Effective Methods to Prevent Dislocations After Total Hip Arthroplasty

Guest Faculty: Nicolaas C. Budhiparama, Jr., MD

Institution: Nicolaas Institute for Constructive Orthopaedic Research & Education Foundation, Jakarta, Indonesia

Dislocation after total hip arthroplasty (THA) is one of the

Dislocation after total hip arthroplasty is a potentially devastating complication that can be difficult to manage. Many patient and mechanical factors have been associated with an increased risk of dislocation. Surgical options include the use of larger femoral heads, unconstrained tripolar femoral heads, dual mobility designs and newer constrained devices. Advances in bearings have expanded prosthetic head options from traditional sizes to diameters as large as 60 mm. Large heads enhance stability secondary to increased range of motion before impingement and

increased jump distance prior to subluxation. [3,5]

Risk factors for dislocation can be categorized as impingement-independent and impingement-related. Impingement-independent factors involve compromise of soft tissue tension and maybe related to insufficient offset, improper position of the hip center, insufficient tissue balance, trochanteric avulsion, compromised abductor muscle or inadequate soft tissue closure. Patient specific factors include neurologic disorders, advanced age, gender, diagnoses such as developmental dysplasia and rheumatoid arthritis, number of previous surgeries, non-compliant patient behavior and substance abuse. While the posterior approach has been associated with a higher rate of dislocation versus the direct lateral approach, the incidence has markedly decreased with current emphasis on repair of the posterior capsular structures. The direct lateral approach (presenter's preference) has the advantage of improved visualization of the acetabulum and femur without the compromising the posterior capsular structures which are integral to the stability of the hip. [3,4,6] Impingement-related risk factors for dislocation can be subdivided into several groups. While larger heads have been shown to decrease incidence of dislocation, head-to-neck ratio may be more important. Inadequate head-to-neck ratio produces impingement. Considering a standard neck length in a 7° included angle taper, range of motion prior to impingement increases from 127.4° for a 28mm head to 138.62° for a 36mm head. Additionally, the taper geometry has an effect on range of motion. A 36mm head with a 7° included angle taper will allow 138.6° range of motion prior to impingement while the same head size with 12/14 allows 132.09°. A neck design with flat sides or trapezoidal shape enhances range of motion prior to impingement. A long versus short neck is advantageous for minimizing bony impingement. Acetabular liners without high walls or labrums decrease impingement. Optimization of femoral and acetabular component position can decrease impingement. Finally, restoration of proper offset and removal of osteophytes can prevent bone and soft tissue impingement.

A thorough evaluation of the soft tissues is warranted because a tenuous or stretched abductor mechanism increases the risk of dislocation. Prosthetic stability can be enhanced by positioning the acetabular component in a reduced, more horizontal angle of inclination. A constrained acetabular component or a snap-fit cup with an extended labrum can also be helpful when dislocation potential is increased. The effectiveness of such intraoperative techni-

cal modifications can be enhanced by modifying the postoperative rehabilitation program to include the use of an abduction orthosis.

At the time of component reduction the surgeon must make final determinations with respect to stability and leg length. Optimally, the acetabulum should be reconstructed to maintain the anatomic hip center and the femur should be reconstructed to restore its anatomic length. When dealing with the issue of hip stability versus leg length, one should always opt for stability. If a trochanteric osteotomy has been performed, stability may be enhanced by advancement of the trochanteric fragment. If a posterolateral approach has been performed, attempts should be made to repair the short external rotators. If the direct lateral approach has been used, meticulous approximation of the myofascial sleeve should be performed.

Postoperative management is dictated by the extent of surgical reconstruction performed. Stability as assessed at reduction is critical in determining need for a hip abduction orthosis during initial physical therapy and rehabilitation. The physical therapist should be apprised of concerns regarding stability and instruct the patient with respect to hip precautions such as prolonged sitting in a chair, techniques for rising from a toilet, climbing stairs and riding in a car. If a trochanteric osteotomy was performed, there should be appropriate delay in commencing hip abduction exercises. With respect to dislocation, prevention is the best treatment and paramount to avoiding this complication. The soft tissue envelope about the hip must be respected in every primary and revision arthroplasty. Component position and orientation must be optimized. Restoration of offset and leg length helps to restore soft tissue balance and tension. The use of large femoral heads with reduced tapered geometries enhances the range of motion prior to impingement and therefore, diminishes the incidence of dislocation. Constrained liners may be indicated but represent a necessary evil and should be used with caution. [2] Our disappointing experience with the S-ROM Poly-Dial constrained liner has led us to explore newer designs. [1,2] Several newer designs are approved for use in the U.S. One particular design used in our practice allows constraint of a 36mm head. [1] Therefore, the range of motion prior to impingement varies from 109 to 114°, a significant enhancement over previous designs. Results have improved with the introduction of newer designs. [1]

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O2B3

Low Dislocation Rate in 100 Consecutive Revision Total Hip Replacements with Large Diameter Bearings

Primary Author: Pranai K. Buddhdev

Institution: North West Thames Deanery, London

Coauthors: Neil Davies (West Hertfordshire Hospitals Trust, UK), Tim Waters (West Hertfordshire Hospitals Trust, UK)

INTRODUCTION: Revision total hip arthroplasty is becoming increasingly common due to implant failure and higher patient demand of activity. In 2011, the National Joint Registry (UK) collected data on 8,639 revision hip arthroplasty procedures. Dislocation rates following revision surgery have been reported in the literature to be be-

tween 7-20%. We postulate that the use of larger femoral head sizes reduces the dislocation rate.

AIM: The objective of this study was to assess the early dislocation rate of revision total hip replacements with large bearing diameters (head size > 36mm).

METHOD: We prospectively studied 100 consecutive patients undergoing revision total hip arthroplasty by a single surgeon (TW) (2009-2012). All patients had a minimum of 6 months follow-up. Data was collected with regards to: reason for revision, state of the abductors, size of bearing surfaces and post-operative complications including dislocation.

RESULTS: All patients underwent revision surgery through a posterior approach. This included a trochanteric osteotomy in 11 patients. Care was taken to repair the posterior soft tissues where feasible. There were 38 males/62 females (average age 72 years). The reasons for revision included aseptic loosening (68), recurrent dislocation of primary THA (11), infection (11), Pain (5) and peri-prosthetic fracture (5). All patients received a large femoral head size; 36mm (90), 40mm (9) and 44mm (1). The abductor mechanism was found to be compromised in 11 patients. Two patients experienced dislocations post-operatively; both occurred within 3 months of surgery and in both the abductor mechanisms were not intact. There were three deep infections. One (previously infected case) was treated with a further two-stage revision. One of the two dislocations was infected and revised to excision arthroplasty. The third case was treated with suppressive antibiotic therapy. There were three peri-prosthetic fractures; one was revised to a longer-stemmed prosthesis and two with cable-plating.

CONCLUSION: This study showed that larger femoral head sizes (>36mm) are associated with a lower dislocation risk in patients undergoing revision total hip replacements compared to smaller head arthroplasty studies previously reported in the literature. An intact abductor mechanism remains to be a key factor in the risk of dislocation and the utmost care with the anatomical repair of the soft tissues is paramount.

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O2B4

Three-Dimensional Computerized Preoperative Planning of Acetabular Prostheses Implantation in Total Hip Arthroplasty with High-riding Dislocation DDH

Primary Author: Yi Zeng

Institution: Department of Orthopaedic Surgery, West China Hospital, West China Medical School, Sichuan University

Coauthors: Oujie Lai (Department of Orthopaedic Surgery, West China Hospital, West China Medical School, Sichuan University), Bin Shen (Department of Orthopaedic Surgery, West China Hospital, West China Medical School, Sichuan University), Jing Yang (Department of Orthopaedic Surgery, West China Hospital, West China Medical School, Sichuan University)

OBJECTIVE: we prospectively studied whether the CT-based 3D computerized pre-operative planning are accuracy and reliability to predict acetabular component size, hip rotation center and acetabular component coverage in high-riding dislocation developmental dysplasia hip (DDH) patients.

METHODS: 20 high-riding dislocation DDH patients (20 hips) were included in this study between September 2009 and February 2011. All patients had pre- and post-operative CT scans and data were transferred digitally to Mimics software. The 3D pre-operative planning was performed using Mimics software to predict the acetabular component size, hip rotation center position and acetabular com-

ponent coverage. The results were compared with the traditional acetate templating technique and post-operative results.

RESULTS: The mean predicted acetabular component size by 3D computerized planning was 45 mm, 1 mm lower than the mean implanted size of 46 mm. 70% (14/20) components were predicted exactly and 30% (6/20) components were predicted with one size using 3D computerized planning, comparing 25% (5/20) components were exactly, 45% (9/20) components were with one size and 30% (6/20) were with two size or more using conventional acetate templating technique. There was a high correlation between the 3D computerized planned acetabular component size, hip rotation center distance, acetabular component host coverage and that found post-operatively. 5 patients were considered to need structural bone graft in 3D computerized planning, which were high coincident with the post-operative results.

CONCLUSION: CT-based 3D computerized pre-operative planning using Mimics software is an accurate and reliable technique for patients with high-riding dislocation dysplastic hips undergoing total hip arthroplasty.

O2B5

Are Hip Precautions Necessary after Posterior Approach to Total Hip Arthroplasty?

Primary Author: Aidin Eslam Pour

Institution: University of Michigan

Coauthors: Thomas L. Bradbury (Emory University), Greg A. Erens (Emory University), James R. Roberson (Emory University), Alec Johnson (Emory University), Richard Thomas (Emory University)

INTRODUCTION: The routine use of posterior hip dislocation precautions is typically utilized postoperatively following total hip arthroplasty via a posterior surgical approach. This has included use of an abduction pillow and limiting adduction, internal rotation and flexion more than 90 degrees for a minimum of 6 weeks postoperatively. This may slow the course of rehabilitation, increase the length of hospital stay and the total cost of the procedure, and add additional anxiety to the patient. We conducted this study to see if posterior hip precautions are necessary after total hip arthroplasty via a posterior approach when the hip

meets certain intraoperative criteria for stability.

METHODS AND MATERIALS: All patients in our institute undergo routine hip stability testing during primary total hip arthroplasty via a posterior approach. Before October 2010, all of our primary total hip arthroplasty patients were placed on routine hip precautions. We stopped hip precautions in October 2010 for all the patients who were noted to meet hip stability criteria intraoperatively. We prospectively compared the consecutive patients who underwent this procedure without hip precautions with a retrospective control group of patients who had hip precautions.

RESULTS: We had 650 patients in each group. In the case group, there was 1 postoperative dislocation (0.2%) within the first 3 months after surgery. In the control group (with hip precautions), 2 patients (0.3%) sustained hip dislocation within 3 months after surgery ($p=0.5$). The mean hospital stay was 2.5 (0-11) days for the case group and 2.7 (1-9) days for the control group ($p=0.03$). Patients in the case group were discharged to home more often compared to the control group (83.7% versus 83.4%), but the difference was not significant ($p=0.48$). There was no difference in the Harris Hip score improvement between the two groups. Higher percentage of the patients in the case group received larger femoral head implant (35% versus 14%, $p<0.001$) and elevated rim polyethylene liner (70% versus 57%, $p<0.001$).

CONCLUSION: Intraoperative hip stability testing is necessary for all patients who undergo primary total hip arthroplasty via a posterior approach. If the hip is not stable intraoperatively, the surgeon should ensure that all sources of potential instability have been evaluated and managed. This may include implant sizing, implant position, and all sources of internal and external impingement. Use of a larger diameter head and elevated rim polyethylene may help with the stability of the hip. If the hip meets our stability criteria intraoperatively, we feel that formal hip precautions may not be necessary postoperatively.

O2B6

Dislocation After THR - Is It Solved? The Role of Large Femoral Heads

Primary Author: Ed Marel

Institution: Peninsula Orthopaedics and the AOA NJRR

Dislocation after Total Hip Replacement (THR) remains the second most common reason for revision in the Australian Orthopaedic Association National Joint Replacement Registry (AOA NJRR) and is the most common reason out to 3 years post operatively. There are many causes and associations of dislocation, including patient behaviour and (often unrecognized) spinal pathology leading to adverse component orientation. Femoral ball head size along with the head:neck ratio and the head:cup ratio are all important. Data from the AOA NJRR demonstrates a lower revision rate for dislocation with larger head sizes in all bearing surface combinations.

Data from the AOA NJRR confirms that the revision rate for replaced hips using non cross-linked polyethylene cups increases along with the head size, but this is not seen with cross-linked polyethylene cups.

THR using cross-linked polyethylene has a lower revision rate than THR using non cross-linked polyethylene, this difference is evident after only 3 months and the difference increases with time. The 12 year Cumulative Revision Rate (CRR) is 5.3% compared to 10.1%.

This lower rate of revision is due to a reduced revision rate for both dislocation and loosening/lysis. The revision rate for dislocation at 1 year was 0.4% for THR with cross-linked polyethylene and 0.7% with non cross-linked polyethylene.

Head sizes of 32mm and greater were used in 56.5% of THR with cross-linked polyethylene but only 12.7% of those with non cross-linked polyethylene. There was no difference in the revision rate for dislocation when head sizes of 32mm and less were compared, the difference was due to the higher proportion of larger head sizes used with cross-linked polyethylene.

However there are reasons why the benefits of larger femoral ball heads may not increase with increasing head size, this is chiefly because of altered cup subtended angles (and femoral head offset) geometries incorporated into cup and liner designs, especially the ceramic on ceramic bearings.

Larger head sizes may also increase the risk of taper disease, especially with smaller tapers and softer metal alloys. Exchangeable neck prostheses, introduced to allow surgeons more control over orientation and offset have a higher revision rate in the AOA NJRR and this increased

revision rate is due to prosthetic dislocation as well as loosening/lysis.

O2B7

The Influence of Design on Posterior Horizontal Dislocation Distance in Common Sizes of THA

Primary Author: Jim Nevelos

Institution: Stryker Orthopaedics

Coauthors: Christopher Heffernan (Stryker Orthopaedics), James Macintyre (Stryker Orthopaedics), David Markel (St John Providence Health, MI), Michael Mont (Lifebridge Health, Baltimore)

INTRODUCTION: Dislocation is a concern in total hip arthroplasty (THA). Risks may be higher in smaller cups (where smaller head sizes are used), or in larger components such as those used in revisions where the head size / shell outer diameter (OD) ratio is decreased. Dual mobility (DM) devices may be effective in managing dislocations. Historically, dual mobility devices have been cylindrospherical in design. However, some of the newer dual mobility designs include an anatomic rim, a sub-hemispheric, and a modular design. This study investigated posterior horizontal dislocation distance (PHDD) for these new designs of DM cups across a range of head and cup sizes.

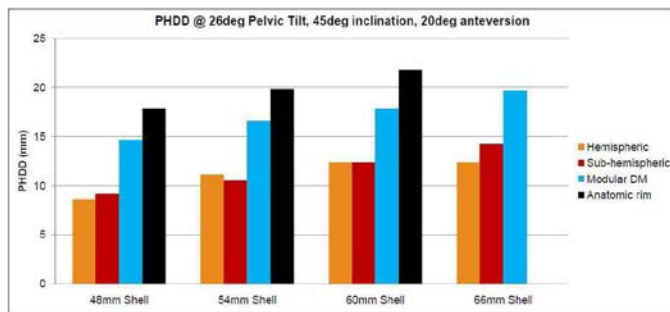
METHODS: Previous work has identified a new 3-D measurement of hip replacement stability, the PHDD [1]. A CT scan of a pelvis was imported into Pro/Engineer 3D CAD software (Parametric Technology Corporation, Needham, MA, USA). The acetabular component was virtually implanted in a defined orientation (45° inclination / 20° anteversion). The pelvis was rotated (26° forward tilt) after implantation of the component to represent a low chair rise situation which may be a high risk position for dislocation (Figure 2). Three acetabular component sizes were chosen -small primary (48mm), standard primary (54mm), and standard revision (60mm). Implants tested were a generic hemispheric type component (Hemi) with a head size typical for that cup OD; a dual mobility design with a sub-hemispheric cup (E1 Active, Biomet, Warsaw, IN); a modular dual mobility design with a 2.4mm cylinder (MDM, Stryker Orthopaedics, Mahwah, NJ); and a dual mobility design with an anatomic rim (ADM, Stryker Orthopaedics, Mahwah, NJ). The sub-hemispheric design was

modeled using information from the implant brochure and templates. It was hemispheric externally with up to 165 degrees of acetabular-head coverage internally. The anatomic rim implant was positioned in the pelvis per surgical technique.

RESULTS: The range of head sizes and cup sizes tested is shown in Figure 1 along with the measured PHDDs. These results are shown graphically in Figure 2. The anatomic rim dual mobility design is not currently available in 66mm OD.

Cup Size	Design Type & Head size	PHDD (mm)
48mm	28mm Hemispheric	8.6
	42mm Sub-hemispheric	9.2
	36mm Modular DM	14.6
	42mm Anatomic Rim	17.8
54mm	36mm Hemispheric	11.1
	48mm Sub-hemispheric	10.5
	42mm Modular DM	16.5
	48mm Anatomic rim	19.8
60mm	40mm Hemispheric	12.4
	54mm Sub-hemispheric	12.3
	46mm Modular DM	17.8
	54mm Anatomic Rim	21.8
66mm	40mm Hemispheric	12.4
	60mm Sub-hemispheric	14.2
	52mm Modular DM	19.6

DISCUSSION: This study confirms that cup design affects three-dimensional jump height or PHDD more than the head size for various shell sizes. Comparing the standard hemispheric fixed bearings and the sub-hemispheric dual mobility design, the PHDDs are roughly equivalent across the size range despite the much larger heads used in the sub-hemispheric style dual mobility design. In the commonly used 54mm cup size, the sub-hemispheric dual mobility design used a 48mm head, but this had a lower PHDD than a conventional 36mm head in a fixed, hemispheric bearing. Across the 48 to 60mm shell size range, the anatomic rim had the highest PHDD values. The modular dual mobility design showed the second highest jump heights in all sizes up to 66mm, where it was the highest. Compared to the conventional fixed bearing designs, the anatomic design had a PHDD at least 78% higher for all sizes while the modular design ranged from 43 to 70% higher across the shell size range analyzed.



Clinical Outcomes of TKA

O3A1

The Indications for Revision in Total Knee Arthroplasty

Guest Faculty: Jean-Noël Argenson, MD, PhD

Institution: Institute For Locomotion, Aix-Marseille University, Marseille, France

I. Introduction

- A. Excellent functional and survivorship results after modern TKA
 1. Improvement in patient selection and indication
 2. Improvement in design and bearing surfaces
 3. Improvement in techniques and ancillaries

B. Increased number of TKA expected

1. Number expected, "the rise of the Baby boomer"
2. Despite improvement increasing number of expected revisions

C. Reasons for revision today after TKA

1. Early and late revisions
 - a. Before five years
 - b. After five years

2. Overall main reasons

- a. Loosening
- b. Infection
- c. Polyethylene wear
- d. Instability
- e. Pain/stiffness
- f. Osteolysis

g. Malposition

II. What are the main indications for early revisions

A. Infection up to 30% of the causes

- a. Can we keep the implant?
- b. One stage revision?
- c. Two stages revision

B. Instability and malposition up to 27 % of the causes

- a. Instability: up to 20% of TKA
- b. Bony and/ligament problems
- c. Malposition is not only a matter of frontal alignment
- d. Internal rotation of the implants

III. What are the main indications for late revisions?

A. Polyethylene wear: up to 34%

B. Aseptic loosening up to 24%

C. Instability

D. Fractures

- a. Evolving population: the rise of the elderly
- b. Evaluate the bony recipient
- c. Global medical management of the patient to avoid fractures

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O3A2

Mobile-Bearing TKA: Beyond 10-year Results

Guest Faculty: Raymond H. Kim, MD

Institution: Colorado Joint Replacement, Denver, CO, USA

Mobile-bearing TKA designs offer the advantage of allow-

ing increased implant conformity and contact area without dramatically increasing stresses transmitted to the fixation interface. The incorporation of polyethylene bearing mobility, such as in a rotating platform TKA design, allows rotation through the tibial tray-polyethylene bearing articulation and effectively minimizes the transfer of torsional stresses to the fixation interface that have been associated with fixed-bearing TKA implants. Various studies evaluating TKA using the rotating platform system reported no evidence of radiographic loosening, even at 20-years radiographic follow-up and reported that revision TKA was required in 0-0.2% due to aseptic loosening. Indications for the use of the mobile-bearing TKA remain unclear. Clinically, fixed and mobile-bearing TKA systems have performed similarly in outcome studies. A recent meta-analysis was performed to determine the clinical outcomes of mobile-bearing TKA. With regard to bearing complication rates, implants placed prior to 1995 displayed higher rates (1.6%) in contrast to those placed after 1995 (0.1%), likely secondary to improved surgical technique. Fifteen-year survivorship of the rotating-platform mobile-bearing group was 96.4%.

O3A3

Quality of Life Following TKR in 3 Distinct Patient Populations

Primary Author: Sureshan Sivananthan
Institution: Stanford University

Coauthors: Robert Nelissen (Leiden University Medical School, Holland), Nicolaas Budhiparama (Medistra Hospital, Indonesia), Christopher Mow (Department of Orthopaedic Surgery, Stanford University School of Medicine)

INTRODUCTION: Total Knee Replacement (TKR) is among the most common orthopaedic surgeries performed in the United States, with approximately 676,000 TKRs were performed last year. Despite the large number of patients undergoing this procedure there remains a 10 - 15% dissatisfaction rate following TKR. We set out to study if patient satisfaction following TKR varied between different continents with different cultures and ethnicities.

PATIENTS AND METHODS: We studied a consecutive sample of 60 TKRs performed in dedicated joint replacement centers in 3 continents; North America, Europe and Asia. All patients had a minimum of 2 years follow up.

All 3 groups were matched in terms of age, sex and indication for surgery. All patients were followed prospectively with preoperative and postoperative quality of life questionnaires, including SF-36, KOOS and Knee Society Scores (KSS). Our null hypothesis was that results of TKR showed no difference between the continents. Analysis of Variance (ANOVA) was used to test for difference between the patient cohorts.

RESULTS: All 3 cohorts of patients reported significant ($P<0.05$) improvements in their quality of life scores. Patients from Asia had significantly lower ($P<0.05$) pre-operative function scores which improved to match their western counterparts post operatively. Patients from Holland had significantly lower improvement in their function scores ($P<0.05$) compared with their US and Asian counterparts.

CONCLUSIONS: Total Knee Replacement provided similar benefits and improvement in quality of life to patient populations in all 3 continents as measured by SF-36, KSS and KOOS. Asian patients were found to have worse pain scores on presentation possibly related to their cultural reluctance to undergo surgery. Patients in Europe had lower post operative functional scores possibly due to their higher expectations from the knee replacement surgery.

O3A4

Long-Term Clinical Outcome and Survivorship of PFC Sigma Fixed-Bearing and Rotating-Platform TKAs in the Same Patients

Primary Author: Young-Hoo Kim
Institution: The Joint Replacement Center of Korea Ewha Womans University MokDong Hospital

Coauthors: Jang-Won Park (The Joint Replacement Center of Korea Ewha Womans University MokDong Hospital), Jun-Shik Kim (The Joint Replacement Center of Korea Ewha Womans University MokDong Hospital), Sourabh S. Kulkarni (The Joint Replacement Center of Korea Ewha Womans University MokDong Hospital)

BACKGROUND: To our knowledge, no study to date has compared press fit condylar (PFC) Sigma mobile- and fixed-bearing prostheses in the same patients for longer than ten years of follow-up. The purpose of the current study was to compare: the functional and radiographic re-

sults, the prevalence of osteolysis, and the overall revision rates at a mean of 12.1 years follow-up.

METHODS: The current study consisted of a consecutive series of 444 patients (mean age, 66.5 ± 7.4 years) who underwent bilateral simultaneous total knee arthroplasty at the same surgical setting. All of these patients received a PFC Sigma mobile-bearing prosthesis in one knee and PFC Sigma fixed-bearing prosthesis in the contralateral knee. At the time of each follow-up (mean 12.1 years; range, ten to thirteen years), the patients were assessed clinically and radiologically.

RESULTS: Postoperative total knee scores (95 compared with 94 points), McMaster Universities Osteoarthritis Index (19 compared with 18 points), University of California, Los Angeles activity score (5 compared with 5 points), range of motion ($129^\circ \pm 6.3^\circ$ compared with $127^\circ \pm 6.8^\circ$), and radiographic findings did not differ significantly between the two designs of the implants, on the basis of the numbers, at the final follow-up. The prevalence of aseptic loosening (1.4% compared with 1.8%) did not differ significantly between two designs. No knee in either group had osteolysis. The estimated survival rate as the revision end point was 98.2% (95% confidence interval, 91% to 99%) at 12.1 years in the PFC Sigma mobile-bearing prosthesis group and 97.5% (95% confidence interval, 91% to 99%) at 12.1 years in the PFC Sigma fixed-bearing prosthesis group.

CONCLUSIONS: The findings of the present long-term clinical study suggest that excellent clinical and radiological results were achieved with both PFC Sigma mobile- and fixed-bearing cruciate-retaining total knee designs. However, there was no significant clinical advantage for a mobile-bearing over a fixed-bearing total knee arthroplasty.

O3A6

Primary Total Knee Arthroplasty among Nonagenarian Patients: Patient Characteristics and Clinical Outcomes

Primary Author: Alexander Miric

Institution: Southern California Permanente Medical Group

Coauthors: Maria CS. Inacio, PhD (Southern California Permanente Medical Group), Matthew P. Kelly, MD

(Southern California Permanente Medical Group), Robert S. Namba, MD (Southern California Permanente Medical Group)

INTRODUCTION: As the US nonagenarian population continues to grow, more patients aged 90 and over will become candidates for total knee arthroplasty (TKA). They are likely to have a greater number of associated medical problems which may increase the risk for postoperative morbidity and mortality. The purpose of this study was to evaluate the patient characteristics and incidence of postoperative morbidity, mortality and readmission among nonagenarian patients who underwent TKA.

METHODS: A retrospective analysis of prospectively collected data by a Total Joint Replacement Registry was conducted. All elective, primary TKAs from 4/1/2001 to 12/31/2011 were included. Patient characteristics (age, sex, body mass index (BMI), race), co-morbidities (congestive heart failure, valvular disease, peripheral vascular disease, hypertension), general health (assessed by the American Society of Anesthesiologist Score (ASA)), and post-operative outcomes (length of stay (LOS), complications, readmission and mortality) were assessed. Individuals aged ≥ 90 years old at time of surgery were compared to those of patients aged < 80 and those 80-89 years old. Descriptive statistics were employed.

RESULTS: 216 (0.3%) of the 81,835 primary TKAs performed during the study period were performed among nonagenarians. The mean follow up time of the cohort was 3.0 years. Nonagenarian patients were predominantly white (74.5%), female (63.4%) and diagnosed preoperatively with osteoarthritis (98.2%).

(All data groups below in following order: patients < 80 , 80-89, and > 90 years of age)

In comparison to patients < 80 and 80-89 years old, nonagenarians had the highest prevalence of ASA scores > 3 (37.3% vs. 52.3% vs. 59.3%, respectively), congestive heart failure (2.3% vs. 6.9% vs. 9.5%), and valvular disease (2.6% vs. 8.0% vs. 12.2%). The nonagenarian prevalence of peripheral vascular disease (3.7% vs. 10.4% vs. 9.5%) and hypertension (59.0% vs. 71.8% vs. 70.3%) was similar to that of patients 80-89 and greater than that of patients < 80 . Nonagenarians had the lowest BMI (32.0 kg/m² vs. 27.7 kg/m² vs. 25.3 kg/m²) and the lowest prevalence of diabetes (29.9% vs. 25.3% vs. 15.3%).

The LOS of nonagenarians (mean 3.3 days, standard deviation (SD) =1.6) was longer than that of patients <80 (2.9 days (SD =1.6)) and that of patients 80-89 (3.2 (SD =1.8)). Nonagenarians had the highest rates of deep vein thrombosis (0.5% vs. 0.8% vs. 0.9%), 90-day readmission (5.8% vs. 10.9% vs. 12.2%), and 90-day mortality (0.2% vs. 0.8% vs. 3.7%). No significant differences in the incidence of infection (deep or superficial) or pulmonary embolism were observed.

DISCUSSION AND CONCLUSION: In a large series of nonagenarians undergoing TKA we observed that despite advanced age and a higher prevalence of some co-morbidities, nonagenarians had a LOS and complication rates comparable to those of younger TKA patients. Furthermore, postoperative mortality was within expected mortality for individuals 90 years and older. Higher readmission rates, however, highlight the benefit of close follow up during a prolonged postoperative period.

TKA among nonagenarians can be performed safely with a perioperative morbidity and mortality that is acceptable to both patient and surgeon.

O3A7

Patient-Specific Total Knees Demonstrate a Higher Manipulation Rate Compared to “Off-the-Shelf” Implants

Primary Author: Amar S. Ranawat

Institution: Hospital for Special Surgery

Coauthor: Peter B. White (Hospital for Special Surgery)

OBJECTIVE: Patient-specific or “custom” total knee replacements have been designed to fit the arthritic knee in primary total knee arthroplasty (TKA) better than “off-the-shelf” implants. Using computer technology, patient-specific cutting-blocks and custom-made implants are created to more accurately fit the contour of the knee and reproduce the anatomic J-curve with the hope of providing a better functional outcome.

PURPOSE: This retrospective, matched-pair study evaluates manipulation under anesthesia (MUA) rates in cemented patient-specific cruciate-retaining (PSCR) TKA compared to that in both cemented posterior-stabilized

(PS) and non-cemented cruciate-retaining rotating-platform (NC CR RP) TKA.

MATERIALS AND METHODS: From 2010 through November of 2012, 21 PSCR TKAs were performed in 19 patients. Using medical records from our patient database, these patients were matched for age, side, deformity, diagnosis, Charnley Class, and preoperative range of motion (ROM) with 42 PS TKA performed during the same time period by the same surgeon using the same intra- and postoperative protocols. Additionally, 11 NC CR RP TKA were performed and evaluated based on the same criteria. Pre- and postoperative radiographs were performed using criteria as described by The Knee Society.

RESULTS: Preoperatively the custom CR RP TKA cohort had a larger average ROM compared to the PS TKA cohort (P-value= 0.006). Postoperatively, however, the custom CR RP TKA cohort overall was found to have a significantly decreased average ROM compared to both the PS and NC CR RP TKA cohorts (2.0°-110.6° P-value= 0.0002 and 2.4°-117.3° P-value= 0.0003, respectively). 6 of the 21 (28.6%) PSCR TKAs performed underwent MUA to improve postoperative ROM. One manipulation was unsuccessful and the patient is scheduled for revision for arthrofibrosis. No patients in either the matched PS group or the CR RP group underwent postoperative MUA. Clinical and radiographic analysis including pre-operative ROM, deformity, side, Charnley Class, posterior tibial slope angle, epicondylar axis and posterior condylar offsets provided no insight into the reason for this higher MUA rate in the PSCR knees.

CONCLUSION: MUA rates in the patient-specific TKA group were significantly higher than that in the matched PS and NC CR RP groups. No correlations were found to clearly indicate the cause of the higher MUA rate among the PSCR knees. Early manipulation is recommended for stiffness with these custom devices.

LEVEL OF EVIDENCE: Level III, Retrospective comparative study

KEYWORDS: Patient-specific total knee, Manipulation, TKA Hip Resurfacing

Hip Resurfacing

O3B1

Minimum 10 Year Survival and Outcome of the Birmingham Hip Resurfacing – An Independent Series

Primary Author: Koen A. De Smet

Institution: Anca Clinic

Coauthors: Catherine Van Der Straeten (University Hospital Ghent), Alessandro Calistri (Anca Clinic Roma)

INTRODUCTION: Hip resurfacing designer centres have reported survivorships between 88.5–97% at 10 years. Arthroplasty Registries reported less favourable results especially in females' gender and small sizes. The aim of this study was to evaluate the minimum 10-year survival and outcome of the Birmingham Hip Resurfacing from an independent specialist centre.

METHODS: Since 1998, 1989 BHR's have been implanted in our centre by a single hip resurfacing specialist. The first 249 BHR, implanted between 1999 and 2001 in 232 patients (17 bilateral) were included in this study. The majority of the patients were male (163; 69%). The mean age at surgery was 50.6 years (range: 17 – 76), with primary OA as most common indication (201; 81%), followed by avascular necrosis (23; 9.2%) and hip dysplasia (11; 4.4%). Mean follow up was 10.2 years (range: 0.1 (revision) to 13.1). Implant survival was established with revision as the end point. Harris Hip Scores (HHS), radiographs and metal ion levels were assessed in all patients. Sub-analysis was performed by gender, age (<55years; ≥55years), diagnosis and femoral component size (<50 mm; ≥50 mm).

RESULTS: Of the 232 patients, 16 were deceased (4 bilateral BHR), 13 unwilling/unable to present for follow-up but with the BHR in situ and 9 revised. 207 BHR were evaluated at minimum 10 years postoperatively. Failure modes included 2 component malpositioning, 2 loose femoral heads, 1 fracture, 1 metal sensitivity, 2 impingement and 1 with high metal ions. The overall survival was 95.6% (95% CI: 94.2–97.1) at 12.8 years. The mean HHS was 97.7 (range: 65 – 100). Survivorship in men was 98.7% (95%CI: 97.5–99.9%) at 13 years. Survivorship in women was inferior to men ($p=0.002$): 88.7% (95%CI: 85.2–

92.2%) at 12 years. There was no difference in survivorship with different pre-operative diagnosis ($p=0.61$) or age groups ($p=0.27$) and no difference in survival between men and women in the <55 age group but a significant difference in the ≥55 group. Head sizes <50 mm had a significantly worse survival (90.4%) versus ≥50 mm (97.5%) ($p=0.007$). Acetabular component position was measured with EBRA. 88.4% of cups were in the safe zone ($40-45 \pm 10^\circ$ inclination; $15-20 \pm 10^\circ$ anteversion). The median ion levels were Cr:1.4μg/l; Co:1.0μg/l. In 24 patients the ion levels were undetectable. Five patients (2.6%) had ions above the upper acceptable limits of Cr:4.6μg/l; Co:4.0μg/l for unilateral or Cr:7.4μg/l; Co:5.0μg/l for bilateral HRA.

DISCUSSION: This study reports more than 10-year survival of BHR from an experienced specialist, including his learning curve. The overall 12.8-year survival of 95.6% was superior to registry reported figures of THA amongst young patients and corresponded well with reports from designer centres. In women, survivorship was inferior and related to smaller component sizes and age (>55), but the >10-year clinical outcome in non-revised cases was excellent. In patients <55years with OA, survival was 97.2% with no gender difference. In well-functioning BHR, the metal ions were low and decreased significantly with time. The results of this study support the use of HRA with a good design.

O3B2

Debonding of the Porous Coating of the Acetabular Component: A Late Failure Mode of Hip Resurfacing Arthroplasty

Primary Author: Thomas P. Gross

Institution: Midlands Orthopaedics, P.A.

Coauthor: Fei Liu (Midlands Orthopaedics, P.A.)

INTRODUCTION: Uncemented acetabular component fixation has been considered the most reliable fixation method in contemporary metal-on-metal hip resurfacing arthroplasty (HRA). During prospective long-term follow-up of a HRA device, we have encountered a surprisingly high incidence of this complication and wish to alert surgeons and manufacturers of this problem.

METHODS: The study group was comprised of all 373 HRAs performed by a single surgeon using this hybrid

hip resurfacing implant from May 2001 to March 2005. The acetabular component features a dual-coated bone ingrowth surface of plasma-sprayed titanium plus hydroxylapatite. There were a total of 34 revisions identified at the time of this study.

RESULTS: There were 5 other cases (1.3%) of late acetabular loosening all occurring greater than 8 years postoperatively at an average of 9 ± 1 years after the primary surgery. All of these patients were functioning well with radiographically stable implants for at least 8 years. Intraoperative findings included debonding of large portions of the porous coating which remained adhered to the underlying bone. We concluded that these cases represented primary mechanical implant failures. There was a moderate amount of wear debris, presumably from the backside. There was no bone loss evident. There were no soft tissue masses. There were also 2 cases of adverse wear failure with pain and soft tissue masses diagnosed preoperatively with well-fixed implants. One of these patients also suffered component debonding prior to revision. Two (2/5; 40%) cases had an acetabular inclination angle $\geq 50^\circ$. Implant Debonding accounted for 5/8 (63%) of all acetabular failures and 14.7% (5/34) of all failures, while failure of ingrowth caused only 1/34 (3%) and adverse wear failures accounted for only 6% (2/34) of all failures.

CONCLUSION: We recommend that manufacturers re-evaluate the fixation strength of their own particular methods of bonding titanium plasma spray to a cobalt-chrome substrate, particularly in regards to fatigue failure and that they make improvements to ensure a longer duration of bone-implant fixation.

O3B3

Long Term Performance of Metal on Metal Hip Resurfacing Arthroplasty in Asian - 8 to 15 Years Follow Up

Primary Author: Yoon Je Cho

Institution: Department of Orthopedic Surgery, School of Medicine, Kyung Hee University

Coauthors: Dong Cheol Nam (Department of Orthopedic Surgery, School of Medicine, Kyung Hee University), Eun seong Sagong (Department of Orthopedic Surgery, School of Medicine, Kyung Hee University), Myung Seo Kim (Department of Orthopedic Surgery, School of Medicine,

Kyung Hee University)

PURPOSE: Metal-on-metal hip resurfacing arthroplasty (MoM HRA) has emerged as a viable treatment procedure with the advent of improved metal-on-metal prostheses.

However, it remains controversial issues because this procedure has been reported about mechanical and biologic problems. The purpose of this study was to determine the clinical and radiologic results after MoM HRA despite these controversial issues.

MATERIALS AND METHODS: Between December 1998 and May 2005, 185 hips of 169 patients underwent MoM HRA using Birmingham Hip Resurfacing System® at single center. 166 hips (26 hips of female, 140 hips of male) of 144 patients have been reviewed for at least 8 years after MoM HRA. Mean follow-up period was 102.6 (96-182) months. Their mean age at the time of operation was 37.7(16-67) years old. Clinically, Harris hip scores (HHS), UCLA activity scores and range of motion were evaluated. Radiologically, radiolucency around implants, radiolucent line around stem of femoral component, narrowing of retained neck, impingement sign around head-neck junction, stress shielding, and heterotopic ossification were evaluated in the serial anteroposterior and groin lateral radiographs of hip. Complications such as joint dislocation, infection, implant loosening, femoral neck fracture and pseudotumor were evaluated. Failure was defined as revision arthroplasty due to the complications.

RESULTS: Clinically, average HHS was improved from 81.7 points to 98.5 points at last follow-up. Average UCLA activity score at last follow-up was 9.0 points. Range of motion at last follow-up was not increased significantly. Radiologically, Osteolytic lesion of head-neck junction was shown in 12 cases (7.2%) and radiolucent line around stem of femoral components was shown in 3 cases (1.8%). Moderate narrowing changes of retained femoral neck were noticed in 4 cases (2.4%). Impingement sign was seen in 12 cases (7.2%). Heterotopic ossification was found in 5 cases (3.0%). There was no case with hip dislocation, infection or pseudotumor. Revision surgeries after the primary resurfacing arthroplasty were performed in 3 cases (1.8%). Two hips were revised to the conventional total hip arthroplasty (THA) because of loosening of acetabular component. One case of femoral component loosening was revised to THA using big metal head with retained acetabular component. The survival rate was 97.4%

with a mean follow-up of 102.6 months.

CONCLUSIONS: MoM HRA demonstrates good survivorship in average 102.6 months follow-up study. Most of patients show excellent clinical results with high level of activity score. Prevalence of complications is extremely lower than concern and the allergic reaction to the metal ion, especially pseudotumor, have not been found at long term follow up. Safety of MoM HRA is comparable and performance they have shown is much superior to that of THA. MoM HRA can be an alternative to THA in especially young or active patients with coxarthrosis.

O3B4

Patient Function and Satisfaction: Hip Resurfacing Versus Large Head Total Hip Replacement

Primary Author: Brekke, A

Institution: The Institute of Orthopedic Research and Education, Houston, TX

Coauthors: Osadebe, U. (The Institute of Orthopedic Research and Education, Houston, TX); Stocks, G. (Fondren Orthopedic Group, Houston, TX); Barrack, R. (Washington University School of Medicine, St. Louis, MO); Nunley, R. (Washington University School of Medicine, St. Louis, MO); Mathis, K. (The Methodist Hospital, Houston, TX); Shimmin, A. (Melbourne Orthopedic Group, Melbourne Australia); Noble, P. C. (The Institute of Orthopedic Research and Education, Houston, TX and The Methodist Hospital, Houston, TX)

INTRODUCTION: Registry data confirms poor survivorship of some designs of hip resurfacing prostheses (HRA) and big head THR. Nonetheless, there remains a clinical need for a hip arthroplasty solution that will address the demands of young, physically active patients. With this in mind it is useful to examine the functional outcomes of large femoral head THR prostheses as compared to HRA. The purpose of this study was to examine and compare the actual levels of post-operative activity and satisfaction in patients receiving HRA or large head THA.

MATERIALS AND METHODS: With IRB approval, 249 primary, unilateral THA and HRA patients completed a self-administered Hip Function Questionnaire (HFQ) at least one year post-operatively. The patients consist-

ed of 2 groups: (i) 132 patients (52% male; average age: 62.6 years) who received a THR with an average head diameter of 35.5mm (min: 32mm). (ii) 82% male; average age: 53.2 years. The HFQ was based on a similar instrument validated by Weiss et al for evaluation of functional outcomes after Total Knee Replacement. The HFQ assessed each subject's satisfaction, expectations, symptoms and ability to perform a series of 94 activities encompassing exercise, sports, recreation and daily living. Data from completed questionnaires was filed into a database, and regression and ANOVA analyses were conducted to determine activity frequency, symptom prevalence and correlates to satisfaction.

RESULTS: More HRA patients considered themselves physically active than large head THA patients (HRA: 79% vs THA: 45%; $p<0.0001$) (Figure 1). One third (36%) of the HRA group had run further than a ¼ mile since their operation compared to only 9% of the large head THA group ($p<0.0001$). Both groups reported similar levels of participation in daily living activities such as gardening and kneeling ($p=0.85$). However, HRA patients participated more frequently in sporting activities (e.g. swimming, golf), gym exercises (e.g. weightlifting, aerobics), and high demand contact sports (e.g. jogging, basketball) ($p<0.0001$, $p=0.03$, $p<0.0001$; respectively). Patients in both groups reported similar levels of satisfaction with the outcome of their procedure (THA: 92%; HRA: 90%).

Fewer HRA patients reported limitations during at least one of the twenty daily living activities, such as turning or climbing stairs (26% vs. 44% THA; $p<0.0001$). Approximately 20% of both groups experienced hip pain (HRA: 16% vs THA: 20%; $p=0.64$), and joint stiffness at least once per week (HRA: 19% vs THA: 16%; $p=0.67$). The groups relied on analgesic relief from their residual symptoms at similar rates (HRA: 10% vs THA: 8%; $p=0.89$). However, more THA patients reported that their hip feels normal (89% vs 82% HRA; $p=0.12$), though the difference was not statistically significant.

DISCUSSION: In this study, resurfacing patients were an average of 9 years younger than the large femoral head THA patients and were considerably more active even when young patient and male cohorts of the large head THA group were isolated. Both groups endured somewhat regular pain and stiffness, yet reported high satisfaction with the outcome of the procedure. Despite significant limitations in daily living activities, more large head THA

patients reported that their hip feels normal than HRA patients. Large head THA patients seemed to be satisfied with some restored ability regardless of prevailing symptoms or limitations. The data indicate that HRA patients value their physical abilities, including high-demand activities, despite the recurrence of hip symptoms with activity.

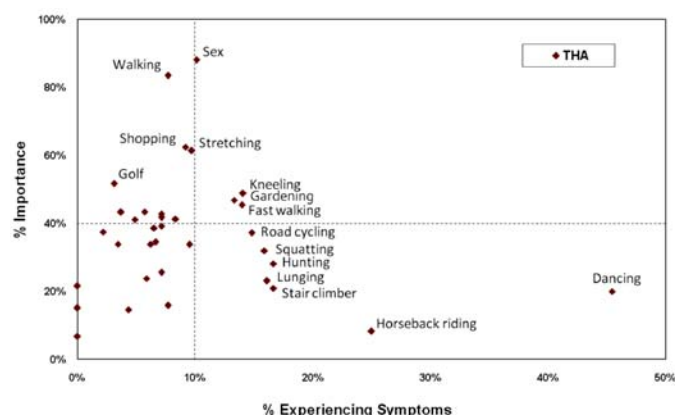


Figure 1. THA patients: Percentages of subjects experiencing significant symptoms during activities they feel are important

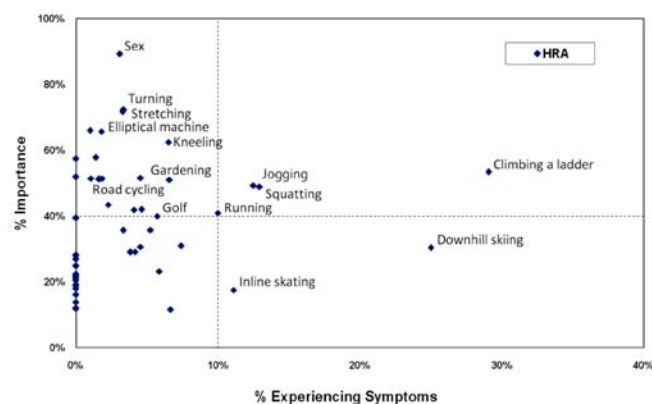


Figure 2. HRA patients: Percentages of subjects experiencing significant symptoms during activities they feel are important

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O3B5

Randomized Controlled Trial Comparing Nine Hip Resurfacing Designs

Primary Author: Catherine Van Der Straeten

Institution: Ghent University Hospital

Coauthor: Koen De Smet (Anca Medical Center)

INTRODUCTION: Systemic levels of metal ions are surrogate markers of in-vivo wear of metal-on-metal hip resurfacings (MoMHRA). The severity of the wear is associated with component size and positioning but also with design specific features such as coverage angle, clearance and metallurgy. A randomized controlled trial (RCT) comparing 9 different hip resurfacing designs was conducted at hip resurfacing specialist centre to evaluate the possible difference in ion release, clinical and radiographic outcome, complications and revision rate between different HRA designs.

METHODS: Patients scheduled for a unilateral MoMHRA were randomized to receive one of 9 different HRA designs (20 per group). Only patients who had no other metal implants and a normal renal function were included. Surgical, clinical (Harris Hip Score and UCLA activity scale) and radiographic data and Chromium (Cr) and Cobalt (Co) levels in whole blood, serum and urine were compared at preoperative, 3, 6, 12, 24 and 60 months intervals. In the Titanium-Niobium-coated prosthesis group, Titanium (Ti) ions were also measured. Complications, re-interventions and revisions were noted.

RESULTS: 129 patients were included as 3 designs were discontinued: ASR after market withdrawal, DUROM and MITCH for cup fixation problems. The other groups were ACCIS, ADEPT, BHR, Conserve Plus, Conserve Plus Aclass, and RECAP. In all groups except ACCIS, Cr and Co ion concentrations increased from preoperative till 1-year (running-in) and subsequently levelled off (steady-state). There was a significant correlation between whole blood, serum and 24 hour urine levels ($p < 0.01$). Overall mean ion concentrations (Cr $1.5 \mu\text{g/l}$ and Co $2.0 \mu\text{g/l}$) were low at all intervals. Outliers occurred more often in the RECAP and ASR groups. ACCIS at 1 year ($p < 0.01$) and DUROM at 2 years ($p < 0.05$) had the lowest levels. For the ACCIS design, Cr and Co levels were untraceable till 1 year but increased at 2 years whilst Ti levels were elevated with a peak at 6 months. Cr and Co levels were higher in females ($p < 0.001$) and with smaller head sizes. Seven HRA were revised at a mean of 25.6 months follow-up (11-48 months): 2 RECAP (high wear/loosening), 1 ASR (high wear), 1 ADEPT (metal allergy), 1 Conserve plus (metal allergy), 1 BHR (infection), 1 ACCIS (loosening).

Discussion: In general, metal ion levels were low in all MoMHRA designs. Outliers and increasing ion levels occurred more often with designs with smaller coverage angle and in smaller sizes, associated with edge loading

causing higher wear. Differences in ion levels between resurfacing designs may also reflect differences in clearance and metallurgy. The lower ion levels with the DUROM design are probably related to its highest coverage angle and its metallurgy. The TiNb surface coating of the ACCIS prevents Cr and Co release in the running-in phase whilst peak Ti concentrations at 6 months illustrate the wearing-off of the TiNb coating with formation of a wear patch at the contact area of the articulation. Once the TiNb coating is worn off at the contact area, Co and Cr release starts and systemic Co and Cr levels increase.

O3B6

The Impact of Pelvic Tilt on Functional Cup Position in Metal on Metal Hip Resurfacings

Primary Author: Joseph D. Maratt

Institution: Hospital for Special Surgery

Coauthors: Christina Esposito (Hospital for Special Surgery), Brett Frykberg (Hospital for Special Surgery), Seth A. Jerabek (Hospital for Special Surgery), David J. Mayman (Hospital for Special Surgery), Edwin Su (Hospital for Special Surgery)

INTRODUCTION: Decreased contact patch to rim (CPR) distance has been shown to be predictive of increased metal ion levels in hip resurfacing and is likely an indicator of edge loading. Both acetabular component position and size influence the CPR distance. Sagittal pelvic tilt has an impact on the functional anteversion and inclination of an acetabular component. We studied the impact of pelvic tilt on functional acetabular component position and its impact on CPR distance.

MATERIALS AND METHODS: An anatomically accurate three-dimensional model of the pelvis was obtained from BodyParts3D (Database Center for Life Science, The University of Tokyo, Tokyo, Japan) and rendered in Matlab 2013a (The MathWorks Inc., Natick, MA) with the center of rotation (COR) of the left acetabulum at the origin of the coordinate system. Sagittal pelvic tilt was measured using the anterior pelvic plane (APP), which is defined by the left and right anterior-superior iliac spines (ASIS) and the pubic symphysis. Neutral or 0° of pelvic tilt was defined when the APP was aligned to the coronal plane or the radiographic view of the pelvis (in a sagittal profile of the pelvic model the ASIS were in line with

the pubic symphysis). Radiographic inclination and anteversion measurements of the acetabular component, as defined by Murray et al, were used to measure the position of the acetabular component. Subhemispheric acetabular shells with implant geometries of the Birmingham Hip Resurfacing (BHR) and Conserve Plus (C+) were positioned with the COR at the origin, 40° radiographic inclination and 20° radiographic anteversion. The pelvis and acetabular shell were rotated through the COR of the hip to create 30° of anterior (positive value) and posterior (negative value) tilt in 1° increments. Functional radiographic anteversion and inclination of the acetabular shell was the radiographic anteversion and inclination measurement of the pelvis with varying degrees of anterior and posterior tilt. CPR distance was calculated using the functional position of the acetabular component. This sequence was repeated for the range of implant sizes.

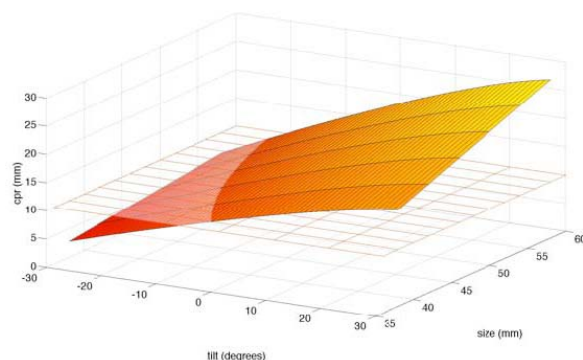
RESULTS: Each degree of posterior pelvic tilt results in an average increase of 0.74° in functional anteversion and 0.26° increase in functional inclination. CPR distance calculated from tilt adjusted acetabular position showed that as little as 5 degrees of posterior tilt could decrease CPR distance below 10 mm (Table 1). This effect was most significant with smaller component sizes (Figure 1) and was similar for both implant geometries.

DISCUSSION: The results of this study demonstrate how pelvic tilt changes the functional acetabular component position in hip resurfacing. This has important implications, as a decrease in the CPR distance has been associated with an increased incidence of edge loading and higher wear. The effect of pelvic tilt is greater in smaller implant sizes. This size dependent effect of pelvic tilt may be a contributing factor in the higher failure rate in females. Correcting for pelvic tilt may optimize functional component position, resulting in an increased CPR distance, lower metal ion levels and improved implant survival.

Table 1: Degree of pelvic tilt which causes CPR distance to decrease below 10 mm for a component positioned with 40° of inclination and 20° of anteversion based on the APP.

Size	Tilt (°)	
	BHR	C+
38	-5	-7
42	-10	-11
46	-14	-15
50	-17	-18
54	-20	-20
58	-22	-22

Figure 1: Pelvic Tilt vs. Component Size vs. CPR distance. The plane drawn at 10mm represents the safe threshold for CPR distance.



O3B7

Changes in Bone Mineral Density of the Acetabulum and Proximal Femur After Total Hip Resurfacing Arthroplasty

Primary Author: Qiang Huang

Institution: Department of Orthopaedic Surgery, West China Hospital, West China Medical School, Sichuan University

Coauthors: Bin Shen (Department of Orthopaedic Surgery, West China Hospital, West China Medical School, Sichuan University), Jing Yang (Department of Orthopaedic Surgery, West China Hospital, West China Medical School, Sichuan University), Zongke Zhou (Department of Orthopaedic Surgery, West China Hospital, Sichuan University)

Our aim was to investigate the changes in bone mineral density (BMD) of acetabulum and proximal femur after total hip resurfacing arthroplasty. A comparative study was carried out on 51 hips in 48 patients. Group A consisted of 25 patients (26 hips) who had undergone total hip resurfacing and group B of 23 patients (25 hips) who had had large-diameter metal-on-metal total hip arthroplasty (THA). BMD around the acetabulum and proximal femur were measured using dual-energy x-ray absorptiometry (DEXA) at two weeks, 6 months, one year and annually thereafter during the three years after surgery. At final follow-up, the acetabular net mean BMD decreased by 11% in group A and 10% in group B with no differences between two groups ($p=0.35$). For the femoral side, in Gruen zone 1, the mean BMD increased by 4% in group A, whereas it decreased by 11% in group B ($p=0.029$). In Gruen zone 7, the mean BMD increased by 8% at the final follow-up in group A, whereas it decreased by 13% in group B ($P=0.02$). In both groups the mean BMD increased by

3% in Gruen zone 3, 4, 5, and 6. So, the bone loss of the acetabulum demonstrates stress shielding three years after total hip resurfacing arthroplasty, which transfers normal load to the proximal femur.

The Great Debate: Knees

O4A1

Mobile Bearing Total Knee Arthroplasty Is Advantageous

Guest Faculty: Douglas A. Dennis, MD

Institution: Adjunct Professor, Dept. of Biomedical Engineering, University of Tennessee; Adjunct Professor of Bioengineering, University of Denver; Assistant Clinical Professor, Dept. of Orthopaedics, University of Colorado School of Medicine, Denver, CO, USA

Goals of current total knee arthroplasty (TKA) design are focused on reduction of polyethylene wear while avoiding high stresses at the implant fixation interface. Video fluoroscopic analyses have demonstrated numerous kinematic abnormalities following TKA which accelerate wear including paradoxical anterior femoral translation and femoral condylar lift-off.

Use of mobile bearing TKA provides numerous mechanisms to reduce polyethylene wear by allowing increased implant conformity and contact area without transferring excessive loads to the fixation interface. Increased sagittal conformity has been shown in fluoroscopic kinematic studies to reduce paradoxical anterior femoral component sliding during gait, thereby reducing shear stresses on the tibial polyethylene insert. Increased coronal conformity dramatically reduces peak contact stresses should femoral condylar lift-off occur. Kinematic data is supported by very low wear rates observed in the first three decades of use with mobile bearing TKA as well as knee simulator analyses which have demonstrated a four-fold reduction in polyethylene wear in rotating platform TKA designs. Retrieval wear analysis has demonstrated mean wear rates for rotating platform TKA to be less than half that of fixed

bearing TKA (0.02mm/yr vs 0.05mm/yr for fixed bearing TKA). Bearing mobility permits self-correction of tibial component rotational malalignment, reducing the potential for angular post wear in posterior cruciate substituting TKA. The presence of bearing mobility also allows for some self-correction of an increased Q-angle, facilitating central patellar tracking, reduced lateral retinacular release rates, and reduced patellofemoral forces. Bearing mobility allows the bearing to self center with the femoral component. Recent in vivo fluoroscopic data has demonstrated the rotational relationship of the femoral vs. tibial component is often different when tested in non-weight-bearing vs. weight-bearing conditions. Therefore, the rotational relationship chosen intra-operatively when performing a fixed bearing TKA may not be ideal when the patient applies weight-bearing load postoperatively. In a mobile bearing TKA, the bearing can rotate and self-center with the femoral component, if necessary, after load is applied.

The basic science data is supported by clinical results. A recent meta-analysis of clinical results of mobile bearing TKA has demonstrated a 15 year survival of 96.4%, a loosening rate of 0.33%, and a bearing complication rate of 0.12% in mobile bearing TKAs performed after 1995.

Prospectively randomized studies of fixed vs. mobile bearing TKA demonstrate similar results but are limited in number and follow-up duration. Non-comparative ten year results of fixed vs. mobile bearing TKA are also similar but one must realize these reports typically involve elderly subjects (>60-65 years) who walk one million cycles annually. Results may not be similar in the younger patients often receiving TKA today who will require greater than 25 years of function and typically ambulate up to six million cycles annually.

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O4A2

Fixed Bearing TKA is Better A Debate

Guest Faculty: Alfred J. Tria Jr., MD

Institution: St Peter's University Hospital, Somerset, NJ, USA

The results of mobile bearing and fixed bearing TKAs are exactly the same with long term follow up in the literature. Most of the studies have been reported by designing surgeons or surgeons with very extensive experience with the specific implants. Mobile bearing TKA has some desirable attributes such as the decreased possibility of polyethylene wear, ease of setting the proper rotation of the tibial component, and the final range of motion of the knee. However, most surgeons are less familiar with the design of the mobile bearing TKA. The kinematic motion of the knee is not anatomic and tibial insert spin out can lead to an unexpected revision.

Fixed bearing TKAs have stood the test of time with 20 to 30 year follow up in the literature. All surgeons are familiar with the designs and the kinematics are getting closer and closer to the normal knee. The average surgeon in the USA performs 2 to 3 TKAs per month and should be presented with the easiest and most reproducible design for implantation.

If the results are indeed equal, the surgeon should choose the most reproducible surgery with the easiest technique; and that certainly is the fixed bearing TKA.

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O4A3

Customizing TKA is the Future

Guest Faculty: William B. Kurtz, MD

Institution: Tennessee Orthopedic Alliance, Nashville, TN, USA

Ever since the first hinged replacement was performed by Leslie Gordon Percival Shiers in the 1950's, subsequent knee replacement designs have moved away from artificially imposed constraints and tried to mimic the native knee anatomy and biomechanics. Over the past 40 years, the improvements in 3D imaging have proven that large variations exist between patients' knee size, knee shape, J curve shapes and varus joint line. Through the 80's and 90's, surgeons tried to utilize different alignment techniques with mechanical jigs to solve these anatomic differences, namely gap balancing and measured resection. Over the last decade, some surgeons have utilized computer navigation and pre-navigation with patient specific jigs to attempt to restore the varus joint line and achieve more normal knee kinematics through kinematic alignment. However, the symmetric implants utilized with kinematic alignment require complicated bone cuts that are non-perpendicular to the mechanical axis to restore the varus joint line. Some off the shelf implants have been designed specifically for female patient and others have been designed with a set amount of varus built into the knee design, both of which have been an improvement, but do not accommodate the variations presented within the patient population. Studies conducted on the efficacy of patient-specific instrumentation have shown mixed results, with some reports showing similar results to conventional techniques, while others have shown higher percentage of correctly aligned knees, albeit with a significant amount of outliers. Improvements in manufacturing and imaging have finally

advanced enough that in addition to patient specific instrumentation, the patient can now receive a customized knee implant designed to accommodate the large patient variation in knee size, knee shape, J curve shape and varus joint line. Use of patient specific instrumentation, in conjunction with customized, individually made TKAs seems to be a promising technology to consistently achieve mechanical axis alignment, along with the optimum fit, and restoration of the patient's native geometry.

O4A4

Customizing TKA is the Future – Disagree: There is No Benefit to the Patient

Guest Faculty: John J. Callaghan, MD

Institution: University of Iowa, Iowa City, IA, VA Medical Center, Iowa City, IA, USA

Coauthors: Lawrence & Marilyn Dorr Chair, University of Iowa, Iowa City, IA, VA Medical Center, Iowa City, IA

Over 31 years of practice, I have utilized the traditional approach to knee alignment in TKA reconstruction of the arthritic knee. This includes creation of a neutral mechanical axis, a femoral tibial angle of five to nine degrees of valgus and a joint line parallel to the floor. This is done by resecting the proximal tibial bone perpendicular to the shaft of the tibia and resecting an amount of femoral bone to place the distal femur in five to seven degrees of valgus. The amount of bone resected from the distal femur, proximal tibia, and posterior femoral condyles is determined in a way that the flexion gap is equal to the extension gap. The posterior femoral condylar resection is determined using the transepicondylar axis and is parallel to the cut surface of the tibia. Symmetry of the two gaps medially and laterally is obtained by performing ligament releases rather than ligament tightening.

In twenty year follow-up studies from our institution using posterior cruciate retaining and posterior cruciate sacrificing designs with cement fixation and the technique described, the results were extremely durable even with the use of gamma in air polyethylene for the cruciate retaining knee. The revision prevalence for loosening as 6% and for the cruciate sacrificing component, the revision for loosening prevalence was 0%. This occurred even though all knees were not aligned within 3 degrees of mechanical axis. My experience and the experience of other surgeons

who used a system designed in the early 1980's (PCA, Howmedica) where the intent was to resect the tibia so as to leave it in 3 degrees of varus provided less durable results. Therefore, I recommend reconstructing the knee in an alignment that we know provides durable results rather than to simply replace the knee in the previously aligned position. My feeling is that if the patient's articular cartilage wore out in this position, the components will wear out over a time of extensive use.

O4A5

Why Patient Specific Instruments Are Ready For Prime Time

Guest Faculty: Fred D. Cushner, MD

Institution: ISK Institute, New York, NY; NS - LIJ Orthopedic Institute, New York, NY, USA

It is no secret that as surgeons, we often miss the mark in regards to alignment at the time of TKA. In fact, misalignment has been cited as a primary cause of knee failures and it has been estimated that 20-30 % of the time, a neutral mechanical alignment is not achieved and is off by over 3 degrees.

This debate will discuss the benefits of Patient Specific Instruments

1. Less Blood Loss
2. Less Operative Time
3. More Accurate Coronal Alignment
4. Less surgical trays
5. Better Rotational Alignment
6. Ease of use in Complex Cases
7. Benefit in Bilateral TKA's
8. Retained Hardware Use
9. Complex previous fractures/nonunions

While many ways to obtain computer guidance during the TKA Procedure, Patient Specific Instruments remain a safe, reproducible, easy, and cost effective method to obtain proper TKA alignment.

O4A6

Patient Specific Instrumentation (PSI) is Not the Future

Guest Faculty: Arlen D. Hanssen, MD

Institution: Mayo Clinic, Rochester, MN, USA

Increased interest in the use of PSI has been primarily due to claims of increased radiographic accuracy, increased efficiency with lower operative times and lower cost, and improved clinical outcomes. The question remains, what evidence is there that that these goals have been achieved?

Radiographic Accuracy. Of the 17 current studies in the literature; 11 have shown no difference in the radiographic alignment and outliers; 3 have shown differences of questionable clinical significance (ie. 1-2 degrees and < 10% difference in outliers, and in 3 studies PSI was worse. Victor et al, in a Level 1 RCT concluded that there were more outliers in the PSI group (22%) and in 28% of PSI group required modification to the procedure. **Cost Analysis.** Barrack et al evaluated savings from decreased operative time and instrument processing costs compared to the additional cost of the MRI and PSI. While the cutting guides had significantly lower total operative time and instrument processing time, the estimated \$322 savings was overwhelmed by an \$1,500 additional cost of the MRI and the PSI cutting guide. **Clinical Outcomes.** There are no available data demonstrating improvement with the use of PSI.

The only logical conclusion is that at this time PSI does not achieve its stated goals.

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O4A7

I Align Along the Mechanical Axis

Guest Faculty: W. Norman Scott, MD, FACS

Institution: Insall Scott Kelly Institute for Orthopaedics & Sports Medicine, New York, New York, USA

Mechanical alignment techniques include and overall assessment of the hip-knee-ankle alignment, flexion/extension gap techniques, measured resection techniques and ligament releases. The techniques are a composite of visually appropriate landmarks that allow the surgeon to build a checks-and-balances surgical technique. The anatomical landmarks are readily assessed at time of surgery allowing the procedure to be reproducible as will be demonstrated.

This is in contrast to the concept of kinematic alignment, which depends on the concept of 2 non-visualized transverse axes of the femur: The primary transverse axis, about which the tibia flexes and extends, and the secondary transverse axis about which the patella flexes and extends. The third axis is the longitudinal axis through the tibia, which is perpendicular to the transverse axis of the femur about which the tibia flexes and extends.

Kinematic alignment is confirmed by calculating the asymmetry of the thickness or the distal and posterior femoral articulating surfaces. The whole technique centers around reestablishing the bone, cartilage and Kerf surfaces to recreate an un-visualized transverse axis of the femur. The

surgical technique consists of 4 steps:

1. Removing osteophytes
2. Adjusting the plane of the tibial cut
3. Releasing the posterior capsule
4. Medializing or lateralizing the tibial component

This technique is done either via shape-matching the femoral component to the theoretical articular surface of the femur on a 3-D model, which has been created by filling in the worn surfaces with the use of proprietary software, or, an unconventional use of a conventional system of instruments can be used to produce the kinematic alignment, as I am sure Dr. Howell will discuss. This theory, unlike mechanical alignment, allows for many hypothetical assumptions that are difficult to identify at time of surgery.

Mechanical alignment is preferred over kinematic alignment because it is based on decades of experience, is reproducible and does not require an adherence to non-visualized surgical landmarks.

O4A8

Kinematically Aligned TKA is Better

Guest Faculty: Stephen M Howell, MD

Institution: University of California, Davis, Sacramento, CA, USA

An accepted principle in total knee arthroplasty (TKA) is to restore normal kinematics, which is described by three axes in the knee. [2,4,5,8,9]

In mechanically aligned TKA the surgeon cuts the distal femur and proximal tibia perpendicular to the femoral and tibial mechanical axes. Insall called these cuts a compromise because they change the angle and level of the natural joint line. [10] Surgeons should be aware when mechanically aligning a TKA that they will frequently have to manage a wide range of collateral ligament imbalances that are complex, cumulative, and uncorrectable by collateral ligament release, and a wide range of changes in limb and knee alignment from normal. Patients who perceive these changes in stability, limb alignment, and knee alignment may be dissatisfied and require counseling. [4]

In kinematically aligned TKA the surgeon cuts the distal femur and proximal tibia to restore the natural angle and

level of the joint lines thereby minimizing these undesirable consequences. [2,4-6] A Level 1 RCT showed that kinematic alignment provided better pain relief and restored better function and range of movement compared to mechanical alignment. [1] A prospective study of 203 patients (208 knees) treated with a primary kinematically aligned TKA and evaluated at a median follow-up of 6.3 years (range, 5.8-7.2 years) showed that the revision-rate /100 component years for kinematically aligned TKA (0.40, 95% confidence interval (CI) 0.18 to 0.93) was not different from reports of mechanically aligned TKA (0.64, 95% CI 0.44 to 1.19). The mean Oxford Knee Score (42.7, 95% CI 41.6 to 43.7) was 10 points higher than reports of mechanically aligned TKA (32.6, 95% CI 31.9 to 33.4). Kinematically aligned TKA does not negatively affect six year implant survival and provides better function than mechanically aligned TKA even though 80% of tibial components are aligned in varus. [7]

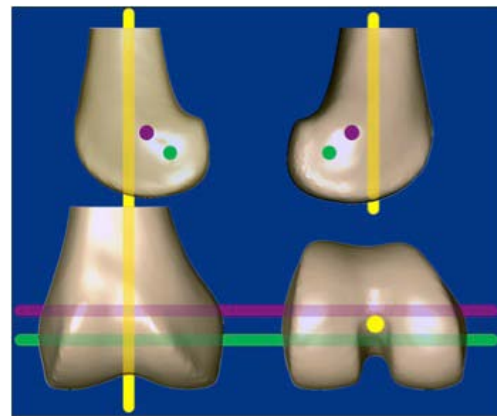


Figure 1. The green line indicates the transverse axis in the femur about which the tibia flexes and extends. The magenta line indicates the transverse axis in the femur about which the patella flexes and extends. The yellow line indicates the longitudinal axis in the tibia about which the tibia internally-externally rotates on the femur. Each axis is parallel or perpendicular to the natural joint line throughout the motion arc. [3,5,11]

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The Great Debate: Hips & Shoulders

O4B1

Why I do the Direct Anterior Approach (DAA)

Primary Author: William Hozack, MD

Institution: Walter Annenberg Professor of Orthopedic Surgery, Rothman Institute Orthopedics, Thomas Jefferson University, Philadelphia PA

THA is about functionality, and soft tissue damage affects functionality. Consequences of soft tissue damage include weakness, limp, soreness, heterotopic ossification, stiffness, and a general disappointment with the result.

Since the DAA is an approach between nerves (superior gluteal and femoral) and between muscles (TFL and Sartorius/Rectus femoris), it has the potential to maximize patient functionality. The DAA approach does not violate the gluteus maximus muscle, nor the ITB. It also spares the gluteus medius and minimus muscles. Bergin et al (JBJS 2011) evaluated inflammatory markers after DAA and PLA and found them to be significantly lower with the DAA (in theory suggesting less overall soft tissue trauma).

The DAA preserves the posterior capsule, which minimizes the risk of dislocation and eliminates the need for hip precautions. This serves to enhance patient confidence and speed of recovery. While speed of recovery is not the MOST important factor surrounding THA, patients like the ability to return to work and other activities quickly after the surgery. The ability of patients undergoing DAA THA to achieve a faster recovery has been documented in several studies.

Complications specific to the DAA include going through a learning curve, specifically if the DAA is adopted after finishing your training program. In the learning curve, a higher rate of complications is likely, as documented by Woolson (JOA, 2009). Lateral femoral cutaneous nerve neuropraxia is common after DA

A (up to 80% in one study by Goulding, CORR 2010), so patients should be informed of this possibility. No functional limitations seem to be incurred, however.

What is good about the DAA?

1. MIS, done properly
2. Anatomic dissection between nerves and muscles
3. No hip precautions
4. Faster early recovery
5. Earlier return to work

What is neutral about the DAA?

1. Long term clinical results no different
2. Surgical pain equivalent
3. Complications equally frequent
4. Not safer
5. Implants do not last longer

What is bad about the DAA?

1. Thigh numbness
2. Learning curve increases complications

O4B3

Total Hip in Young Patient's Ceramic On Ceramic - Pro

Primary Author: Laurent Sedel

Institution: Hopital Lariboisière, Paris France

Young patient's needs are different: strenuous activities, sports, and long term survivorship are the objectives. Ceramic on ceramic couple had already proved this possibility. By its excellent biological response, fibrous tissues generation, and lack of osteolysis on the long term, ceramic on ceramic is the answer. Moreover fibrous tissues generation is possibly the reason for hip stability observed on the long run in contradiction with prosthesis having polyethylene in the construct. In different studies concerning long term results in the young age, the results were outstanding. Problems encountered were related to poor acetabular fixation with the first generation cemented components but after 1989, press fit metal back ceramic liner solved the problem. Then few failures were encountered, limited number of fractures and no fractures documented since 10 years, very limited clinical problems related to noise generation which appears to be more a problem of ceramic prosthesis design. These excellent results can be observed if strict conditions were fulfilled, ie excellent alumina product with high density and small grain size, adapted clearance, 32 mm head and liner with a ceramic thickness always more than 6 mm, liner in excess, cone angle of 5° 40'. Surgical

technique must be adapted concerning cleaning of Morse taper and strict position of ceramic insert into the metal back.

Risk figures given to the young patients at the moment are 5% revision at 10 years and 10% revision at 20 years. Also, we advise no activities restriction after the first 6 months.

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O4B4

Debate: Ceramic-on-Ceramic for Young THA Patients – Con

Guest Faculty: Ray C. Wasielewski, MD

Institution: University Ortho Physicians Inc, Columbus, OH, USA

Over the last 30+ years, all THA articulations have been fraught with various problems such that the optimal mate-

rial wear couple has not yet been established. This is particularly true in the young patient where bearing longevity and ability to do bearing exchange-only at revision arthroplasty are needed.

The highly cross-linked polyethylenes are demonstrating 10+ year results with minimal failures and osteolysis. Vitamin-E enhanced polyethylene may further enhance the properties and longevity of highly crosslinked polyethylene. Hard bearings have suffered recalls, noise and new FDA scrutiny bringing into question whether their added expense is the correct choice even in a young patient.

Newer generation ceramics might have mechanical properties to prevent fracture and decrease “simulator wear” but their metallurgy includes Yttrium, Chromium (CrO₃) and Strontium creating new potential wear debris problems. These new metal elements will be dispersed throughout the peri-articular debris burden. Not only will this sand-like debris be very abrasive at exchange arthroplasty these additives and oxides have unknown effects. Additionally, micro-separation described by Komistek et al on hip fluoroscopy will preferentially damage a hard ceramic on ceramic couple with unknown consequences over the 20 – 30 year desired life expectancy. This 55 year old wants a 35-year THA with a Ceramic femoral head articulating against highly cross-linked polyethylene that is friendlier in all regards.

O4B5

Femoral Head Size: Bigger Is Better - Pro

Guest Faculty: Adolph V. Lombardi Jr., MD, FACS

Institution: Joint Implant Surgeons, Inc.; The Ohio State University Wexner Medical Center; Mount Carmel Health Systems; New Albany, OH, USA

Dislocation continues to be an unfortunate, frequent complication of primary total hip arthroplasty (THA). Reported incidence ranges from less than 1% to 5% with a recent Medicare claims data analysis of 58,521 patients reporting 3.9% dislocation in the first 26 weeks postoperative. [1] Numerous patient factors may contribute to increased dislocation risk: aging, female gender, lower muscular disorders, cognitive dysfunction, dysplasia, previous femoral neck fracture, and rheumatoid arthritis. The correlation between higher surgeon and hospital volume and lower dislocation rates has also been established. [2] Recent advances

in implant design allow for use of larger prosthetic heads that more accurately reconstruct native femoral head size and improve head-neck ratio. The desire for larger heads is based on literature that shows a direct relationship between increasing femoral head size improving implant stability. [3-10] Because the neck of a femoral component is much smaller than the native human femoral neck, matching head size markedly improves head/neck ratio – a benefit in younger patients and those with high-demand lifestyle. Increased volumetric polyethylene wear has previously limited femoral head size to 32 mm or less. However, the development of highly crosslinked polyethylene and its superior wear characteristics allows use of larger (greater than 32 mm) femoral heads, with several reports documenting improved wear characteristics independent of head size. [11-20] Large femoral heads offer the benefit of increasing the ROM before component-to-component impingement while increasing the displacement necessary before dislocation. It has been recognized that by increasing femoral head component size, a corresponding increase in head-neck ratio occurs, thereby allowing greater ROM. [21] A study conducted on an anatomic full size hip model found femoral heads greater than 32 mm virtually eliminate component-to-component impingement. [22] The benefit of increased head size was seen in a study of 22-mm and 40-mm femoral heads; the displacement required for dislocation increased by approximately 5 mm with 40-mm heads when the acetabular component is in 45° of abduction. [6] A number of studies have shown increasing femoral head size increases implant stability, thereby reducing postoperative dislocations. [3,5-8,23] We previously reported an incidence of 12 dislocations in 1518 primary THAs (0.8%) done with femoral heads 32 mm or less through a standard direct lateral approach. [24] More recently we reported on dislocation rates in primary THA with large-heads ≥ 36 mm in diameter in several material combinations in 1748 patients (2020 hips). [25] With mean follow up of 2.8 years only 1 dislocation occurred for a rate of 0.05%.

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O4B7

Reverse TSA for Proximal Humeral Fractures

Guest Faculty: Edwin E. Spencer Jr., MD

Institution: Knoxville Orthopaedic Clinic, Knoxville, TN, USA

The treatment of proximal humeral fractures has evolved significantly over the past decade. The most popular options include ORIF with various plate configurations, percutaneous pinning and prosthetic replacement. The key is to choose the most predictable form of treatment with the fewest potential complications. Although this debate will focus on prosthetic replacement for the treatment of proximal humeral fractures, we will discuss treatment indications for all forms of treatment including nonoperative.

The results of hemiarthroplasty for fracture hinge on the healing of the tuberosities. With an approximate 50% rate of tuberosity malunion or nonunion when using a hemiarthroplasty, the reverse TSA has become increasingly popular. The reverse TSA is the most common revision option in a failed hemiarthroplasty for fracture, therefore many decide to use it in the primary situation in case the tuberosities fail to heal. However even with a reverse TSA, greater tuberosity healing yields a much better result with greater function and external rotation strength when compared to those in whom the tuberosities did not heal. We will discuss tips and tricks for performing a reverse TSA for fracture to maximize the results.

O4B8

Hemiarthroplasty for the Treatment of Proximal Humerus Fractures

Guest Faculty: John W. Sperling, MD, MBA

Institution: Professor of Orthopedic Surgery, Mayo Clinic, Rochester, MN, USA

While there has been increasing interest in the use of the reverse arthroplasty for the treatment of four part proximal humerus fractures, there continues to be a role for hemiarthroplasty in select patients. This comprises young active patients with fractures not amenable to fixation. Every effort is made to attempt to fix fractures in young patients to avoid placement of an arthroplasty.

If hemiarthroplasty is selected, the author favors the use a convertible stem that can also be used with reverse arthroplasty. This can considerably facilitate revision surgery in the future if the patient develops tuberosity resorption or glenoid wear. The stem can be retained in many patients making the revision to reverse more straightforward without necessitating stem removal.

The author prefers for both reverse arthroplasty and hemiarthroplasty to use a short stem if possible. This helps manage potential complications including periprosthetic fractures. In addition, the author chooses to avoid cement if possible. Frequently, the stem can be impacted in place with outstanding rotational and height stability. If excellent stability cannot be obtained, the author tries to use a small amount of cement proximally. One should avoid placement of cement down the entire humeral shaft. This makes it extremely difficult if the stem needs to be removed due to revision or infection.

Secure fixation of the tuberosities is essential to encourage healing and maximize patient function. There are multiple published techniques on tuberosity repair. Each highlights the importance of fixation of the tuberosities to the humeral shaft as well as to each other. Moreover, the author has found it valuable to use intra-operative fluoroscopy to confirm that the tuberosities are in the right position at the conclusion of the procedure.

Fluoroscopy also confirms proper height of the humeral head. One wants to avoid over-stuffing the joint. The surgeon needs to see 30 to 50% translation of the humeral head in an anterior and posterior direction with the head facing straight across from the glenoid with the arm in the neutral position. Based on the security of the repair, one then decides on the specific post-operative rehabilitation program. There has been a tendency towards a less aggressive rehabilitation program to try to encourage tuberosity healing.

UKA: What's the latest?

O5A1

Long-Term Survival Analysis of UKA by A Single Surgeon

Guest Faculty: Dae K. Bae, MD, PhD

Institution: Kyung Hee University, Seoul, South Korea

Coauthors: Sang J. Song (Kyung Hee University), Dong B. Heo (Kyung Hee University)

INTRODUCTION: The purpose was to evaluate clinical and radiologic results and to analyze the survival rate of unicompartmental knee arthroplasty (UKA) using three different implants.

METHODS: Between December 1982 and January 1996, a total of 103 UKAs in 74 patients were performed. There were 13 Modular II(Group I), 44 Microloc(Group II), and 46 Allegretto(Group III) unicompartmental knee arthroplasties. The average follow up period was 14.5 years(range, 1.0 to 28.6 years). For clinical assessment, the hospital for special surgery (HSS) scoring system and range of motion (ROM) were evaluated. For radiologic assessment, the femorotibial angle (FTA) was measured. Survival rates was analyzed using the life-table and Kaplan-Meier's method. In order to evaluate factors influencing the survival rate, the Mantel-Cox log-rank test was performed with variables such as kinds of implants, age and diagnosis.

RESULTS: The average HSS score improved from 56.4 preoperatively to 93.0 postoperatively. The average HSS score at the last follow up was 81.7. The average ROM was 132.8° before UKA, which changed to 132.0° at the last follow-up. The femorotibial angle was valgus 1.7° before UKA, which improved to valgus 3.8° after UKA, but decreased to valgus 1.6° at the last follow-up. The overall 5-, 10-, and 20-year survival rates were 92.1%, 83.7%, and 68.6%, respectively. Without censoring, the survival rates were 92.2%, 84.5%, and 72.8%. According to the type of implants, Group I showed 10-year survival of 92.3%, Group II of 74.8%, and Group III of 89.0% ($p=0.008$). The survival rate was lower in patients <65 years ($p = 0.016$). Revision TKAs were performed in 29 knees among 103 cases. The average period from UKA to revision TKA was

9.4 years. The causes of revision TKA were polyethylene wear (19 knees), aseptic loosening (9 knees), and infection (1 knee).

CONCLUSION: The average HSS score was improved from 56.4 to 81.7, but we consider reduction of the score according to the follow up period. Among 103 knees, 29 knees had revision total knee arthroplasty and the overall 10-year survival rates was 83.7%, but Group II showed the lowest survival rate of 74.8%.

O5A2

Unicompartmental Knee In Octogenarians

Guest Faculty: S.K.S. Marya, MS, DNB, MCH, FRCS, FICS

Institution: Max Institute of Knee & Hip Replacement Surgery, New Delhi, India

BACKGROUND: Unicompartmental knee arthroplasty (UKA) has specific indications, producing excellent results. It, however, has a limited lifespan and needs eventual conversion to total knee arthroplasty (TKA). It is, therefore, a temporizing procedure in select active young patients with advanced unicompartmental osteoarthritis (UCOA). Being a less morbid procedure it is suggested as an alternative in the very elderly patients with tricompartmental osteoarthritis (TCOA). We performed UKA in a series of 45 octogenarians with TCOA predominant medial compartment osteoarthritis (MCOA) and analyzed the results.

MATERIALS AND METHODS: Forty five octogenarian patients with TCOA predominant MCOA underwent UKA (19 bilateral) from January 2002 to January 2012. All had similar preoperative work-up, surgical approach, procedure, implants and postoperative protocol. Clinicoradiological assessment was done at 3-monthly intervals for the first year, then yearly till the last followup (average 72 months, range 8-128 months). Results were evaluated using the knee society scores (KSS), satisfaction index [using the visual analogue scale (VAS)] and orthogonal radiographs (for loosening, subsidence, lysis or implant wear). Resurgery for any cause was considered failure.

RESULTS: Four patients (six knees) died due to medical conditions, two patients (three knees) were lost to follow up, and these were excluded from the final analysis. Bar-

ring two failures, all the remaining patients were pain-free and performing well at the final followup. Indications for resurgery were: medial femoral condyle fracture needing fixation subsequent conversion to TKA at 2 years (n=1) and progression of arthritis and pain leading to revision TKA at 6 years (n=1).

CONCLUSION: UKA has shown successful outcomes with regards to pain relief and function with 96.4% implant survival and 94.9% good or excellent outcomes. Due to lower demands, early rehabilitation, less morbidity, and relative short life expectancy, UKA can successfully manage TCOA in the octogenarians.

O5A3

500 Consecutive Robotic Arm Assisted Medial UKA: An Outpatient Procedure that Consistently Increases ROM

Primary Author: Frederick Buechel

Institution: Physicians Regional Medical Center

INTRODUCTION: UKA allows replacement of a single compartment in patients who have isolated osteoarthritis. However, limited visualization of the surgical site and lack of patient-specific planning provides challenges in ensuring accurate alignment and placement of the prostheses. Robotic technology provides three-dimensional pre-op planning, intra-operative ligament balancing and haptic guidance of bone preparation to mitigate the risks inherent with current manual instrumentation. The aim of this study is to examine the clinical outcomes of a large series of robot-assisted UKA patients.

METHODS: The results of 500 consecutive medial UKAs performed by a single surgeon with the use of a metal backed, cemented prosthesis installed with haptic robotic guidance. The average age of the patients at the time of the index procedure was 71.1 years (range was 40 to 93 years). The average height was 68 inches (range 58"-77") and the average weight was 192.0 pounds (range 104-339 pounds). There were 309 males and 191 females. The follow-up ranges from 2 weeks to 44 months.

RESULTS: Surgical Technique: The technique evolved from a one night stay with a tourniquet and a retinacular "T'd" arthrotomy, to a same day surgical procedure with a 2.5-3 inch straight medial arthrotomy that is muscle spar-

ing and tourniquet free allowing all patients to go home the same day with only 2-3 weeks of formal physical therapy post op, less pain medication and a quicker return to their preoperative range of motion.

CLINICAL OUTCOMES: All patients increased their ROM by 3-6 months postop. The return to preoperative ROM was seen by 6 weeks with an increased ROM of 5-10 degrees by 1 year. 6 out of 500 patients were converted to a TKA (1.2%). Two for deep infection (one had severe venous stasis disease preop), Three for medial pain despite stable, well aligned implants, and one who developed pain at around 6 weeks that had a large scar band that formed across the top of the tibial poly causing pain with weight bearing.

CONCLUSION: This evolved surgical technique along with the use of the sophisticated, patient-specific preoperative and intraoperative planning software combined with haptically guided bone resection allowed most patients, regardless of age, to have their procedure performed as an outpatient. This new technique can provide significant savings to the healthcare system in terms of costs of hospital days, costs of rehabilitation, costs in pain medication and quality of life in the acute post operative period with no increased risk of failure, loosening, malalignment, DVT, PE, infection, return to the OR, readmissions, or manipulation.

O5A4

Top Ten List – Why Patella - Femoral Replacements Are a Good Option

Guest Faculty: Fred D. Cushner, MD

Institution: ISK Institute, New York, NY; NS - LIJ Orthopedic Institute, New York, NY, USA

PARTIAL KNEE ARTHROPLASTY BENEFITS: Patella Femoral Replacements are a bone conserving option. The analogy has been made numerous times. A dentist does not take out all of one's teeth while only one is decayed. Or, do you change all of one's tires while only one is flat. Perhaps if all the other tires are bad but if the other 3 are normal, we would consider this an aggressive option.

CRUCIATES ARE PRESERVED: The debate continues regarding Posterior Substituting versus Cruciate retaining Designs. Now newer designs (variations of old designs) are being introduced that preserved both cruciate liga-

ments. Improved Balancing and better Proprioception have been claimed as advantages but certainly any mid range instability is avoided when just the patella and trochlea are resurfaced.

IMPROVED PLACEMENT OPTIONS: There are more equipment options now available to perform a patella femoral replacement with improved placement techniques. The surgeon has at their disposal reaming systems, Custom systems based on pre-operative CT scans, robotic Assistance and even Custom prosthetic Designs. Patella Femoral Arthroplasty has come a long way and technique is now more reproducible.

PATIENT SATISFACTION WITH TKA IS NOT PERFECT: While good long term results are reported with TKA and excellent longevity has been noted, this does not tell the complete picture. Post operative knee patients do report anterior knee pain on a frequent basis and continued patient symptoms persist despite a "successful" TKA procedure.

EXCELLENT CLINICAL RESULTS NOTED WITH PATELLA FEMORAL REPLACEMENT: Sisto reported their results (JBJS 2006, JULY 1988 (7) 1475-1480) of 25 custom Patella-Femoral Replacements and a 100 percent were noted to be doing well with 18 excellent and 7 good results noted. Leadbetter (CORR, 2005 JULY (436)91-99) reported on a literature review of 12 studies with disease progression at the tibial- Femoral joint noted as a common form of failure. Coojman (JBJS BR 2003 Aug 85 ,836-4-840) noted excellent long term results at 17 years with only 2 failures in 56 patients noted to arthritis progression.

IT IS AN EASY REVISION: Lets face it, this is not that complicated of a revision. The femoral component is easily removed with patella often being maintained. There may be some insignificant anterior bone loss but standard primary femoral components are usually sufficient at time of the revision (Acta Orthop 200, Feb 80(1) 62-66).

CURRENT PROCEDURES WITH LOWER COMPLICATION RATES: Historically, with inferior designs and instruments, a significant complication rates were noted with Patella-Femoral Resurfacing Procedures. Lonner recently reported a complication rate of 4% with current designs compared to 17% with first generation designs. (CORR 2004NOV (428)158-165).

BETTER INDICATIONS: Current Indications help select the ideal patient. This procedure is best for isolated arthritis of the anterior knee compartment. Best results are seen when proper patella alignment can be achieved and soft tissue balance occurs. Mild patella malalignment can be corrected at the time of surgery but in severe dislocation incidents, the procedure should be avoided

WEAR IS NOT AN ISSUE: While arthritis progression can occur, osteolysis or prosthesis wear has not been reported. Therefore, it appears safe for patients to go back and maintain an active lifestyle.

IT IS A FUN PROCEDURE: Patients do well and appreciate the benefits mentioned above.

O5A5

Postoperative Evaluation Of Accuracy In Navigated Unicompartmental Knee Arthroplasty Using A Three-Dimensional Digital Templating System

Primary Author: Akihiko Toda

Institution: KOBE Kaisei Hospital

Coauthors: Kazunari Ishida (KOBE Kaisei Hospital), Tomoyuki Matsumoto (KOBE Kaisei Hospital), Hiroshi Sasaki (KOBE Kaisei Hospital), Koji Takayama (KOBE Kaisei Hospital), Kazuki Kodato (KOBE Kaisei Hospital), Ryosuke Kuroda (KOBE Kaisei Hospital), Masahiro Kurosaka (KOBE Kaisei Hospital), Nao Shibamura (KOBE Kaisei Hospital)

INTRODUCTION: The success of unicompartmental knee arthroplasty (UKA) is highly dependent on the accuracy of component and leg alignment. Computer-assisted surgery is gaining popularity in total knee arthroplasty with numerous studies reporting improved accuracy and decreased variability in implant position and postoperative limb alignment compared with conventional techniques. However, literature evaluating the accuracy of computer-navigated UKA is limited. Therefore, this study aimed to investigate the accuracy of component positions in navigated UKA using a three-dimensional (3D) image-matching system. To the best of our knowledge, this study is the first to evaluate the accuracy of implant placement position in UKA using 3D image-matching systems.

MATERIALS AND METHODS: Twenty-three patients (10 men and 13 women) underwent computer-assisted UKA performed by a senior surgeon from September 2011 to August 2013. All surgeries were performed using an image-free navigation (NA) system (Stryker 4.0 image-free computer navigation system; Stryker Orthopedics, Mahwah, NJ). Two types of UKA implants (10 cases: Unicompartmental High-Flex Knee System, Zimmer, Warsaw, IN; 13 cases: Triathlon Partial Knee Resurfacing System; Stryker) were used in the subjects. We recorded the femoral and tibial bone resection angles toward the mechanical axis using NA intraoperatively. In addition, we measured the coronal, sagittal, and rotational alignment of the femoral and tibial components using the 3D image-matching system, ATHENA Knee (Soft Cube, Osaka, Japan; AA). We compared NA with AA, and a deviation of $>3^\circ$ from the value recorded by AA was defined as an outlier.

RESULTS: We observed coronal outliers of $>3^\circ$ for the femoral component in 4 of the 23 patients and for the tibial component in 3 of the 23 patients. We also observed sagittal outliers of $>3^\circ$ for the femoral component in 5 of 23 patients and for the tibial component in 3 of the 23 patients. Twenty-two tibial components were placed in external rotation relative to the Akagi's line.

DISCUSSIONS AND CONCLUSIONS: In UKA, evaluating the alignment of the femoral component using radiographs is difficult. 3D image-matching analysis enables evaluation of the alignment of components. In both coronal and sagittal alignment, there were a definite proportion of outliers. The ratio of outliers in rotational alignment was especially higher than that in coronal and sagittal alignment. In UKA, identification of bony landmarks is difficult because of the small operation field. Therefore, careful surface mapping of particular bony landmarks is necessary.

O5A6

Treatment of Periprosthetic Tibial Plateau Fractures in Unicompartmental Knee Arthroplasty: Plates Versus Cannulated Screws

Primary Author: Jörn B. Seeger

Institution: Department of Orthopaedics and Orthopaedic Surgery - UKGM

Coauthors: Daniela Haas (University Hospital Heidel-

berg), Sebastian Jaeger (University Hospital Heidelberg), Eric Röhner (University Hospital Jena), Michael Clarius (Vulpius Klinik Bad Rappenau)

INTRODUCTION: Periprosthetic tibial plateau fractures (TPF) are rare but represent a serious complication in unicompartmental knee arthroplasty (UKA). The most common treatment of these fractures is osteosynthesis with cannulated screws or plates. The aim of this study was to evaluate two different treatment options for periprosthetic fractures.

MATERIALS AND METHODS: Twelve matched, paired fresh-frozen tibiae with periprosthetic tibial plateau fractures were used for this study. In Group A, osteosyntheses with cannulated screws were performed, whereas in Group B plates fixated the periprosthetic fracture. DEXA bone density measurement and standard X-rays (AP and lateral) were performed before loading the tibiae under standardised conditions with a maximum load of up to 10.0kN. After the specimens had been loaded, fracture patterns and fracture loads were analysed.

RESULTS: In the plate group all tibiae fractured with a median load of $F_{max}=2.64$ (0.45-5.68) kN, whereas in the group with cannulated screws fractures occurred at a mean load of $F_{max}=1.50$ (0.27-3.51) kN. The difference was statistically significant at $p<0.05$.

DISCUSSION: Angle-stable plates showed significantly higher fracture loads than fixation with cannulated screws. Cannulated screws show a reduced stability of the tibial plateau. Therefore in periprosthetic tibial plateau fractures, osteosyntheses with angle-stable plates should be recommended instead of cannulated screws.

05A7 Improved Lateral Knee Compartment Congruence Following Medial Unicompartmental Arthroplasty

Primary Author: Saker Khamaisy
Institution: Hospital for Special Surgery

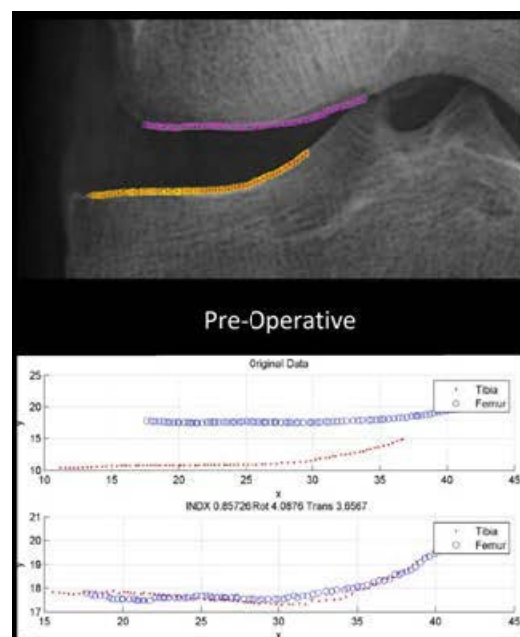
Coauthors: Hendrik A. Zuiderbaan (Hospital for Special Surgery), Ran Thein (Hospital for Special Surgery), Andrew D. Pearle (Hospital for Special Surgery)

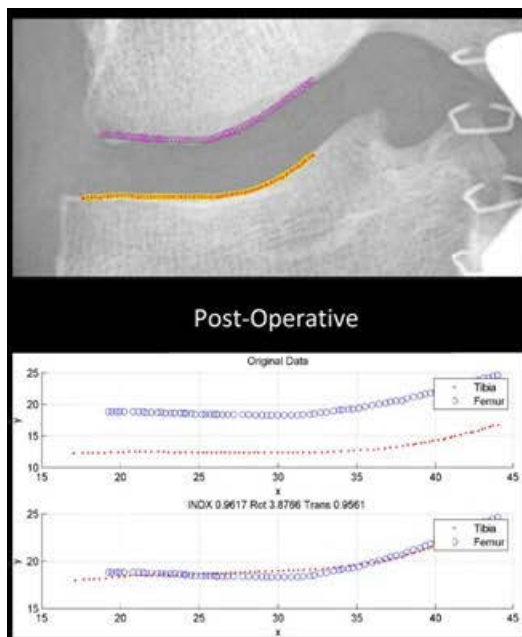
INTRODUCTION: Unicompartmental knee arthroplasty (UKA) is a successful treatment for single compartment knee osteoarthritis (OA). However, OA progression in the adjacent knee compartment is considered a leading cause for failure and revision surgery. The purpose of this study is to evaluate lateral compartment congruence following medial UKA.

METHODS: Retrospectively, we evaluated lateral knee compartment congruence in 174 knees following medial UKA and in 41 normal knees of healthy control group. Congruence was measured pre and postoperatively using specially developed software based on Iterative Closest Point (ICP) algorithm. The ICP algorithm performs rigid transformation that best aligns digitized articular surfaces (Figure 1); thereby, it evaluates the geometric relationship between the surfaces and calculates a congruence index (CI).

RESULTS: The CI in the lateral compartment of the healthy control group was $0.98 (\pm 0.01)$. In Medial UKA group, the preoperative CI of the lateral compartment was $0.88 (\pm 0.10)$ which improved significantly to $0.93 (\pm 0.08)$ following implantation of a UKA ($p=0.001$). In 82% the CI improved after UKA implantation, while in 18% the CI decreased postoperatively.

CONCLUSION: Medial UKA is not only a resurfacing procedure of the medial knee compartment but also improves the lateral compartment congruence in most cases. Therefore, medial compartment UKR may be protective against OA progression in the lateral compartment.





non-linear contact finite element model. The head/neck interface consisted of the tapered trunnion and head bore. When assembled on the trunnion, a moment arm exists between the center of rotation of the head and the trunion contact pressure centroid. Stability was determined at 36 cup orientations, for five distinct dislocation challenges, for five distinct femoral head diameters (32, 36, 40, 44 and 48mm) resulting in a total of 900 FE simulations. Seven head diameters were investigated from 32mm to 56mm, in 4mm increments to evaluate trunion wear.

RESULTS: Stability (measured in terms of femoral head subluxation) improved with increased diameter, although diminishing benefit was seen for size increases beyond 40mm. By contrast, at the trunnion interface unabated increase in stress was observed for femoral heads exceeding 40mm, with the greatest effect seen for larger values of head diameter. Linear wear at the trunnion interface demonstrated a similar dependence upon head size, accelerated wear observed for femoral head diameters exceeding 40mm for both gait and sit-to-stand motions.

CONCLUSIONS: The current parametric finite element results corroborate recent clinical evidence that large-diameter heads for MoM THA have a tendency to undergo deleterious wear generation at the head/trunnion interface. Although there were marginal additional improvements in construct stability, the propensity for trunnionosis-inducing wear increased substantially for head diameters greater than about 40mm.

Trunion Issues

O5B2

Trunion Corrosion: Effect of Femoral Head Diameter

Guest Faculty: John J. Callaghan, MD

Institution: University of Iowa, Iowa City, IA, VA Medical Center, Iowa City, IA

Coauthors: Jacob M. Elkins (University of Iowa Department of Orthopaedics and Rehabilitation), Thomas D. Brown (University of Iowa Department of Orthopaedics and Rehabilitation)

INTRODUCTION: A number of recent reports have indicated an unacceptably high rate of wear-associated failure with large diameter bearings, possibly due in part to increased wear at the trunnion interface (“trunnionosis”). We evaluated the potential tradeoff between implant stability and trunion wear using a modular total hip arthroplasty finite element model.

METHODS: Computational simulations were executed using a previously developed and physically-validated

O5B3

Metal Corrosion on Head-Neck Junction Induce Periprosthetic Scar Tissue as Adverse Reaction to Metal Debris

Primary Author: Tomoaki Yoshikawa

Institution: Orthopaedic Surgery, Nagai Hospital

Coauthors: Toru Yamakawa (Ise Red Cross Hospital), Joji Morikawa (Ise Red Cross Hospital), Satoshi Hosoi (Suzuka University of Medical Science), Akihiro Sudo (Mie University Graduate School of Medicine)

INTRODUCTION: It is increasingly reported that metal corrosion at head-neck junction of femoral component was found in postoperative cases treated with total hip arthroplasty (THA), and it is considered that the metal cor-

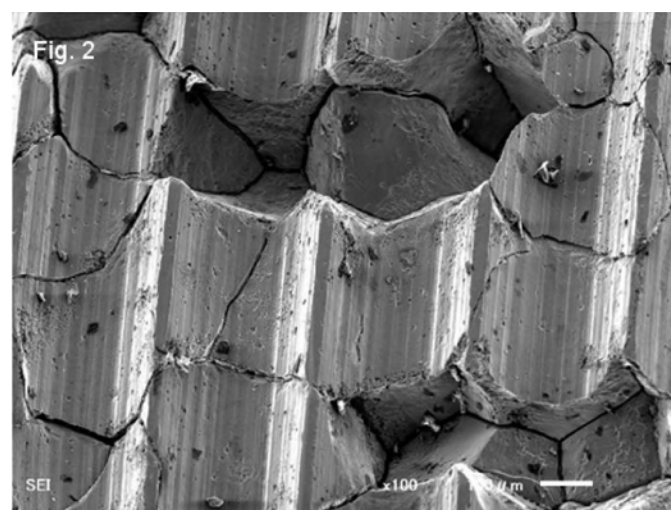
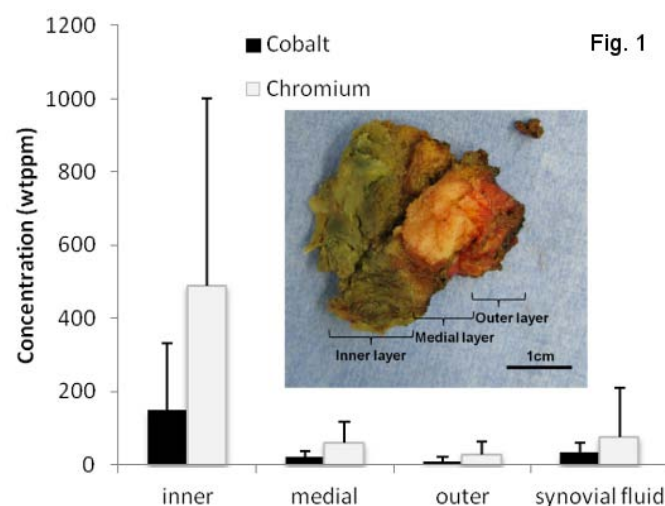
rosion is one of cause of adverse reaction to metal debris (ARMD). We experienced ten ARMD cases in which the metal corrosion was found at the head-neck junction during the revision surgeries from 38 hips which we operated with particular metal on metal (MoM) THA. We presumed that these ARMD was induced by metal corrosion on head-neck junction. The purpose of present study is to investigate cause of ARMD by measurement of metal level, histological analysis, energy dispersive X-ray spectrometry (EDS) of the metal debris, and scanning-electron-microscopic (SEM) analysis surface of the tapered neck of the femoral component.

METHODS: All ARMD cases showed deposit of metal debris on head-neck junction and massive periprosthetic scar tissues at revision surgery. Histological analysis and measurement of metal level were performed on three locations in the scar tissue: inner, middle, and outer layer. EDS was performed to analyze component of deposits. Outer surface and transverse surface of tapered neck were analyzed by SEM to evaluate the metal corrosion in tapered neck.

RESULTS: The Co and Cr level in the inner layer of periprosthetic scar tissue were significantly higher than those of the other layer (Fig. 1). In histological analysis of inner layer, necrotic and avascular scar tissue was found in absence of inflammatory cell. The EDS analysis indicated two different content ratios of O and C by location of metal corrosion deposit. Some area of the deposit included more O than C, others had the reverse. The Cr concentration was significantly higher where the O concentration was greater. SEM analysis indicated the formation of pit corrosion, intergranular stress corrosion cracking (IGSCC), and striation pattern in the metal tissue of tapered neck (Fig.2).

DISCUSSION: The inner layer of scar tissue and the metal debris included high level of Co and Cr. Moreover, EDS analysis indicated that some part of the metal debris could be produced due to tribochemical reaction (TCR) on head-neck junction. TCR have the potential to be the cause of metal corrosion, and it was considered this metal corrosion induced the generation of debris on the head-neck junction. Moreover SEM analysis had shown the pit corrosion and grain boundary cracking on the outer surface of the tapered neck, and sustained the present of metal corrosion on tapered neck, too. The presence of striation on the transverse cross section indicated metallic fatigue in tapered neck. This finding might had suggested mechanical

stress was associated with the metal corrosion, especially IGSCC. In conclusion, present study suggested that occurrence mechanism of metal corrosion was varied due to the combination of articulation or the corrosion environment, the metal corrosion induced metal debris which included high level of Co and Cr on head-neck junction, and the necrotic and avascular scar tissue was generated as ARMD by toxicity of Co and Cr ion.



O5B4 Development and Validation of a Quantitative Method to Calculate the Volume of Material Loss from the Taper-Trunnion Junction

Primary Author: Sevi B. Kocagoz
Institution: Drexel University

Coauthors: Richard J. Underwood (Drexel University, Exponent Inc. Philadelphia), Daniel W. MacDonald (Drexel

University), Judd S. Day (Drexel University, Exponent Inc. Philadelphia), Steven M. Kurtz (Drexel University, Exponent Inc. Philadelphia)

INTRODUCTION: Material loss from taper junctions in orthopedic devices is a clinical concern. Previous studies of explants relied on visual scoring to quantify the fretting-corrosion damage on the component interfaces. Previous research has shown that visual fretting-corrosion evaluation is correlated to the volume of material loss[1], but scoring is semi-qualitative and does not provide a quantitative measure of the amount of material removed from the surface. The purpose of this study was to develop and validate a quantitative method for measuring the volume of material lost from the surfaces of explants at the taper-trunnion junction.

METHODS: We used 10 new exemplar taper adapter sleeves for this study (Ceramtec, Plochingen, Germany). Although our methodology is intended for retrieved implants, by using exemplar devices we were able to create clinically realistic taper damage in a controlled and repeatable manner using machining tools. Taper surfaces were measured before and after in vitro material removal using a roundness machine (Talyrond 585, Taylor Hobson, UK). The mass of artificially removed material was also measured gravimetrically using a microgram balance (Sartorius, CPA225D, accuracy = $\pm 0.00003\text{g}$).

The surface profiles were analyzed using a custom Matlab script and the Taylor Hobson Talymap software was used to provide 3D visualizations of the pattern of material loss. The calculated volume of material loss was compared to the gravimetric value. Finally a sensitivity analysis was conducted to determine the optimum number of traces to characterize the material loss from taper junctions.

RESULTS: Our calculations of material loss predicted over 99% of the variation in gravimetric material loss (Figure 1, $r^2 = 0.9962$). Examples of the pattern of material removal from explanted components resembled the patterns reported in explants (Figure 2). The sensitivity analysis showed that a minimum of 24 axial profiles are required for measurements to stay within 2% of the volume calculated with 144 traces for cases with an axisymmetric wear pattern.

DISCUSSION: We have developed and validated a quantitative method for the material loss from taper junctions

in orthopedic devices. Our sensitivity analysis showed that a minimum of 24 profiles are required to calculate volumetric material loss accurately, however a further sensitivity analysis is required to establish the minimum number of profiles required to accurately characterize “asymmetric” wear patterns. The measurement of 24 profiles takes approximately 20 minutes. The validation thus far has comprised material loss in an axisymmetric pattern. Work is underway to validate the evaluation of tapers with an asymmetric wear pattern. The axisymmetric and asymmetric patterns are realistic representations of wear patterns seen in explanted taper surfaces. This validated method of estimating material loss from taper junctions will be used in our ongoing research program to understand the mechanisms of fretting-corrosion in retrieved orthopaedic tapers. [1] Kocagöz SB, Underwood RJ, MacDonald DW, Higgs GB, Day JS, Siskey RL, et al. Does Visual Inspection of the Taper Head / Stem Junctions in Metal-on-Metal Hips Adequately Characterize Material Loss from Corrosion and Wear? Orthop. Res. Soc., San Antonio, TX, USA: 2013.

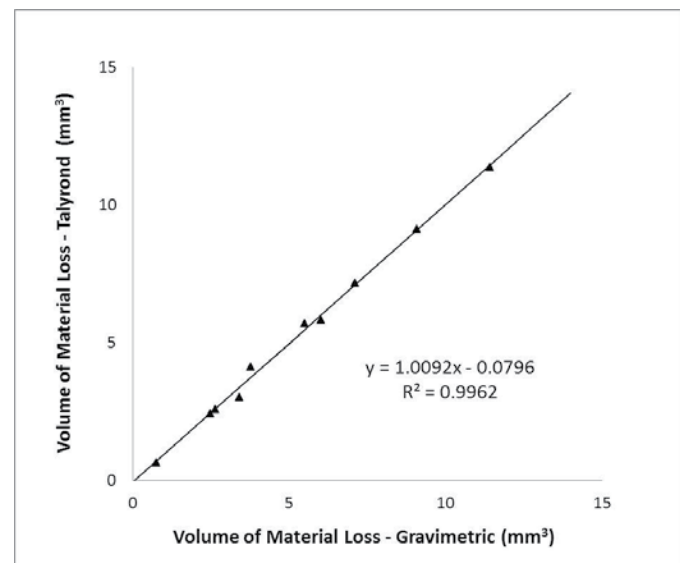


Figure 1: Plot of volume of material loss from gravimetric versus Talyrond methods.

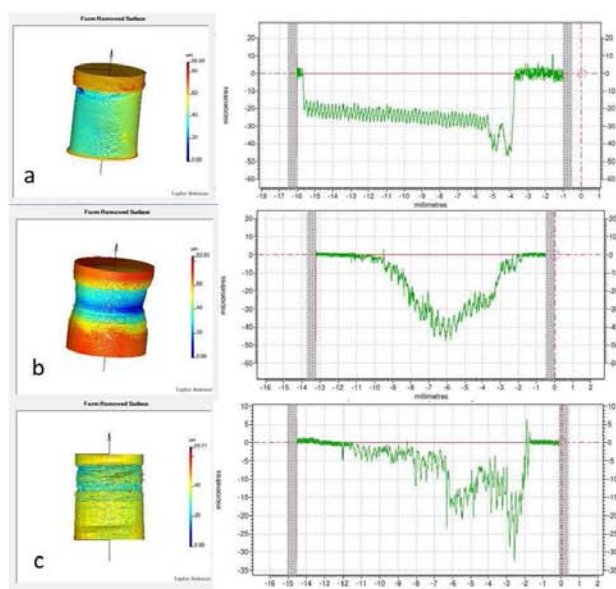


Figure 2: Examples of the material loss patterns internally on explanted (a) and new (b,c) taper adapter sleeves. The estimated volumetric material loss was 7.93mm³, 9.12mm³ and 2.47mm³ in figures a, b and c respectively.

O5B5

In Vitro Electro-chemical Testing of Conventional Total Hip Replacement Tapers

Primary Author: Jim Nevelos

Institution: Stryker Orthopaedics

Coauthors: Viswa Swaminathan (Stryker Orthopaedics), Ahmad Faizan (Stryker Orthopaedics), Kevor TenHuisen (Stryker Orthopaedics)

INTRODUCTION: This in vitro test was designed to evaluate the relative electro-chemical performance of three different commercially available hip femoral component tapers. In particular, this study investigated the effect of taper material combination: Ti6Al4V/CoCrMo [Accolade II] vs. TMZF/CoCrMo [Accolade TMZF] and design: V40 taper [Accolade II] vs. C taper [Secur-Fit] (all Stryker Orthopaedics, Mahwah, NJ) on the electro-chemical performance under physiologically relevant loading conditions.

MATERIALS AND METHODS: The test methodology utilized in this study is similar to the test method adopted by Gilbert et al. for evaluating taper electro-chemical performance [1]. The stems were embedded in epoxy (10° valgus /9° flexion orientation), and the heads and necks were pre-wetted with saline (PBS, pH 7.4) before assembling with a single ramp load of 2 KN (line of force nominally 35° to neck axis). Testing involved a short-term load-

ing scheme where cyclic load magnitude was incremented in steps (from 100 N up to 3200 N, 3 min at each load at 3 Hz, R=0.1) followed by a long-term loading scheme where cyclic loading continued for 1 million cycles (3200 N at 3 Hz, R=0.1). After 1 million cycles loading, samples were allowed to recover for a period of time and the short-term loading scheme was repeated. All tests were performed in phosphate buffered saline solution at room temperature. Electrochemical measurements were taken periodically throughout the duration of the test using a three electrode arrangement consisting of a taper working electrode, Ag/AgCl reference electrode and an auxiliary electrode made of the same material as that of the stem taper. A minimum of four samples were tested per group and all statistical analyses were performed using one-way ANOVA methods.

RESULTS AND DISCUSSION: The results showed that the average current and current amplitude increased and the potential dropped with increasing load magnitude. For different groups, the onset load ranged from 960 to 1204 N, (Short-term I data, Figure 1) and the mean currents at maximum applied load ranged from 1.3 to 2.2 μ A. No statistically significant differences were observed between different taper designs or material combinations tested in this study. The long-term testing data showed that extent of fretting corrosion decreased with increasing number of cycles (Figure 2). Also, the fretting corrosion onset load for Accolade II and Accolade TMZF significantly increased.

CONCLUSIONS: The results from this in vitro bench top testing showed that these differences in material combination and taper design did not influence the electro-chemical performance of the tapers. Further study will include exploration of the effects of taper surface finish, taper assembly conditions, more complex loading mechanisms, and more aggressive solution conditions on the corrosion performance of different tapers.

References:

1. Goldberg JR, Gilbert JL. In vitro corrosion testing of modular hip tapers. J Biomed Mater Res B Appl Biomater 2003; 64B (2):78-93.

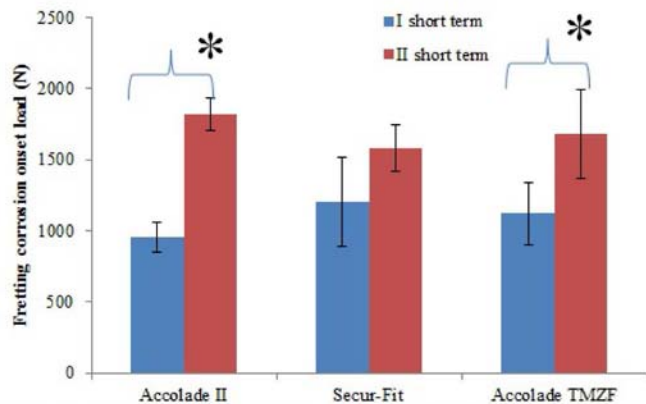


Figure1. Comparison of fretting corrosion onset load obtained from the short-term varying cyclic load test done before and after 1 million cycles loading. For Accolade II and Accolade TMZF, the plot shows statistically significant increase ($p < 0.05$) in the load required to initiate fretting corrosion.

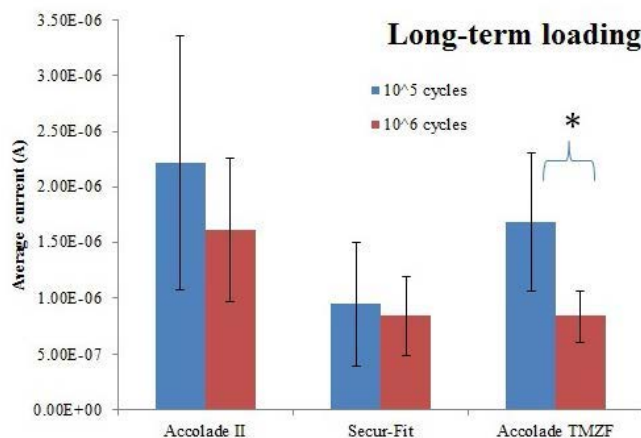
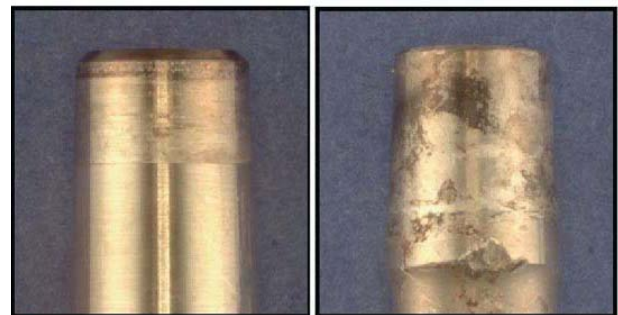


Figure2. Mean and SD of average currents generated at 100,000 and 1,000,000 cycles of loading. The current levels at 1 million cycles are lower compared to the current levels at 0.1 million cycles for all sample groups. For Accolade TMZF, current average at 1 million cycles were significantly different ($p < 0.05$) from that of values obtained at 100,000 cycles loading.

Introduction: The feature of modular junctions offers significant advantages to fine-tuning joint mechanics in total hip arthroplasty. However, the unsuitability of some materials in certain orthopaedic applications such as the use of titanium alloy as a bearing surface forces the selection of using dissimilar materials.

Historically, in vivo corrosion has not been a well-understood phenomenon. Some studies have implied that the level of corrosion existing with the use of titanium and cobalt chrome combination is acceptable.

New observations, however, suggest that, under certain conditions, some implant designs combine Ti-6Al-4V and Co-Cr-Mo may exhibit corrosion.



Examples of fretting and corrosion titanium stems used with C.C. heads

Forms of Corrosion: There are three basic forms of corrosion: Galvanic, Crevice, and Fretting. Galvanic corrosion can occur when two dissimilar metals in physical contact are exposed to electrically-conductive fluids, such as found in vivo.

Crevice Corrosion can develop when a gap or crevice of sufficient size is present between a metal and another excess positive charge forms in the crevice, creating an electrochemical potential (battery) between that portion of the metal inside the gap and that portion outside the gap.

Fretting and fretting Corrosion can occur when two metallic surfaces move repeatedly against one another. This can then break down the passive oxide layer of metal. This destruction of passive oxide layer may initiate and help sustain the galvanic and/or crevice corrosion of two metals.

Quality Control Issues: Fretting can occur between two poorly fitting implant components, such as modular head/neck taper or modular neck/stem taper. Tapers with high areas of stress, and mismatched manufacturing tolerances can contribute to fretting and fretting corrosion. Taper

O5B6 Optimizing Modular Tapers for Total Hip Arthroplasty

Primary Author: Timothy McTighe

Institution: Joint Implant Surgery & Research Foundation

Coauthors: Declan Brazil (JISRF & Signature Orthopaedics), John Keggi (TSI™ Study Group, JISRF & Orthopaedics New England), Louis Keppler, (TSI™ Study Group, JISRF & St. Vincent Medical Center), Robert Kennon, (TSI™ Study Group, JISRF & Orthopaedics New England), David Campbell, (TSI™ Study Group & Wakefield Orthopaedic Clinic), Edward J. McPherson (TSI™ Study Group, JISRF & L.A. Orthopaedic Institute)

styles with an optimal angle and greater surface area provide a better fit between components by increasing the surface area of contact between them. Large surface areas minimize stress by distributing the force over a large area. Taper designs with smaller surface areas and/or improper angles distribute the force over a smaller region, and thus more stress is created within the components.

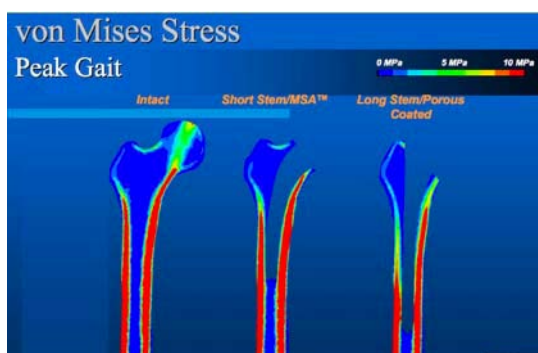
Materials and Methods: We have studied the effect of tensile stresses of both conventional length stems with conventional neck resections and compared them to a novel short curved neck sparing tissue preserving stem design and have found correlation between FEA modeling and plain radiographics.

Additionally, FEA was done looking at principal stress in femoral component designs of a conventional length stem compared to a short curved neck preserving style stem. Also, analysis was done on how to reduce stress concentration on both head/neck tapers and neck/stem tapers.

Mechanical & Electrochemical corrosion testing were performed on a modular short Stem. • Testing was performed on both un-coated and TiN coated implants at the modular junction. • Mechanical Testing consisted of Neck Endurance testing per ISO7206-6 and then dis-assembly after testing and measurement of weight loss to determine wear. • Electrochemical corrosion testing consisted of ASTM F1875.

- TiN coated implants was completed at DOT in Germany.
- All mechanical Testing was performed by independent lab.

RESULTS: Fretting analysis data along with FEA modeling will be presented clearly demonstrating enhanced designs and techniques for the reduction of stress, reduction of particulate debris and potential reduction of corrosion activity.

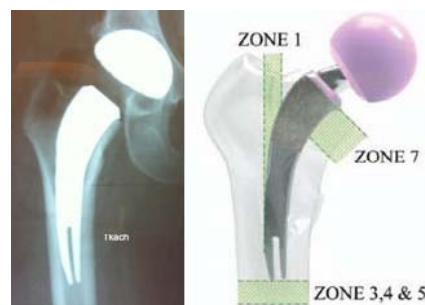


FEA modeling comparing intact femur to short curved and conventional stem.

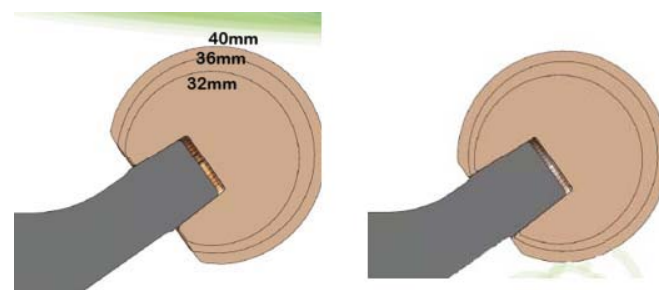
FEA modeling has demonstrated better potential for bone remodeling with short curved neck preserving stems as compared to traditional cementless stems.

Short curved neck preserving designs reduce stress on modular neck junctions while reducing bending and torsional loads.

Taper junctions (head-neck & neck-stem) can be designed to be safe and effective features in a contemporary hip system. Not all tapers are designed equal and are a result of specific material, fabrication and quality control issues.



Example of a short curved neck sparing stem with modular junctions.



Taper Engagement for Heads
Standard or current design New improved taper engagement

Increasing taper length increases taper surface contact while reducing stress and micromotion at taper interface. Thus reducing fretting corrosion issues.

There is no need to eliminate modular junctions just the need to improve on their individual quality control.

Diagnostic & Imaging Techniques for the Knee

O6A1

3D Imaging of the Knee Using Ultrasound

Guest Faculty: Mohamed R. Mahfouz, PhD

Institution: University of Tennessee, Knoxville, TN, USA

One of the key challenges for computer aided diagnosis in orthopedics is the heavy reliance of capital equipment such as the CT or MRI imaging modularity that are not available in regular clinic and doctors' office. The use of ultrasound (US) in orthopedics diagnosis has gained interest in the recent decade due to its relatively low cost and radiation-free nature. JointVue's 3D imaging technologies overcomes the foregoing problems and other shortcomings, drawbacks, and challenges of high cost or high radiation exposure imaging modalities to generate a patient-specific model by US techniques.

A new system for reconstruction of 3D of the knee joint bones using ultrasound RF data was developed. Using a B-mode ultrasound machine, the operator scans the joint of the patient. The EM tracking system provides the location and orientation of the US probe, which are used to determine the location of the scan data.

The raw US RF signal is filtered by the RF filtering and a multi-tier processing and reconstruction algorithms. The RF filtering algorithm corrects for artifacts generated by non-normal angle between the probe and the anatomy. Anatomical interface scanned from multiple angles are ranked based on reflected power profile and the most probable sample for that interface is determined statistically. The multi-tier signal processing algorithm consists of multiple feature extraction, registration, Bayesian prediction and correction layers. The first layer is detecting the features of single US scanning profile, while the second layer registers the 2D scanning profile to the 3D space. The last tier of processing uses a real time Bayesian prediction and correction algorithm to shape a 3D CAD bone model based on the output of the US data. In addition, The US signal can be used to detect soft tissue detection by integrating the statistical shape models (SSM) methods to estimate the thickness of the cartilage. The algorithm runs directly on

the ultrasound machine to capture the RF data, process it in real-time to extract the bone and soft tissues contours from the acquired ultrasound signal while the joint being scanned.

The US reconstructed bones are compared to the MRI data, where the RMSE is 1.5mm. With such results the use of such reconstruction technology will offer a safer, more cost effective alternative for joint imaging.

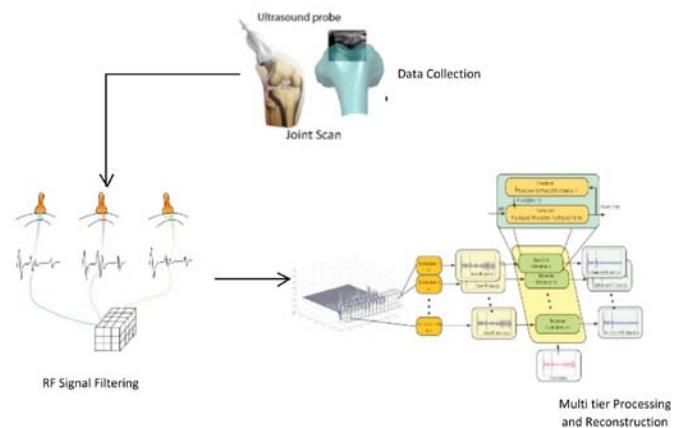


Figure 1 - Signal processing method for 3D reconstruction with US.

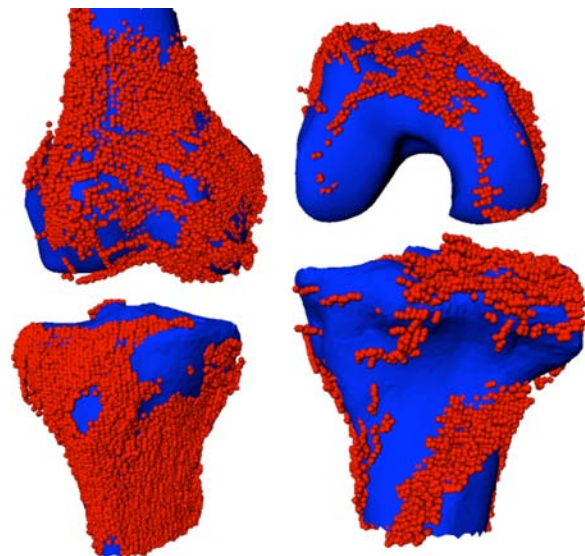


Figure 2 - 3D reconstructed bone model (blue), Raw US scan data (red dots)

O6A2

Needle Guided Injection Using 3-D Ultrasound

Guest Faculty: Ray C. Wasielewski, MD

Institution: University Ortho Physicians Inc, Columbus, OH, USA

Coauthors: Komistek, RD; Mahfouz, MR; To, G; and Fatah, EEA

Many 2-D ultrasound technologies are now available for Joint injection. Even with some of the newer guidance systems these technologies do not provide optimal methodology and accuracy to meet the needs of many orthopedic surgeons and their often less skilled assistants. A real-time 3-D guided system would provide the ability for joint injection to be done in the office setting by all physicians and their qualified staff.

JointVue's technology can use any 2-D ultrasound machine's hardware and probe as its proprietary patented software converts the A-mode (RF) probe signal directly to a 3-D Joint Image. Because the 3-D image is not created from the intermediate intensity images, the patient's actual joint - created by ultrasound scanning - is nearly as accurate as 3-D images created from MRI and CT. Once the 3D image is created, an EM Guided needle can be easily placed into the joint insuring accurate real time joint injection. This is particularly important due a surprisingly high rate of missed joints (even knee) and the expense of current substances being injected. The creation of a 3-D image also allows for a more robust injection reimburse along with this increased quality and efficacy.

A partially disposable sensor embedded silicone drape being developed in conjunction with this 3-D injection technology will make it possible to do injections in small joints and correct for patient motion in real time during injection. These "Smart Drapes" have ultrasound sensors and IMU's that will allow the computer interface to relocate the position of the patient's bones relative to the injection needle after joint movement, allowing for the possibility of even more accurate real time 3-D joint injection.

The JointGuide technology allows injections to be done in the office rather than expensive facilities. Even difficult joint injections of the hip, shoulder, sacro-iliac or spine facet joint, could be moved to the office from more expensive radiology departments. Another savings is the potential to de-skill many joint injections so that the point of care is with the lowest cost provider (PA's, Nurses, etc.). Healthcare insurers and payors want these cost effective changes and will likely be very acceptant of this new JointGuide technology.

O6A3 **Three Dimensional Articulating Cartilage Modeling Using Statistical Atlases**

Primary Author: Emam E. Abdel Fatah

Institution: University Of Tennessee

Coauthors: J. Michael Johnson (TechMah LLC), Mohamed R. Mahfouz (University Of Tennessee)

INTRODUCTION: Mapping of soft tissue and bone thickness are active areas of research in many fields, including the medical field where cartilage mapping is of great importance in studying the progress of osteoarthritis. Osteoarthritis is a disease characterized by structural change of bone, loss of articulating cartilage, and pain. MRI is the standard imaging protocol for modeling cartilage, using MRI different models have been developed for modeling articulating cartilage of e knee. However many of these models are not three dimensional and can't be used as a direct input for a femoral and tibial cartilage prediction in case of lack of MRI. In this paper a three dimensional cartilage model has been developed using statistical atlases in order to generate accurate anatomical correspondence across entire training set.

METHODS: Cartilage modeling process is a two tier process. Firstly, it involves modeling the bone cartilage interface (BCI) by identifying vertices with high probability of belonging to the BCI. The second tier is modeling the statistical distribution of the measured cartilage thickness at the identified BCI. Thirty-seven MRIs of knee joints were used from the Osteoarthritis Initiative dataset. Only normal knees were selected in this analysis (Zero OARSI atlas grade). MRIs were manually segmented using experts, and four surface models were generated for the femur bone and cartilage, and tibia bone and cartilage tibia. The femur and tibia bone were added to the statistical atlas to generate dense correspondence between the training sets[1]. Next step involves determining vertices on bone model that corresponds to the true bone cartilage interface. The cartilage thickness at each of these vertices was then computed by finding the normal distance between the BCI and outer cartilage surfaces. PCA was then computed along with the mean and standard deviation for both the femur and tibia.

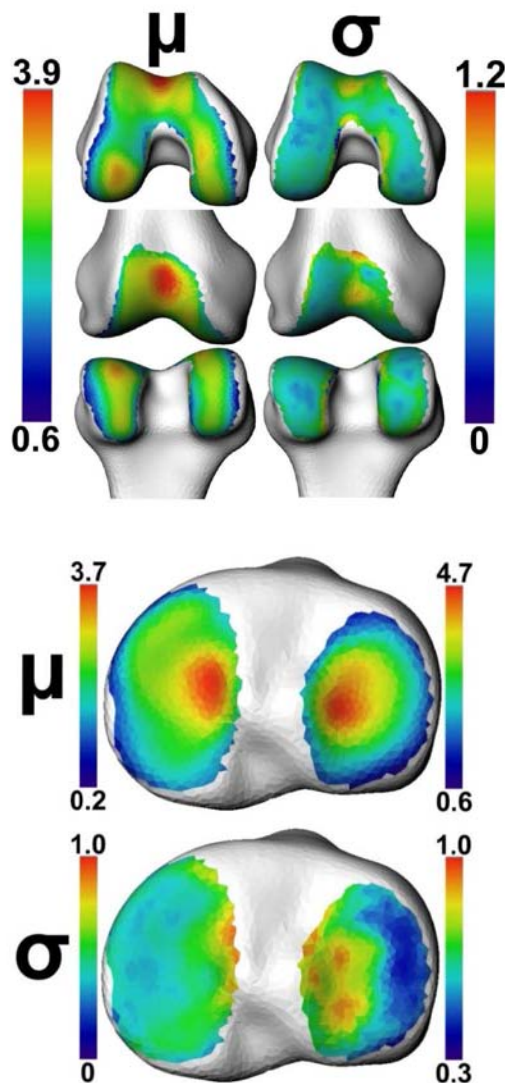
RESULTS: Figure 1 shows the mean and standard deviation of the cartilage thickness on the femur, which was found to be 2.5 mm with standard deviation of 1.3 mm.

Figure 2 shows the mean and standard deviation map for the lateral and medial tibia cartilage. The lateral cartilage was thicker with a mean of 2.6 mm and a 1 mm standard deviation compared to 1.9 mm mean and 0.7 mm standard deviation on the medial side.

DISCUSSION: The results of this analysis showed that the anterior trochlear area of the femoral cartilage was the thickest cartilage. The medial anterior side was found to be thicker than the lateral anterior side, whereas the lateral middle was thicker than the medial middle. Proposed three dimensional cartilage map can be used as a base for a cartilage prediction model in case of absence of MRI.

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**ICJR Pan Pacific Basic Science
Research Award Winner**

O6A4

Mobile Verses Stationary Fluoroscopy: Is There an Advantage

Primary Author: Ian M. Zeller

Institution: University of Tennessee

Coauthors: Trevor F. Greico (University of Tennessee), Matthew A. Young (University of Tennessee), Adrija Sharma (University of Tennessee), William R. Hamel (University of Tennessee), Richard D. Komistek (University of Tennessee)

INTRODUCTION: Although stationary fluoroscopy has been a practical resource for determining in vivo knee kinematics, there are limitations that have restricted the use of this technology. While using stationary fluoroscopy patients can only perform a fraction of normal daily living and must slow these activities down to avoid ghosting of the images and remain in the field of view. A Mobile Tracking Fluoroscopic (MTF) unit has recently been developed that can track patients in real-time as he/she performs various activities at more natural speeds. The objective of this study was to compare in vivo kinematics for patient's evaluated using stationary fluoroscopy and patient's evaluated using mobile fluoroscopy in order to investigate potential advantages and disadvantages for both technologies.

METHODS: The MTF unit is a unique mobile robot that can acquire real-time x-ray sequences of hip, knee, or ankle joint motion while a subject walks/maneuvers naturally within a laboratory floor area. Because of its mechanical design, test protocols can involve many types of maneuvers such as chair rises, stair climbing/descending, ramp crossing, walking, etc. Since the subjects are performing such actions naturally, the resulting fluoroscope sequences capture the full functionality of their musculoskeletal anatomy. 10 Patients in the study were initially fluoroscoped using a stationary unit and then using the MTF unit. In addition those results were compared to an extensive database of stationary fluoroscopic data.

RESULTS: Initially, patients were requested to perform gait, stair-rise, stair descent, chair-rise and a deep knee bend under stationary fluoroscopy. Unfortunately, all of

these activities could not be captured, under normal conditions, using a stationary fluoroscopy unit. Therefore, only a deep knee bend, step-up and chair-rise were usable activities, when performed at slower than normal speeds. Using the MTF unit, all five activities could be captured while exposing patients to half the radiation dosage due to the fact that five activities using the MTF required significantly less time than three activities using a stationary fluoroscopy unit. The resulting kinematics for the patients using a stationary fluoroscopy unit demonstrated less overall motion compared to the MTF analysis. This was hypothesized to be due to the slower speeds required to perform the activities. These observed differences in kinematics included slight variations in anteroposterior sliding and significant variations in axial rotation measurements during each activity. In both cases the MTF analysis demonstrated more pronounced motion for each activity.

DISCUSSION: This study has revealed that there are distinct advantages for using a MTF unit, compared to a stationary unit. Patient exposure to radiation was significantly reduced, activities were performed more quickly, and were captured effectively on the first trial. In addition, patients were able to perform multiple activities at normal speeds and these analyses show more femorotibial motion than those assessed using a stationary fluoroscopy unit. Ghosting of the images, seen when using a stationary fluoroscopy unit was not evident using the MTF. Future analyses with the MTF will involve more challenging activities, such as stop and start and sequential motion patterns to better represent activities of daily living.

O6A5

Utility of a New Developed Motion Capture with Infrared Camera System in ACL-Insufficient Knees

Primary Author: Eiichi Nakamura

Institution: Department of Orthopaedic Surgery, Faculty of Life Sciences, Kumamoto University, Japan

Coauthors: Yasunari Oniki (Department of Orthopaedic Surgery, Faculty of Life Sciences, Kumamoto University, Japan), Nobukazu Okamoto (Department of Orthopaedic Surgery, Faculty of Life Sciences, Kumamoto University, Japan), Hiroaki Nishioka (Department of Orthopaedic Surgery, Faculty of Life Sciences, Kumamoto University, Japan)

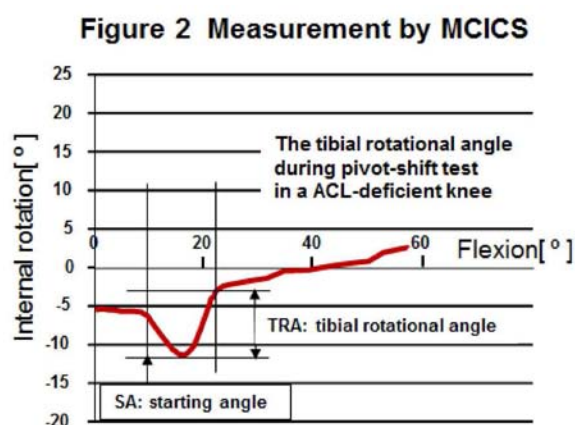
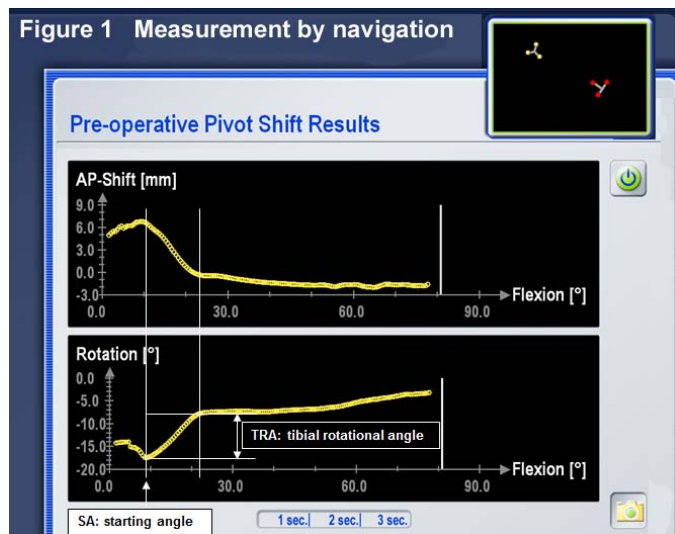
PURPOSE: Development of more objective clinical evaluation of the rotational instability in the ACL - insufficient knee is critical to evaluate its function extensively and to improve the outcome in the ACL reconstructive surgery. However, there are few available quantitative methods for the rotational instability in a clinical use^{1, 2}. We have developed a new noninvasive motion capture with infrared camera system (MCICS; Anima Co. Ltd., Tokyo, Japan) for analysis of in vivo three-dimensional kinematics of the knee. The purpose of this study are to compare our MCICS with the standard validated commercial navigation system in terms of reliability and repeatability of the rotational kinematics in the ACL-insufficient knee, and to validate the utility of our MCICS.

METHODS: Thirteen unilateral ACL injured patients (mean age 18 y.o.) were enrolled in this study. The injured knees in all patients were evaluated during the pivot shift test by a single surgeon (E.N.) before reconstruction under anesthesia using a commercial image-free navigation system (Brain Lab, ACL 2.0, Heirnstetter, Germany) with trackers secured by bone screws (Navi) and our MCICS. During the pivot-shift test, the starting angle of the pivot-shift phenomenon (SA; °), and tibial rotational angle defined as the amount of rotational angle when an anterior subluxation and a subsequent reduction in the tibial plateau from the femoral condyle (TRA; °), were extracted from the kinematics data recorded by both system. The verification of the MCICS was analyzed using the interclass correlation coefficient (ICC) for those values between both system. A p-value less than 0.05 were considered to be statistically significant.

RESULTS: The pivot-shift phenomenon in all patients was determined as a sudden tibial external rotational movements in both system (Figure 1 and 2). The averaged SA in the MCICS and Navi was 12.5° (range; 5° to 30°) and 11.0° (range; 4.2° to 18.4°), respectively, showing the great consistency (ICC 0.808, p Conclusions These results indicate that based on the quantification of a dynamic rotatory knee laxity reproduced and evaluated by the pivot-shift test, our newly developed noninvasive system (MCICS) could be as accurate as the validated navigation system, particularly within range of knee flexion during the pivot-shift test. Our MCICS also has some advantages such as no limitation of the measurement location or an examining room, and capability of the analysis on the performance at high speed, which could be useful in diagnosis of ACL pathology and the postoperative evaluation of surgical reconstruction.

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O6A6 Prospective Investigation DVT/PE after TKA Using Contrast Enhanced CT and Venous Ultrasonography in Japanese Patients

Primary Author: *Atsushi Sato*

Institution: *Department of Orthopaedic Surgery, Showa University Fujigaoka Hospital*

Coauthors: *Soshi Asai (Department of Orthopaedic Surgery, Showa University Fujigaoka Hospital), Shin Kato (Department of Orthopaedic Surgery, Showa University Fujigaoka Hospital), Takayuki Koya (Department of Orthopaedic Surgery, Showa University Fujigaoka Hospital), Masahiko Maekawa*

Total knee arthroplasty (TKA) is one of the most successful surgeries to relieve pain and dysfunction caused by severe arthritis of the knee. Despite developments in prophylactic methods, deep venous thrombosis (DVT) and pulmonary embolism (PE) continue to be a serious complication following TKA. Otherwise DVT/PE is known to be a relatively low incidence in Asian patients, its accurate incidence is still controversial. Therefore, we prospectively investigated the incidence of DVT/PE after TKA by contrast enhanced computed tomography (CE-CT) and venous ultrasonography (US) in Japanese Patients.

METHODS: We prospectively investigated 51 patients who underwent primary TKA at the hospital from July 2013 to December 2013. All were of Japanese ethnicity. The mean age at the surgery was 74.9 years and average BMI was 26.0. There were 45 (88.2%) cases of osteoarthritis and 5 (9.8%) of rheumatoid arthritis. A single knee surgery team performed all operations with cemented type prostheses by utilizing pneumatic tourniquet. There were 21 cases of one-staged bilateral TKA and 30 of unilateral TKA, including 9 use of navigation system (Table 1). All patients were applied intermittent pneumatic compression (IPC) until 24 hours and graduated compression stockings for three weeks after the operation. Beginning from the day after the surgery, the patients were allowed walking with walker, along with the gradual range of motion exercise for physical thromboprophylaxis. Low-dose unfractionated heparin (LDUH) as a chemical thromboprophylaxis was administered subcutaneously for 3 days after the surgery. Informed consent was obtained regarding this thromboprophylaxis protocol. CE-CT and venous US were performed at the 4th day after surgery and images were read by a single senior radiologist team. The patients without DVT/PE by examination, they did not take additional chemical thromboprophylaxis. In cases of existence of DVT/PE, continuous heparin administration and oral warfarin were applied and adjusted in appropriate dose for treatment. Warfarin was continued to be applied for at least three months until the patients had no symptoms and normal D-dimer level. Additional ultrasonic echocardiography (UCG) was performed in the patients with PE, who

were treated by cardiologist depending on severity of condition.

RESULTS: CE-CT was performed in 42 patients (82.3%), otherwise nine patients (17.7%) could not take the examination because of exclusion criteria. There was no side-effect regard to contrast medium. The incidence of DVT and/or PE was 32 patients (62.7%), including two PE (3.9%), 21 DVT (41.1%) and nine both PE and DVT (17.6%) (Table 2). Sixteen patients were used LDUH routinely for 3 days after surgery. Five patients were used continuous heparin administration and oral warfarin instead of using LDUH because of medical co-morbidities. Additional continuous heparin administration and oral warfarin after LDUH use was needed in 26 patients. Three patients who had duodenal ulcer with chronic pancreatitis, massive PE with right heart strain and multiple DVT/PE with HIT antibody were needed another treatment.

CONCLUSION: We prospectively investigated 51 patients for DVT/PE after TKA using CE-CT and venous US. The incidence of DVT/PE after TKA was 62.7%, including 21.5% of PE, as high frequency in Japanese patients.

Table 2. Incidence of DVT/PE after TKA

Performed CE-CT	42 (82.3%)
Performed venous US	51 (100%)
DVT and/or PE	32 (62.7%)
Fetal PE	2 (3.9%)
Non fetal PE	0
DVT	21 (41.1%)
PE+DVT	9 (17.6%)

O6A7

Flexion Angle and Cartilage Degeneration in Osteoarthritic Knees Using Data from the Osteoarthritis Initiative

Primary Author: J Michael Johnson

Institution: University of Tennessee - Knoxville/TechMah, LLC

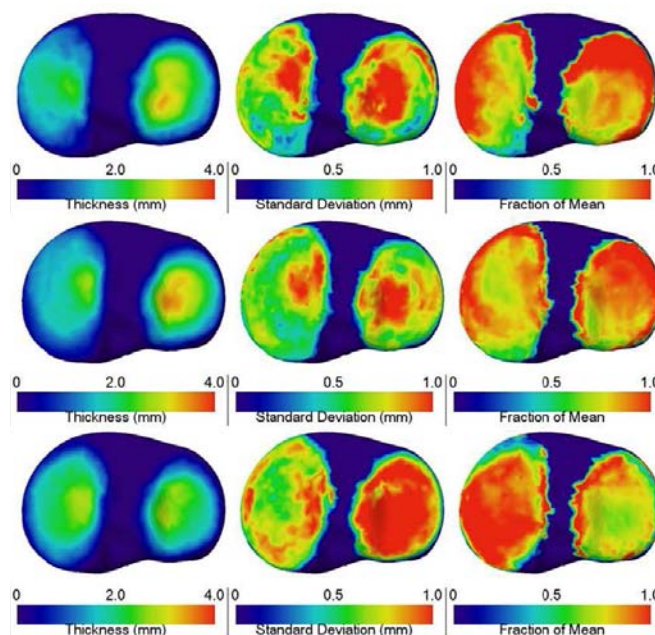
Coauthors: Emam E. Abdel Fatah (University of Tennessee - Knoxville), Mohamed R. Mahfouz (University of Tennessee - Knoxville)

Change to the femorotibial cartilage is a debilitating symptom of osteoarthritis (OA). These changes involve fibrillation, formation of lesions, and cartilage loss. It is known that cartilage is thicker in regions of the articulating surfaces which bear load during normal activity and that chronic abnormal loading is positively correlated with cartilage degeneration. Currently, little work has been done relating cartilage wear patterns of normal, varus and valgus knees with knee kinematics. This work utilizes magnetic resonance imaging (MRI) for cartilage quantification, coupled with statistical surface models for tracking morphological changes of the cartilage thickness across degenerative populations. Statistical models for the cartilage thickness of varus, valgus and neutral OA knees were created using manually segmented bone and cartilage models in such a way that each point on the bone model has an associated cartilage thickness. For kinematic analysis, 4 healthy patients underwent fluoroscopy during deep knee bend. Bone surface models for each healthy patient were registered to the frames of the fluoroscopy and kinematics were interpolated for the entire range of motion. Mean contact regions were determined on the statistical database from 0° - 120° flexion in increments of 20°. Cartilage thickness statistics were reported in the medial and lateral compart-

Table 1. Patients Demographics

Number of patients	51
Gender	
Male	6
Female	45
Mean age at surgery (yr)	74.9
Average BMI (kg/m ²)	26.0
Smoking	0
Antiplatelet therapy	5
Diagnosis	
Osteoarthritis	45
Rheumatoid arthritis	5
Other	1
Operation types	
One-staged bilateral	21
Unilateral	30

ments in each contact area for each flexion angle. Thickness was normalized by the gender-specific mean healthy thickness at each point inside the contact area. 40 Caucasian males (mean age: 63 years) and 40 Caucasian females (mean age: 63 years) were used for the healthy subset. The degenerative subset consisted of subjects diagnosed with OA and scored between 1 and 3 on the Kellgren-Lawrence scale. Within the OA subset, there were 20 varus knees (10 male, 10 female, 10 KL1, 5 KL2, 5 KL3), 18 valgus knees (8 male, 10 female, 4 KL2, 5 KL2, 9 KL3) and 10 neutral knees (4 male, 6 female, 3 KL1, 4 KL2, 3 KL3). Image data for these analyses are from an OAI public use data set. Average cartilage loss across all flexion angles was $81.4 \pm 8.9\%$ for neutral knees, $80.2 \pm 7.2\%$ in varus knees and $85.2 \pm 15.3\%$ for valgus knees. In neutral OA knees, the region with the most cartilage loss in the lateral compartment occurred at 60° flexion, where cartilage had relative thickness of $77.1 \pm 7\%$. In the medial compartment, most wear occurred at 0° flexion with $77.4 \pm 6.2\%$ relative thickness. In valgus OA knees, the region of most cartilage wear in the lateral compartment occurred at 20° flexion with relative thickness of $66.4 \pm 3.4\%$. There was little apparent wear in the medial compartment for valgus knees, with most wear occurring at 0° flexion with $91.0 \pm 5.5\%$ relative thickness. The varus knees contained regions of similarly high wear in both the medial and lateral compartments with relative thickness of $75.9 \pm 7.5\%$ at 60° in the lateral and $77.0 \pm 5.4\%$ at 20° in the medial. Figure 1 shows mean contact region relative thickness. Figure 2 is a map of relative cartilage thickness.



Metal-on-Metal THA: Never Again



**ICJR Pan Pacific North American/
European Clinical Research Award
Winner**

O6B3

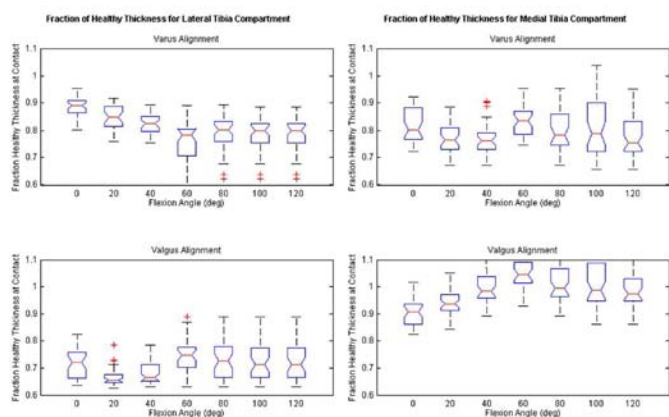
Early Results of Revision of Failed Metal on Metal Hip Arthroplasty

Primary Author: Scott T. Ball

Institution: University of California, San Diego, CA, USA

Coauthors: Colin Yung (University of Hong Kong), Craig Swenson (Scripps Memorial Hospital, La Jolla), Christine B. Chung (University of California, San Diego)

INTRODUCTION: To date, there have been few reports of the results of revisions for failed metal-on-metal hip arthroplasties (MoM HA's). These series have included relatively modest numbers, and classification of the severity of the adverse local tissue reactions (ALTR) has been under-reported. In this study, early outcomes and complications



are analyzed as a function of pre-operative MRI grade and intra-operative ALTR severity.

METHODS: This is a retrospective review of revisions of 121 failed MoM HA's performed between 2008 and 2012. Indications for revision include ALTR (n=94), loose cup (n=13), combined loose cup and ALTR (n=11), and recurrent dislocation (n=3). When pre-operative MRI's were available, these were graded according to Anderson's system. Intra-operative findings were graded for severity according to an ALTR score. Post-operative complications were recorded. Correlations between pre-operative MRI grade, intra-operative ALTR score and post-operative complication rates were analyzed using Spearman's rank correlation.

RESULTS: The average time to revision was 47 months (range: 7-198 months). In cases where the cup required revision, the average increase in outer diameter was 4.1 mm (range: 2 – 10 mm). Average revision head size was 38 mm (range: 32 – 48 mm). 18 patients (15%) experienced complications which included dislocation (n=11 / 9%), infection (n=5 / 4%), recurrent pseudotumor requiring operative treatment (n=5 / 4%), and VTE (n=1 / 0.9%). The pre-operative MRI grade correlated significantly with the intra-operative ALTR score ($p=0.03$), and both the ALTR score and MRI grade correlated significantly with post-operative complications ($p<0.01$).

CONCLUSION: Revisions for failed MoM HA's can be heterogenous ranging from simple loose cups to severe ALTR's. It is important to consider the severity pre-operatively and plan accordingly to minimize the risk of post-operative complication. The pre-operative MRI grade has good prognostic significance and may alert the surgeon and patient to an increased potential for complications after surgery.

O6B4 Metal Ion Levels and Clinical Outcomes of Ceramic-on-Metal Matched Ceramic-on-Ceramic THA

Primary Author: Kwang Woo Nam

Institution: Jeju National University Hospital

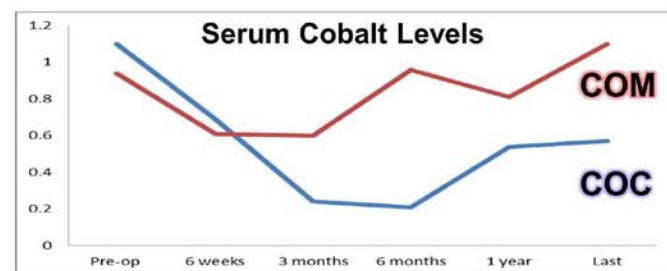
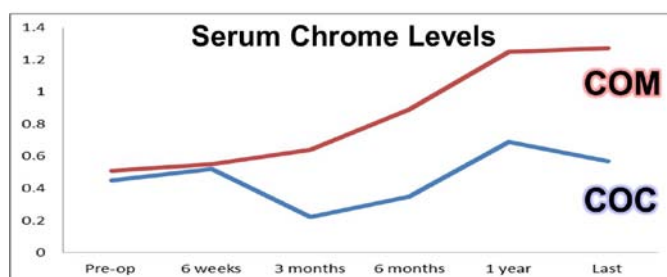
Coauthors: Kyu-Bum Seo (Jeju National University Hospital), Sang-Rim Kim (Jeju National University Hospital),

Hee Joong Kim (Seoul National University Hospital), Jeong Joon Yoo (Seoul National University Hospital)

INTRODUCTION: Metal ion level and clinical outcomes of ceramic-on-metal bearing were comparable to ceramic-on-ceramic THA in this prospective controlled trial. Methods: We classified 118 consecutive THA cases at one institution into two groups: Group I and Group II. Group I, 85 cases, received a THA using ceramic-on-metal couplings and Group II, 33 cases, received ceramic-on-ceramic bearing THA. The implant differed only in the bearing surfaces used. We compared the serum levels of cobalt (Co) and chromium (Cr) and functional outcome scores preoperatively, and at 6 weeks, 3, 6, and 12 months postoperatively.

RESULTS: There was no significant difference in the changes and absolute value of Co and Cr levels between the groups (Co $p > 0.05$, Cr $p > 0.05$). The WOMAC hip scores improved in both groups with no significant difference in the changes and absolute values ($P > 0.05$). No complication associated with implant has occurred in the CoM group during follow-up period (one dislocation and one liner fracture in the CoC group).

DISCUSSION & CONCLUSION: CoM bearing THA has showed the metal ion levels and the clinical results comparable to CoC couples except for the relatively high metal ion in bedding-in period. Ceramic-on-Metal THA can give a solution to the patients young, active, and with higher demands.



O6B5**Correlation of Metal Ion Levels and Patient Outcome Scores After Revision of Large Diameter Metal on Metal Total Hip Arthroplasty***Primary Author: Rohit Rambani**Institution: Leeds Teaching Hospital NHS Trust**Coauthor: Rahul Jain (York District Hospital)*

Revision of large diameter metal on metal total hip arthroplasty (MoM) increased after a number of patients presented with symptoms and increased levels of metal ions in the blood. We conducted a study to correlate the patient's symptoms with the metal ion levels and patient outcome scores after revision total hip replacement.

A total of 86 patients (88 hips) who underwent MoM THRs with large-diameter femoral heads between March 2004 and June 2008 and had subsequent revision were included in the study. Patient Outcome scores including Harris hip scores, oxford hip scores, EQ5D, serum metal ions levels, radiographs and MRI scan were obtained.

There were 84 patients (86 hips) eligible for evaluation at a mean follow-up of 1.8 years (1 to 3.5). Metal ion levels correlated well with EQ5D scores with the metal ion levels decreased with improved scores gradually upto 1 year follow-up. 64 patients had cup only revision and were polyethylene acetabular component with small-diameter metal head. All patients showed improvement in symptoms and scores upto one year after which there was a minimal improvement. The study highlights the correlation of metal ion levels and patient outcome scores after revision of large diameter MoM THR.

O6B6**Biomet Metal-on-Metal Total Hip Arthroplasty: Up to Eight Year Follow Up Results***Primary Author: Fei Liu**Institution: Midlands Orthopaedics, P. A.**Coauthor: Thomas P. Gross (Midlands Orthopaedics, PA)*

BACKGROUND: Metal-on-metal total hip arthroplas-

ty (THA) implants have been widely debated due to the adverse wear issue related to the bearing surfacing. However, more recent studies have shown that the high metal ion problems that occur after surgery with this type of implant may not be exclusively related to the all metal bearing surfaces, but mainly due to the recently modified connecting tapers. Biomet is one of few companies who have not changed their original taper design for their THA implants. The purpose of this study was to present our up to eight-year clinical results.

METHOD: Between November 2004 and April 2011, all of the 196 cases in 167 patients (77 male vs. 89 female) performed by a single surgeon were included in this study. The Biomet Magnum/Jumbo metal-on-metal total hip arthroplasty implants were utilized for all of the cases. The average age was 59 ± 11 years at the time of surgery. Thirteen patients deceased from causes unrelated to THA. The primary diagnosis was OA in 124 cases; followed by AVN in 41 cases, dysplasia in 12 cases and other causes in the remaining 19 cases. The average acetabular component sizes were 54 ± 4 mm. Clinical and radiographic examinations were performed prospectively, and the results were analyzed.

RESULTS: The mean duration of follow-up was 5 ± 2 years. There were four revisions: 1) one was due to an adverse wear issue with a cobalt level of $109 \mu\text{g/l}$ and a chromium level of $77 \mu\text{g/l}$. The primary diagnosis was OA for this case. The acetabular inclination angle was 65° . The acetabular component was revised using the Biomet Magnum Tri-Spike component with the acetabular inclination angle of 41° ; one year after the surgery, the metal ion level results showed a cobalt level of $2.4 \mu\text{g/l}$ and a chromium level of $9.7 \mu\text{g/l}$ with a Harris hip score of 100. This patient also has a total knee replacement on the same side. 2) one due to acetabular component loosening; the HHS was 100 two years after the revision 3) two due to deep infection; the HHS was 93 at one year and 100 at three years after the revision correspondingly. The metal ion results were available for 114 patients at the time of this study. Four patients had metal ion levels $\geq 7 \mu\text{g/l}$; three out of these four patients' levels were $\geq 10 \mu\text{g/l}$ and one out of these four had levels $\geq 15 \mu\text{g/l}$. Using failure of any component as the end point, the Kaplan-Meier Survival rate was 99.5% at five years and 96.7% at eight years for the whole group.

CONCLUSIONS: This study suggests that Biomet metal-on-metal THA showed a high success rate with a low ad-

verse wear rate. Our clinical results may suggest that all metal bearing surfaces may not be the key to the recent adverse wear issue. The surgical technique and taper problems in other implants may be the major causes. Further studies need to confirm our results.

O6B7

Metal Ion Levels in a Hip Resurfacing Design with a Titanium Niobium Surface Technology

Primary Author: Catherine Van Der Straeten

Institution: Ghent University Hospital, Belgium

INTRODUCTION: Systemic levels of metal ions are surrogate markers of in-vivo wear of metal-on-metal hip resurfacings (MoMHRA). The wear-related generation of metal ions is associated with component size and positioning but also with design specific features such as coverage angle, clearance, metallurgy and surface technology.

OBJECTIVES: The objective of the current study was to investigate whether a hip resurfacing design (ACCIS) made of chrome-cobalt-molybdenum alloy but with TiNb engineered bearing surfaces would generate less chromium (Cr) and cobalt (Co) ions during and after the run-in phase of wear. We also wanted to investigate whether Ti ions would be present instead indicating a certain wear of the surface.

METHODS: Whole blood and serum Cr and Co levels were measured at 3, 6, 12 and 24 months. consecutive Ti levels were measured in the same whole blood and serum samples used for the Cr and Co measurements (ICP-MS).

RESULTS: The Cr and Co levels were untraceable during the running-in phase till 1 year. After that, there was a significant increase visible at the 2 years interval for both Cr and Co. Overall mean ion concentrations ($\text{Cr} < 1.5 \mu\text{g/l}$ and $\text{Co} < 2.0 \mu\text{g/l}$) were low and remained below the established acceptable upper limits ($\text{Cr} < 4.6 \mu\text{g/l}$ - $\text{Co} < 4.0 \mu\text{g/l}$) at all intervals. Elevated whole blood Ti levels were demonstrated in all patients, with a peak level at 6 months although there was no statistical difference between the measurements at 3, 6, 12 and 24 months. These findings correspond with a release of titanium ions (Ti) from the TiNb surface during the running-in phase. The whole blood Ti levels found in the ACCIS patients (mean levels of $9.16 \mu\text{g/l}$, $12.54 \mu\text{g/l}$ and $9.17 \mu\text{g/l}$ at 3, 6 and 12 months respective-

ly were higher compared to whole blood Ti levels in the literature for uncemented grit-blasted acetabular and femoral MoMTHA components and Ti plasma spray coated MoMHRA acetabular components. In those reports, the Ti release is due to passive corrosion from non-articulating surfaces (acetabular and/or femoral fixation surfaces) and is thus likely to be less elevated compared to release due to articulating surface wear as with the ACCIS HRA. The Ti plasma spray coating from the HRA acetabular components produced a significantly higher Ti corrosive release compared to the Ti grit-blasted uncemented surfaces of the THA.

CONCLUSION: The ACCIS design has no traceable Cr and Co ions in the running in phase because of its TiNb ceramic surface coating that prevents Cr and Co release. Once the coating is worn off, which only happens at the patch area of friction, a release of Co and Cr ions starts. The TiNb coating protects the CoCrMo surface from corrosion by acting as a seal and therefore Cr and Co ions are absent in the running phase of the articulation. It is possible that the lower Cr and Co levels are maintained in the long-term provided the non-bearing surfaces which do not wear off, remain protected from corrosion by the TiNb coating, and thus will not release Cr and Co ions.

Computer and Robotic Assisted Surgery

O7A1

The Role for TKA Computer Navigation in 2014

Guest Faculty: Raymond H. Kim, MD

Institution: Colorado Joint Replacement, Denver, CO, USA

Post-operative mal-alignment has been implicated in decreased long-term survival of TKA. Improper mechanical alignment has been shown to alter the load distribution on the tibial plateau and lead to increased polyethylene wear in TKA. Despite the improvements in contemporary manual alignment systems over the years, mal-alignment

greater than 3° occurs in up to 26% of TKAs regardless of surgeon experience. The vast majority of the literature indicates improved accuracy and decreased outliers with computer navigation as well as additional benefits such as reduced blood loss and decreased systemic embolization. Despite the convincing literature regarding improved alignment with computer navigation, no navigation studies demonstrate an improvement in clinical outcomes. The data regarding increased failure with mal-alignment, coupled with data showing decreased outliers with CAS-TKA may lead one to assume CAS-TKA will lead to decreased failures, however, long-term clinical data is necessary before routine use of CAS-TKA can be recommended.

O7A2

Evaluation of a New Image Free Computer-Assisted Guidance System

Primary Author: Bernard N. Stulberg, MD

Institution: Cleveland Clinic, 1730 West 25th Street, Cleveland OH, USA

Coauthors: Nicolas S. Hohl (Exactech, Strasbourg, France); Michel Brax (Haguenau Hospital, Haguenau, France); Gerard C. Giordano (Joseph Ducuing Hospital, Toulouse, France); Sandrine Polakovic (Blue-Ortho, Grenoble, France)

INTRODUCTION: Total knee arthroplasty (TKA) is a common procedure with good success rates. The literature shows resection accuracy plays a crucial role in device longevity. Computer guidance is used by some surgeons to enhance accuracy.

OBJECTIVES: This study reports on a continuous series of knee prostheses implanted by three senior surgeons between July 2010 and August 2013.

METHODS: 288 TKA were implanted at the Haguenau Hospital, Haguenau, France (Site 1), Joseph Ducuing Hospital, Toulouse, France (Site 2) and Cleveland Clinic, Cleveland, OH, USA (Site 3) using a new computer-assisted guidance system. Surgeons were able to use a unique feature of this new computer assisted guidance system to define personalized steps to be assisted during surgery. Each centre in this study used different surgical profiles. Planned tibial and femoral cuts were compared to actual cuts digitized using the system. Operating time and exter-

nal femoral rotation were analyzed and post-operative leg alignment was compared to pre-operative.

RESULTS: The mean error between planned and digitized proximal tibial cuts was $0.26^\circ \pm 1.11$ of valgus and $0.06^\circ \pm 0.99$ of posterior slope for Site 1, $0.07^\circ \pm 0.89$ of varus and $0.53^\circ \pm 0.90$ of anterior slope for Site 2, and $0.27^\circ \pm 1.04$ of varus and $0.15^\circ \pm 1.05$ of posterior slope for Site 3. The mean error between planned and digitised femoral distal cuts was $0.03^\circ \pm 0.99$ of varus and $0.67^\circ \pm 1.36$ of extension for Site 1, $0.14^\circ \pm 0.85$ of varus and $0.49^\circ \pm 0.94$ of extension for Site 2, and $0.11^\circ \pm 0.92$ of varus and $0.02^\circ \pm 1.60$ of flexion for Site 3. Average operating time was 38 minutes for Site 1, 29 minutes for Site 2, and 39 minutes for Site 3. External femoral component rotation relative to the posterior condyles ranged from 0° to 18° with an average of 3.7° degrees for Site 1 and from -3° to 8° with an average of 3.0° for Site 2. External rotation relative to the transepicondylar axis (TEA) ranged from -7° to 4° with an average of -0.7° degrees for Site 3. Post-operative Hip-Knee-Ankle angle (HKA) varied between 177° and 182° with an average of 179° for Site 1, 172° to 184° with an average of 179° for Site 2, and 177° to 185° with an average of 181° for Site 3. Pre-operative HKA ranged from 162 to 191°.

CONCLUSIONS: Despite different techniques and teams, all surgeons experienced similar results. Cuts were aligned in the frontal plane, while guidance was harder to follow in the sagittal plane, possibly due to saw blade bending during resection. Average surgical time was similar. Computer guidance added an average of 10 minutes to standard surgical times. All surgeons agreed the increased accuracy justified the additional time. Regardless the site, all average femoral rotations were close to the accepted 3° standard relative to the posterior condyles or 0° relative to the TEA. Average post-operative HKA was 179°. HKA scores were within 3° of perfect alignment in all Site 1 cases, 96% of Site 2 and 95 % of Site 3 cases. According to the literature, HKA between 177° and 183° is linked with high implant survival. Participating surgeons associated Exactech GPS with satisfactory immediate post-operative results.

O7A3

Two Year Survivorship of Robotically Guided Unicompartamental Knee Arthroplasty

Primary Author: Martin Roche

Institution: Holy Cross Hospital

Coauthors: Thomas Coon (St. Helena Hospital), Frederick Buechel (Physicians Regional Medical Center), Jon Dounchis (Naples Community Hospital), Todd Borus (Legacy Salmon Creek Medical Center), Andrew Pearle (Hospital for Special Surgery)

SUMMARY: This study examines the two year survivorship of an anatomically designed UKA implant using a new robotically guided technology that has been shown to improve implant positioning and alignment.

INTRODUCTION: Successful clinical outcomes following unicompartmental knee arthroplasty (UKA) depend on component positioning, soft tissue balance and overall limb alignment which can be difficult to achieve using manual instrumentation. A new robotically guided technology has been shown to improve post-operative implant positioning, and limb alignment in UKA. This multi-center study examines the survivorship of this robotically guided procedure coupled with a novel, anatomically designed UKA implant at two years post-operative.

METHODS: 959 patients (1080 knees) in an initial series and part of an IRB approved study underwent robotically guided surgery to receive a medial UKA from six surgeons at separate institutions. All patients received a fixed bearing metal backed onlay as the tibial component. Patients were consecutive for each respective surgeon. Each patient was contacted at a minimum two year follow up and asked a series of 5 questions to determine implant survivorship and patient satisfaction. 207 patients were either lost to follow up or deceased, resulting in a 78% enrollment rate. 752 patients (854 knees) were successfully enrolled in the study and surveyed. 55% of patients were male; the average age was 69 ± 10 years and the average BMI was 29.3 ± 4.9 at the time of the index procedure. The surgeons were well varied in monthly procedure volumes; the lowest volume surgeon in this series performed an average of 4.6 procedures per month while the highest volume surgeon in this series performed an average of 15.8 procedures per month.

RESULTS: Ten knees were reported as revised for an overall revision rate of 1.1% at a minimum two year follow up. 3 revisions occurred due to unexplained pain, 3 revisions occurred due to infection, and 4 revisions occurred due to implant loosening. 93% of patients reported feeling either "Very Satisfied" or "Satisfied".

CONCLUSIONS: Excellent survival and satisfaction out-

comes were noted in this subset of patients. This robotically guided procedure shows promise of improved survivorship rates for UKA compared to what is currently reported in implant registries and comparative studies.

O7A4

Improving Outcomes of Lateral Unicompartmental Knee Arthroplasty with Robotic-Assisted Surgery

Primary Author: Gary Poehling

Institution: Wakeforest University School of Medicine

Coauthors: Marco Augart (Wakeforest University School of Medicine), Johannes F. Plate (Wakeforest University School of Medicine), Thorsten M. Seyler (Wakeforest University School of Medicine), Michael Akbar (Wakeforest University School of Medicine), Volker Ewerbec

INTRODUCTION: There is renewed interest in the use of minimally invasive unicompartmental knee arthroplasty (UKA) for patients with limited degenerative disease of the knee due to improved surgical techniques and prosthetic design. However, patient satisfaction following UKA for lateral compartment disease have been suboptimal with increased revision rates. Robotic-assisted UKA has been shown to improve precision and accuracy of component placement, which may improve outcomes of lateral UKA. The purpose of this study was to compare the outcome of robotic-assisted UKA to conventional UKA for degenerative disease of the lateral compartment with the hypothesis that robotic-assisted lateral UKA results in superior outcomes compared to conventional UKA.

METHODS: The institution's joint registry was searched for patients who underwent UKA for limited degenerative disease of the lateral knee compartment between 2004 and 2012 and a total of 125 lateral UKAs were identified. The medical records of all patients were reviewed and assessed for the type of surgical procedure used (robotic-assisted versus conventional), length of hospital stay, and occurrence of revision surgery. Preoperative and postoperative radiographs were assessed for tibiofemoral angle, femoral and tibial joint line angle, posterior tibial slope, and orientation of the femoral and tibial components.

RESULTS: A total of 88 (85 patients) robotic-assisted and 37 (36 patients) conventional UKA were analyzed and

compared. Patient age and BMI were similar between patients with robotic-assisted (64.2 ± 11.5 years, 28.7 kg/m^2) and conventional UKA (64.2 ± 11.5 years [$p=0.998$], 30.5 kg/m^2 [$p=0.107$]). The length of stay was significantly shorter after robotic-assisted UKA (1.7 days) compared to conventional UKA (2.3 days, p Correction of the tibio-femoral angle was significantly higher in patients with conventional UKA (8.7 to 176.9 degrees) compared to patients with robotic-assisted UKA (3.4 to 174.3 degrees, p In the robotic-assisted UKA group, 2.2% were revised, compared to 5.4% revised in the conventional UKA group (p

DISCUSSION AND CONCLUSION: This study found a decreased revision rate in robotic-assisted lateral UKAs compared to conventional lateral UKA. Furthermore, patients who received robotic-assisted UKAs had a shorter postoperative hospital stay compared to patients who received conventional UKA. Implant orientation was improved in robotic-assisted UKA compared to conventional UKA. UKA is a technically challenging procedure with limited joint visualization and less tolerance for acceptable component position. Malaligned components may lead to impaired joint biomechanics causing pain and disease progression to other knee compartments. Robotic-assisted UKA systems offer increased accuracy of component placement with objective soft-tissue balancing. Improved component positioning with robotic-assisted UKA systems may improve the long-term survival of UKA in patients with limited lateral degenerative disease.

O7A5

Computer Navigation Systems in Unicompartmental Knee Arthroplasty – A Systematic Review

Primary Author: Rajesh Nair

Institution: Vancouver Island Health Authority

PURPOSE: Computer navigation systems were introduced into unicompartmental knee arthroplasty (UKA) in the early 2000's to improve radiological positioning of the implant. While studies have shown lower radiological outliers with navigated UKA it is still unclear whether this has transformed into improved clinical outcome. This is the first systematic review examining the published literature to see if the use of this technology improves quality of life, knee function, and implant survivorship in UKA. The purpose of this study was to determine if any clinical or functional parameters are improved with navigated UKA compared with conventional manual instrumentation techniques.

METHODS: A systematic review of the literature (2002-2013) for articles that compared clinical results of navigated UKA against conventional techniques. All randomized control trials, meta-analyses, and retrospective studies were included. Variables of interest were radiographic alignment, clinical outcome, cost, and survival rates. A meta-analysis was not conducted due to the low number of randomized trials that would introduce biases and prevent a balanced view of navigated UKA.

RESULTS: The literature has shown that navigation systems improved postoperative limb alignment and narrowed the range of outliers in all planes of component orientation. One study that has published implant survivorship data at 7-years found no differences between navigated and conventional knees (78.6% vs 100%; $p=0.0625$). Studies with data on clinical outcome reported no significant differences ($p>.05$) in KSCRS, WOMAC, Hospital for Special Surgery, Oxford Knee Score, SF-36, and range of motion. Complications unique to navigated UKA include pin site infections and fractures. Mean duration of surgery is increased by 15 minutes with the navigated cohort. Studies describing the financial impact of using navigation systems have stated it can be cost-effective if the revision rates are lowered to a specific level and the longevity of the implant is extended but there is a lack of cost-effectiveness data comparing conventional versus navigated UKA. Additional costs involved with navigation systems include extra resources, training, maintenance upgrades, and different software requirements for different implants.

CONCLUSION: Navigated UKA improved the postoperative limb alignment and component positioning but this did not convert into better knee function, range of motion, quality of life, or implant survivorship in the short- to mid-term. Financial costs attached to hardware and software usage and maintenance are also significant. Most of the studies referenced are underpowered and poorly controlled. There is no clear evidence demonstrating the usefulness of navigation systems in UKA, thus impeding universal acceptance of this technology by surgeons. Definitive evidence can only be generated with large, randomized, prospective studies. The results of this review are similar to those reported for navigated total knee arthroplasty.

O7A6

Intraoperative Assessment of Mechanical Alignment Accuracy Using Computer Navigation in a Patient Specific TKA System

Primary Author: Gary A. Levensgood

Institution: Sports Medicine South

INTRODUCTION: Correct lower limb alignment post TKA surgery depends on the accurate alignment of the femoral and tibial implant components with respect to existing bone. A mechanically neutral limb alignment has been linked to success and increased survivorship post-surgery. Patient specific instrumentation has been introduced with the goals of improving the accuracy of bone cuts and achieving neutral mechanical alignment. The purpose of this study was to utilize computer navigation intra-operatively as a confirmatory assessment of the accuracy of patientspecific jigs and implants, in setting alignment to the neutral mechanical axis.

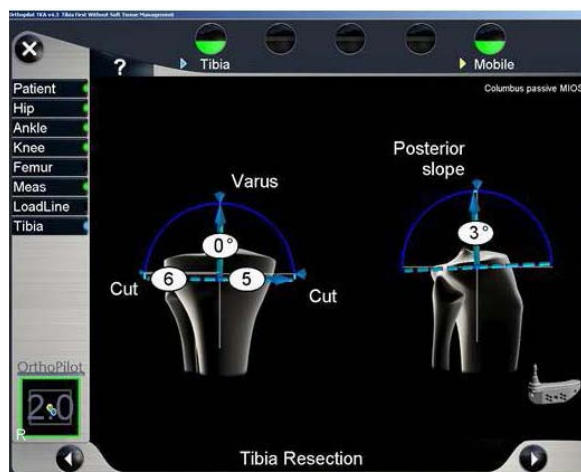
METHODS: A consecutive series of 63 patients undergoing TKA, utilizing patient specific instruments and implants, were prospectively measured with intraoperative computer navigation. Seven patients had incomplete pre-operative data and were excluded from the analysis, resulting in a total of 56 patients. The instruments and implants were first created utilizing pre-operative CT imaging. All patients were then navigated during surgery, prior to any bone cuts, to determine mechanical alignment. The patient-specific instruments were then utilized per the manufacturer's recommendations and bone cuts were made. All bone cuts were recorded utilizing the navigation system as a confirmatory measurement. The patient-specific implants were then fixated and surgery completed (Figure 1). Final mechanical alignment was then recorded, again utilizing the navigation system for the assessment.

RESULTS: The patient-specific instruments and implants provided neutral alignment of the tibial component in 85.7% (48/56) of patients, with the remaining 8 (14.3%) patients being with $\pm 1^\circ$ from neutral (Figure 2). A neutral femoral varus/valgus angle was achieved in 73.2% (41/56) of the patients with 12/15 of the remaining patients being within $\pm 2^\circ$. Overall neutral mechanical alignment was seen in 82.1% of patients (46/56). In the remaining 10 patients each had a post-operative alignment within $\pm 2^\circ$ of neutral, with no outliers. The average post-operative amount of deformity for this cohort 0.22° (range $0-2^\circ$; std dev: 0.49°)

which was found to be statistically significant with the pre-operative condition ($p < 0.0001$).

Pre-implantation, an extension deficit was observed in 60.7% (34/56) of patients averaging 7.97° . Post implantation, all 56 patients (100%) exhibited no extension deficits as measured with navigation.

DISCUSSION: Patient-specific instruments and implants accurately restore neutral mechanical alignment as measured by intra-operative computer navigation. The patient-specific instruments aligned all patients in this cohort to within $\pm 2^\circ$ of neutral. It is well documented that the restoration of neutral mechanical axis is a key factor in achieving long-term survivorship. Specifically legs that are aligned to within $\pm 3^\circ$ of neutral have been shown to have significantly better survivorship. Studies conducted on other patient specific cutting guides have demonstrated varying results in terms of attaining neutral mechanical axis alignment post-surgery. Errors in aligning the limb within $\pm 3^\circ$ of neutral have ranged from as low as 9.4% to as high as 75%. This current study presents favorable results for the patient specific system when compared to other systems tested previously.



O7A7**Smart Navigated Non-Implant-Specific Instruments for Knee Arthroplasty***Primary Author: Hani Haider**Institution: Department of Orthopaedic Surgery and Rehabilitation, University of Nebraska Medical Center**Coauthors: O. Andres Barrera (Department of Orthopaedic Surgery and Rehabilitation, University of Nebraska Medical Center), Ibrahim Al-Shawi (Department of Orthopaedic Surgery and Rehabilitation, University of Nebraska Medical Center), Alvaro Pinto (Department of Orthopaedic Surgery and Rehabilitation, University of Nebraska Medical Center)*

Current projections point to a large increase in arthroplasty surgeries over the next 20 years. Implant manufacturers typically offer each hospital multiple sets of instruments, each dedicated to one of their implant system models. Each set includes over 100 mechanical alignment and other instruments (jigs), typically housed in multiple trays. These instruments increase engineering and production costs to the manufacturer, the training burden for surgeons, and increase costs for the hospital for sterilization and other logistics. Recent patient specific instruments address some of this burden but involve scalability, potential liability and speed challenges. Some of the custom jigs design and all its manufacture are delayed and removed from the surgeon, and cannot be changed during surgery.

We aimed to develop revolutionary freehand navigated bone cutting technology for joint replacement without implant specific mechanical jigs, without expensive and cumbersome robots, and optionally also even without external navigation tracker equipment.

The innovation facilitates the navigation of freehand-held bone cutting instruments (sagittal or reciprocating power saws and drills) with real-time 3D graphical feedback guidance provided to the surgeon. The dynamic feedback can be viewed on a small color LCD touch screen mounted on the hand held tool, and/or on a separate large computer monitor in the operating room. The onboard screen version helps not distract the surgeon from viewing the physical surgical site. Another feature slows down or even stops the cutting instrument if it deviates in any 3D position or orientation from the planned bone osteotomies for proper implant alignment within any envelope of 3D errors. The

allowable 3D deviations are not only user-selectable but do not have to be uniform in all dimensions or orientations. For example, a tighter tolerance may be ascribed to the frontal varus-valgus alignment of the bone cuts compared to the axial rotational ones if so chosen. A variation of the system which will be presented even transforms the traditional orthopaedic power instrument (e.g. sagittal saw, drill, etc.) into a “smart instrument” which can track itself in 3D around the surgical scene without external navigation hardware, and still optionally prevent the surgeon from deviating from the planned cuts. Another novel technology feature is the graphical projection of the surgical guidance (for alignment) on the bone from a miniature projector imbedded within the electronics of the smart power instrument (sagittal saw or drill).

Based on synthetic and cadaveric bone experiments this cutting-edge technology promises faster, cheaper, easier and more accurate bone osteotomies. It assists the surgeon naturally with miniaturized electronics and intelligence on-board the same powered bone cutting instruments they are highly used to. Joint replacement surgery is highly successful currently, but this technology promises freedom from bulky robotics or even external navigation equipment making instrumentation more utilitarian and economical but with advanced navigational and computational power buried within. A solution that increases benefits to the patient and surgeon alike, while reducing infection risks and costs, may transform patient care in an overburdened field which is expected to continue to grow in the coming years.

Hip Mechanics & Robotics

O7B1**In Vivo Mechanics of the Hip Joint***Guest Faculty: Richard D. Komistek, PhD**Institution: Center for Musculoskeletal Research, University of Tennessee, Knoxville, TN, USA*

INTRODUCTION: In vivo fluoroscopy has been used to determine hip implant motion during treadmill gait and

abduction/adduction maneuvers. These studies have documented hip separation where the femoral head slides in the superolateral direction leading to separation of external medial aspect of the femoral head from the internal medial aspect of the acetabular liner. Sound sensor technology has also been used to determine vibration signals when hip separation is prevalent in a hip implant. The overall objective of this study is to utilize in vivo fluoroscopic and sound sensor data as input to a mathematical model to determine the hip joint bearing surface forces for total hip arthroplasty (THA), implanted using various surgical techniques.

METHODS: An inverse dynamic mathematical model was developed, using Kane's Dynamics, for the human lower extremity to assess the bearing surface forces at the femoral head – acetabular cup interface. Under fluoroscopic surveillance, patients were asked to perform normal gait on a treadmill. A sound sensor was also attached, externally, near the hip joint to determine vibration signals that propagate during THA motion. Three-dimensional position and orientation of the femoral and acetabular components were defined using in vivo fluoroscopy data, with respect to the Newtonian reference frame, transformed into relative reference frames, defined using temporal functions and then input into the mathematical model.

RESULTS: One of the most interesting findings was the sounds derived for various bearing surface interfaces. Subjects having a ceramic-on-ceramic THA produced clicking, grinding, grating and squeaking sounds, while subjects having a metal-on-polyethylene THA experienced a clicking and knocking sound. Most concerning was the sound derived for a metal-on-metal THA which was similar to a “rusty door hinge”. The THA force for each subject during treadmill gait varied considerably ranging from 2.5 to 4.7 times body weight. Further evaluations were conducted for subjects implanted with various surgical techniques, but there was no statistical difference between the amount of hip separation and/or the maximum bearing surface force. When hip separation was introduced into the mathematical model, the maximum hip forces increased 10-25% compared to instances where no separation occurred.

CONCLUSION: Determination of in vivo forces in the hip is critical to understand implant longevity and the viability of THA success. Temporal force profiles derived at the hip joint bearing surface can be used in knee simulators

and finite element analyses to determine in vivo stresses and predict how successful a hip implant may be throughout a patient's lifetime. Implanted hip forces are generally much higher than normal hip forces and can vary considerably from patient to patient and the use of bearing material. It seems that hip separation does play a significant role in the maximum amount of force generated as the bearing surface as the greater amount of hip separation leads to higher bearing surface interaction forces.

O7B2

Computer Simulation of Osteochondroplasty for Treatment of Femoro-acetabular Impingement

Primary Author: NK Chan

Institution: Institute of Orthopedic Research and Education, Baylor College of Medicine, and Department of Orthopedic Surgery, University of Texas Health Sciences Center, Houston, Texas, USA

Coauthors: C Fuchs, R Valle, SK Ismaili, MS Adickes, PC Noble

INTRODUCTION: Femoro-acetabular impingement reduces the range of motion of the hip joint and is thought to contribute to hip OA. Surgical treatments attempt to restore hip motion through resection of bone at the head-neck junction. Due to the broad range of morphologies of FAI, the methodology of osteochondroplasty has been difficult to standardize and often results in unexpected outcomes, ranging from minimal improvement in ROM to excessive head resection with loss of cartilage and possibly neck fracture. In this study we present a method to standardize three-dimensional bony resection to enable reproducible pre-operative planning, while optimizing outcomes.

METHODS: Computer models of six femora with classic signs of cam FAI were reconstructed from CT scans. On each model, the femoral shaft and femoral neck were defined with longitudinal axes and the femoral head by a sphere of best fit. Boundaries defining the maximum allowable extent of anterior resection were constructed; (i) superiorly and inferiorly along the femoral neck at 12:30 and 5:30 on the clock face, simulating the boundary of the vascularized synovial folds; (ii) around the head-neck junction along the edge of the articular cartilage; and (iii) at the base of the neck, perpendicular to the neck axis, 20-

30mm lateral to the articular junction. Complex 3D resection surfaces were generated joining all 4 boundaries with 3 depths of maximum bony resection of the CAM lesion, 2mm (small), 4mm (medium), and 6mm (large). The resection surface was constructed such that it followed the surface of the sphere of best fit to the femoral until the maximum resection depth. For each depth of CAM resection we measured (i) the alpha angle, (ii) the anterior offset of the head-neck junction, and (iii) the volume of bone removed by the osteochondroplasty procedure. Additionally, we used computer simulations to measure the maximum internal rotation of the hip in 90° flexion and 0° abduction before and after each resection.

RESULTS: The initial alpha angles of the femora averaged 63.8°, with a corresponding average anterior head-neck offset of 5.8mm and average maximum internal rotation of 16.3°. Implementation of the preoperative plans demonstrated that alpha angles of less than 55 degrees (small: 48.8°, medium: 40.8°, large: 35.3°) could be achieved using resection depths of 2mm, 4mm, and 6mm. This led to increases in the internal rotation of the hip of 7.8° ($p<0.001$), 11.8° ($p<0.001$), and 14.8° ($p<0.001$), respectively, with anterior offsets of 7.98mm, 9.92mm, and 11.24mm at each depth of resection.

CONCLUSIONS: Our study shows that, through computerized preoperative planning, joint ROM can be restored by recreating a normal alpha angle with the minimum necessary bone resection. Use of this method can ensure that osteochondroplasty is customized to each deformity with removal of only the minimum necessary amount of bone to correct each bony abnormality. We believe the boundaries we have set will enable surgeons to consistently and quantitatively reproduce and teach osteochondroplasty, and that this method is readily adaptable to computerized machining of the femur intraoperatively.

O7B3

Biomechanical Analysis and Short-Term Clinical Results of a Triple-Tapered Polished Cemented Stem Implanted with or Without Cement Mantle

Primary Author: Hirotugu Ohashi

Institution: Osaka Saiseikai Nakatsu Hospital

Coauthors: Satoshi Iida (2. Matsudo City Hospital), Izumi

Minato (3. Niigata Rinko Hospital)

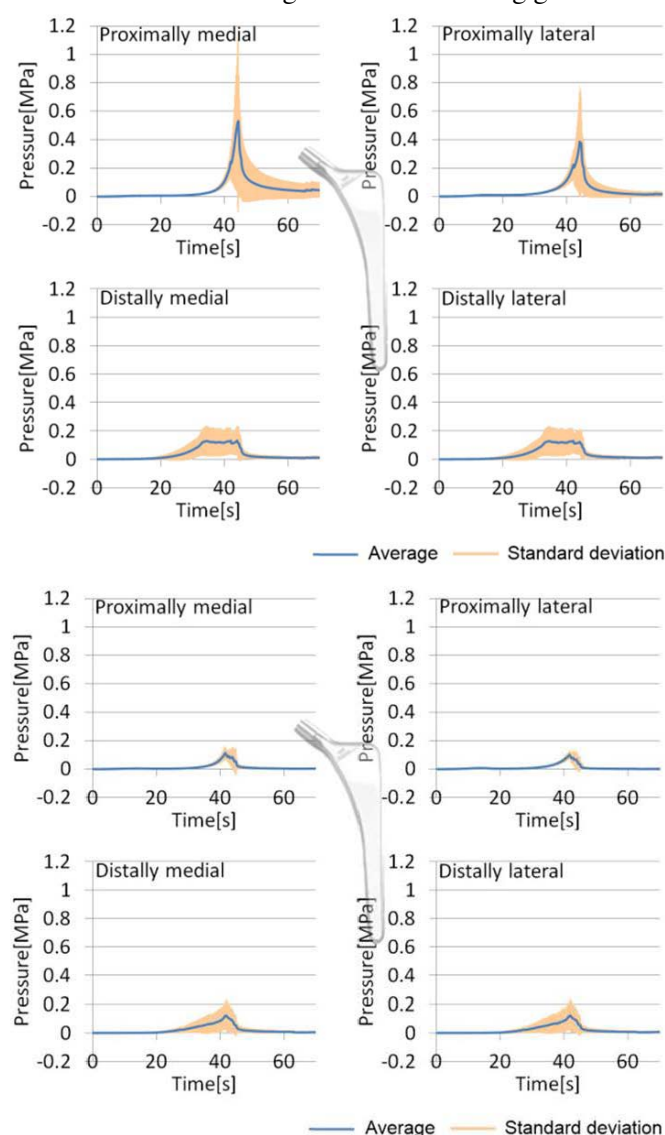
INTRODUCTION: There are two techniques currently use for cemented stem during THA. One is cement mantle technique that produces complete cement mantle around the stem. The other is line-to-line technique that produces a cavity which is the same size as the stem. As the cement mantle thickness is different between these techniques, the cement might act as different way. In this study, the pressure at the cement-bone interface during stem insertion and the stem subsidence after cyclic loading were measured in vitro using a new designed triple-tapered polished cemented stem (Trilliance, B.Braun Aesculap, Germany). Furthermore, we clinically investigated the short-term results of the initial 150 cases in a multicenter study.

MATERIALS AND METHODS: [Biomechanical study] Through drilled holes at medial and lateral cortex in proximal and distal part of the plastic bone, 4 pressure sensors were set. Six triple-tapered polished stems without end cup were implanted with line-to-line technique (technique L), and 6 stems with end cup were implanted with cement mantle technique of at least 2mm in thickness (technique M). The pressure at bone-cement interface was measured during stem insertion. Then, the specimen was mounted on the biaxial material testing machine. A cyclic load of 300 N to 3000 N with a frequency of 0.75 Hz was applied for 14000 cycles. The stem subsidence was measured at the end of loading process. [Clinical study] 139 THA and 11 bipolar hemiarthroplasties were performed in three hospitals. 100 stems were implanted with technique L and 50 stems were implanted with technique M. The average follow-up period was 2 years and 8 months. Clinical results were evaluated by Japanese Orthopaedic Association (JOA) hip score. Cementing grade, stem subsidence, radiolucent line, cortical hypertrophy, stress shielding, and cement fracture were investigated on plain radiographs.

RESULTS: The peak cement pressure at the proximal part was higher in technique L (Fig. 1) than technique M (Fig. 2). There was no difference at the distal part. The average subsidence was 0.082 mm in technique L and 0.075 mm in technique M. JOA hip score improved from 42.6 points to 86.6. Cementing grade classified by Barrack was grade A in 101 hips (technique L=70, M=31), grade B in 46 (L=28, M=18), and grade C in 3 (L=2, M=1). The average subsidence was 0.41 mm in technique L and 0.42 mm in technique M. Radiolucent line was not found, and cortical hypertrophy was observed in one hip in technique L. Grade 2

stress shielding classified by Engh was observed in 3 hips in technique L. Cement fracture was not observed.

DISCUSSION AND CONCLUSIONS: Biomechanical study showed that the cement pressure during stem insertion was higher at the proximal part in technique L, and the stem subsidence was similar in both techniques. The clinical results were satisfactory in both techniques and the stem subsidence was similar at final follow-up. These biomechanical and clinical results indicated that the advantages of line-to-line technique were to facilitate cement penetration into bone leading to better cementing grade.



O7B4 Cup Positioning in Total Hip Arthroplasty Using the A Robotic Hip System: A Pilot Study

Primary Author: Benjamin G. Domb

Institution: Hinsdale Orthopaedics/American Hip Institute

Coauthors: Youssef F. El Bitar (American Hip Institute), Timothy J. Jackson (American Hip Institute), Dror Lindner (American Hip Institute), Itamar B. Botser (American Hip Institute), Christine E. Stake (American Hip Institute)

BACKGROUND: Acetabular cup positioning is an extremely delicate step when performing total hip arthroplasty (THA). Several methods have been developed to improve the accuracy and consistency of placement of the THA components in the correct three-dimensional (3D) orientation. Improper implantation of the cup has been associated with several complications including dislocation, component impingement, leg length discrepancy, altered hip biomechanics, accelerated bearing surface wear, and revision surgery. The placement of the cup within a “safe zone” of inclination and anteversion has been described by Lewinnek et al¹ and later modified by Callanan et al². Placing the cup outside that “safe zone” is associated with an increased rate of significant complications, which affects both clinical outcomes and quality of life of patients undergoing THA. The purpose of this prospective matched-pair controlled study was to compare the acetabular cup placement of two groups of patients who underwent THA by the same surgeon through a posterior approach: one using the conventional technique and the other using the robotic-assisted technique.

MATERIALS AND METHODS: Between Sep 2008 and Sep 2012, THAs which were performed by the senior surgeon through a mini-posterior approach were reviewed. The radiographic cup positioning of the robotic-assisted THAs were compared to a matched-pair control group of conventional THAs performed by the same surgeon via the same approach. The match was done for gender, age ± 5 years, and body mass index (BMI) ± 7 units.

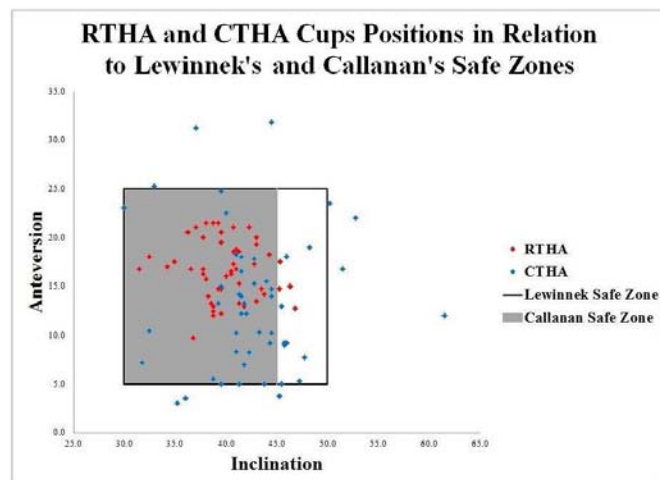
RESULTS: After exclusions, a total of 50 THAs were included in each group. Strong inter- and intra-observer correlations were found for all radiographic measurements ($r > 0.82$, $p < 0.001$). 100% of cases in the robotic-assisted THA group were within Lewinnek’s “safe zone” (inclination 30°-50°, anteversion 5°-25°) compared to 80% of

cases in the conventional THA group ($p = 0.001$). 92% of cases in the robotic-assisted THA group were within Callanan's "modified safe zone" (inclination 30° - 45° , anteversion 5° - 25°) compared to 62% of cases in the conventional THA group ($p = 0.001$) (Figure 1).

CONCLUSION: Robotic-assisted THA was very consistent in placing the acetabular cup within both Lewinnek's and Callanan's safe zones, with minimal intra-operative technical complications, a small learning curve, and no increase in operating room or surgical time. However, further studies need to be performed in order to reflect on the long-term clinical outcomes, the possible long-term complications, and the cost-effectiveness of robotic-assisted THA.

References:

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2. Callanan MC, Jarrett B, Bragdon CR, et al.: The John Charnley Award: risk factors for cup malpositioning: quality improvement through a joint registry at a tertiary hospital. Clinical orthopaedics and related research 2011;469:319-329.



O7B5

In Vivo Hip Kinematics Captured Using a Mobile Fluoroscopy Unit

Primary Author: William R. Hamel

Institution: University of Tennessee, Mechanical, Aerospace & Biomedical Engineering

Coauthors: Richard D. Komistek (University of Tennessee), Douglas Dennis (), Matthew Young (University of Tennessee), William Anderson (University of Tennessee)

Previously, a state-of-the-art, advanced mobile fluoroscopy unit was developed that can be used to track and image human joints. As the human preforms a normal motion activity, the mobile fluoroscopy unit tracks the human and follows them during the motion (Figure 1). The first studies conducted using this unit pertained to the human knee, while performing activities that could not be tracked using a stationary unit. More recently, a second generation, TFS II unit was developed that includes numerous advancements beyond the original TFS presented earlier, including modifications that facilitate comprehensive hip studies. Previously, all hip fluoroscopy studies have been conducted using a stationary fluoroscopy unit, while the patients performed treadmill gait, as this was the only activity that could be imaged. Unfortunately, patients are restricted during this motion and most patients do not perform a normal gait motion while on a treadmill. Hip tracking involves machine requirements that are substantially different than knee tracking, especially with regard to stair climbing and ramp-type maneuvers (Figure 2). In this paper, the hip tracking features of TFS II will be presented. Initial human subject experiments, which show the machine's ability to obtain anterior-posterior hip joint images during natural movements and walking, will be presented. Also, numerous other activities, previously not assessed using a stationary unit will be discussed.



Figure 2. TFS II Hip Configuration

O7B6

Robotic Arm Assistance Improves Accuracy and Clinical Outcome Compared with Manual THA Technique

Primary Author: Richard L. Illgen

Institution: University of Wisconsin, Madison

Coauthors: Jennifer J. Christopher (Stryker Mako), Michael A. Conditt (Stryker Mako)

INTRODUCTION: While THA is regarded as one of the most successful surgeries in medicine, recent studies have revealed that ideal acetabular cup implantation is achieved as little as 50% of the time. Malalignment of the acetabular component in THA may result in dislocation, reduced range of motion, or accelerated wear. Recently, robotic-assisted surgery has been introduced to reduce the errors in component placement. The purpose of this study is to longitudinally assess the accuracy of cup placement of a single surgeon at three points in time: directly following a total joint fellowship, after 10 years of experience with manual instrumentation, and directly after adopting robotic technology.

METHODS: 300 patients received posterior approach THA at a single center by a single surgeon representing three series of 100 consecutive patients in each series. Series A included the first 100 THA patients following joint fellowship (2/2000 – 5/2002). Series B included the last 100 THA patients before adopting robotic technology (12/2010 – 1/2012) and series C included the first 100 THA patients using robotic assistance (4/2012 – 4/2013). Comparisons included age, sex, diagnosis, implant head size, blood loss (EBL), operative time, LLD, early dislocation and infection (within 6 months). The post-operative abduction and version of the cup was measured using PACS imaging software from the AP and cross-table lateral radiographs. Abduction was measured using a transverse line at the level of the teardrop and the lateral opening angle of the cup relative to this reference line. Anteversion was measured using the ischial method described by Schmalzreid on the crosstable lateral view and accounts for pelvic flexion.

RESULTS: Cup placement in series A was within the Lewinnek safe zone 31% of the time, 45% in series B and up to 74% in series C ($p < 0.05$). With the robotic series C, the three-dimensional pre-operative plan was ob-

tained from the software. The average error (final placement – plan) was $-0.7 \pm 2.1^\circ$ for inclination and $1.1 \pm 2.0^\circ$ for version. 93% of the inclination measurements and 94% of the version measurements were within 5° of the plan and 100% of both measurements were within 10° of the plan. Of note, 26% of the robotic cases were planned outside the Lewinnek safe zone to accommodate for patient deformity and optimize correction to achieve the targeted combined anteversion of the acetabular and femoral components. Improved accuracy correlated with lower dislocation rates (Series A, B, C were 5%, 3%, 0%, respectively, $p < 0.001$). Series C operative times were longer than series B (143 versus 129 minutes, $p < 0.01$). EBL was less with series C than series B (Series A, B, C: 533cc, 437cc, 357cc; $p < 0.0001$).

DISCUSSION: Robotic assistance in THA leads to significantly more precise acetabular cup placement. 10 years of experience resulted in a 45% increase in precision, while adding robotic assistance resulted in a 139% increase in precision compared to the surgeon's initial performance. Highly accurate techniques may allow surgeons to decrease the risk of dislocation, promote durability and improve the ability to restore appropriate leg length and offset.



**ICJR Pan Pacific Asia/Australia
Research Award Winner**

O7B7

Patient Specific Acetabular Cup Orientation in Functional Positions using Musculoskeletal Modelling: A Pre-operative Planning Tool

Primary Author: Ed Marel

Institution: Peninsula Orthopaedics

Coauthors: Leonard R. WALTER (Peninsula Orthopaedics), Michael SOLOMON (Sydney Orthopaedic Specialists), Jim PIERREPONT (Optimized Ortho)

Achieving optimal acetabular cup orientation in Total Hip Replacement (THR) remains one of the most difficult challenges in THR surgery (AAOR 2013) but very little has been added to useful understanding since Lewinnek published recommendations in 1978. This is largely due to difficulties of analysis in functional positions. The pelvis is not a static reference but rotates especially in the sagittal

plane depending upon the activity being performed. These dynamic changes in pelvic rotation have a substantial effect on the functional orientation of the acetabulum, not appreciated on standard radiographs [Fig1].

Studies of groups of individuals have found the mean pelvic rotation in the sagittal plane is small but large individual variations commonly occur. Posterior rotation, with sitting, increases the functional arc of the hip and is protective of a THR in regards to both edge loading and risk of dislocation. Conversely Anterior rotation, with sitting, is potentially hazardous.

We developed a protocol using three functional positions – standing, supine and flexed seated (posture at “seat-off” from a standard chair). Lateral radiographs were used to define the pelvic tilt in the standing and flexed seated positions. Pelvic tilt was defined as the angle between a vertical reference line and the anterior pelvic plane (defined by the line joining both anterior superior iliac spines and the pubic symphysis). In the supine position pelvic tilt was defined as the angle between a horizontal reference line and the anterior pelvic plane. Supine pelvic tilt was measured from computed tomography.

Proprietary software (Optimized Ortho, Sydney) based on Rigid Body Dynamics then modelled the patients’ dynamics through their functional range producing a patient-specific simulation which also calculates the magnitude and direction of the dynamic force at the hip and traces the contact area between prosthetic head/liner onto a polar plot of the articulating surface, Fig 2. Given prosthesis specific information edge-loading can then be predicted based on the measured distance of the contact patch to the edge of the acetabular liner.

Delivery of desired orientation at surgery is facilitated by use of a solid 3D printed model of the acetabulum along with a patient specific guide which fits the model and the intra-operative acetabulum (with cartilage but not osteophytes removed) - an incorporated laser pointer then marks a reference point for the reamer and cup inserter to replicate the chosen orientation.

RESULTS AND CONCLUSIONS: The position of the pelvis in the sagittal plane changes significantly between functional activities. The extent of change is specific to each patient. Spinal pathology is a potent “driver” of pelvic sagittal rotation, usually unrecognised on standard ra-

diographs. Pre-operative patient assessment can identify potential orientation problems and even suitability for hard on hard bearings.

Optimal cup orientation is likely patient-specific and requires an evaluation of functional pelvic dynamics to pre-operatively determine the target angles.

Post-operatively this technique can identify patient and implant factors likely to be causing edge loading leading to early failure in metal on metal bearings or squeaking in ceramic on ceramic bearings.

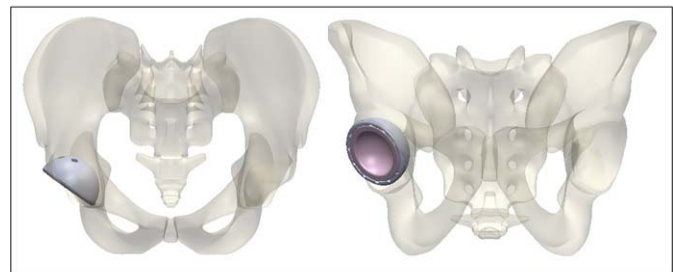


Fig 1. Functional Orientation: The same pelvis with 30° Anterior Rotation (left) and 30° Posterior Rotation (right). The cup orientation (40° Inclination and 25° Anteversion to the Anterior Pelvic Plane) changes from 36° Inclination and 1° Anteversion to 56° Inclination and 46° Anteversion to the Coronal Plane

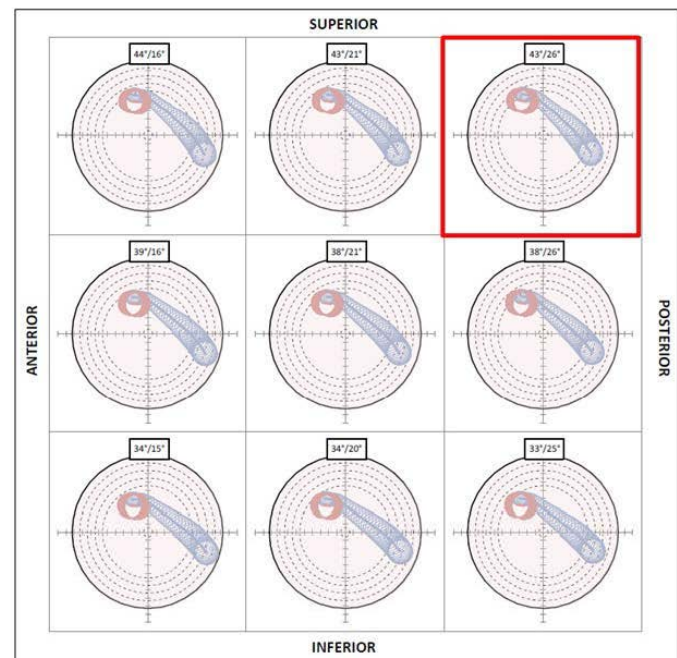


Fig 2: Optimized Ortho polar plots predicting the contact patch path between standing (red circles) and sitting (blue circles) for nine different cup orientations. The red box is the proposed optimal orientation to keep the contact patch equidistant from the anterosuperior and posterior edges. An optimal of 43°/26° in this patient.

PSI: Current Status

O8A1

PSI – The Importance of your Radiographer

Guest Faculty: Jasmeet Singh Saren, MsOrtho

Institution: HSC Medical Center, Kuala Lumpur, Malaysia

In the past decade, there have been new innovative ways to perform Total Knee Replacements. Orthopaedic surgeons, especially in Asia love to try out these new “toys”. From computer-aided surgery (CAS) to Robotic surgery and now Patient Specific Instrumentation, we have all tried it at least once or twice in our practice.

I started using an MRI based PSI in 2012 and was excited to be one of the first to start it in my country Malaysia. Let me share with you some of the issues I had with this and how to ensure that you have a perfect TKA using PSI.

O8A2

PSI: Opportunities and Challenges for the Future

Guest Faculty: Mohamed R. Mahfouz, PhD

Institution: University Of Tennessee, Knoxville TN, USA

Patient specific instrumentation (PSI) is becoming increasingly common in joint arthroplasty due to its potential to improve surgical outcomes, reduce necessary instrumentation and reduce procedural costs. Current research suggests that PSI reduces surgical outliers and is as accurate as conventional instrumentation and surgical navigation at aligning implants, making PSI an attractive option for less experienced or low-volume surgeons – or in cases with severe or unusual deformities. Generally, PSI refers to a patient matched, disposable instrument which is manufactured from a rapid prototyping process. The patient matching requires reconstruction or segmentation of patient specific surface models. The reduction in instrumentation is often offset by the increased imaging costs – most often MRI or CT – and significant processing time for generating anatomical models

The primary challenge facing PSI developers is reducing imaging costs while maintaining the high accuracy neces-

sary for sufficient matching when placed on the anatomy. Driven by this, there is significant development towards generating PSI from digital x-ray, x-ray fluoroscopy, biplanar x-ray and ultrasound – all of which are less expensive than MRI or CT. The technical challenges arising from utilizing inexpensive imaging techniques lie in reproduction of complex geometries arising from osteophytes and bone deformities.

Clinically, the two objectives of PSI should be improving OR efficiency while bettering patient outcomes. Regarding efficiency, instrument reduction is accomplished in conventional PSI – and can be further accomplished with the replacement of entire cutting blocks and sizing components. Still, a major factor affecting OR time and patient outcomes for TKA is ligament balancing – currently missing from nearly all PSI preoperative planning platforms. This discussion will address current PSI challenges and potential solutions, while discussing situations and surgical techniques where PSI is of particular interest.

O8A3

Patient-Specific Implants and Cutting Guides Better Approximate Natural Kinematics than Standard Total Knee Arthroplasty

Primary Author: Shantanu Patil

Institution: Orthopaedic Research, Scripps Health

Coauthors: Adam Bunn (Orthopaedic Research, Scripps Health), William D. Bugbee (Orthopaedic Research, Scripps Health), Clifford W. Colwell (Orthopaedic Research, Scripps Health), Darryl D. D'Lima (Orthopaedic Research, Scripps Health)

INTRODUCTION: Despite over 95 % survivorship of total knee Arthroplasty (TKA), patient satisfaction is less compelling with anywhere from 14-39% of patients reporting dissatisfaction with their TKA result. Studies of knee anatomy have revealed distinct anatomical differences in gender and race; this variation in anatomic sizes leads to compromises during surgery as it is impossible to maintain implant inventories that precisely match every individual. Patient-specific TKA designs are a promising technology that constructs the TKA to match the patient's native anatomy. The current study was designed to test kinematics of patient-specific prostheses implanted using patient-specific cutting guides. We hypothesized that restoring the artic-

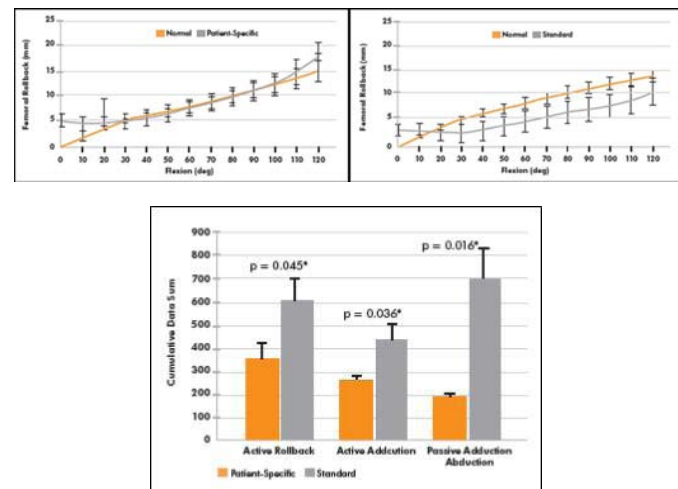
ular surface and maintaining the femoral offsets and geometry to that of the native joint will also restore the normal knee kinematics.

METHODS: Preoperative CT scans were obtained from 9 matched pairs of human cadaveric knees. One knee of each pair was randomly assigned to one of two groups. The first group was implanted with an off-the-shelf posterior-cruciate-retaining TKA, while the contralateral knee was implanted with patient-specific implants using patient-specific cutting guides. Each knee was tested preoperatively as an intact, normal knee, by mounting the knees on a dynamic, quadriceps-driven, closed-kinetic-chain Oxford knee rig (OKR), which simulated a deep knee bend from full extension to 120° flexion. Following surgical implantation with either the off-the-shelf or patient-specific implant, the knees were mounted on the OKR and tested again. Femoral rollback, tibiofemoral rotation, tibial adduction, patellofemoral tilt and shift were recorded using an active infra-red tracking system.

RESULTS: The kinematics of the knees implanted with the patient-specific design more closely approximated normal femoral rollback (Figure 1), and tibial adduction than the knees implanted with the standard design. To reduce the effect of variability among the cadaveric specimens, the change in kinematic measures was quantified as the absolute difference between the normal kinematic measure and the same measure after implantation for each knee. The cumulative difference from normal kinematics was calculated by summing the area beneath the curve (Figure 2). The cumulative difference in kinematics from normal was statistically lower for the patient-specific group compared to the standard group for all kinematic measures except for patellar shift.

DISCUSSION: Femoral rollback is an important feature of healthy kinematics and was qualitatively and quantitatively significantly closer to the normal knee for the patient-specific design. Tibial rotation is also important and is thought to improve range of flexion. In both implant designs the tibia rotated internally with flexion, with patient-specific group closely approximating normal rotation. Tibial adduction-abduction is linked to soft-tissue balance. The patient-specific group more closely approximated normal tibial adduction suggesting that ligament balance was better restored. On passive testing of the range of adduction-abduction, the patient-specific implant resulted in varus-valgus laxity that was significantly closer to the normal

knee compared to the off-the-shelf implant. Importantly, standard deviations show that off-the-shelf TKAs have a higher degree of variability than normal knees or patient-specific knees. A patient specific design, restores normal articular geometry, and maintains alignment is more likely to result in normal kinematics.



O8A4

In-Vivo Tibial Fit Analysis of Patient-specific TKA System versus Off-the-shelf TKA

Primary Author: Gregory M. Martin

Institution: JFK Medical Center

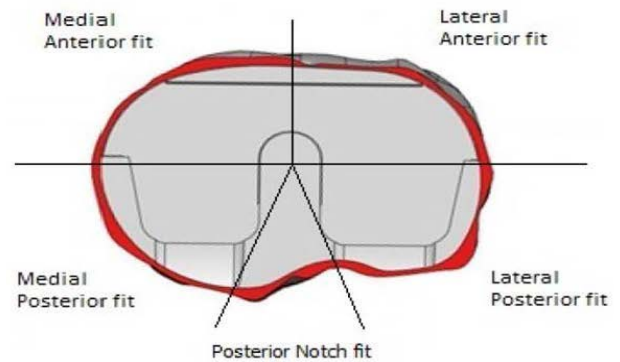
INTRODUCTION: Surgeons are frequently faced with the intraoperative challenge of compromising maximal tibial coverage against proper rotational alignment, resulting in the need to up or down-size tibial components. This leads to conditions where tibial implants either don't cover parts of the resected tibia or components overhang the resected tibial bone. Improper implant fit has been found to increase the prevalence of clinically significant knee pain and implant loosening in off-the-shelf (OTS) total knees. Recently, a patient-specific TKA has been introduced that optimizes the femoral and tibial components to the patient's native geometry. The purpose of this study was to compare the tibial fit of a patient-specific TKA to that of OTS TKAs intra-operatively, in the same patient.

METHODS: Thirty-three (33) patients undergoing TKA with a patient-specific system were compared to assess the fit of the tibial tray intra-operatively. After tibial preparation, a series of tibial trials from 3 different OTS-TKA de-

signs were fit to the operative knee. Each trial was optimally sized and positioned based on the surgeon's judgment, while maintaining proper rotational alignment. Implant fit data (overhang and underhang) for the best matched tibial trial of each OTS knee was recorded in five tibial zones (antero-medial, antero-lateral, postero-medial, postero-lateral and posterior tibial notch) (Figure 1). Once all measurements were complete, the patient-specific tibial tray was implanted, and all measurements were repeated.

RESULTS: Analysis reveals that surgeons prefer to undersize the tibia to prevent overhang of the cortical bone. In the four medial/lateral zones analyzed, underhang of the tibial component was seen in 12% of patient-specific TKAs, and an average 33% in the 3 OTS groups (30%, 30% and 39% for OTS-1, 2 and 3 respectively). Significant overhang of >3mm of the tibial component was seen in 0% of patient-specific TKA, while each of the 3 OTS groups had 21% of cases with significant overhang. For the patient-specific TKA, only 12% (avg=2.18mm) of patients experienced underhang of the tibial notch, while the corresponding values for the 3 OTS TKA groups (OTS-1, 2 and 3 respectively) were 73% (avg=5.79mm), 100% (avg=13.31mm) and 100% (avg=9.64mm). In the 3 OTS groups, underhang was most frequently seen in the postero-medial zone, while the antero-lateral zone was the most frequent zone experiencing overhang.

DISCUSSION: Results show that patient-specific TKA can significantly improve tibial fit in all regions of the resected tibial plateau. This could play an important role in reducing knee pain and patient dissatisfaction, resulting from overhanging components and soft-tissue impingement and implant loosening due to poor tibial bone support and resultant subsidence. We also noted that increased tibial coverage could be attained by upsizing the OTS implants, however this led to a significant internal rotation of components in order to avoid unacceptable overhang. By providing better coverage on the tibial plateau, a patient-specific TKA can reduce the instances of the surgeon making compromises on sizing the tibial component in order to achieve correct rotational alignment.



O8A5 Hospital Outcomes and Cost for Patients Undergoing a Customized Individually Made TKA vs Off-The-Shelf TKA

Primary Author: Martin, GM; Swearingen, A; Culler, SD.

INTRODUCTION: Despite excellent survivorship, published literature suggests there are between 15-39% of patients dissatisfied with the result of their TKA. Newer technologies may improve the value of care delivered to TKA patients by providing better clinical outcomes at similar or lower total cost of care. The purpose of this study was to compare a variety of the hospital outcomes between patients undergoing TKA using either customized individually made (CIM) TKA or a Standard Off-the-Shelf (OTS) TKA.

METHODS: A retrospective review was conducted for consecutive TKA patients treated in a single institution, by the same surgeon, between March 2010 and November 2013. The study sample consisted of 248 TKA hospitalizations having received either CIM TKA (126) or OTS TKA (122). Data collected included: patient demographics, length of procedure metrics, length of hospital stay, blood transfusion rates, patient discharge disposition, adverse event rates at discharge, at 30 and at 90 days, and total hospital cost. Hospital costs were calculated from billed charges, and were adjusted into 2013 US Dollars by using the appropriate annual value for the hospital specific cost/charge index for all hospitalizations under DRG 470. Univariate differences in selected outcome measures between the two study arms were assessed with Chi-square analysis or Fisher's exact test for discrete variables and Student's t test for continuous variables. A p-value of ≤ 0.05 was considered statically significant in this study.

RESULTS: There were no statistical differences in the demographics (age, sex, BMI) between the two arms. The CIM implant showed significantly lower transfusion rates (2.4% vs 10.7%; $p=0.009$). The adverse event rate at discharge was significantly lower in the CIM arm than the OTS arm (1.6% vs 13.9%; $p<0.001$). Differences in length of stay reached borderline significance (CIM 3.0 vs OTS 3.2; $p=0.057$). When discharge disposition was analyzed, it was seen that a significantly lower percentage of patients in the CIM group were discharged to acute care facilities (2.4% vs 13.9%; $p<0.001$). In addition, when comparing a subset of the data among patients receiving a simultaneous bilateral TKA, patients in the CIM group were more likely to be discharged to home or home with care when compared to the OTS group (58% vs 17%; $p<0.001$). Finally after adjusting for inflation, total hospital cost between the two groups was not statistically different (CIM \$16,192 vs OTS 16,240; $p=0.913$).

CONCLUSION: Patients treated with a CIM implant had significantly lower transfusion rates and lower adverse event rates than patients treated with OTS implants. Patients treated with a CIM implant showed a trend towards a shorter length of stay and a better discharge disposition than patients in the OTS arm. These improved outcomes for the CIM group were achieved without an increase in hospital costs. Future studies need to be conducted to examine the potential hospital savings associated with lower inventory management and sterilization cost savings with the single package CIM implant.

O8A6 Influence of PCL in a Patient Specific Total Knee Implant: A Biomechanical Study

Primary Author: Jeremi Leasure

Institution: The Taylor Collaboration

Coauthors: Ryan O'Shea (SF Orthopaedic Residency Program), William Camisa (The Taylor Collaboration), Katrina Tech (The Taylor Collaboration), Jennifer van Warmerdam (St. Mary's Medical Center), William McGann (St. Mary's Medical Center)

INTRODUCTION: Total Knee Arthroplasty (TKA) is a highly successful procedure; however, patient satisfaction rates are lower indicating a need for improvement. Previous investigations have shown PCL retaining implants do

not mimic native kinematics which may be the driving factor to the low satisfaction scores. Patient specific TKA designs are a promising technology that has shown to closely match native kinematics and may be robust enough to stabilize deficient PCL knees. The aim of our study was to compare the kinematics of intact and resected PCL in order to elucidate the role of the PCL with patient specific knee implants. Given the congruency and inherent stability of a patient specific implants, we hypothesize that there is no difference in the kinematics of a PCL retaining knee compared to a PCL deficient knee.

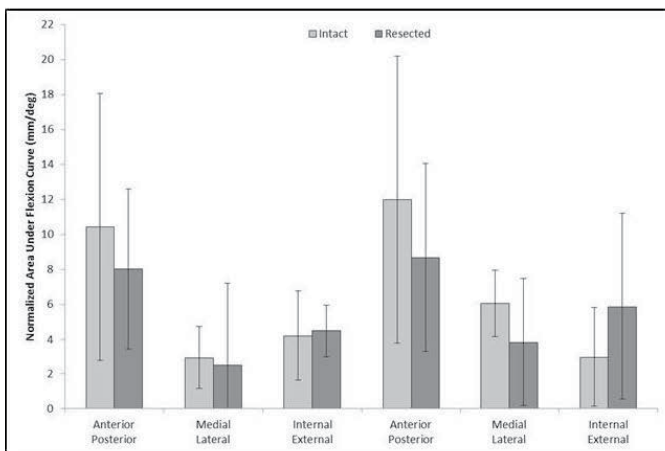
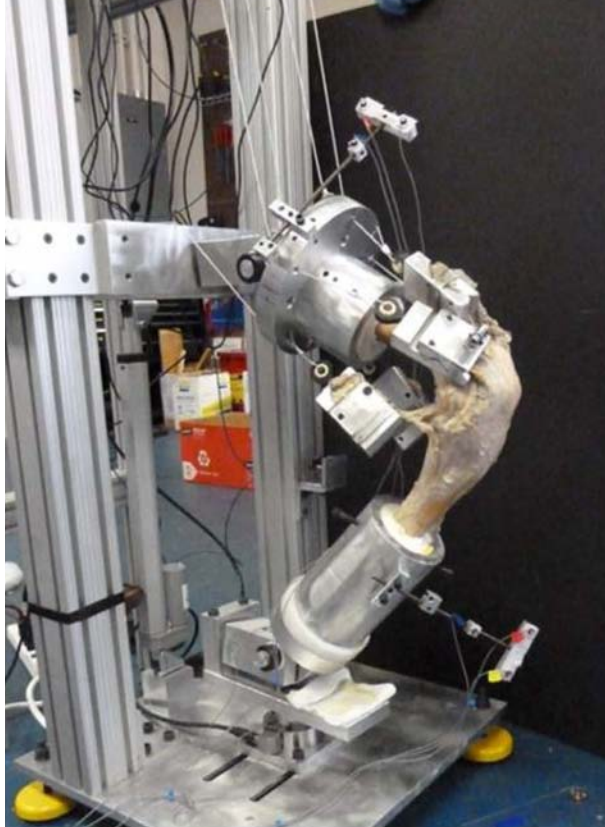
METHODS: We tested our hypothesis by studying the biomechanics of the implant in seven cadaver knees with intact PCLs. Each knee was mounted on an Oxford Rig (Figure 1) and flexed to simulate squatting. Anterior-posterior translation, medial-lateral translation and internal-external rotation of the tibiofemoral articulation were recorded throughout flexion. The PCL was subsequently transected and the procedure repeated for each specimen. Comparison between the intact and deficient PCL kinematics was carried out with a 2 way ANOVA test.

RESULTS: The change in anterior-posterior translation from intact to resected tended to decrease in value through mid-flexion from a mean of -1.52mm to -2.81mm. This represented a statistically insignificant ($p=0.55$) 1.29mm anterior shift of the femur from its intact position post resection. During deep flexion, the change was a statistically insignificant ($p=0.44$) 2.21mm anterior shift of the femur once the PCL was cut. The change in medial-lateral translation decreased through mid-flexion from a mean of -0.97mm to -0.67mm. This represented a statistically insignificant ($p=0.88$) 0.30mm medial shift of the femur post resection. During deep flexion, the change was a statistically insignificant ($p=0.44$) 3.87mm medial shift in the femur in the absence of the PCL. The change in internal-external rotation increased through mid-flexion from a mean of -0.03deg to -0.62deg. This represents a statistically insignificant ($p=0.44$) 0.65deg internal rotation of the femur when the PCL was cut.

Further analysis of the overall behavior of the groups through analyzing the area under the flexion curves further illustrated insignificant differences after the PCL was removed (Figure 2).

DISCUSSION: We observed similar kinematic profiles between the intact-PCL and resected-PCL groups. We ob-

served trends of anterior translation, medial translation, and decreased external rotation of the femur in late flexion in the absence of the PCL; however, these trends were not statistically significant. Our data indicate patient specific total knee replacements do not rely on the PCL for stability and constraint. The clinical implications of our findings suggest patients who present with deficient PCLs and receive patient specific TKR may not experience the instability inherent with traditional cruciate retaining designs.



O8A7

Accuracy of Digital Templating for Total Knee Arthroplasty: A Step Towards Template-Directed “Patient-Specific” Instrumentation

Primary Author: Seth A. Jerabek

Institution: Hospital for Special Surgery

Coauthors: Kaitlin M. Carroll (Hospital for Special Surgery), Alexander S. McLawhorn (Hospital for Special Surgery), David J. Mayman (Hospital for Special Surgery)

INTRODUCTION: Preoperative templating is a critical part of preoperatively planning for total knee arthroplasty (TKA). It allows the surgical team to anticipate necessary instrumentation and components required in the operating room, and templating assists orthopedic surgeons delivering reproducible outcomes. Template-directed instrumentation (TDI) may be a feasible strategy for inventory and equipment management, whereby instrument trays, trials and implants are tailored to an individual case, potentially reducing cost and improving OR efficiency. The purpose of this study was to determine the accuracy of modern digital templating for preoperative selection of TKA implant sizes, as a step toward TDI.

METHODS: We retrospectively reviewed 60 consecutive patients (63 knees) that received primary TKA by a single surgeon, who digitally templated each case to predict implant sizes. One week prior to surgery, standing anteroposterior and lateral knee digital radiographs were obtained. Radiographs were calibrated using a calibration marker of known size (25 mm). Radiographs were accessed using our institution’s PACS, and templating was performed using its proprietary software (Sectra AB, Linköping, Sweden). Templated sizes for the femoral and tibial components were compared to the sizes of the components implanted, with one-tailed Mann-Whitney U-test to assess significance. Fisher exact tests were used to assess the relationship between preoperative alignment and morbid BMI (>35 kg/m²) and templating error. Alpha level was set at 0.05 for all tests.

RESULTS: There were 29 (46%) right knees, 34 (54%) left knees and 3 (4.7%) bilateral procedures. The mean patient age was 68±8.9 (range 49-91) years. The study population consisted of 38 females (60%) and 22 males (35%) with an average BMI 32±6.03. Both varus (70%) and valgus (30%) knees were templated. There was no difference

between the templated and actual component sizes for the tibial ($p=0.27$) or femoral ($p=0.31$) components. Preoperative templating predicted the exact size of 40 (63%) of both femoral and tibial components, and 62 (98%) femoral and 61 (97%) tibial components were templated to within one size (Table 1). When templating did not predict the exact size, it predicted one size too large in 61% of cases. The overall accuracy between the preoperative template size for the combined femoral and tibial components was 56% of the time for exact size, and 97% of the time within one size for both the femoral and tibial component. There was no correlation between BMI and imprecisely templated tibial ($p=0.59$) or femoral ($p=0.31$) components, and there was no relationship with preoperative alignment ($p=0.19$ and $p=0.31$, for tibial and femoral components, respectively) (Figure 1).

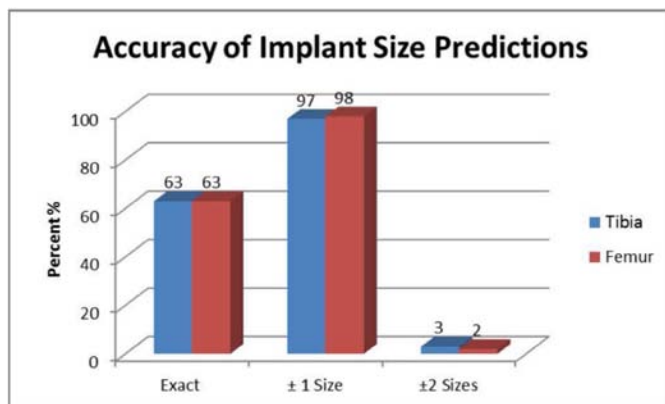
CONCLUSIONS: Preoperative digital templating is an accurate method for predetermining implants for TKA with in one size. This study suggests that “patient-specific” TDI may be a feasible strategy for inventory and equipment management, which can reduce cost and improve OR efficiency.

Table 1: Results Summary

N=63	Up 1 size	Down 2 sizes	Down 1 Size	Exact	Within 1 size
Tibia	7	2	14	40 (69%)	61 (97%)
Femur	8	1	14	40 (63%)	62 (98%)

Both Tibia and Femur BOTH were Exact= 35/63 (56% of the time)

Both Tibial and Femur Within 1 size (up or down)=61/63 (97% of the time)



Rotator Cuff and Instability

O8B1

Reverse Shoulder Arthroplasty for the Massive Rotator Cuff Tear

Guest Faculty: John W. Sperling, MD, MBA

Institution: Mayo Clinic, Rochester, MN, USA

There has been increasing interest in the use of the reverse arthroplasty to manage the massive rotator cuff tear. Over the course of the past 10 years, significant knowledge has been gained that has resulted in a significant decrease in the rate of complications with the reverse.

Pre-operative planning is critical to ensure proper component placement. At minimum, high quality AP and axillary radiographs are necessary. In my practice, I obtain a thin cut CT scan on all patients. This allows one to understand the version of the glenoid, the specific wear pattern, and the amount of wear. A growing area of interest is the use of patient specific instrumentation. This tool may help facilitate accurate component placement as well as decrease the number of outliers.

Intra-operatively, there continues to be debate about the proper humeral version. Initially, the humeral component was placed in neutral version. Now, a number of surgeons place the humeral component in 20 to 30 degrees of retroversion. In this position, the humerus faces across from the glenoid with the arm in the neutral position. There has also been a strong trend toward the use of uncemented humeral components and shorter stems. This may facilitate flexibility at the time of surgery as well as facilitate future revision surgery if necessary.

Initially, there was concern that there would be a high rate of glenoid loosening with the reverse. However, the rate of glenoid baseplate loosening has been shown to be low. Placing the glenoid baseplate with 10 degrees of inferior tilt has been shown to significantly decrease the rate of loosening. In addition, eccentric glenospheres have decreased the overall rate of notching which was reported to be high in the initial series in the literature.

The indications for the reverse arthroplasty continue to broaden. Mid-term studies are encouraging in treating a spectrum of shoulder disorders including the massive rotator cuff tear.

O8B2 Revision Arthroplasty

*Guest Faculty: Edwin C. Spencer Jr., MD, Knoxville
Institution: Orthopaedic Clinic, Knoxville, TN, USA*

Failures of shoulder arthroplasty are multifactorial and the most common ones are specific to the type of operation. Failure of hemiarthroplasty is usually secondary to glenoid arthrosis while failure of total shoulder arthroplasty is usually secondary to glenoid loosening. Hemiarthroplasty for fracture failure is usually secondary to tuberosity malunion or nonunion although component malposition is seen as well. Infection can occur in all arthroplasties and might require staged operations. The revisions are based on the mode of failure and deficiencies including both osseous and soft tissue.

One must consider all the problems in a methodical order and then determine the most predictable solution. Mechanical issues such as bone loss on the glenoid and bone loss on the humeral side will be discussed using both allograft and autograft. Other mechanical issues including cuff dysfunction and instability will be discussed. The reverse TSA offers the ability to address many of the above problems but is not the only solution. We will discuss in a case based fashion revision arthroplasty and tips for managing these complex situations.

O8B3 Coracoid Graft Osteolysis after Latarjet Procedure

*Primary Author: Giovanni Di Giacomo
Institution: Concordia Hospital for Special Surgery*

Coauthor: Alberto Costantini (Concordia Hospital for Special Surgery)

BACKGROUND: The Latarjet procedure has been advocated as an option for the treatment of antero-inferior shoulder instability in certain groups of patients but pro-

gression of the transferred coracoid bone graft to osteolysis has been reported in the literature. This could be one of the causes of the Latarjet procedure failure.

METHODS: The authors performed a computed tomography scan analysis of 26 prospectively followed up patients after the Latarjet procedure to determine the location and the amount of the coracoid graft osteolysis.

RESULTS: The most relevant osteolysis was represented by the superficial part of the proximal coracoid, whereas the distal region of the coracoid bone graft, especially in the deep portion, is the one least involved in osteolysis and with the best bone healing.

DISCUSSION: Our study suggests that the bone block effect from the Latarjet procedure may not be its principal effect in its treatment of antero-inferior shoulder instability in patients without significant bony defects. To the Authors knowledge, this is the first coracoid graft osteolysis study after the Latarjet procedure for antero-inferior shoulder instability using CT scan analysis.

KEYWORDS: Shoulder; Instability; Latarjet; Coracoid; Osteolysis; Bone Graft.

LEVEL OF EVIDENCE: Level II

O8B4 Biomechanical Comparison Between the Trapezius Transfer and Latissimus Transfer for Irreparable Posterosuperior Rotator Cuff Tears

*Primary Author: Reza Omid
Institution: University of Southern California*

Coauthors: Nathanael D. Heckmann (University of Southern California), Lawrence Wang (Orthopaedic Biomechanics Laboratory, VA Long Beach Healthcare System and University of California, Irvine), Michelle McGarry (Orthopaedic Biomechanics Laboratory, VA Long Beach Healthcare System and University of California, Irvine)

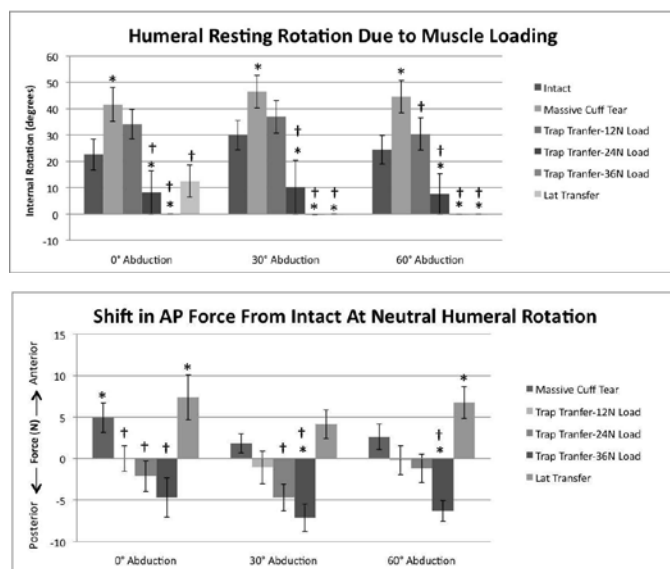
BACKGROUND: The purpose of this study was to compare the biomechanical effects of the trapezius transfer and the latissimus dorsi transfer in a cadaveric model of a massive posterosuperior rotator cuff tear.

METHODS: Eight cadaveric shoulders were tested at 0°, 30°, and 60° of abduction in the scapular plane. Rotational range of motion and humeral rotation angle due to muscle loading were measured. Glenohumeral kinematics and joint reaction forces were measured throughout the range of motion. After testing in the intact condition, the supraspinatus and infraspinatus were resected, simulating a massive rotator cuff tear. The lower trapezius transfer was then performed. Three trapezius loading conditions (12N, 24N, 36N) were applied to simulate lengthened, properly tensioned, and over-constrained grafts, respectively. Next the latissimus dorsi transfer was performed and tested. A repeated-measures analysis of variance was used for statistical analysis.

RESULTS: Internal rotation due to muscle loading increased with massive cuff tear at all abduction angles (p Conclusion: The lower trapezius transfer is biomechanically superior to the latissimus transfer in restoring native glenohumeral biomechanics and joint reaction forces.

CLINICAL RELEVANCE: The trapezius transfer may be an option for patients with massive cuff tears; clinical studies to evaluate the trapezius transfer are warranted.

LEVEL OF EVIDENCE: Basic Science Study



O8B5

Hydrodynamic Suture Passing: A New Concept, Demonstration of PASTA Repair

Primary Author: Andrew C. Kim

Institution: Rancho Valley Orthopaedic Surgery Medical Clinic, Inc.

INTRODUCTION: Suture passing into soft tissue is one of the main steps in arthroscopic soft tissue repair and reconstruction. The passage of sutures is currently carried out by mechanical delivery powered by mechanical force: for example, a rigid monofilament suture is pushed by mechanical force through a cannulated needle, and this rigid suture is used as a shuttle for a soft braided suture passage; direct carrying of a braided suture is done by flexible solid needle carrier pushed by finger in various clamp mechanisms.

Hydrodynamic suture passing is carried out by moving a braided suture through a cannulated needle by hydrodynamic force. In fluid filled environment of arthroscopic procedures, this is simple, fast, and natural.

Hydrodynamic suture passing has a number of advantages. One of the unique beneficial features is being able to move the suture in both directions (bi-directional) and to the desired length of the suture, quickly and easily. This unique character helps number of complex procedures to be done more simply: PASTA rotator cuff tendon repair, subscapularis tendon repair, remplissage procedure, labrum repair, meniscus repair of the knees, etc.

Hydrodynamic PASTA Repair, an Example: PASTA repair is done by first percutaneous insertion of a cannulated needle through the healthy portion of a partially torn supraspinatus; the suture is passed hydrodynamically until the half length is passed. Then the half length suture is grasped by a crabclaw clamp and brought out of the joint through a 6 mm diameter cannula which is placed at the anterior margin of the supraspinatus tendon next to the long head of biceps tendon. Next, (with the half length suture still in the lumen) the needle is pulled out of the tendon and walked over on the bursa side of the tendon surface. Then the remaining suture is passed hydrodynamically into the joint cavity. The second half of the suture is brought out through the 6 mm cannula, and now one pair of horizontal mattress suture is done. Same steps can be repeated to have more suture pairs, depending on the size of the tear. At this point,

the surgeon engages a knotless anchor of surgeon's choice, and deploys the anchor adjusting the tension of the suture to optimum as the anchor is deployed.

Footages of both conventional and hydrodynamic repair procedures will be demonstrated for comparison. It can be seen that hydrodynamic method eliminates many steps of the conventional method to make the procedure faster. The entire procedure is done with the scope maintained in the glenohumeral space without moving to subacromion space.

CONCLUSION: The hydrodynamic method of suture passing can be a valuable addition for PASTA repairs and other arthroscopic repair and reconstruction surgeries.

Patella: Small Bone, Big Concern?

O9A1

Patella Resurfacing: Is it Necessary?

Guest Faculty: Robert L. Barrack MD

Institution: Washington University School of Medicine, St. Louis, MO, USA

BACKGROUND: Patella resurfacing in TKA remains controversial. The purpose of this study was to compare the long-term clinical outcome in TKA in patients undergoing bilateral TKAs with one patella resurfaced and the other patella nonresurfaced.

METHODS: Twenty-nine patients (58 knees) underwent primary bilateral TKA for osteoarthritis. These patients were enrolled in a prospective randomized double blinded study and represent a subset of a larger study of patella resurfacing. All patients received the same posterior cruciate sparing TKA. Patients each had one knee randomized to treatment with or without patella resurfacing. The contralateral knee then received the alternative patellar treatment, such that all patients had one knee with a resurfaced patella and the other nonresurfaced. Clinical evaluations consisted of routine radiographic and clinical follow-up

and included with a Knee Society Score patellofemoral specific patient questionnaire. Twenty-eight patients (56 knees) participated and were followed for a mean of 118 months (range, 69-146 months).

RESULTS: There were no significant differences between the knees treated with and without patellar resurfacing with regard to range of motion, KSCRS, or the pain and function scores. Forty-six percent (13/28 patients) of patients preferred the resurfaced knee, 36% (10/28) the non-resurfaced knee, and 18% (5/28) had no preference. Two patients (7%) in the nonresurfaced group required revision for a patellofemoral related complication, compared to one patient (3.5%) in the group with a resurfaced patella.

CONCLUSIONS: Ten year follow-up reveals equivalent results for resurfaced and nonresurfaced patellae in TKA with regards to ROM, KSCRS, pain and function, or patellofemoral symptoms. In this large series of bilateral TKAs, 64% of patients either preferred the unresurfaced knee or had no preference.

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O9A2

Mechanics of Anatomic and Dome Patellae

Guest Faculty: Paul J. Rullkoetter, PhD

Institution: Center for Orthopaedic Biomechanics, University of Denver, Denver, CO, USA

Coauthors: Clare K. Fitzpatrick, PhD (Center for Orthopaedic Biomechanics, University of Denver, Denver, CO), Peter J. Laz, PhD (Center for Orthopaedic Biomechanics, University of Denver, Denver, CO)

INTRODUCTION: Complications related to the patellofemoral (PF) joint remain a common cause for revision of total knee arthroplasty. Design and relative alignment of patellar and femoral components have been identified as important factors impacting the kinematics, contact mechanics, and functional performance of the PF joint and ultimately, the long-term success of TKR. Anatomic components are thought to better replicate natural kinematics, while, intuitively, dome-compatible components eliminate a degree-of-freedom (DOF) that the surgeon must consider during patellar component alignment. In this study, a dynamic finite element (FE) model of the PF joint was used in combination with a probabilistic analysis to evaluate the effects of variation in component design, alignment, and loading on PF mechanics during a deep flexion activity.

METHODS: A previously-validated, dynamic finite element (FE) model of the PF joint was used to evaluate PF mechanics during deep flexion for dome, modified dome, and anatomic designs (Figure 1). Quadriceps loading was ramped to 2000 N at 120 degrees flexion. Probabilistic analyses were performed to investigate the effects of variability in patellar and femoral component alignment and quadriceps load distribution on predicted PF mechanics for each implant design. The probabilistic analyses included seven input parameters reported to affect PF mechanics: femoral internal-external (I-E) alignment, patellar I-E, flexion-extension (F-E), and adduction–abduction (A-A) alignments, patellar medial-lateral (M-L) and inferior-superior alignment, as well as percentage of the quadriceps load on the VMO tendon. Ten output parameters were evaluated over a 100-trial Monte Carlo simulation, including 6-DOF kinematics, peak PF contact pressure, contact area, peak von Mises internal stress, and M-L force due to contact. Model-predicted output bounds were determined for each output parameter throughout the range of femoral flexion, in addition to model sensitivities. Critical alignment and loading parameters were identified for each design, and subsequently compared between designs in order to identify design-specific differences.

RESULTS: Kinematic predictions for the dome produced substantially more I-E rotation than the anatomic design (range of motion (ROM) of the mean trial was 17, 11.5, and 8.5 degrees for dome, modified dome, and anatomic, respectively). The dome demonstrated the least amount of variation in contact mechanics and internal stresses with respect to alignment and loading variability. However, the anatomic design, while wide bounds of variability were

predicted, had consistently greater contact area and lower contact pressure than the dome (Figure 2). The anatomic component produced the least amount of patellar F-E (sagittal plane tilt); mean range of patellar F-E was 53, 47, and 39 degrees for the dome, modified dome, and anatomic components, respectively. Patellar flexion of the anatomic component was most influenced by F-E alignment, while the spherical dome was more influenced by S-I position. Femoral I-E alignment correlated strongly with a number of kinematic outputs as well as contact force, and was identified as the most influential parameter.

CONCLUSION: Patellar tracking and mechanics with the domed components should inherently be more robust to malalignment than the anatomic design due to a lack of rotary constraint and consistent contact regions between the constant radius patellar and femoral trochlear articulating surfaces. By comparison, the conforming anatomic patellar and femoral components were designed to more closely replicate natural tracking, including improved flexion-extension and internal-external rotation throughout flexion. Anatomic components will therefore be less robust to alignment perturbations than the domed design, as evidenced by greater output bounds across contact mechanics measures. However, despite alignment variability in the anatomic design, it consistently produced lower contact pressure and higher contact area across the probabilistic envelope in addition to the more natural tracking characteristics.

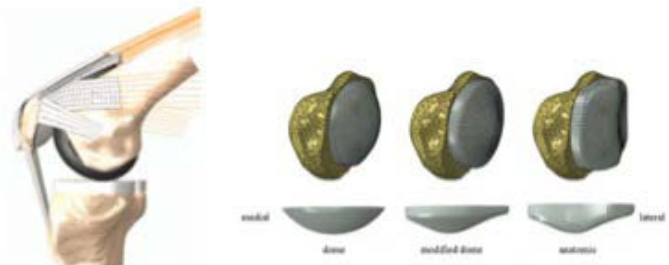


Figure 1. Computational model of the patellofemoral joint (left), dome, modified dome, and anatomic components (right).

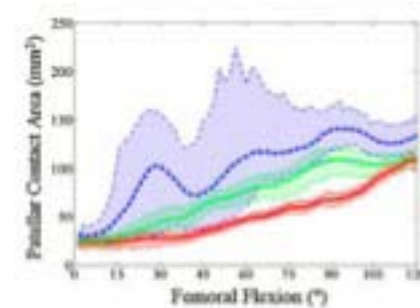


Figure 2. Mean curve and bounds of contact area for dome (red), modified dome (green), and anatomic (blue) components as a function of flexion angle with variable alignment parameters.

O9A3 To Resurface Or Not To Resurface – That IS The Question

Guest Faculty: Fred D. Cushner, MD

Institution: ISK Institute, New York, NY; NS - LIJ Orthopedic Institute, New York, NY, USA

INTRODUCTION: Orthopedic Surgeons like to debate the finer points of surgical technique. While topics such as how to handle the PCL, Ideal DVT Prophylaxis method, and favorite prosthesis may not have a clear debate winner, this is not true for the debate surrounding Patella Resurfacing. This talk will present the clear facts why resurfacing the patella is clearly the correct choice.

1. Bearing Surfaces: Do we really believe that cartilage on metal is a good long term bearing surface. Is this the type of bearing surfaces we want in the current TKA cohort population that is younger and heavier than patients in the past?
2. The cartilage at the patella is not normal. A recent study at our institution showed that even “normal” patella have significant pathologic changes
3. Anterior Knee pain- This is common following TKA in all patients and significantly increased in the obese patient. How does one distinguish anterior knee pain from pain from an unresurfaced patella
4. Second operations to resurface a patella are often unsuccessful
5. Patella Complication rate from resurfacing is low with several studies showing a 1% incidence
6. All Prosthesis Designs are not created equal. A patella friendly design is needed if patella resurfacing is not performed. Results from one study design does not mean success from another design
7. Meta-Analysis Results show higher revision rates with unresurfaced designs
8. Parvizi et al- Less patient satisfaction with unresurfaced patella
9. Pakos et al- Less reoperation and less anterior knee pain with resurfacing
10. Select Resurfacing- For young patients- Does this make sense? Once again, is cartilage on metal a good choice for patients where prosthesis will be present for 20-30 years
11. Bilateral Knee Studies- More favor the resurfaced knee

12. Swedish Registry Data- 1.4X higher revision rate with no patella resurfacing

So what are we trying to fix? Patella Complications are rare and most studies, Meta-Analysis Reviews and Registry Data favor Patella Resurfacing

O9A4 Total Knee Arthroplasty With or Without Patellar Resurfacing With Grade IV Osteoarthritis in Patellofemoral Joint

Primary Author: Jong-Keun Seon

Institution: Center for Joint Disease, Chonnam National University Hwasun Hospital

Coauthors: Eun-Kyoo Song (Center for Joint Disease, Chonnam National University Hwasun Hospital), Ha-Sung Kim (Center for Joint Disease, Chonnam National University Hwasun Hospital)

INTRODUCTION: Despite the excellent clinical success of total knee arthroplasty (TKA), controversy remains concerning whether or not to resurface the patella. This has led to a number of randomized controlled trials. Randomized controlled trials constitute the most reliable source of evidence for the evaluation of the efficacy of a potential intervention. But most of these studies include all degree of osteoarthritis of the patellofemoral joint. So we did this prospective study to compare clinical and radiological outcomes after TKA with or without patellar resurfacing in patients with grade IV osteoarthritis on patellofemoral joint.

MATERIALS AND METHODS: 123 cases (93 patients) with Kellgren-Lawrence grade IV osteoarthritis on patellofemoral joint were enrolled for this study. At the operating room, they were randomly assigned to undergo patella resurfacing (62 cases) or patella retention (61 cases). Among them, 114 cases that could be followed for more than 2 years were included in this study (resurfacing group; 59 cases, retention group; 55 cases). When patellar retention was performed, osteophytes of the patella were removed and marginal electrocauterization was carried out. Preoperative and postoperative clinical outcomes were evaluated and compared regarding the Hospital for Special Surgery Patellar (HSSP) score (total 100 point; anterior knee pain, functional limitation, tenderness, crepitus, Q-strength). We also compared Hospital for Special Surgery (HSS) and

WOMAC scores, and range of motion (ROM). We also compared radiological outcomes at the final follow up, with regards to mechanical axis of the lower limb, patella tilt and patella congruence angle between two groups. Results: Average HSSP score was 85 in resurfacing group, 83 in retention group, which were showing no significant differences between groups ($p=.75$). Anterior knee pain subscale also showed no significant differences between groups (40 in resurfacing group, 36 in retention group, $p=0.52$). HSS score improved to 94 points in resurfacing group and 95 points in retention group showing no significant difference ($p=.92$). While WOMAC score and range of motion was 32 point and $128 \pm 10.5^\circ$ in resurfacing group, respectively, they were 29 point and $126 \pm 11.5^\circ$ in retention group, without significant inter-group difference ($p>.05$). There were no differences between two groups in mechanical axis of the lower limb and patella tilt, patella congruence ($p>.05$).

CONCLUSION: Clinical and radiological outcomes were ‘good’ after TKA with or without patellar resurfacing in patients with high grade osteoarthritis of the patellofemoral joint without significant differences. Thus, this study suggested that TKA without patellar resurfacing is a good treatment option in patients with high grade osteoarthritis of the patellofemoral joint.

O9A5 Patella Implants Option for Treatment of TKA Patients with Patella Baja

Primary Author: Abraham P. Wright

Institution: DePuySynthes

Coauthors: Chadd W. Clary (DePuySynthes), Clare K. Fitzpatrick (University of Denver), Paul J. Rullkoetter (University of Denver)

INTRODUCTION: Patella baja has been identified as a risk factor for issues related to total knee arthroplasty (TKA), including patella crepitus and clunk [1] and reduced extensor mechanism efficiency [2-4]. In addition, studies have shown that surgical technique and implant design interacts with patella baja in a manner that has the potential to either attenuate or improve implant performance [1, 2]. The purpose of this study was to utilize a computational model to investigate the potential for reduced crepitus risk and improved extensor efficiency of a novel an-

atomic-style patella implant compared to a dome-style patella.

METHODS: A validated finite element model of a cadaveric knee in the Kansas Knee Simulator (KKS) was utilized (Abaqus, Simulia) [1, 5]. The extensor mechanism was modeled as fiber-reinforced composite structures, capable of wrapping around the implant. A deep knee bend (DKB) was performed to 120° knee flexion during which composite contact between the quadriceps and femoral component was measured. In addition, an “effective” moment arm was calculated by dividing the incremental quadriceps elongation by the corresponding increase in flexion. Posterior stabilized TKA components (ATTUNE™ Knee System, DePuy Synthes, Warsaw, IN) with two designs of patella components were tested. The medialized dome patella had an axisymmetric convex articular surface whereas the medialized anatomic patella had a concave lateral surface and convex medial surface (Fig. 1). Three different patella locations were examined to assess implant performance in patella baja.

RESULTS: With patella baja, the results demonstrated an increase in soft-tissue contact area and a decrease in extensor mechanism efficiency in mid to deep flexion. The anatomic patella experienced reduced patellar flexion (wrt tibia) (Fig. 2), resulting in less overall soft-tissue contact and less contact at matching tibiofemoral flexion points than the medialized dome. The composite contact results for the medialized dome (Fig. 1, bottom) and the anatomic component (Fig. 1, top) show that both components prevented contact around the entrance to the inter-condylar box. The extensor mechanism efficiency was increased with the anatomic patella in deeper flexion, with a 4.7% reduction in quadriceps force at 90° flexion.

DISCUSSION: Our results demonstrated that patients with patella baja have more soft-tissue contact with the femoral component, and are therefore more at risk of painful crepitus [1]. Implant design is one factor that may help reduce the potential for crepitus by preventing soft-tissue contact in the critical regions surrounding the entrance to the inter-condylar box. The anatomic patella reduced soft-tissue contact by reducing patellar flexion and thereby moving the quadriceps tendon away from the femoral component. Our results also demonstrated that patella baja reduced extensor mechanism efficiency in mid to deep flexion, and that the anatomic patella increased efficiency in deep flexion. Based on these findings, surgeons may consider the

anatomic patella as a treatment option for TKA patients with patella baja.

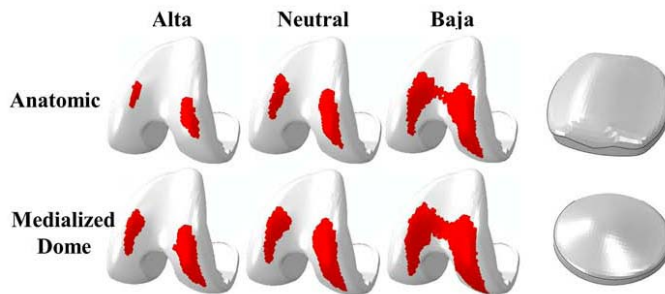


Figure 1: Composite contact areas between the quadriceps tendon and the femoral component for the Attune PS femur with the Anatomic (Top) and Medialized Dome (Bottom) patella components. The patella components are shown enlarged relative to the femoral components to illustrate geometric differences between the two designs.

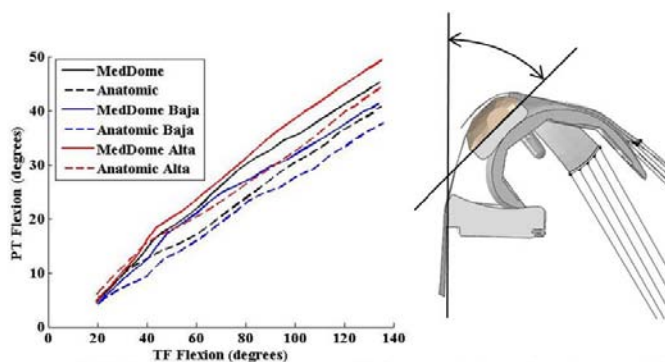


Figure 2: Graph (left) shows relationship of PT Flexion (patellar flexion wrt tibia) to TF Flexion between medialized patella and anatomic patella component. Image (right) illustrates the PT flexion measurement.

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O9A6

A Novel Freehand Technique for Osteotomizing the Patella in Total Knee Arthroplasty

Primary Author: John Hollingdale

Institution: Central Middlesex Hospital

Coauthors: Angelos Assiotis (Central Middlesex Hospital), Simon Mordecai (Hillingdon Hospital)

Patellar resurfacing, in the context of total knee replacement (TKR), has been subject to controversy for several years. There is however evidence that it reduces anterior

knee pain and the rate of re-operation after TKR. Manufacturers have developed several cutting jigs in order to ensure accurate resection of the patellar articular surface. These jigs make patellar eversion necessary in order to be applied on the bone and also the plane of the resection is not referenced off any fixed anatomical landmark.

Although other freehand techniques have been described in the literature, we describe a reproducible method of performing the patellar resection that allows for an accurate cut. Furthermore, the patella resection plane is parallel to the trochlea, something that may be difficult to achieve with various cutting jigs. The final significant advantage of the described technique lies in avoiding eversion of the patella, with several articles in the literature reporting better range of movement, a reduced risk of patellar tendon injury and reduced post-operative pain when compared with techniques that involve patella eversion.

The femoral trial implant is inserted and the knee flexed at 30°. Patellar thickness is measured with calipers and the level of resection marked along the long axis of the bone with diathermy. A metal ruler is inserted between the distal femur and femoral trial and this will be parallel to the newly resurfaced patello-femoral joint. The patella is not everted; instead, it is stabilised in the trochlear groove with two towel clips by the assistant and the resection performed with an oscillating saw at the marked level, with the blade parallel to the ruler (Fig.1). The patella is prepared as normal thereafter. Currently all patients requiring patellar resurfacing in our institution are undergoing this technique and the short term results are very promising.

In conclusion, we describe a new reproducible technique for patellar resection that does not depend on jigs and utilises a fixed anatomical landmark. It can be performed simply with the use of calipers, a ruler and a saw, regardless of the set used for the TKR. Avoiding patellar eversion puts less strain on the extensor mechanism and is an added benefit.



O9A7

Length Change Behavior of Native Medial Patellofemoral Ligament Fiber During Knee Flexion: An In Vivo Study

Primary Author: Si Young Song

Institution: Dongtan Sacred Heart Hospital, Hallym University College of Medicine

Coauthors: Kyo-Chul Noh (Kangnam Sacred Heart Hospital), Young-Jin Seo (Dongtan Sacred Heart Hospital)

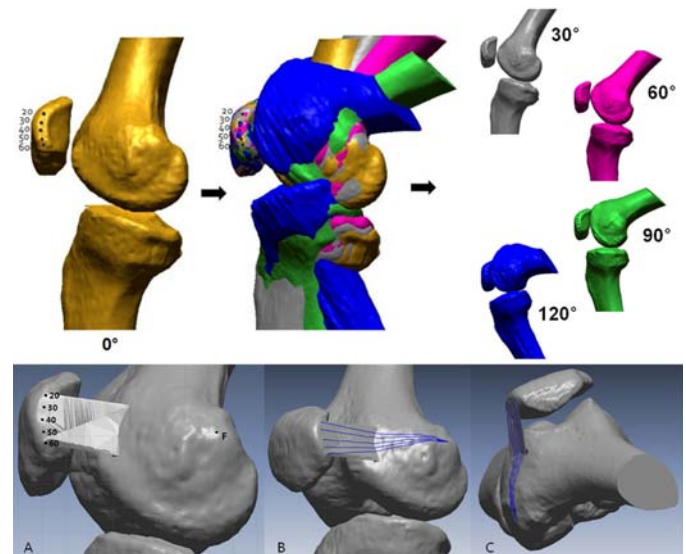
INTRODUCTION: To date, in vivo length change behavior of native MPFL fibers throughout the range of knee motion still remains to be clarified. We hypothesized that the native MPFL does not behave as a simple bundle of fibers with constant length but as a continuum of ligament fibers with differential length change during knee flexion. The purposes of this study were to (1) measure the length changes of the native MPFL fibers, and (2) determine the length change behavior for the MPFL fibers during knee flexion in vivo.

METHODS: The subject comprised eleven male volunteers with no history of knee pathology. The mean age was 32.0 ± 3.9 years. The right knee of each subject was scanned with a CT scanner at five different knee flexion angles (0° , 30° , 60° , 90° and 120°). Customized software was used to create, manipulate, and analyze the 3D model. The 3D knee model at 0° of flexion was chosen as a reference. On the patellar side, five points were determined: 20% (point 20), 30% (point 30), 40% (point 40), 50% (point 50) and 60% (point 60) from the superior pole of the patella. On the femoral side, femoral insertion point

(point F) described by Schoettle et al was marked at translucent 3D image model of a true lateral view of the knee. The patellar model at 0° of flexion was superimposed on each discrete patellar model at 30° , 60° , 90° , and 120° of flexion.[Fig.1] Using this process, identical patellar points were automatically established on the 3D models at 30° , 60° , 90° , and 120° of flexion. Identical femoral points on the 3D models at 30° , 60° , 90° , and 120° were established using the same method. The shortest line which connects these attachment sites was designated as the MPFL fiber. We created 5 virtual fibers which connects these points, and digitally measured the length of the different fibers. [Fig.2]

RESULTS: Throughout the knee flexion-extension arc, the average length changes were 9.1 ± 2.5 mm in F20, 9.1 ± 2.5 mm in F30, 8.1 ± 2.6 mm in F40, 6.9 ± 2.4 mm in F50, and 6.9 ± 1.7 mm in F60. However, length changes in these five fibers were not significantly different. ($P = 0.08$) Regarding the length change pattern, the lengths of two superior fibers (F20 and F30) and a middle fiber (F40) increased as the knee flexed from 0° to 30° , and decreased beyond 30° of flexion. In contrast, in two inferior fibers (F50 and F60), F50 showed an increase during flexion from 0° to 30° , and then plateau pattern from 30° to 60° , and a decrease from 60° to 120° . F60 showed an increase during flexion from 0° to 60° and a decrease during further flexion.

CONCLUSION: Superior and middle fibers exhibit their maximal length at low flexion angles, and inferior fibers exhibit their maximal length at mid-flexion angles. The MPFL is not a single bundle structure but a complex of functionally various fibers with some taut and others slack.



Specialized Hip Procedures

O9B1

Harnessing the Regenerative Power of the Periosteum: Surgical and Scientific Perspectives

Primary Author: Melissa L. Knothe Tate

Institution: University of New South Wales, Graduate School of Biomedical Engineering

Coauthor: Ulf R. Knothe (Cleveland Clinic)

A recent study from hip replacement patients shows that stem cells derived from the periosteum of the femoral neck share similar regenerative properties to marrow derived stem cells. This talk looks prospectively at the intersection of joint replacement and regenerative medicine in context of a series of research studies in an ovine critical sized femoral defect model, where periosteum or periosteum substitute seeded with periosteum derived cells shows remarkable capacity for osteo- and chondrogenesis.



ICJR Pan Pacific Clinical Science Research Award Winner

O9B2

Ceramic-on-Ceramic and Ceramic-on-Highly Cross-Linked Polyethylene Bearing in Patients Younger Than Thirty Years of Age

Primary Author: Young-Hoo Kim

Institution: The Joint Replacement Center of Korea Ewha Womans University MokDong Hospital

Coauthors: Jang-Won Park (The Joint Replacement Center of Korea Ewha Womans University MokDong Hospital)

BACKGROUND: Very few studies have performed alumina-on-alumina ceramic and alumina-on-highly cross-linked polyethylene bearing in patients younger than thirty years of age. The purpose of this prospective randomized study was to compare the clinical and radiographic results as well as osteolysis prevalence of cementless total hip ar-

throplasty using an alumina-on-alumina and alumina-on-highly cross-linked polyethylene bearing in young active patients.

METHODS: We prospectively studied the two groups of patient cohorts. In one group, we prospectively compared the results of 100 patients (200 hips) who had undergone a cementless total hip arthroplasty with an alumina-on-alumina ceramic bearing at one hip and an alumina-on-highly cross-linked polyethylene at the other. There were 66 men and 34 women with a mean age of 28.9 years. (range, 21 to 29 years). The mean follow-up was 13.5 years (range, 11 to 14 years). In another group, we prospectively studied 50 patients (60 hips) younger than 30 years of age who underwent cementless total hip arthroplasties using an alumina-on-highly cross-linked polyethylene. Hip score, functional activity, incidence of osteolysis and aseptic loosening were studied. There were 34 men and 16 women with a mean age was 28.3 years (range, 21 to 29 years). The mean follow-up was 11.8 years (range, 11 to 13 years).

RESULTS: In the first group, Harris hip, Western Ontario and McMaster Universities Osteoarthritis Index scores did not show significant differences between the two groups of bearing. Radiographic findings were similar between the two groups. The mean polyethylene linear penetration was 0.032 ± 0.005 mm per year. No hips in either group displayed osteolysis. Survivorship with revision as the end point at 13.5 years was 100% for the femoral component in both groups and 99% for the acetabular component. In the second group, the mean preoperative Harris hip score was 38 points, which was improved to 95 points (range, 85 to 100 points) at the 11.8 years. The mean polyethylene linear penetration was $0.031 \text{ mm} \pm 0.005 \text{ mm}$ per year. No hip had osteolysis or aseptic loosening.

CONCLUSIONS: The clinical and radiographic results of using an alumina-on-alumina ceramic and alumina-on-highly cross-linked polyethylene bearing have been functional well without osteolysis at a 11 years minimum and a mean of 12.7 years follow-up in patients younger than 30 years old.

O9B3**Failure Of The Tantalum Rod For management Of Early Femoral Head Necrosis***Primary Author: Wael S. Abdelmegied**Institution: Ain Shams University, Cairo, Egypt**Coauthors: Ayman A. Bassiony (Ain Shams University, Cairo, Egypt), Mohamed K. Asal (Ain Shams University, Cairo, Egypt)*

BACKGROUND: Conventional core decompression is a well known procedure for treatment of avascular necrosis of the femoral head. Weight bearing are usually restricted in the early weeks postoperative to avoid the risk of fracture. Implantation the new tantalum rod after reaming of the necrotic area is supposed to give the advantages of decompression, support necrotic area from collapse, lower the risk of subtrochanteric fracture and allow for the early weight bearing. The objective of this study is to evaluate the effectiveness of use of the tantalum rode in management of early stages avascular necrosis.

PATIENTS AND METHODS: Twenty patients were treated with core decompression and implantation of a tantalum rod with mean age of 30.4 years. The cases were evaluated radiologically by X-rays, C-T and MRI. The etiology included 16 cases idiopathic and four patients corticosteroid induced. According to the classification system of Steinberg fifteen hips had stage-II disease, and five hips had stage-III disease.

RESULTS: The Harris Hip score was improved from 42.5 (range from 23 to 60) preoperatively to an average of 77.5 (range from 34 to 95) at 6 weeks postoperatively. A progressive deterioration of the results over time. At the last follow up of 2 years, twelve patients underwent total hip replacement with failure rate of 60% because of persistent pain and failure of the rod to prevent the head collapse and intraarticular penetration (figure 1).

CONCLUSION: Core decompression and implantation of porous tantalum rod for avascular necrosis of the femoral head gives no more advantage over core decompression only in the midterm follow up. The results were deteriorating over time with conversion to total hip arthroplasty without a significant technical challenge (figure 2).

**O9B4****Treatment of Extensively Involved Femoral Head Osteonecrosis in Adolescents by High Degrees Posterior Rotational Osteotomy***Primary Author: Takashi Atsumi**Institution: Department of Orthopaedic Surgery, Showa University Fujigaoka Hospital**Coauthors: Satoshi Tamaoki (Department of Orthopaedic Surgery, Showa University Fujigaoka Hospital), Ryosuke Nakanishi (Department of Orthopaedic Surgery, Showa University Fujigaoka Hospital), Minoru Watanabe (Department of Orthopaedic Surgery, Showa University Fujigaoka Hospital)*

The necrotic focus of the femoral head is predominantly located in the loaded portion. If lesion size is extensive in

loaded portion, the femoral head will usually progress to collapse. Preservation of the joint is viewed as important to avoid joint replacement procedures in young patients, especially in adolescents. However, joint preservation of femoral head necrosis with extensive collapsed lesions in adolescents is usually difficult. We evaluated the effectiveness of the use of a high degrees posterior rotational osteotomy in this patient population.

Methods and Patients: We reviewed 33 hips of 31 adolescent's patients with severe femoral head necrosis treated by high degrees posterior rotational osteotomy with a mean of 6.2 year follow-up (range; 2-18 years). The mean age of patients was 14 years, with 15 girls and 16 boys. Eleven patients had history of steroids administration, 10 were followed by slipped capital femoral epiphysis, 8 were followed by femoral neck fracture, remaining 4 were Perthes' disease. Apparent collapse (greater than 3 mm) was noted in 31 hips preoperative AP radiographs. Fifteen hips showed joint space narrowing. All hips showed extensive lesion below the acetabular loaded portion. No viable area was seen on 29 hips on AP radiographs, Lateral small viable area was disclosed on 4 hips. Of the anterior or posterior viable area on correct lateral radiographs, viable area was noted on less than one third on both anterior and posterior portion in all 33 hips. Mean posterior rotational angle was 117 degrees, with a mean of 18 degrees of additional intentional varus position. We studied the extent of viable areas below acetabular roof on AP radiograph and 45°flexion AP radiographs during 3 months after operation. Post-operative bony scintigraphy (6 weeks), Prevention from re-collapse, Progressive joint space narrowing were also investigated.

O9B5

The Prevalence of Acetabular Retroversion in Asymptomatic Adults

Primary Author: Georgi I. Wassilew

Institution: Charite University Hospital - Berlin, Germany

Coauthors: Carsten Perka (Charite University Hospital - Berlin, Germany), Viktor Janz (Charite University Hospital - Berlin, Germany)

INTRODUCTION: Acetabular retroversion has been implicated as a risk factor for the development of early hip osteoarthritis. In clinical practice standard osseous signs

such as the cross-over sign (COS) and the posterior wall sign (PWS) are widely used to establish the diagnosis of acetabular retroversion on plain radiographs. Despite standardized radiological evaluation protocols, an increased pelvic tilt can lead to a misdiagnosis of acetabular retroversion in AP radiographs and 2D MR or CT scans. Previous studies have shown that the elimination of observer bias using a standardized methodology based on 3D-CT models and the anterior pelvic plane (APP) for the assessment of COS and PWS results in greater diagnostic accuracy. Using this method a prevalence of 28% for COS and 24% for PWS has been found in a cohort of patients with symptoms indicative of FAI, however the prevalence of both signs in asymptomatic adults remains unknown. This study therefore sought to establish the prevalence of the COS and PWS in relation to the APP in an asymptomatic population using a reliable and accurate 3 D-CT based assessment.

METHODS: A large pool of consecutive CT scans of the pelvis undertaken in our department for conditions unrelated to disorders of the hip was available for analysis. Scans in subjects with a Harris hip score of less than 90 points were excluded leaving a sample of 100 asymptomatic subjects (200 hips) for this study. A previously established 3D analysis method designed to eliminate errors resulting from variations in the position and orientation of the pelvis during CT imaging was applied to determine in order to assess the prevalence of the COS and PWS in relation to the APP. Here, the acetabuli were defined as retroverted if either the COS, PWS or both were positive.

RESULTS: From the total of 200 hips a positive COS was identified in 24% (48/200) and a positive PWS was detected in 6.5% (13/200) relative to the APP using the CT data. A. In male adults a COS was observed in 25.4% (29/114) and a PWS in 10.5% (12/114). In female adults a COS were observed in 22.1% (19/86) and a PWS in 1.2% (1/86).

DISCUSSION: The high incidence of acetabular retroversion observed using an accurate 3D-CT based methodology shows that this anatomic configuration might not differ in frequency between asymptomatic individuals and patients with symptomatic FAI. Patients presenting with hip pain and evidence of FAI should therefore be subjected to strict diagnostic scrutiny, as the presence of a COS and/or PWS shows a poor correlation with the presence of symptomatic disease. In our collective of asymptomatic adults the COS showed a higher incidence than the PWS.

Additionally a deficiency of the posterior acetabular wall was rare in asymptomatic adults compared to FAI patients. Therefore, the question whether an abnormal acetabular version does indeed lead to the development of osteoarthritis in all patients warrants further study. Although an association between osteoarthritis and femuro-acetabular impingement is believed to exist, long-term epidemiological studies are needed to establish the natural history of these anatomical configurations.

O9B6

The Use of Receiver Operating Characteristics Analysis in Determining Cut-off Value of D-dimer for Prediction of Calf Intermuscular Deep Vein Thrombosis After Total Hip Arthroplasty

Primary Author: Qinsheng Hu

Institution: Department of Orthopaedics, West China Hospital, Sichuan University

Coauthors: Bin Shen (Department of Orthopaedics, West China Hospital, Sichuan University), Jing Yang (Department of Orthopaedics, West China Hospital, Sichuan University), Zongke Zhou (Department of Orthopaedics, West China Hospital, Sichuan University), Pengde Kang (Department of Orthopaedics, West China Hospital, Sichuan University)

OBJECTIVE: D-dimer testing is suggested as a recommended option for predicting of suspected DVT, but no clear cut-off values about calf intermuscular DVT have been defined. The current study aimed to determine the cut-off values of D-dimer for prediction of calf intermuscular DVT after THA and evaluate its clinical significance.

METHODS: 108 patients underwent primary THA by the same surgeon were included in current study, using the same incision and prosthesis. Color duplex ultrasonography (US) was performed preoperatively and 5 d postoperatively in order to detect any evidence of DVT of the lower limb. All the preoperative US results were negative. All patients were grouped into thrombosis (n=28) and not thrombosis groups (n=80) according to the 5 d US results. Plasma D-dimer was measured preoperatively and 1 d, 3 d, 5 d postoperatively. Receiver operating characteristics (ROC) analysis was performed according to the results.

RESULTS: Comparing with the not thrombosis group, postoperative D-dimer value of thrombosis group increased significantly at each time point ($P < 0.01$), and the peak value got at postoperative 1 d: the not thrombosis group 4.94 ± 1.27 mg/l, the thrombosis group 8.96 ± 1.67 mg/l ($P < 0.01$). ROC curve showed that D-dimer less than 5.9 mg/l at day 1 after surgery, or less than 4.1 mg/l of D-dimer at day 3 excluded DVT.

CONCLUSION: Calf intermuscular DVT should not be ignored, appropriate cut-off values of D-dimer is useful for the prediction and exclusion of calf intermuscular DVT after THA surgery. D-dimer in Calf intermuscular DVT patients is different from the theoretical cut-off values. Cut-off value analyzed in this study has high sensitivity and specificity for detecting Calf intermuscular DVT.

O9B7

Reconstruction for Proximal Medial Segmental Defect of Femur Using Metal Mesh and Impacted Morselized Allograft

Primary Author: Toshiki Iwase

Institution: Hamamatsu Medical Center

Coauthors: Tadashi Ito (Hamamatsu Medical Center), Daigo Morita (Hamamatsu Medical Center)

INTRODUCTION: Segmental defects of the femur present a major problem during revision hip arthroplasty. In particular, proximal medial segmental defect may compromise initial and long-term femoral stem stability.

OBJECTIVE: The objective of the present study is to assess mid-term follow-up results at least two years after femoral revision comprising reconstruction for proximal medial segmental defect using metal mesh and impacted morselized allograft.

METHODS: We performed 28 femoral revisions with reconstruction for proximal medial segmental defect in 25 patients between 2002 and 2011. The average age was 69.0 years, and the average follow-up period was 5 years and 10 month. All surgeries were performed using a cemented polished collarless tapered stem. The proximal medial segmental defect was reconstructed with metal mesh with doubled stainless wires. Large sized morselized cancellous allograft was tightly impacted into the cavity between the

phantom stem and the metal wire mesh (Fig.1). Nineteen hips were reconstructed with impaction bone grafting of the femur, and 7 hips with cement-in-cement technique except for the reconstructed proximal medial segmental defect region.

For clinical assessment, Merle d'Aubigné and Postel hip scores were recorded. For radiological assessment, antero-posterior hip radiographs were analyzed pre-operatively, and post-operatively at one month, 6 months and every 6 months thereafter. Clear lines around the femoral component using Gruen zone classification, stem subsidence in cement mantle, and change of stem axis were recorded. Kaplan-Meier survival analyses were performed with any re-operation of the femoral component or aseptic loosening as end points.

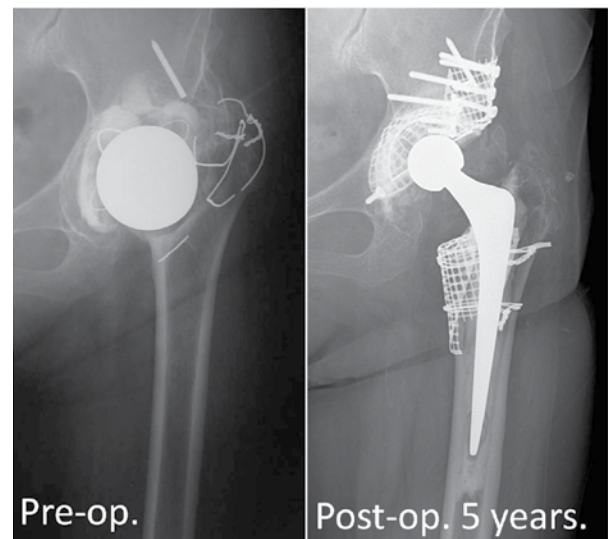
In one case, the histological appearance of a biopsy specimen of the most proximal part of the reconstructed region, which was obtained at a later surgery for infection at 4 years after the revision, is described.

RESULTS: For clinical assessment, the mean Merle d'Aubigné and Postel hip scores improved from 11.0 points before the operation to 14.9 points at the final follow-up. For radiological assessment, no clear lines at the cement-bone interface and no stem axis changes were detected. Twenty-seven of 28 hips showed less than 2 mm of stem subsidence at the final follow-up and one hip showed 2.2 mm stem subsidence. Both hips of one female patient underwent a one stage stem exchange because of an infection that occurred 48 months after revision. No cases showed aseptic loosening up to and including the last follow-up.

The Kaplan-Meier survival analysis revealed that the survival rate at five years after revision was 90.7% with any type of re-operation on the femoral side as the endpoint and 100% with aseptic stem loosening as the endpoint, respectively. A biopsy specimen taken from the most proximal part of the reconstructed region at 4 years after surgery in the infected case showed almost complete regeneration of viable bone with normal marrow spaces with partially formed granulation tissue.

CONCLUSION: Reconstruction using metal mesh and tightly impacted morselized allograft is a favorable method for the correction a proximal medial segmental defect. The procedure is simple and reliable, achieving initial and

mid-term stem stability even for femurs with a complete proximal medial segmental defect.



O9B8 Diagnostic of Sports Groin Pain Syndrome

Primary Author: Oleksandr Kostrub

Institution: State Institution Institute of Traumatology and Orthopedics Academy of Medical Sciences of Ukraine

Coauthors: Roman Blonskyi (State Institution Institute of Traumatology and Orthopedics Academy of Medical Sciences of Ukraine), Ivan Zasadnyuk (State Institution Institute of Traumatology and Orthopedics Academy of Medical Sciences of Ukraine)

INTRODUCTION: Sports Groin Pain Syndrome (SGPS) represents 5 – 11.2% of all sports injuries. Groin Pain Syndrome (GPS) occurs and localises depending on the type of sports activity undertaken and occurs most frequently in team sports such as football, hockey, etc.

MATERIALS AND METHODS: In the period from 2004 to 2013 we thoroughly examined 286 patients with Groin Pain Syndrome that underwent treatment at the Clinic of Sports and Ballet Injuries SI “Institute of Traumatology and Orthopedics National Academy of Medical Sciences of Ukraine”, Kyiv, and divided them into 7 groups depending on the localization of the pathological process:

1. Tendogenous – injury of tendons of adductor thigh muscles, or oblique and rectus abdominis muscle, etc. (139 patients);

2. Myogenous – partial or complete injuries of m. iliopsoas, m. mm. adductor longus et brevis, m. gracilis, to the distal part of m. rectus abdominis, to the front of m. adductor magnus, and proximal of m. rectus femoris (24 patients);
3. Arthrogenous – traumatic injuries of the articular lip of the hip joint, traumatic defects of acetabular articular cartilage and femoral head, loose osteocartilaginous fragments, injury of coxofemoral joint (34 patients);
4. Osteogenous – traumatic and stress fractures of proximal femur and pelvic bones (9 patients);
5. Symphogenous – pubic symphysis, pubic symphysis instability, etc. (32 of patients);
6. Inguinal – sports hernia (41 patients);
7. Neurogenous – post-traumatic neuropathy: n. ilioinguinalis, iliohypogastricus, geni-tofemoralis etc. (7 patients);

FINDINGS: The SGPS diagnosis was established based on the medical history, the results of clinical and equipment-based examinations as well as differential diagnostics with other syndromes and diseases. The most informative equipment-based examinations were MRI (accuracy – 89%) and sono-graphic screenings (accuracy – 84%), less informative – X-ray (12%) and spiral CT (23%). To improve the SGPS diagnostics accuracy we have developed an MRI examination method that applies colour mapping. This examination method applies digital processing of standard MRI images in PD FS (Proton Density Fat Saturation) using PC software that transforms different gray shades into various colour ranges. Thus, improving the differentiation of finer tendon changes, the difference between various gray shades is less perceivable by the eye, whereas the differences between various colours is more clearly perceived by the eye to allow achieving the SGPS diagnostics accuracy of up to 98%.

Patients with intra-articular hip injuries were subjected to therapeutic and diagnostic arthroscopy. The medical conditions for hip arthroscopy were as follows:

1. Injury of acetabular articular lip (14 patients)
2. Injury of acetabular articular cartilage (9 patients)
3. Injury of the articular cartilage of femoral head (4 patients)
3. Injury of the round ligament of femoral head (2 patients)
4. Loose osteocartilaginous fragments (3 patients)

CONCLUSIONS: In our opinion, by far the most promising way to solve this problem is by clear diagnostics of the pathological process and the timely and adequate, pathogenesis-based mini-invasive treatment of patients using endoscopic equipment and advanced medical practices.

Knee Kinematics I

O11A1

Preoperative Knee Kinematics Robustly Correlates with Postoperative Knee Kinematics in Total Knee Arthroplasty

Primary Author: Tokifumi Majima, MD, PhD

Institution: International University of Health and Welfare, Asushiobara City, Japan

We have previously reported that patients who demonstrated medial pivot kinematics pattern after total knee arthroplasty (TKA) had better clinical results than that of non-medial pivot pattern. However, it is unclear how preoperative kinematics pattern affects postoperative knee kinematics. The aim of this study was to evaluate the relationship between preoperative and postoperative knee kinematics pattern in TKA.

This is a study of 38 patients with medial osteoarthritis who underwent a primary TKA using a CT-based navigation system from July 2010 to September 2012. All the operations were performed by a single surgeon using a subvastus approach and the same posterior cruciate ligament substituting type (PS type) of prosthesis (Genesis II™ total knee system, Smith & Nephew, Memphis, TN). The proximal tibia osteotomy and the distal femur osteotomy were set on the navigation system perpendicular to the mechanical axis in the coronal plane with 3° tibial posterior inclination in the sagittal plane. The coronal plane ligament imbalance was corrected until the gap imbalance was fewer than 2 mm. This gap balance was checked using a ligament balancer (Smith & Nephew) at 80 N in medial and lateral compartment of the knee. The navigation system was used to measure the flexion gap with the CAS ligament balancer (Depuy, Warsaw, IN, USA) at 90° knee flexion. The amount of external rotation on femoral osteotomy

was adjusted by the navigation system with a balanced gap technique. The patella was resurfaced and a lateral release was not performed. We measured each kinematics pattern immediately after capsule incision (preoperative knee kinematics) and after implantation (postoperative knee kinematics) in TKA. Subjects were divided into two groups based on kinematics patterns: a medial pivot group (group M) and a non-medial pivot group (group N). A chi-square test was used for statistical analysis. P values less than 0.05 were considered significant.

There were 19 knees in group M and 19 knees in group N at preoperative knee kinematics measurement. Nineteen knees in group M at preoperation resulted in 14 knees in group M and five knees in group N at postoperative knee kinematics measurement. On the other hand in group N at postoperation. Preoperative knee kinematics significantly correlates with postoperative knee kinematics ($P < 0.01$). Our results suggest that preoperative knee kinematics robustly impacted upon postoperative knee kinematics in most cases.

In conclusion, this study revealed that a precise bone cut assisted by a navigation system and a modified gap technique could not improve the knee kinematics pattern in most cases. Further technical improvement or a new implant design is required to correct preoperative abnormal knee kinematics in TKA.

O11A2

In Vivo Kinematics for Customized, Individually Made vs. Traditional TKA During a Deep Knee Bend and Rising From a Chair

Guest Faculty: Harold E. Cates, MD

Institution: Center for Musculoskeletal Research, University of Tennessee, Knoxville, TN, USA

Coauthors: Matthew Anderle, BS; William H. Hamel, PhD; Adrija Sharma, PhD; Richard D Komistek, PhD

INTRODUCTION: Previous fluoroscopic studies were conducted using a stationary fluoroscopy unit that was not able to track the full movement of a patient. More recently, a mobile fluoroscopy unit was developed that can be utilized to capture subjects performing unconstrained motions that more accurately replicate the everyday demands that patients place on their operated knees. The objec-

tive of this study was to determine the in vivo kinematics for subjects having either a customized individually made (CIM) posterior cruciate retaining implant or a traditional posterior cruciate retaining (CR) TKA while performing both a deep knee bend to maximum knee flexion and while rising from a chair.

METHODS: Twenty subjects, having either a CIM or traditional CR knee implants, implanted by the same surgeon, were assessed in this study. Ten subjects had a CIM CR total knee arthroplasty (TKA) and 10 were implanted with a traditional-type CR TKA. Fluoroscopic videos were captured for the patients, while they performed both a deep knee bend to maximum knee flexion and while performing a chair-rise under mobile fluoroscopic surveillance. Each video was digitized, corrected for distortion, and then analyzed to determine kinematics using a 2D to 3D image registration technique.

RESULTS: Subjects in this study having a CIM TKA achieved greater axial rotation and more normal-like femorotibial contact patterns. During a deep knee bend, on average, subjects having a CIM TKA experienced -3.5 mm of posterior femoral rollback compared to only -1.3 mm for subjects having a traditional TKA. The average amount of axial rotation was similar for the two groups (CIM = 4.6o, Traditional = 4.4o). However, all subjects having a CIM CR TKA experienced posterior femoral rollback of their lateral condyle, while 50% of the subjects having a traditional CR TKA experienced an anterior slide of their lateral condyle during flexion, consistent with a paradoxical rollback opposite the normal knee. During a chair-rise, on average, subjects having a CIM CR TKA experienced 5.3 mm of roll forward for their lateral condyle, while this amount was only 2.5 mm for a traditional CR TKA. Also, subjects having a CIM CR TKA experienced, on average, 10.6o of normal axial rotation, while subjects having a traditional CR TKA experienced only 6.7o. During a deep knee bend, subjects having a CIM CR TKA achieved 106o of weight-bearing knee flexion, while subjects having a traditional CR TKA achieved only 103o.

CONCLUSION: Previous to the introduction of CIM TKA, knee implants were designed based on J-curves that had been derived from anatomic averages in order to fit a majority of the population. More recently, an implant has been designed based on the anatomical geometry for each individual patient correcting any underlying deformities (flattening, osteophytes, etc.). In this study, patients

having a CIM CR TKA seemed to experience a benefit as they achieved more normal-like kinematic patterns. During both a deep knee bend and rising from a chair, subjects having a CIM CR TKA achieved more normal motion of their lateral condyle and greater magnitude of axial rotation. Most interesting was the fact that all subjects having a CIM CR TKA experienced normal motion of their lateral condyle, while 50% of the subjects having a traditional CR TKA experienced an anterior slide of their lateral condyle during a deep knee bend consistent with a paradoxical roll-back, opposite of the motion pattern of the normal knee.

O11A3

In Vivo Kinematics of Fixed vs Mobile Bearing Revision TKA for Weight-Bearing Activities

Primary Author: Mathew Anderle

Institution: University of Tennessee

Coauthors: Adrija Sharma (University of Tennessee), Richard D. Komistek (University of Tennessee), Douglas A. Dennis (Colorado Joint Replacement)

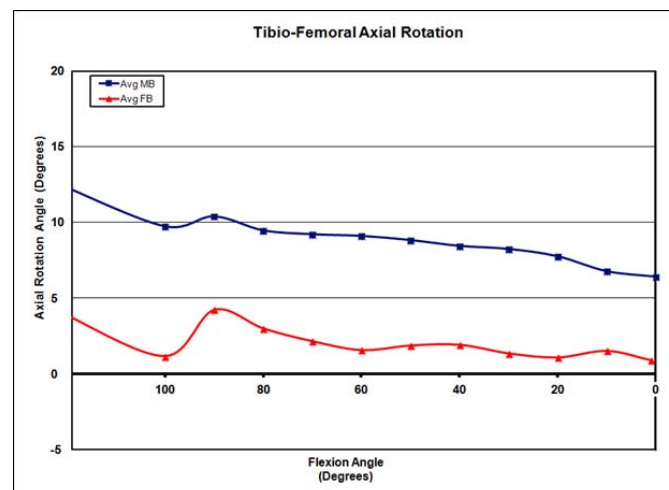
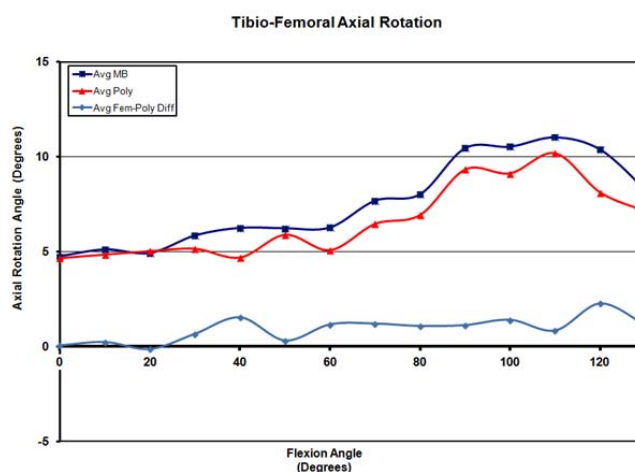
INTRODUCTION: Previous in vivo kinematic studies have focused mainly on primary total knee arthroplasty (TKA), comparing implant designs and range-of-motion. Not many studies have looked into the in vivo kinematics of revision TKA, especially during multiple weight-bearing activities using fluoroscopy. The objective of this study was to compare the in vivo kinematics of subjects having either a fixed or mobile bearing constrained-condylar posterior-stabilized revision TKA during four weight-bearing activities.

METHODS: Twelve subjects were implanted with the fixed bearing version and ten subjects with the mobile bearing version of the same implant design, a constrained-condylar TKA. Under fluoroscopic surveillance, each subject performed a: deep knee bend (DKB), chair rise, gait, and stair descent. The mobile bearing's polyethylene was implanted with four strategically placed tantalum beads to allow for fluoroscopic tracking. A 3D-2D model-fitting algorithm was used to determine the in vivo 3D kinematics of each subject for each activity.

RESULTS: Bearing rotation was shown in each of the ten mobile bearing subjects. The average amount of bearing rotation during the DKB from full extension to maximum

flexion was 2.48° (max = 10.4° , min = -8.06°). The femur conformed well to the polyethylene in the mobile bearing design on average within 2° (Figure 1). The mobile bearing design showed higher amounts of axial rotation than the fixed bearing counterpart for each of the four activities. The mobile bearing design saw a significantly larger axial rotation at toe off for both gait ($p = 0.0159$) and stair descent ($p = 0.0205$) than the fixed bearing design (Figure 2).

DISCUSSION: The kinematics of the fixed bearing version were more hinge-like, compared to the mobile bearing version of the same TKA design, which experienced more normal-like motion patterns. The femur also remained conformed in the mobile bearing design, but the bearing had the ability to rotate freely in the axial direction which allowed for greater amounts of axial rotation. It is hypothesized that the mobile bearing TKA induces less stress in the cam/post mechanism due to the bearing rotation, whereas the fixed bearing TKA may experience high torsional stress as the cam/post mechanism resists axial rotation.



O11A4

Correlations Between Navigation-based Femorotibial Kinematics Pattern and Flexion Angle After Total Knee Arthroplasty

Primary Author: Kazunari Ishida

Institution: Kobe Kaisei Hospital

Coauthors: Nao Shibamura (Kobe Kaisei Hospital), Tomoyuki Matsumoto (Kobe University Graduate School of Medicine), Hiroshi Sasaki (Kobe Kaisei Hospital), Koji Takayama (Kobe University Graduate School of Medicine), Akihiko Toda (Kobe Kaisei Hospital)

INTRODUCTION: Kinematic studies are considered important because alterations of knee motion patterns could lead to abnormal wear of the prosthetic components, soft tissue damage, and patient dissatisfaction in total knee arthroplasty (TKA). Among evaluation methods, navigation-based intraoperative kinematic measurements might provide instructive clinical information for refinement of soft tissue tension, and rotational adjustment, and information on the anticipated postoperative clinical outcomes. However, few studies have compared intraoperative kinematics and preand postoperative clinical outcomes, such as the maximum flexion angle. The purpose in this study is to reveal the correlation between the rotational, varus/valgus patterns and maximum flexion angle in navigated TKA.

METHOD: Fifty-four posterior stabilized (PS) TKA implanted using an image-free navigation system were evaluated. At registration and after implantation, tibial internal rotation angles and coronal mechanical axis at maximum extension, 30, 45, 60, 90°, and maximum flexion were collected. The rotational patterns were divided into four groups: (1) subjects with increasing tibial internal rotation following knee flexion (Group 1 [G1]); (2) subjects with tibial external rotation by the mid-flexion range following tibial internal rotation up to maximum flexion (Group 2 [G2]); (3) subjects with tibial external rotation by 90° flexion following tibial internal rotation of more than 2° up to maximum flexion (Group 3 [G3]); and (4) subjects with continuous tibial external rotation up to maximum flexion (Group 4 [G4]) and were examined the correlation with varus/valgus angle, and maximum flexion angle before and after operation.

RESULTS: Maximum flexion angles at postoperation was positively correlated with that of preoperation. Tibial in-

ternal rotation from 90° of flexion to maximum flexion at registration was correlated with maximum flexion angles at pre- and postoperation. Magnitude of tibial rotation at registration was positively correlated with tibial internal rotation after implantation. Compared to different kinematic patterns among four groups, the results after implantation found no statistically significant difference among four groups. The group with tibial external rotation up to 90° of flexion, thereafter tibial internal rotation at registration got better flexion angles, compared to those of another groups ($p < 0.05$). Furthermore, the group with limited extension showed worse flexion angles ($p < 0.05$). Varus angles at maximum extension in G1 and G2 were significantly larger than in G3 and G4 at registration, suggesting that varus deformity affects rotational pattern. Valgus patterns with flexion were found in all groups at registration, however the patterns were not found after implantation.

CONCLUSION: Navigation-based kinematic patterns found at registration predicts postoperative maximum flexion angle in PS TKA. Furthermore, it is suggested that preoperative varus deformity and flexion contracture influenced the maximum flexion angles. Navigation-based kinematics can be useful information during TKA surgery.

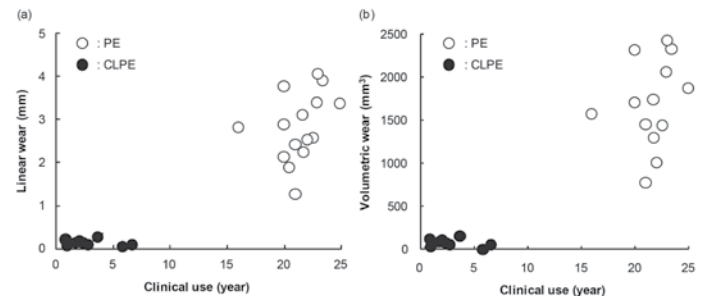


Fig. 1. (a) Linear and (b) volumetric wear of retrieved conventional PE and CLPE cups.

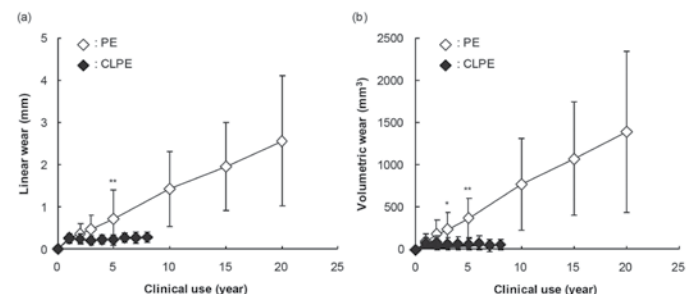


Fig. 2. (a) Linear and (b) volumetric wear of conventional PE and CLPE cups by radiographic analysis.

O11A5

Semimembranosus Release Reduces Tibial Internal Rotation During Flexion in Cruciate-retaining Total Knee Arthroplasty

Primary Author: Tomoyuki Matsumoto

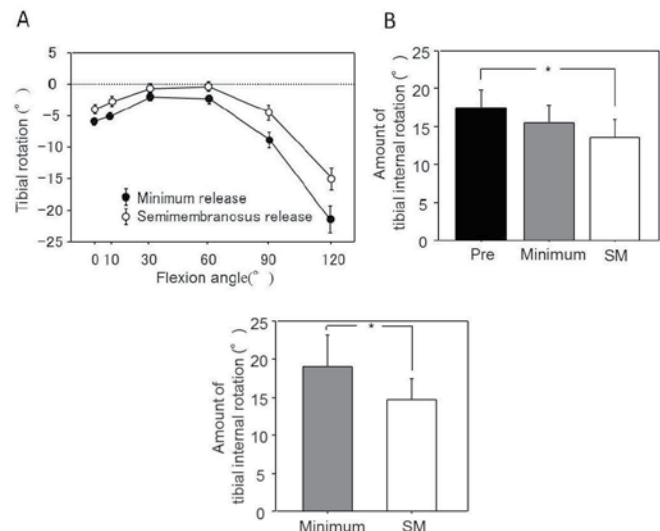
Institution: Kobe University Graduate School of Medicine

Coauthors: Koji Takayama (Kobe University Graduate School of Medicine), Yohei Kawakami (Kobe University Graduate School of Medicine), Kazunari Ishida (Kobe Kaisei Hospital), Hirotugu Muratsu (Steel Memorial Hirohata Hospital), Tokio Matsuzaki (Kobe University Graduate School of Medicine)

PURPOSE: Surgeons sometimes encounter moderate or severe varus deformed osteoarthritic cases in which medial substantial release including semimembranosus is compelled to appropriately balance soft tissues in total knee arthroplasty (TKA). However, medial stability after TKA is important for acquisition of proper knee kinematics to lead to medial pivot motion during knee flexion. The purpose of the present study is to prove the hypothesis that step by step medial release, especially semimembranosus release, reduces medial stability in cruciate-retaining (CR) total knee arthroplasty (TKA).

METHODS: Twenty CR TKAs were performed in patients with moderate varus-type osteoarthritis (10° Results: Kinematic pattern in step by step medial release exhibited external tibial rotation during mid-range of flexion and then shifted to internal tibial rotation toward to 120 degrees of knee flexion (Fig. A). During 60 to 120 degrees of flexion, semimembranosus release significantly reduced the amount of internal tibial rotation compared with pre-release (Fig. 1B). Tibial anterior translation showed no significant differences among each procedure. After all prostheses implanted, the amount of tibial internal rotation during 60 to 120 degrees of knee flexion was significantly maintained in minimum release compared with semimembranosus release group (Fig. 2).

CONCLUSIONS: Semimembranosus release reduces tibial internal rotation in CR TKA, suggesting that semimembranosus release should be avoided in case of moderate varus-type osteoarthritis for considering medial stability.



O11A6

3-D In Vivo Femoro-tibial Kinematics of Tri-Condylar Total Knee Arthroplasty During Kneeling Activities for Japanese Patients

Primary Author: Shinichiro Nakamura

Institution: Department of Orthopedic Surgery, Kyoto University, Graduate School of Medicine, Kyoto, Japan

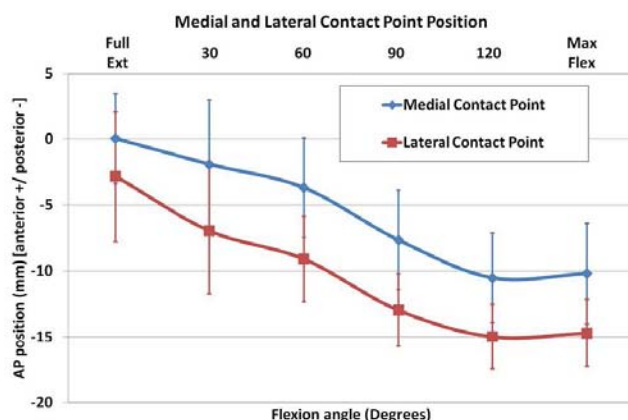
Coauthors: Richard D. Komistek (Center for Musculoskeletal Research, University of Tennessee, Knoxville, TN, USA.), Hiromu Ito (Department of Orthopedic Surgery, Kyoto University, Graduate School of Medicine, Kyoto, Japan), Kenji Nakamura (Department of Orthopedic Surgery, Tamatsukuri-Koseinenkin Hospital)

INTRODUCTION: Deep flexion activities are frequently required after total knee arthroplasty (TKA) for Asian population, especially for active patients. The implant used in the current study was developed for high demand patients requiring deep flexion. It has a unique tri-condylar ceramic femoral design as a third condyle, which replaces the cam-post seen in traditional posterior-stabilized designs (Figure 1). The purpose of the current study was to determine the in vivo three dimensional femoro-tibial kinematics of this tri-condylar implant during a weight bearing deep knee bend activity for Japanese patients.

MATERIALS AND METHODS: Fluoroscopy based in vivo femoro-tibial kinematics of the tri-condylar implant was assessed for 108 knees during a deep knee bend activity, using a three-dimensional model fitting approach.

RESULTS: The average weight-bearing range-of-motion for all knees was 125.5° (Standard Deviation (SD) = 20.5°). At full extension, the average medial and lateral condyle contact positions between the femoral component and the polyethylene were 0.0 mm (SD = 3.4 mm) and -2.8 mm (SD = 5.0 mm), respectively. At maximum flexion, the average medial and lateral condyle contact positions were -10.2 mm (SD = 3.8 mm) and -14.7 mm (SD = 2.6 mm), respectively. On average, the knees implanted with this implant demonstrated -10.2 mm (SD = 4.4 mm) and -11.9 mm (SD = 4.8 mm) of medial and lateral posterior femoral rollback, respectively (Figure 2). Posterior femoral rollback was significantly greater at the lateral condyle ($p = 0.003$). At full extension and at maximum flexion, the average angular rotation was 3.3° (SD = 4.9°) and 7.9° (SD = 7.2°), respectively. The average amount of femoro-tibial axial rotation from full extension to maximum flexion was 4.6° (SD = 5.9°) for all knees. Seventeen out of 108 knees (15.7%) experienced condylar lift-off of either condyle greater than 1.0 mm. Most of the condylar lift-off was seen when the knees were in deep flexion, especially above 120°.

Conclusion: Subjects in this study having the tri-condylar design did experience higher flexion than previously reported studies. Further analysis is being conducted to determine if this increased flexion is due to the tri-condylar design or the Japanese patients in this study. It is hypothesized that the third condyle does appear to offload the femoral condyles, possibly allowing the patient achieve greater weight-bearing knee flexion.



011A7

Restoring Normal Knee Function with Guided Motion (GM) Total Knee Replacement

Primary Author: Peter S. Walker

Institution: NYU-Hospital for Joint Diseases

Coauthors: Michael J. Lowry (NYU-Hospital for Joint Diseases)

The purpose of this study was to determine whether total knee replacements can be designed which will restore the motion characteristics of the normal anatomical knee. The premise is that such designs will result in improved function and will feel like a normal knee to the patient.

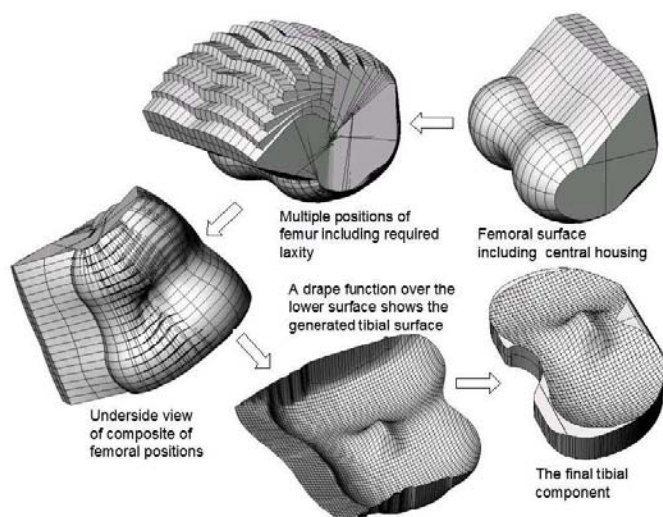
Numerous studies of motion have been carried out on the anatomic knee in cadavers and living subjects. Overall, as the knee was flexed, the lateral contact displaced posteriorly, while the medial contact was relatively immobile. The AP laxities were higher on the lateral than on the medial side, but laxities were reduced with compression. Fluoroscopic studies of total knees (TKA) have shown highly variable motions, but usually symmetric lateral to medial, and frequently with anterior sliding in flexion.

In our study we developed a test machine which applied combinations of compressive (500 Newtons), shear (100 Newtons) and torque (5 Nm), while the knee was flexed dynamically through 0-120 deg. Optical monitoring, and subsequent computer software was used to plot the femoral circular axis on the tibial surface as a motion descriptor. The results were plotted as neutral path of motion, and laxity about that neutral path. Tests on 18 specimens were used to establish a reference data base of anatomic motion. There was variation between knees, but a consistent pattern of relative lateral/medial characteristics. This data was used as the benchmark for assessing the TKA designs.

Firstly, four different PS TKA's were tested, together with a cam-post Guided Motion design. There were variations between designs, but abnormalities included symmetric lateral to medial motions, anterior sliding with flexion, high AP laxities, and excessive constraint in high flexion due to cam-post/posterior lip entrapment. The PS Guided Motion on the other hand showed a more lax lateral side and restrained medial side, with overall motions closer to anatomic, but still with high flexion constraint. This pointed to Guided Motion designs as a way forward.

A previously developed method for generating Guided Motion designs (figure) was then further developed. The method started with the femoral component, which was moved through an anatomical motion path, including the provision of condyle dishing for anatomic laxity values. The method was used to design new Guided Motion concepts: Cam-Post, Converging Condyles, and Intercondylar Saddle.

These designs were then tested. In all cases, the Guided Motion designs produced asymmetric lateral/medial neutral path of motion and laxities about the neutral path. Anterior (paradoxical sliding) was eliminated. Overall, the GM designs produced motion patterns that were much closer to anatomic than the standard PS designs. In each GM design type, it was possible to further optimize, the topic of ongoing work. In conclusion, standard PS designs did not reproduce anatomical motion patterns in a test which simulated a broad spectrum of loading conditions. On the other hand, Guided Motion knees, designed using a computer-graphics method, more closely reproduced anatomic motion. Hence Guided Motion knees may be the way forward to more closely reproduce anatomical function and the feeling of a normal knee.



Bearing Surface Materials

O11B2

Ceramic on Ceramic in Total Hip Replacement: Are Differences in Material and Design Important?

Primary Author: Laurent Sedel

Institution: Aphp and University of Paris Denis Diderot

Ceramic on ceramic proved to give excellent results in total hip replacement. No osteolysis related to little debris production has been widely documented. More recently the fibrous tissue generated around this material could explain the absence of long term dislocation. It is recognised that alumina on alumina couple is especially interesting for use in active and young people. Long life expectancy without revision could then be expected with more than 90% surviving at 20 years. Some problems are currently addressed: noise generation, fracture, stripe wear and impingement. These events, although exceptional could be reduced if we consider in details materials properties and design.

MATERIAL PROPERTIES: All ceramics are not similar.

MATERIAL SELECTION: Pure alumina ceramic (Al_2O_3) is the most well know used since 44 years. Its quality rely on its high purity, high density, limited porosity and small grain size about $2\text{ }\mu\text{m}$. One of its major quality is its mechanical stability over time (Gert Willman). Zirconia ceramic (ZrO_2) has been abandoned because of its poor long term stability, even if its initial mechanical properties were better than regular alumina ceramic. Mixed oxide (Delta*) is at the moment widely in use. Crack propagation is stopped by the zirconia particles that will transform from a tetragonal phase into a monoclinic one. The question is about the stability of such a material in the very long term.

MATERIAL DESIGN: Head size, liner thickness, cone angle, cone characteristics, and liner in excess or recessed, polyethylene back ceramic, ceramic already inside the metal, all of these details could play a positive or a negative role and could explain differences in clinical behaviour.

We always used 32 mm head diameter except for small socket size. Head size of 28 mm were widely utilised. Fracture risks and hip dislocation were both increased. Why to go for 36 mm or more? Increasing head size diminished liner thickness, which appears at the moment to be an important issue.

Cone angle is usually 5°40' for the femoral head. At the socket level some of us used the same cone angle. In many brands, it is a 16° cone angle which is utilised. This last cone angle allows easier removal, but also easier mobilisation of the liner.

Liner in excess or not? Liner in excess increases range of motion. Recessed liner was blamed to increase the risk of impingement and possibility to increase noise generation. Designs of Morse cone either for the stem or for the socket are crucial. Do we need rough metallic surface of the cone to increase the contact after insertion? Does the socket shell be designed both for ceramic or polyethylene? The ceramic liner of the Ceraver* material is constructed with a 5°40' angle. A central tit guide the introduction and avoid any malposition.

CONCLUSION: Alumina on alumina in total hip is especially dedicated to young and active patients; sports are permitted. This is obtained if certain conditions are fulfilled concerning ceramic selection, material design and surgeon skills.



O11B3 Ceramic/Ceramic Bearings in Uncemented Hip Arthroplasty: An Evaluation with Up To 22 Year Follow Up

Primary Author: James M. Buchanan

Institution: Sunderland Royal Hospital

Coauthors: David R M. Fletcher (Sunderland Royal Hospital)

Enthusiasm for metal on metal resurfacing is waning and some implants have been withdrawn from the market.

Successful hip replacement requires sound, long-lasting fixation of the implants coupled with smooth bearings that will not wear out or otherwise fail requiring revision. Hydroxyapatite ceramic (HA) provides, through naturally occurring stem cells, a durable, physiological bond to host bone. Ceramic bearings are smooth and articulate through a system of fluid film lubrication.

Will HA coated hip arthroplasty associated with ceramic bearings generate uncomplicated function in all patients?

Alumina very occasionally fractures but otherwise remains inert and causes no complications. Creaking has been considered.

This is a study to evaluate the outcome of a consecutive series of patients treated with uncemented HA coated implants with ceramic on ceramic (cer/cer) bearings.

AIMS: To establish that HA bonding works and is durable. To establish that Cer/cer bearings are durable and provide trouble-free function.

METHOD: 627 HA hips with cer/cer bearings have been studied with annual review over a period of up to 22 years. Harris Hip Score has been utilised to ascertain pain and function coupled with X-rays to check osseointegration. There are 156 hips in 130 patients who were under 50 years of age at the time of surgery. Alumina ceramic was used in 458 hips and the newer SZirconia Toughened Alumina (ZTA) was utilised for 169 hips. The incidence of aseptic loosening, dislocation, implant fracture and creaking has been investigated.

RESULTS: The first cer/cer hip was inserted in January,

1992 and is still functioning without complication. Aseptic loosening is rare (3 of 1254 components; 0.24%). Failure from mal-orientation with repeated dislocation occurred in six hips 0.48%. Three alumina heads (0.48%) and two alumina liners (0.32%) fractured needing replacement. There have been no failures of ZTA. No patients have thigh pain. Osteolysis and debris disease have not been seen. Only four patients have noticed any creaking but this has not led to any concern or subsequent complication. Creaking is related to rim loading and loss of fluid film lubrication.

There are 238 hips still under review at 10 or more years.

Harris Hip Scores show 91.2% scoring 90+ or 100. Lower scores relate to co-morbid problems from other joints or medical disease.

CONCLUSIONS: Assessments confirm that patients remain well. HA bonding leads to secure, long lasting cementless fixation. Creaking is unusual and not a prelude to any other complication. Occasional failure from broken alumina components has been noted but alumina has now been superseded by ZTA.

Ceramic on ceramic is a reliable bearing couple for patients of any age and either sex.

O11B4

In Vivo Wear and Oxidation Degradation of Retrieved Highly Cross-Linked Polyethylene Cup Against Ceramic Femoral Head

Primary Author: Hiroyuki Oonishi

Institution: Tominaga Hospital

Coauthors: Shihori Yamane (KYOCERA Medical Corporation), Masayuki Kyomoto (KYOCERA Medical Corporation), Mikio Iwamoto (KYOCERA Medical Corporation), Ikuo Kawahara (Tominaga Hospital), Yoshifumi Hanaoka (Tominaga Hospital), Hironobu Oonishi (Tominaga Hospital)

In total hip arthroplasty (THA), osteolysis resulting in aseptic loosening caused by the wear particles from polyethylene (PE) has been recognized as a serious issue. In addition, residual free radicals generated by gamma irradiation which is used for cross-linking to reduce wear of PE and for sterilization, induce the oxidation degradation

of PE and result in the fracture and/or severe wear caused by the reduction of mechanical properties in vivo. In this study, the correlation between in vivo wear and oxidation degradation of retrieved highly cross-linked PE (CLPE) cups against alumina ceramic femoral heads were evaluated.

Retrieved 16 ethylene oxide gas-sterilized conventional PE (i.e., non-cross-linked) cups with clinical use for mean 21.5 years and 10 gamma-sterilized CLPE cups with clinical use for mean 2.9 years were evaluated. The linear wear and the volumetric wear of the retrieved cups were measured using a three-dimensional (3-D) coordinate measurement machine. The shapes of two respective articulating areas (unworn and worn surfaces) with 15- and 30-point intervals, respectively, were measured. The radiographic wear of six conventional PE cups with the mean follow-up of 20.9 years and 60 CLPE cups with the mean follow-up of 7.4 years was also measured by a non-radiostereometric analysis method (Vectorworks® 10.5 software package). Oxidation degradation of the surface, sub-surface and inner for both worn and unworn parts of the retrieved cups was measured using a Fourier-transform infrared (FT-IR) spectroscopy. Oxidation indices were calculated using the peak at 1740 cm⁻¹ and 1370 cm⁻¹ according to ASTM F2012.

The linear wear rate of retrieved CLPE cups (mean: 0.07 mm/years; range: 0.02–0.23 mm/year; 95% CI: 0.03–0.11 mm/year) showed a 51% reduction ($p = 0.002$) compared to retrieved conventional PE cups (mean: 0.14 mm/years; range: 0.06–0.22 mm/year; 95% CI: 0.12–0.16 mm/year) [Fig. 1]. The amount of linear and volumetric wear of retrieved conventional PE and CLPE cups was similar ($p = 0.7$ and 0.1 , respectively) to the results determined by radiographic analysis [Fig. 2]. Unlike the wear properties for PE and CLPE cups, despite the difference of clinical use, maximum oxidation indices of PE cups were similar to those of CLPE cups. The oxidation indices of surface and sub-surface for worn parts of conventional PE showed two times as higher than that for unworn parts. The oxidation indices were almost as same as those for worn and unworn parts of CLPE. This result showed the possibility that even when the free radicals were absent or very few, the oxidation degradation would be induced in vivo.

In conclusion, it was found that oxidation degradation of PE when used with alumina ceramic femoral heads is not correlated to their wear properties. The in vivo oxidation

degradation might not be caused by only residual free radicals.

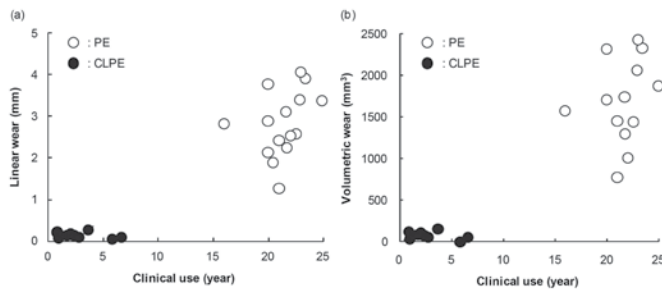


Fig. 1. (a) Linear and (b) volumetric wear of retrieved conventional PE and CLPE cups.

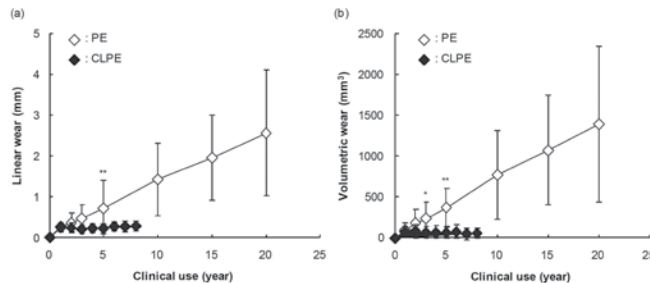


Fig. 2. (a) Linear and (b) volumetric wear of conventional PE and CLPE cups by radiographic analysis.

O11B5 Alumina Ceramics Versus Co–Cr–Mo Alloys; Comparison of Roundness and Roughness of Retrieved Femoral Head

Primary Author: Ikuo Kawahara
Institution: Tominaga Hospital

Coauthors: Hiroyuki Oonishi (Tominaga Hospital), Shiori Yamane (KYOCERA Medical Corporation), Masayuki Kyomoto (KYOCERA Medical Corporation), Mikio Iwamoto (KYOCERA Medical Corporation), Yoshifumi Hanaoka (Tominaga Hospital), Hironobu Oonishi (Tominaga Hospital)

Aseptic loosening induced by wear debris of polyethylene (PE) is the most common cause of long-term failure in total hip arthroplasty (THA). In an abrasive wear mechanism, micrometer-roughened regions and small asperities on the harder surface (i.e., metallic femoral heads) locally plow through the softer surface (i.e., PE cup). Abrasive wear results in the softer material being removed from the track traced by the asperity during the motion of the harder surface. Alumina ceramics was introduced in Europe and Japan in 1970s in aim to reduce PE wear debris. The clinical results have proved the superiority of ceramic-on-PE bearings in wear resistance compared with metal-on-PE bear-

ings. Alumina ceramics is advantageous (neutral shape and smooth surface) for precision machining compared with Co–Cr–Mo alloys, because of its higher hardness. Alumina ceramics are brittle and polycrystalline materials. The inherent fracture resistance is intimately related to grain size. Thus, grain size reduction has resulted in an overall improvement in its resistance. In this study, we evaluated the roundness and the roughness of retrieved two distinct alumina ceramics, and Co–Cr–Mo alloy heads.

Fourteen retrieved alumina ceramic femoral heads were examined: ten femoral heads were made of small grain size alumina (SG-alumina; mean grain size is 3.4 μm) ceramic with a diameter of 28 mm with clinical use for 16–28 years (mean 22 years) and four femoral heads were made of extra-small grain size alumina (XSG-alumina; mean grain size is 1.3 μm) ceramic with a diameter of 26 mm with clinical use for 14–19 years (mean 16 years). Six retrieved Co–Cr–Mo alloy femoral heads with average clinical use for 12–28 years (mean 18 years) were examined: a diameter of from 22 to 32 mm.

The roundness of SG-alumina and XSG-alumina heads was significantly lower than Co–Cr–Mo alloy heads [Fig. 1]. It was thought that the alumina ceramics was advantageous for precision machining compared with Co–Cr–Mo alloys. Also, the surface roughness increased in the order of XSG-alumina, SG-alumina and Co–Cr–Mo alloy head [Fig. 2]. The alumina ceramic head showed the reentrant surface whereas the Co–Cr–Mo alloy head showed the protrusion surface. The extent of abrasive PE wear has been shown to be a function of the roundness and roughness of the Co–Cr–Mo alloy or ceramic surface and the presence or absence of hard third-body particles. When the third-body entrapment occurs during the clinical use, a reentrant form is likely on the ceramic surface while protruding deformation possibly occurs on the Co–Cr–Mo alloy surface. The differences in clinical results may be due in part to the influence of third-body particles. The greater hardness of ceramics renders them more resistant than Co–Cr–Mo alloy to scratching by entrapped abrasive contaminants that can accelerate PE wear. We have good clinical results of more than 20 years using SG-alumina, with XSG-alumina having improved surface morphology, better long term clinical results may be expected.

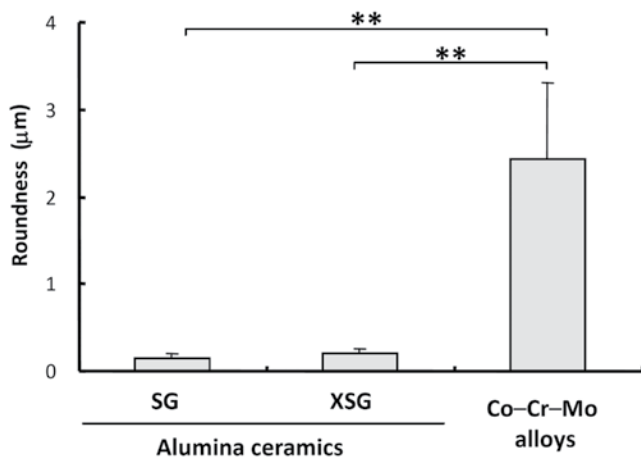


Fig. 1. Out of roundness of the retrieved alumina ceramic and Co-Cr-Mo alloy femoral heads. (**; $p < 0.001$, t-test)

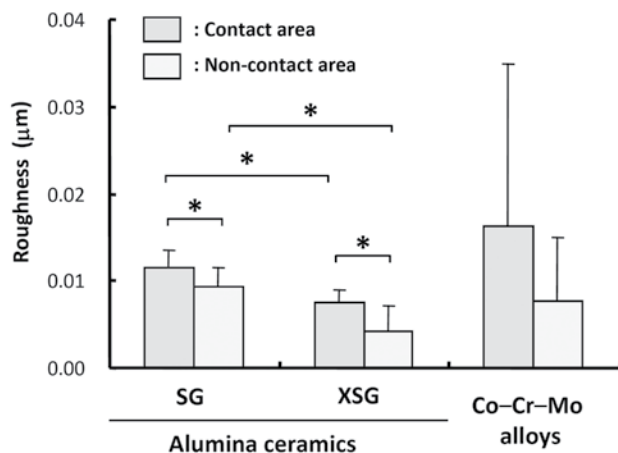


Fig. 2. Surface roughness of the retrieved alumina ceramic and Co-Cr-Mo alloy femoral heads. (*; $p < 0.05$, t-test)

O11B6 Retrieval Analysis of Sequentially Annealed Highly Crosslinked Polyethylene Used in Total Hip Arthroplasty

Primary Author: Daniel W. MacDonald
Institution: Drexel University

Coauthors: Michael A. Mont (Sinai Hospital of Baltimore), Javad Parvizi (Rothman Institute), Arthur Malkani (Jewish Hospital), William Hozack (Rothman Institute), Steven M. Kurtz (Drexel University and Exponent, Inc.)

INTRODUCTION: First generation annealed and sequentially annealed highly crosslinked polyethylene (HXLPE) have documented reduced clinical wear rates in their first decade of clinical use. However, for both types of annealed HXLPE formulations, little is known about their

reasons for revision, in vivo oxidative stability, and resistance to mechanical degradation. We asked whether retrieved sequentially annealed HXLPE liners exhibited (1) similar reasons for revision; (2) improved in vivo oxidation resistance; and (3) improved resistance degradation of mechanical properties, including rim damage, when compared with annealed HXLPE.

METHODS: One hundred eighty five acetabular liners in two cohorts (annealed, sequentially annealed) were consecutively revised and collected in a multi-center retrieval program between 2000 and 2013. We accounted for implantation time between the two cohorts by excluding annealed liners with a greater implantation time than the longest-term sequentially annealed retrieval (5.0 years). Reasons for revision were based on medical records, radiographs, and examination of the retrieved components. Oxidation was measured at the bearing surface, backside surface, locking mechanism, and rim using FTIR (ASTM F2102), and mechanical behavior was measured in the superior and inferior bearing surface using the small punch test (ASTM F2183). We used nonparametric statistical testing to analyze for differences in oxidation, mechanical properties, and wear when adjusting for HXLPE formulation as a function of implantation time. Liners were inspected using optical microscopy for evidence of rim damage, subsurface fatigue, and cracking consistent with previous studies.

RESULTS: Within the first five years of implantation, the acetabular liners in both cohorts were revised most frequently for instability, loosening, and infection. The test results indicated that sequentially annealed HXLPE significantly reduces in vivo oxidation as compared with first generation HXLPE. Oxidation levels of sequentially annealed liners were lower than annealed liners at all measured locations ($p < 0.0001$; Wilcoxon Test; Figure 1). However, regional variation was observed in both cohorts, particularly at the rim of the liners, which had the highest oxidation. Mechanical properties and clinical wear rates were similar between the two cohorts. Additionally, the sequentially annealed cohort appeared to be more resistant to fatigue damage modes at the rim, namely delamination.

CONCLUSIONS: Although we observed evidence of in vivo oxidation in retrieved annealed and, to a lesser extent, in retrieved sequentially annealed acetabular liners, we observed no association between the low levels of oxidation and clinical performance, either in terms of reasons for re-

vision, or based on preservation of mechanical properties at the bearing surface. The findings of this study document the oxidative stability and mechanical behavior of sequentially annealed HXLPE. Because of the short- to intermediate-term follow-up, analysis of longer-term retrievals is warranted.

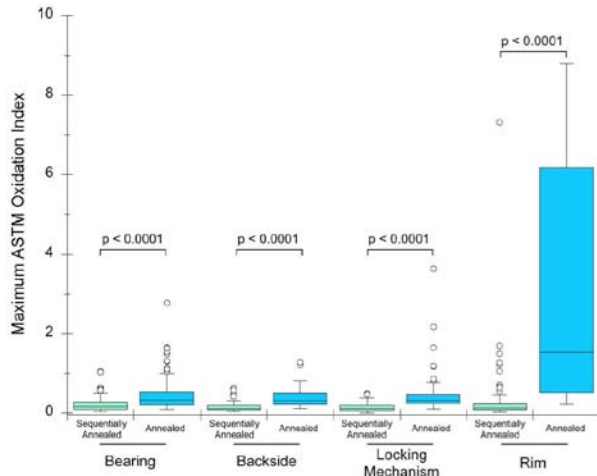


Figure 1: Sequentially annealed liners exhibited significantly lower oxidation at all measured locations when compared with the annealed liners ($p < 0.0001$).

O11B7

Difference of Failure Mode in Metal-on-Polyethylene Cementless THA

Primary Author: Satoshi Nagoya

Institution: Sapporo Medical University, Dept. of Musculoskeletal Biomechanics and Surgical Development

Coauthors: Mikito Sasaki (Sapporo Medical University, Dept. of Musculoskeletal Biomechanics and Surgical Development), Shunichiro Okazaki (Sapporo Medical University, Dept. of Musculoskeletal Biomechanics and Surgical Development), Mitsunori Kaya (Sapporo Medical University, Dept. of Orthopedic Surgery)

Although osteolysis and/or pseudotumor have been recognized to result in failure of metal-on-polyethylene cementless THA, we experienced two types of failure mode in well fixed cementless THA. These modes included tissue reactions with lymphocyte infiltration and macrophage phagocytosis in well-fixed cementless THA. The purpose of this study is to demonstrate failure mode of metal-on-polyethylene cementless THA.

TKA Revisions & Long-term Follow-up

O12A1

Early Clinical Results of Mobile Bearing Revision TKA: A Multicenter Study

Guest Faculty: Douglas A. Dennis, MD

Institution: Adjunct Professor, Dept. of Biomedical Engineering, University of Tennessee; Adjunct Professor of Bioengineering, University of Denver; Assistant Clinical Professor, Dept. of Orthopaedics, University of Colorado School of Medicine, Denver, CO, USA

Coauthors: Raymond H. Kim, MD; Gwo-Chin Lee, MD; Charles Y. Yang, MD; Brian D. Haas, MD

INTRODUCTION: Mechanisms for failed revision total knee arthroplasty (TKA) include aseptic loosening and post damage. Although mobile bearing (MB) revision TKA components can theoretically decrease stress to the tibial baseplate and post, bearing complications are concerning. The purpose of this study is to evaluate the clinical outcomes and bearing complications of MB revisions.

MATERIALS AND METHODS: We retrospectively reviewed 316 consecutive MB revision TKAs performed at 2 centers between 2006 and 2010. There were 183 females and 133 males with an average age of 68 years (41- 94 years). Preoperative diagnosis for revision TKA included aseptic loosening (95), instability (92), infection (52), failed UKA (25), arthrofibrosis (24), fracture (6), malposition (6), osteolysis (6), poly wear (6), mal-alignment (3), and arthrotomy dehiscence (1). Patients were clinically evaluated using the KSS scores for pain and function, bearing complications were recorded, and radiographs were reviewed for signs of loosening and osteolysis.

RESULTS: Average follow-up was 32 months (24 – 72 months). Six patients were lost to follow-up. Prior to surgery, the KSS pain and function scores averaged 45.3 points (12-71) and 50 points (5-80). Following surgery, the mean KSS scores for pain and function was 83 points (34-100) ($p < 0.001$) and 62 points (10-100) ($p < 0.01$) respectively. There were no cases of bearing spin out or instability. 8 knees had subsequent procedures following revision

including arthroscopic debridement for patellar crepitus (3), I+D with polyethylene exchange (2), arthroscopic lysis of adhesions (1), revision for instability (1), and resection arthroplasty (1). Radiographic review showed no evidence of loosening or osteolysis.

CONCLUSION: At short-term follow-up, mobile bearings can be used safely and reliably in revision TKA. Long-term studies are needed to evaluate the theoretical benefits of reduced post wear and prosthetic loosening. As demographic trends reveal younger patients requiring revision TKA, MB revisions may be a reasonable option to potentially improve long-term survivorship.

O12A2

Mobile Bearing Posterior – Stabilized Rotating – Platform Knee Implants – 10 to 13 Year Results

Primary Author: Rajesh N. Maniar

Institution: Lilavati Hospital and Research Centre, Breach Candy Hospital

INTRODUCTION & AIM: Posterior Stabilized Rotating Platform (PSRP) implant, introduced in year 2000 was designed to improve post-operative flexion and provide greater stability with its post and cam mechanism.

To date, there are no reports on this design's performance beyond 10 years by non-designer surgeon. We have analysed the first 133 PSRP knees implanted by a single surgeon, with respect to post-operative range of movement (ROM), functional outcome, incidence of spin-out, osteolysis and survival at minimum 10 years.

MATERIALS AND METHODS: Prospective data was collected for 133 knees in 118 patients undergoing PSRP knee implantation between September 2001 and December 2003. Surgical technique used conventional jigs for alignment, cementing all components and patellar resurfacing. Standard rehabilitation protocol was followed. Post discharge, every follow-up (3 months, 1 year, every 5 years thereafter), involved recording clinical data, knee society score, questionnaire form and radiographic analysis.

RESULTS: Of 118 patients enrolled, 86 (97knees) reached 10-13 year evaluation, 21 (24 knees) died prior to 10 years and 11 (13 knees, 6 overseas patients) were lost to follow

up. Average follow-up was 133.5 months (120 to 150.2 months). Radiological evaluation was complete in 78 patients (88 knees).

Mean Knee score improved from 27 to 96. Mean Function score improved from 53 to 78. Mean pre-operative flexion of 107° (75°- 150°) improved to 127° (90°-155°). 51 knees had post-operative flexion of 130° or more.

No patient had infection, or spin-out. Radiologically, 7 knees had non-progressive radiolucent lines in a single zone, all were in relation to tibia. None showed any evidence of osteolysis (Fig.1). No one needed nor had revision surgery, thus Kaplan-Merier survival rate was 100 % (Fig.2).

DISCUSSION: Considering stability factor, no PSRP implanted patient had any spin out. Contrarily, LCS rotating-platform implant studies report spin-out of 0-9.3%. Other PSRP knee studies too report no incidence of spin-out.

Considering range of movement, average flexion reported with LCS rotating-platform knees varies from 94° to maximum 114°. Our series with PSRP knees achieved average flexion of 127° with maximum flexion of 155°. 65% of our patients achieved flexion over 130°, two third patients could sit crosslegged post surgery. Patello-femoral symptoms were low (7.2%). At 10-13 years post surgery, our PSRP implant series has produced good outcome with 100% survival.

Posterior- stabilized fixed bearing implants are reported to sustain post impingement causing post wear, osteolysis and failure. In posterior- stabilized rotating- platform design, there is rotational decoupling which eliminates post-wear of rotational origin. In our series, no osteolysis was observed at 10-13 years.

CONCLUSION: Rationale of developing posterior-stabilized rotating-platform implant design has been successful in improving ROM (maximum 155°/average 127° against maximum 114° in LCS) and greater stability with no incidence of spin-out of rotating-bearing. As regards wear, no osteolysis was seen until the end of first decade. Prolonged follow-up of the present cohort is under review to know further survival.

O12A3

The Relationship Between Tibiofemoral Contact Stress and Worsening of Knee Pain at 5-year Follow-up

Primary Author: Neil A. Segal

Institution: University of Iowa

Coauthors: Natalie A. Glass (University of Iowa), Tyler J. Stockman (University of Iowa), Andrew M. Kern (University of Iowa), Donald D. Anderson (University of Iowa), Jingbo Niu (Boston University), Felix Eckstein (Paracelsus Medical University and Chondrometrics GmbH), John A. Lynch (University of California San Francisco), David T. Felson (Boston University), Cora E. Lewis (University of Alabama at Birmingham), James C. Torner (University of Iowa), Michael C. Nevitt (University of California San Francisco), Leena Sharma (Northwestern University)

INTRODUCTION: Osteoarthritis (OA) is the most common musculoskeletal disorder in older adults, and the knee is the most commonly affected weight-bearing joint. Knee pain is the most significant symptom and the reason that patients commonly seek care. The ability to predict worsening knee pain could inform design of therapies to delay or prevent disablement. Discrete element analysis (DEA) is a method of estimating articular contact stress, which may provide a feasible means of predicting worsening of knee pain.

METHODS: The Multicenter Osteoarthritis Study (MOST) is a longitudinal cohort study of 3,026 adults, aged 50–79, with risk factors for knee OA. For this ancillary study, articular contact stress estimates were generated for 220 knees (1 knee/participant). Participants were a random sample of the participants at the baseline visit, who underwent coronal 1.5T MRI at baseline and 5-year follow-up. Bone and cartilage boundaries on MRI were segmented to generate knee-specific 3D clouds of points, which were then registered to corresponding bone edges on weight-bearing, fixed-flexion radiographs to rotate the segmented articular surfaces into each participant's weight-bearing configuration. DEA was used to estimate articular contact stress distributions (Figure 1). Knee pain (WOMAC) was assessed at baseline, 30 and 60 months. We hypothesized that peak (maximum) and mean tibiofemoral articular contact stress at baseline is associated with worsening pain by 5-year follow-up. Worsening pain in a knee was defined as present if an increase in WOMAC knee pain met or ex-

ceeded the MDC90 threshold (the minimum detectable change that would denote a true difference). Multiple logistic regression was used to test whether tertiles of peak or mean baseline tibiofemoral articular contact stress were associated with worsening knee pain by 5-year follow-up, adjusting for age, sex, BMI, knee malalignment, clinic site, and baseline knee pain.

RESULTS: Participants' mean (SD) age was 60.1 (6.5) years, weight was 187.0 (35.3) kg, BMI was 29.5 (5.2) kg/m², 64.2% were women and 58.2%, 18.4%, 12.4%, 10.0,% and 1.0% of knees, had KL grades 0, 1, 2, 3 or 4 respectively. Knee alignment was varus (181°) in 16.9%. The average (SD) peak contact stress was 9.40 (4.29) MPa and mean contact stress was 3.30 (0.93) MPa. At baseline, the mean (SD) WOMAC knee pain score was 2.6 (2.9) points (on a 0–20 scale). Given a 14-day test-retest reliability of 0.79, the MDC90 for worsening was 3.0 points and 18 knees (9%) met this criterion. The multi-adjusted odds ratios (OR) suggested a trend towards higher peak and mean contact stress being associated with higher risk for worsening knee pain at 5-years (Table 1).

DISCUSSION: Recent advances in 3D joint imaging and computing power have enabled this initial study of the association between knee-specific tibiofemoral contact stress and worsening of knee pain. The moderately large effect sizes are suggestive of a longitudinal association between higher contact stress at baseline and meaningful worsening in knee pain in older adults with risk factors for knee OA. MRI Segmentation Bone Model Compute Contact Stress at baseline and meaningful worsening in knee pain in older adults with risk factors for knee OA.

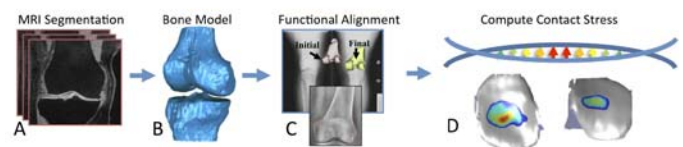


Figure 1: Steps in tibiofemoral contact stress estimation: A) segmentation, B) 3D model, C) registration to weight bearing configuration, D) Discrete Element Analysis

Table 1:

Variable	Tertile of Baseline Contact Stress	% With Worsening Pain	Multi-Adjusted OR (95% CI)*	P-value
Mean Contact Stress	Low	5.97	1 (referent)	
	Middle	5.97	1.47 (0.32, 6.73)	0.6225
	High	14.93	3.25 (0.82, 12.94)	0.0948
	Trend			0.0746
Peak Contact Stress	Low	2.99	1 (referent)	
	Middle	11.94	5.10 (0.96, 27.01)	0.0552
	High	11.94	4.28 (0.80, 22.95)	0.0899
	Trend			0.2254

* Adjusted for age, sex, BMI, malalignment, clinic site, and baseline knee pain

O12A4

Corrosion and Damage Mechanisms in Retrieved Long-Term TKA Femoral Components

Primary Author: Christina M. Arnholt

Institution: Drexel University

Coauthors: Sevi Kocagoz (Drexel University), Daniel W. MacDonald (Drexel University), Jeremy L. Gilbert (Syracuse University), Javad Parvizi (Rothman Institute), Arthur Malkani (Jewish Hospital), Gregg Klein (Hartzband Center for Hip and Knee

INTRODUCTION: The release of metal debris and ions has raised concerns in joint arthroplasty. In total hip arthroplasty (THA), metal debris and ions may be generated by wear of metal on metal bearing surfaces as well as corrosion at modular taper interfaces. The corrosion process at these interfaces is typically understood to be mechanically assisted crevice corrosion (MACC). More recently, inflammatory cell induced corrosion has been identified as a possible source of metal debris and/or ions. Although MACC has been shown to occur at modular junctions in total knee arthroplasty (TKA), little is known about the prevalence of other sources (such as inflammatory cell induced corrosion (ICIC)) in TKA. The purpose of this study was to identify the sources of metallic debris and ion release in long-term implanted (in vivo > 15y) TKA femoral components. Specific attention was paid to instances of ICIC as well as damage at the implant-bone interface.

METHODS: 1873 retrieved TKA components were collected from 2002-2013 as part of a multi-center, IRB-approved retrieval program. Of these, 52 CoCr femoral components were identified as being implanted for more than 15 years (Average: 17.9 ± 2.8 y [Range: 15.0-32.8y]). These long-term TKAs were predominantly revised for loosening, PE wear and instability. 40/52 of the collected components were primary surgeries. Components were examined using visual inspection and optical microscopy to confirm the presence or absence of 5 damage mechanisms relevant to metal release in TKA. Specifically, we inspected the devices for polyethylene failure (leading to metal-metal articulations), MACC corrosion of modular tapers (if modular tapers were present), corrosion damage between cement and back of the implant, wear occurring from third body debris (e.g. bone cement), and ICIC.

RESULTS: Surface damage indicative of corrosion and/or CoCr debris release was identified in 92% (n=48) of the components. Third body wear was the most prevalent damage mechanism identified in 77% (n=40; Figure 1) of these components. ICIC was identified in 38% (n=20, figure 2) of the components. Failure of the polyethylene insert that resulted in metal-metal articulation (between the femoral component and tibial baseplate) was identified in 17% (n=9) of the components, whereas MACC corrosion damage at the cement-implant interface was identified in 7% (n=4) of the components. 50% (2/4) of the long-term modular devices exhibited severe taper corrosion.

DISCUSSION: In this study, we sought to identify mechanisms that could lead to the release of CoCr debris or ions in TKA. Five different mechanisms of potential metal release were identified in this cohort of long term TKAs. However the clinical implications remain unclear for several mechanisms due to the encapsulation of implants in cement limiting the diffusion of corrosion products. None of the devices were revised due to adverse local tissue reactions or biologic reactions to CoCr. Additionally, although we documented the prevalence of each damage mechanism, we did not quantify the amount of material removed. It is likely each mechanism will induce different rates of CoCr release. Therefore, future studies further investigating the mechanisms and quantity of CoCr release in TKA are warranted.

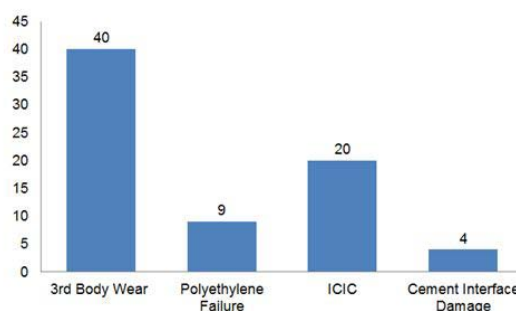


Figure 1: Bar graph showing the prevalence of different damage mechanisms to long term TKA femoral components.

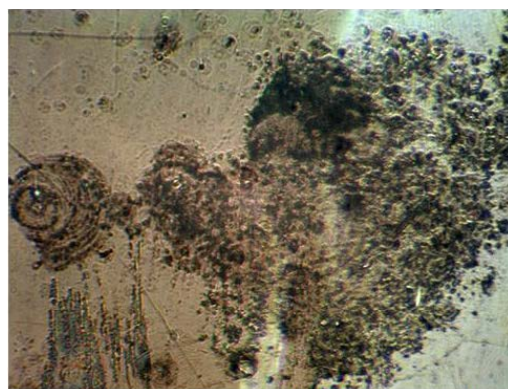


Figure 2: ICIC on femoral component implanted for 18.3 y, revised for polyethylene wear

O12A5

Megaprosthesis: Our Ongoing Experience Between Orthopaedics and Trauma

Primary Author: Giorgio Maria. Calori

Institution: Istituto Ortopedico Gaetano Pini

Coauthors: Emilio Luigi. Mazza (Istituto Ortopedico Gaetano Pini), Massimiliano Colombo (Istituto Ortopedico Gaetano Pini), Emiliano Malagoli (Istituto Ortopedico Gaetano Pini), Simone Mazzola (Istituto Ortopedico Gaetano Pini)

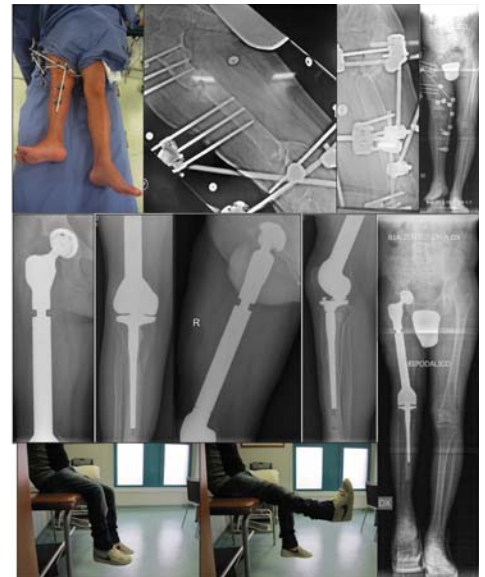
INTRODUCTION: The development of new megaprosthesis for the treatment of large bone defects has offered important opportunities to orthopedic oncologic surgeons for the replacement of skeletal segments such as long bones of the upper and lower limbs and relative joints. Our experience, treating non union and severe bone loss, has brought us, sometimes, to be confronted with the reality of some failures after unsuccessful attempts to reconstruct. Facing with such radiological and / or clinical drastic situations we wanted to apply the principles of Biological Chamber and oncologic surgery with megaprosthetic replacement solutions. We implanted megaprosthesis with either 1 step or 2 steps (previous antibiotated spacer) technique depending on the septic patient conditions. The aim of this study is to retrospectively evaluate both clinical and radiological outcomes in patients underwent to a lower limb megaprosthesis implant.

MATERIALS AND METHODS: In total, we treated 34 patients with megaprosthesis mono-and bi-articular subdivided as follows: proximal femur, distal femur, proximal tibia and total femur. The mean follow-up of patients is about 20 months (6 yrs max, min 4 months) with clinical and serial radiographic revaluations with standard methods (X-ray in 45 days, 3-6-12-18-24 months) as well as monitoring of blood parameters of inflammation for at least 2 months.

RESULTS: Despite the average follow up is not so long, the first patients have now reached five years of monitoring and in all cases we have had encouraging clinical results with good articulation of the segments, no somato-sensory or motorial deficit and acceptable functional recovery. During surgery and, even more, in the pre-operative planning much attention should be given to the evaluation of the extensor apparatus preserving it and, when necessary, rein-

forcing it with tendon substitutes.

DISCUSSION: Megaprosthesis in traumatic and prosthetic failures can therefore be considered, in extreme cases appropriately selected, as a solution available to the orthopedic surgeon? In oncological surgery the opportunity to regive a function, although not ad integrum, to the patient is certainly an element of great fascination for the surgeon and an opportunity for the patient. Unfortunately, the high mortality associated with this disease does not allow us to have long-term follow-up creating a lack of knowledge about the survival of this type of prosthesis and the medium and long-term complications that may occur. Nevertheless, the patients treated by us should be considered as a oncologic patient, not because of the disease but for the limited therapeutic options available (Image 1 and 2).



CONCLUSIONS: We can consider megaprosthesis as a valuable opportunity to restore functionality to patients who have, despite themselves, to deal with such an important disability.

O12A6

Restoration of Joint Line After Revision Total Knee Arthroplasty

Primary Author: Ju Hong Lee

Institution: Chonbuk National University Hospital, Jeonju, South Korea.

Coauthors: Hyuk Park (Chonbuk National University Hospital)

PURPOSE: The aim of this study was to evaluate the difference of joint line restoration in revision total knee arthroplasty (TKA) used the different type of prosthesis.

MATERIALS AND METHOD: 46 cases of revision TKA between April 2003 to December 2011 were included. The causes of revision TKA were 31 cases of infection, 11 cases of aseptic loosening, 3 cases of wear, and 1 case of instability. Prosthesis were used in 18 cases with PFC® sigma knee system (Depuy, Warsaw, Indiana), 15 cases with NexGen® LCKK system (Zimmer, Warsaw, Indiana) and 13 cases with Legion® total knee system (Smith & Nephew, London, UK), and each prosthesis were classified as group 1, 2, and 3. Joint line elevation was measured from medial epicondyle of distal femur on anterior-posterior radiography of the knee. Joint line elevations in respect of each prosthesis were compared through one-way ANOVA.

RESULT: Average of 4.4 ± 2.5 mm (range: $-1.7 \sim 9.1$) elevation was observed compared to joint line of the primary TKA. Based on joint line of the primary TKA, the mean elevation of joint line were 4.9 ± 4.1 (range: $-3.8 \sim 16.4$) mm in group 1, 5.6 ± 4.3 (range: $-0.8 \sim 15.7$) mm in group 2, and 1.3 ± 2.8 (range: $-3.58 \sim 5.3$) mm in group 3. Restoration of joint line for group 3 showed significant difference compared to other groups ($p=0.014$).

CONCLUSION: Prosthesis equipped with various size of the block and offset system would be effective in restoration of joint line that affects clinical results after revision total knee arthroplasty.

O12A7

Stemless Revision TKA Utilizing Press-Fit Metaphyseal Sleeves: Mid-Term Results of a Novel Technique

Primary Author: Kirk Kindsfater

Institution: Orthopaedic and Spine Center of the Rockies

Coauthors: Cindy Sherman (Orthopaedic and Spine Center of the Rockies)

INTRODUCTION: Revision TKA can be a difficult and complex procedure. Bone quality is commonly compromised and stem fixation is required in many cases to provide stability of the prosthetic construct. However, utilization of diaphyseal engaging stems adds complexity to the case and can present technical challenges to the surgeon. Press fit metaphyseal sleeves can provide stable fixation of the construct without the need for stems and allows for biologic ingrowth of the prosthesis. Metaphyseal sleeves sim-

plify the revision procedure by avoiding the need to prepare the diaphysis for stems, alleviating the need for offset stems and decreasing the risk of intraoperative complications. The ability to obtain biologic fixation in the young patient is also appealing. This study reports on the author's mid-term experience with this novel technique.

METHODS: Between May 2007 and June 2009 the author performed 17 revisions TKA that utilized press-fit metaphyseal sleeves without stems on either the tibial side of the joint, the femoral side of the joint or both. Twenty six sleeves were implanted altogether (13 tibial, 13 femoral). Patients were limited to touch down weight bearing for 6 weeks post-operatively. The patients were followed prospectively with clinical and radiographic follow-up at routine intervals.

RESULTS: Average clinical and radiographic F/U for the cohort was 57 months (range 30 – 77). Fourteen of seventeen patients had a minimum of 4 years F/U. Average age at the time of surgery was 58 years (range 46-72) and average BMI was 32.4. Indications for the index revision included nine knees with aseptic loosening and / or osteolysis, two knees for septic loosening, two knees for instability and 4 knees for pain / stiffness or other causes. ROM at pre-op and latest F/U averaged 2-108 deg and 0- 117 deg respectively. Knee Society Scores at pre-op and latest F/U averaged 35 and 86 respectively (range 57- 100). Survivorship analysis revealed 25 of 26 sleeves (96%) to still be in situ at latest F/U. One tibial sleeve was revised at 30 months for septic loosening. Radiographic analysis revealed 22 of the remaining 25 sleeves (88%) to be ingrown. Two tibial sleeves and one femoral sleeve exhibit stable fibrous fixation and are asymptomatic.

CONCLUSIONS: Press-fit metaphyseal sleeves utilized without stems appear to provide excellent stability of the revision TKA construct at mid-term F/U. Biologic fixation appears to be present in the majority of cases. This ability to obtain reliable osseointegration of the revision construct is appealing, especially in the younger revision patient. The sleeves have proven easy to use and there have been no intra-operative complications. This technique appears to provide a simple, but robust alternative when compared to revision TKA with stems in appropriate cases. Further F/U of this cohort is necessary to evaluate long term results.

Alternative Bearings in THA

O12B1

A Next Generation Anatomically Contoured Ceramic Femoral Head

Primary Author: Andrew A. Freiberg

Institution: Massachusetts General Hospital

Coauthors: Kartik Mangudi Varadarajan (Massachusetts General Hospital), Michael P. Duffy (Massachusetts General Hospital), Thomas Zumbrunn, (Massachusetts General Hospital), Harry E. Rubash (Massachusetts General Hospital), Henrik Malchau (Massachusetts General Hospital)

INTRODUCTION: Large diameter femoral heads have been successfully used to prevent dislocation after Total Hip Arthroplasty (THA). However, recent studies show that the distal region of contemporary femoral heads can impinge on native soft-tissues, particularly the iliopsoas, leading to activity limiting anterior hip pain (Fig. 1). To address this we developed an Anatomically Contoured large diameter femoral Head (ACH) that maintains the hemispherical profile of a contemporary large diameter head above the equator, while contouring the distal profile below the equator for soft-tissue relief (Fig. 2). The soft tissue friendly design of the ACH implant was optimized to maintain the dislocation benefits, and to not alter the wear performance and load bearing femoroacetabular contact area of conventional large heads. This was verified via dislocation analysis, hip simulator wear testing, and finite element analysis (FEA).

METHODS: Implant stability was evaluated by simulating dynamic hip dislocation in MSC Adams. A 36mm ACH, a 36mm conventional head, and a 28mm conventional head were tested under two dislocation modes: (A) Posterior dislocation with internal hip rotation; (B) posterior dislocation with combined hip flexion and adduction. Wear performance of 36mm ceramic ACH implants and 36mm conventional ceramic heads articulating against UHMWPE (ultra-high molecular weight polyethylene) liners was compared with a 12-station AMTI hip simulator. Two types of acetabular liners were tested: compression molded conventional PE, and highly cross-linked VitE-

PE liners. To assess the femoroacetabular contact area, a FEA was completed with a 36 mm conventional head and a 36mm ACH implant. The femoral heads were modeled as rigid and articulated against UHMWPE acetabular liner modeled as plastically deformable. Loading cases corresponding to walking, chair sit and deep knee bend activities were analyzed.

RESULTS: The dislocation analysis did not show any differences between the 36 mm ACH implant and the conventional 36 mm head. Both showed increased jump distance compared to the 28 mm conventional head. There was no difference between wear rate of the ceramic ACH implants and the conventional ceramic heads articulating against either UHMWPE liner materials (current results based on 2 million cycles). For example, average wear rate of conventional PE liners articulating against, the conventional ceramic heads and the ceramic ACH implants, was 21.4 ± 4.1 mg/MC and 20.8 ± 4.2 mg/MC, respectively. The FEA analysis also did not show any difference in articular contact area for the ACH and conventional heads articulating against UHMWPE liners.

CONCLUSION: This study showed that, as intended, an anatomically contoured large diameter femoral head designed to provide soft-tissue relief, maintains the stability of conventional implant of the same size, and does not alter the wear performance, and the load bearing articular contact area.

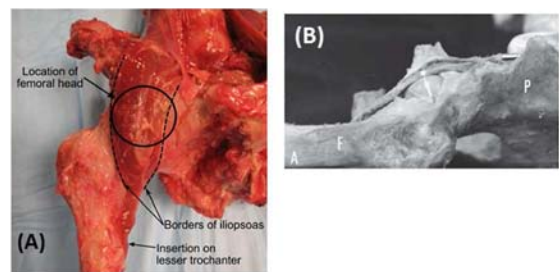


Figure 1. (A) Left hip of cadaver specimen with superficial soft-tissues removed to show iliopsoas muscle and tendon. The iliopsoas travels anteriorly over the femoral head and wraps around the distal femoral head prior to inserting on the lesser trochanter. (B) Sagittal image of cadaver hip from study by Yoshio et al. (J Orthop Sci 7:199-207, 2002) showing iliopsoas tendon articulating with femoral head (P = pelvis, F = femur, arrow indicates iliopsoas femoral head contact).

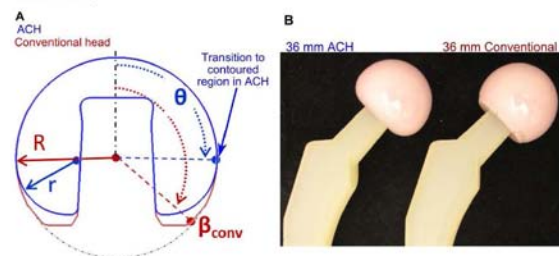


Figure 2. (A) Geometric comparison of a conventional large diameter femoral head and the new Anatomically Contoured Head (ACH) (B) A 36 mm ceramic ACH and a 36 mm ceramic conventional head.

O12B3

What Factors Influence Fretting Corrosion in Modular Total Hip Arthroplasty? A Matched Cohort Study

Guest Faculty: Steven M. Kurtz, MD

Institution: Drexel University and Exponent, Inc., Philadelphia, PA, USA

Coauthors: Daniel W. MacDonald (Drexel University), Sevi B. Kocagoz (Drexel University), Josa A. Hanzlik (Drexel University), Richard J. Underwood (Exponent, Inc. and Drexel University), Jeremy L. Gilbert (Syracuse University), Gwo-Chin Lee (Univers

INTRODUCTION: Recent implant design trends have raised renewed concern regarding metal wear debris release from modular connections. Previous studies regarding modular head-neck taper corrosion were largely based on cobalt chrome (CoCr) alloy femoral heads. Comparatively little is known about head-neck taper corrosion with ceramic femoral heads or about how taper angle clearance influences taper corrosion. This study addressed the following research questions: 1) Could ceramic heads mitigate electrochemical processes of taper corrosion compared to CoCr heads? 2) Which factors influence stem taper corrosion with ceramic heads? 3) What is the influence of taper angle clearance on taper corrosion in THA?

METHODS: 100 femoral head-stem pairs were analyzed for evidence of fretting and corrosion. A matched cohort design was employed in which 50 ceramic head-stem pairs were matched with 50 CoCr head-stem pairs based on implantation time, lateral offset, stem design and flexural rigidity. Fretting corrosion was assessed using a semi-quantitative scoring scale where a score of 1 was given for little to no damage and a score of 4 was given for severe fretting corrosion. The head and trunnion taper angles were measured using a roundness machine (Talyrond 585, Taylor Hobson, UK). Taper angle clearance is the difference between the head taper angle and trunnion angle.

RESULTS: The fretting and corrosion scores were significantly lower for the stems in the ceramic head cohort when compared with the CoCr cohort. Stem alloy and stem flexural rigidity were predictors of stem fretting and corrosion damage in the ceramic head cohort, however not for the CoCr cohort. The mechanism of mechanically assisted crevice corrosion was the same in the two cohorts, with

the exception being that, only one of the two surfaces (i.e., the trunnion) engaged in the oxide abrasion and repassivation process in the ceramic cohort. There was no significant correlation observed between taper angle clearance and visual fretting-corrosion scores for trunnions in the ceramic cohort ($Rho=-0.17$), trunnions in the CoCr cohort ($Rho=0.24$), or the femoral head tapers in the metal cohort ($Rho=-0.05$) (Figure 1). Additionally, visual fretting-corrosion scores in the metal cohort were similar between components with distal contact (negative taper angle clearance) and components with proximal contact (positive taper angle clearance) ($p=0.43$ and 0.56 for head and trunnion scores, respectively).

CONCLUSIONS: The results suggest that by using a ceramic femoral head, CoCr fretting and corrosion from the modular head-neck taper may be mitigated, but not completely eliminated. The findings of this study support further study of the role of ceramic heads in potentially reducing femoral taper corrosion. Taper angle clearance was not correlated with the visual fretting-corrosion scores in the ceramic or CoCr cohort in the present study. The effects of taper angle clearance may not be significant compared to other factors leading to material loss or the lack of correlation may be due to the limitations in the visual scoring method. Research is underway quantify the volume of material release from explants to better understand the reasons for reduced fretting and corrosion observed in the ceramic head cohort.

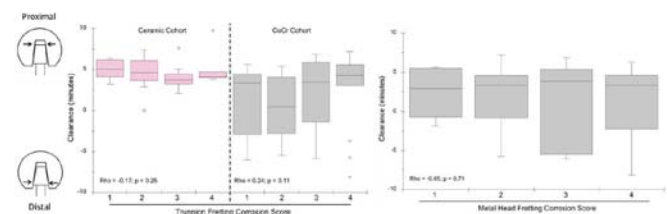


Figure 1: Distribution of measured taper angle clearances for the ceramic and metal cohorts according to trunnion fretting corrosion score (left), and the metal head fretting corrosion score (right).

O12B4

News on Ceramic Wear, Corrosion and Infection

Primary Author: Robert M. Streicher

Institution: CeramTec GmbH

Coauthors: Roman Preuss (CeramTec GmbH), Markus Flohr (CeramTec GmbH), Kim Haeussler (CeramTec GmbH), Javad Parvizi (Rothman Institute), Rihard Trebse (Valdoltra Orthopaedic Hospital), Aldo Toni (Istituto Rizzoli)

INTRODUCTION: Wear related osteolysis, dislocation, fretting corrosion and prosthetic joint infection (PJI) are major factors leading to revision of THA. The effect of using ceramic components to address these issues was investigated to determine their behaviour and potential benefit.

METHODS:

a) *Wear determination*

A series of large CoC articulations (36/40/44 mm) was evaluated using a hip simulator (ISO 14242) up to 5 million cycles. Wear was measured gravimetrically.

b) *Fretting corrosion determination*

Fretting corrosion tests (ASTM F1875) were carried out with 4.5 and 10 kN load using various metal tapers. A fatigue test was applied with the same loads in a corrosive fluid. Additionally, abduction/adduction and flexion loading at 3 kN was applied in simulator. Torque-out tests and surface analysis of the surfaces were performed.

c) *Infections*

For determining the risk of prosthetic joint infection (PJI) dependence on bearing couples four databases were analysed. Additionally data from registers and literature were reviewed. Only data for cementless THA were used. One of the registers also analysed the influence of age at surgery, BMI, pathology and articular coupling using Cox multivariate analysis.

RESULTS:

a) *Wear measurements*

44 mm bearings exhibited highest and 36 mm bearings lowest run-in wear rate. The highest linear wear rate was detected for a 36 mm bearing having a clearance of 20 µm and the smallest was a 44 mm bearing having a clearance

of 70 µm. None of the results were statistically significant.

b) *Fretting corrosion*

The currents from the ASTM testing showed low values even for long-term testing. The strength of the head-sleeve-taper connection was not affected by fatigue testing and no critical change of pull-off forces was observed. No loosening of the connection was detected after hip simulator testing and no critical corrosion effects for ceramic heads with Ti-6Al-4V sleeves. Even stainless steel showed only tribo-chemical layers and plastic deformation of the taper surface.

c) *Infections*

The rate of revisions for infection for the almost 400'000 patients from the various information sources was in the range of 0.2 to 1.1%. Age at surgery and BMI did not influence septic loosening, while articular coupling did, sometimes significant. The trend was identical for all six sources and ceramic components resulted in a lower incidence of revisions for up to 50%.

CONCLUSION: The wear of CoC articulations with large diameter is extremely low and independent on size and geometry. All tests with ceramic heads and titanium sleeves exhibited only minor effects on the modular connection. Even worst case material combinations, high loads, corrosive fluid and high frictional torque did not show any critical results.

Revisions due to infection seem to be also dependent on the bearing couple with a positive influence by using ceramic components. Although only partially significant and due to the complex reasons for infections only regarded a trend, CoP and CoC seem to mitigate the PJI risk.

O12B5

Primary Clinical Result of Alumina-Matrix Composite (AMC) Ceramic Hip Prosthesis

Guest Faculty: Yixin Zhou, MD

Institution: Beijing Ji Shui Tan Hospital Beijing, China

BACKGROUND: Recently, as the representative of a new generation of BIOLOX® delta, alumina matrix composite (AMC) ceramic artificial hip joint prosthesis has begun to be used clinically.

OBJECTIVE: To observe the primary clinical result of AMC ceramic total hip arthroplasty.

METHODS: From January 2010 to September 2012, 639 patients (657 hips) were treated by total hip arthroplasty with AMC; and 521 patients (529 hips) treated with pure alumina prosthesis were served as control group. The follow-up radiographic evaluation and clinical Harris score were retrospectively analyzed. The mean follow-up time was 13.3 months.

RESULTS: There was no significant difference in Harris score between the two groups. During the follow-up, two patients got their ceramic liner broken. No patient complained of the squeaking of prosthesis, no dislocation and loosening of the implant, and no infection, heterotopic ossification, fracture or osteolysis occurred.

CONCLUSIONS: The primary clinical result of AMC hip prosthesis was satisfactory; however, the breaking problem of ceramic liner needs a long-term follow-up.

KEYWORDS: hip; alumina matrix composite ceramic; artificial joints; arthroplasty; implant.

O12B6 Clinical and Radiographic Performance of 32mm and 36mm Heads against Highly Crosslinked Polyethylene (HXLPE): A 5 Year Study Comparing Ceramic and Metal Heads

Primary Author: Amar Ranawat, MD

Institution: Hospital for Special Surgery, New York, NY, USA

INTRODUCTION: Wear and osteolysis are major contributors which limit the durability of total hip arthroplasty (THA)^{1, 2}. Efforts were made to decrease wear by cross-linking polyethylene and using alternate bearing surfaces³. The purpose of this study is to evaluate the wear of 32 and 36mm ceramic heads (BioloX Delta, Ceramtec) against HXLPE (X3, Stryker) and compare it to a similar cohort with chromium-cobalt heads against the same polyethylene.

MATERIALS AND METHOD: 52 hips (48 patients) from ceramic on HXLPE (CX3) group and 32 hips (29 patients) from metal on HXLPE (MX3) group were evaluated at their 5 year follow-up. The mean age of patients was 62 (45-75) in the CX3 group and 73 (60-85) in the

MX3 group reflecting a trend to use ceramics in younger patients. Wear was measured on an AP pelvis X-ray using the computer-assisted Roman 1.70 software. Clinical assessment was conducted using WOMAC (0-100; 0 considered best), PAQ (0-100, lower score indicates better status), HSS (0-40; 40 considered best) and UCLA (0-10; 10 considered best) scores at the final follow-up. The mean follow-up for CX3 and MX3 groups were 4.9 and 4.6 years, respectively.

RESULTS: The mean wear rates were 0.0191 ± 0.044 mm/yr for the CX3 group and 0.0297 ± 0.038 mm/yr for the MX3 group. The mean WOMAC, PAQ, HSS and UCLA scores for CX3 and MX3 groups at final follow-up were 10.1 ± 14.4 and 13.2 ± 17.3 , 16.5 ± 17.8 and 17.1 ± 17.2 , 36.4 ± 5.3 and 31.6 ± 10.5 , and finally 5.9 ± 1.8 and 5.3 ± 1.6 , respectively. Radiographic analysis does not reveal any incidence of osteolysis or loosening in either group. There were no revisions for any reason in either group.

DISCUSSION AND CONCLUSION: Although the CX3 group was a decade younger than the MX3 group, outcomes data and activity levels were similar. Wear rates, on the other hand, were lower for the CX3 group. We currently use Ceramic against HXLPE in the majority of our total hip procedures.

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How Soft-Tissues affect TKA?

O13A1 Ligament Releases

Guest Faculty: W. Norman Scott, MD, FACS
Institution: Insall Scott Kelly Institute for Orthopaedics & Sports Medicine New York, New York, USA

As far back as the 1970's it became apparent that tightening stretched ligaments in the arthritic knee did not work. Subsequently the development of ligament releases heralded the advent of using surface replacements in difficult deformities. Ligament releases and bone deformity must be addressed simultaneously, as will be illustrated.

In classic Gap Balancing the releases have classically been performed prior to the bone resection, whereas with Measured Resection techniques the releases are performed after the bone resection. In the common hybrid techniques of Gap Balancing and Measured Resection, the releases are performed after the flexion/extension gaps and femoral bone sizing and rotational alignment is achieved. Non-conventional surgical techniques, computer assisted, patient specific instruments, robotics usually perform the releases after bone resection.

In the varus knee the contracted medial structures include the joint capsule, MCL (superficial and deep), semimembranosus and pes anserinus. Unlike in the early history of releases these structures are released in a sequential fashion, as will be demonstrated.

Similarly in the valgus knee the contracted structures include the iliotibial band, lateral joint capsule, popliteus and LCL. Today's discussion will detail the surgical techniques via slides and video demonstration.

O13A2 Total Knee Arthroplasty in Severe Deformity

Guest Faculty: Douglas A. Dennis, MD
Institution: Adjunct Professor, Dept. of Biomedical Engineering, University of Tennessee; Adjunct Professor of

Bioengineering, University of Denver; Assistant Clinical Professor, Dept. of Orthopaedics, University of Colorado School of Medicine, Denver, CO, USA

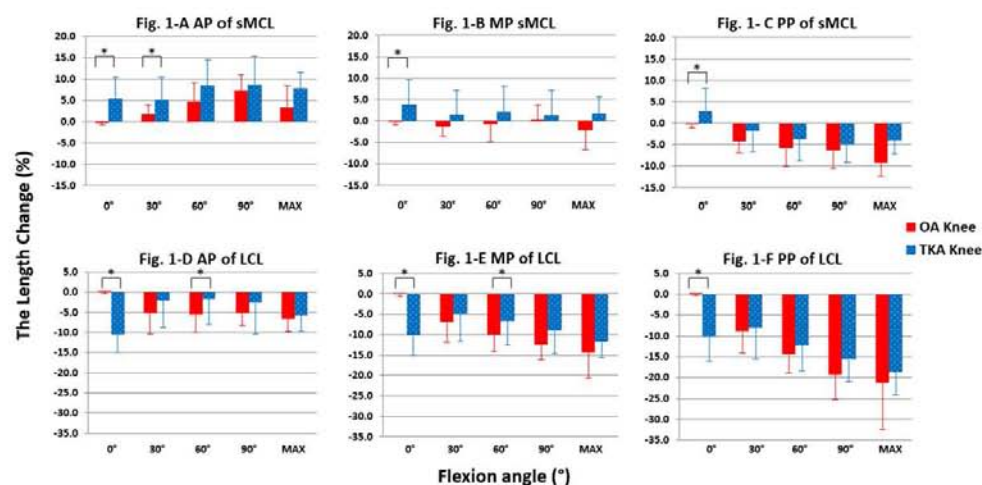
Severe knee deformities are typically associated with ligamentous imbalance and bone loss. They may result from long-standing arthritis, previous osteotomy, fracture malunion, congenital deformities, or metabolic bone disorders. When considering total knee arthroplasty (TKA), the surgeon must determine if the deformity is intra-articular or extra-articular. Many intra-articular deformities can be corrected with an asymmetric intra-articular osseous resection. Extra-articular deformities may require an extra-articular osteotomy, particularly if located close to the knee joint and greater than 15-20 degrees in magnitude. Many severe deformities are associated with large peri-articular osteophytes which require removal before extensive soft tissue releases are performed during TKA. Due to the extensive soft tissue releases often required in cases with severe knee deformity, the surgeon must have a complete TKA system available at the time of operation including prosthetic augments, diaphyseal-engaging stems, and increased levels of prosthetic constraint.

O13A3 In-vivo Function of the Collateral Ligaments and Maximal Flexion in A Posterior Cruciate Retaining TKA

Primary Author: Guoan Li
Institution: Bioengineering Lab., Dept. of Orthopaedic Surg., MGH, Harvard Univ., Boston, MA, USA

Coauthors: Kwan Kyu Park (Dept. of Orthopedic Surgery, Yonsei University, College of Medicine, Seoul, Korea), Ali Hosseini (Bioengineering Lab., Dept. of Orthopaedic Surg., MGH, Harvard Univ., Boston, MA, USA), Tsung-Yuan Tsai (Bioengineering Lab., Dept. of Orthopaedic Surg., MGH, Harvard Univ., Boston, MA, USA)

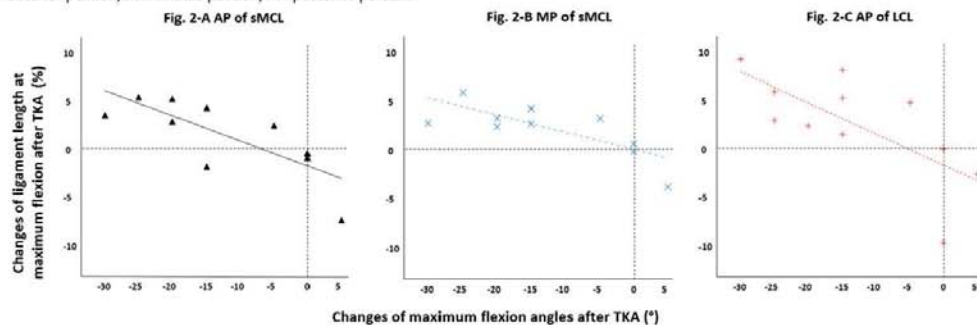
BACKGROUND: Posterior cruciate ligament retaining total knee arthroplasty (CR-TKA) is a widely accepted treatment for end-stage knee osteoarthritis (OA). Although excellent long term survivorship and pain relief have been reported, achieving deep flexion beyond 120° remains a challenge after TKA surgeries. This study investigated the length changes of the superficial medial (sMCL) and lateral collateral ligaments (LCL) before and after a CR-TKA



Figs. 1-A through 1-F The change of ligament length in OA and TKA Knees. Fig. 1-A AP of sMCL: Fig. 1-B MP of sMCL: Fig. 1-C PP of sMCL: Fig. 1-D AP of LCL: Fig. 1-E MP of LCL: Fig. 1-F PP of LCL.

*Significant difference of the length change between the OA and the TKA Knees.

OA: medial knee osteoarthritis; TKA: total knee arthroplasty; sMCL: superficial medial collateral ligament; LCL: lateral collateral ligament; AP: anterior portion; MP: middle portion; PP: posterior portion.



Figs. 2-A, 2-B, and 2-C Correlations between the increases of maximum flexion angles (°) and the changes of the ligaments length at maximum flexion (%) after TKA. Fig. 2-A AP of sMCL: Fig. 2-B MP of sMCL: Fig. 2-C AP of LCL. Points present individual data and lines present the linear regression.

OA: medial knee osteoarthritis; TKA: total knee Arthroplasty. sMCL: superficial medial collateral ligament; LCL: lateral collateral ligament. AP: anterior portion; MP: middle portion; PP: posterior portion.

(High Flex NexGen CR, Zimmer). We hypothesized that if a CR-TKA causes overstretching of the collateral ligaments in high flexion, it could lead to a reduced maximal flexion in the TKA knees.

METHODS: Three dimensional (3D) knee models of 11 patients (with end-stage medial knee OA) including the insertions of the collateral ligaments were created using MR images. Each ligament was divided into 3 equal portions: anterior, middle and posterior portions (AP, MP and PP). Pre- and post-TKA knee kinematics was acquired using a dual-fluoroscopic imaging system during a single-leg weightbearing flexion. The shortest 3D wrapping path of each ligament was measured along the knee flexion path. The relationship between the changes of the maximal knee flexion angles and the changes of the ligament length at maximal knee flexion after TKAs was quantified.

RESULTS: The 3 portions of the sMCL of the OA knees showed a significant decrease in length beyond 90° of flexion, while the 3 portions in the TKA knees showed min-

imal variation in length changes beyond 60° of flexion (Figs. 1A-1C). In comparison of the OA and TKA knees, the sMCL showed only significant increases in length at full extension after TKA (Figs. 1A-1C). All three portions of the LCL had length decrease with knee flexion in OA knees, but in the TKA knees, the lengths of the 3 portions increased until mid-flexion, and then decreased with further flexion except the AP (Figs. 1D-1F). Analysis of the data at maximal flexion of all patients indicated that the increase of the maximum flexion angle of a patient after TKA was negatively correlated with the increases of the lengths of the AP ($p=0.010$, $r=0.733$) (Fig. 2A) and MP ($p=0.049$, $r=0.604$) (Fig. 2B) of the sMCL as well as the AP ($p=0.010$, $r=0.733$) (Fig. 2C) of the LCL at maximal flexion of the patient knee after TKA surgery.

CONCLUSIONS: In patients with CR-TKA, the increases of the length of the collateral ligaments at maximal flexion of the knee compared with those before TKAs were negatively correlated to the increase of the maximal knee flexion angles. Our data suggests that collateral ligament soft tissue balancing should also be evaluated at higher knee flexion angles in order to optimize maximal flexion of the knee after TKAs.

O13A4

Necessity of Posterior Cruciate Ligament Preservation in Severe Flexion Contracture in Total Knee Arthroplasty

Primary Author: Ryutaku Kaneyama

Institution: Funabashi Orthopedic Hospital

Coauthors: Hideaki Shiratsuchi (Funabashi Orthopedic

Hospital), Kazuhiro Oinuma (Funabashi Orthopedic Hospital), Hidetaka Higashi (Funabashi Orthopedic Hospital), Yoko Miura (Funabashi Orthopedic Hospital), Tatsuya Tamaki (Funabashi Orthopedic Hospital)

INTRODUCTION: The knees with severe flexion contracture have smaller extension gap (EG) than usual in TKA; however, many authors recommend posterior cruciate ligament (PCL) resection, which widens the flexion gap (FG) more than the EG. PCL resection for flexion contracture remains controversial to date. To address this issue, we measured the intraoperative EG and FG with the PCL intact in order to assess the characteristics of the gaps and to estimate the degree to which flexion contracture influenced the two gaps.

MATERIALS AND METHODS: Preoperative flexion contracture was divided into 3 categories, FC0 (flexion contracture < 10 degrees), FC10 (10 ≤ flexion contracture < 30 degrees), and FC30 (30 ≤ flexion contracture). The gaps were measured using 3 different methods according to the operation period: a tension device system with 30- and 40-pound tension (groups 1 and 2) and a spacer block system with a 1-mm increment thickness variation (group 3). Groups 1, 2, and 3 included 131, 157, and 214 knees, respectively. The number of knees with FC0, FC10, and FC30, respectively, was 48, 62, and 21 knees in group 1; 53, 81, and 23 in group 2; and 92, 109, and 13 knees in group 3. Student's t-test and paired t-test were applied for statistical analysis.

RESULTS: After bone resection, the average EG and FG in patients with preservation of PCL were 17.0 and 20.3 mm, 16.4 and 20.6 mm, and 16.2 and 20.9 mm in FC0, FC10, and FC30, respectively, in group 1; 18.7 and 21.8 mm, 18.5 and 22.1 mm, and 17.6 and 23.0 mm in group 2; and 18.2 and 19.0 mm, 16.5 and 18.6 mm, and 12.5 and 18.3 mm in group 3, respectively (Table). EG was significantly smaller than FG in all categories in all groups ($p < 0.01$, paired t-test). The average difference between both gaps was 3.3, 4.1, and 4.6 mm in FC0, FC10, and FC30, respectively, in group 1; 3.1, 3.5, and 5.4 mm in group 2; and 0.7, 2.1, and 5.8 mm in group 3, respectively. The gap difference was significantly greater in FC30 than in FC0 in each group ($p < 0.05$, Student's t-test) (Table). To avoid additional widening of the gap difference because of PCL resection, PCL was preserved in 15 (71.4%), 18 (78.3%), and 11 (84.6%) knees even in FC30 in groups 1, 2, and 3, respectively.

CONCLUSION: Many authors have reported that severe flexion contracture should be treated with PCL resection in TKA regardless of widening of FG induced by PCL resection. Although EG and FG were different among 3 groups in our study, the results of the gap difference were similar despite using different measurement methods. In each group, gap difference was significantly greater in FC30 than in FC0. Because PCL resection usually widens the FG more than the EG, the risk of a much larger difference between EG and FG should be considered when the PCL is resected, especially in patients with severe flexion contracture.

O13A5

Malrotated Tibial Component Increases Medial Collateral Ligament Tension in TKA

Primary Author: Shinichi Kuriyama

Institution: Graduate School of Medicine, Kyoto University

Coauthors: Masahiro Ishikawa (Graduate School of Medicine, Kyoto University), Moritoshi Furu (Graduate School of Medicine, Kyoto University), Hiromu Ito (Graduate School of Medicine, Kyoto University), Shuichi Matsuda (Graduate School of Medicine, Kyoto University)

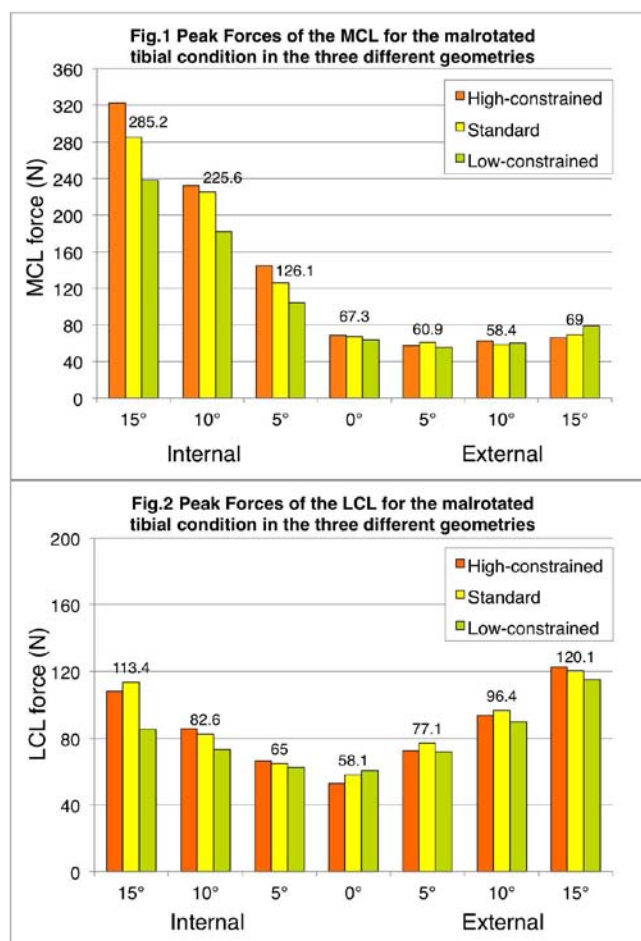
INTRODUCTION: Malposition of the tibial component would lead to various complications after total knee arthroplasty (TKA) such as improper joint kinematics, patellofemoral instability, or excessive wear of polyethylene. However, despite reports of internal component rotation being associated with more severe complications than external rotation, the biomechanical reasons remain largely unknown. In this study, we used a musculoskeletal computer model that simulates knee flexion under quadriceps control and analyzed the effects of malrotated tibial component on lateral and medial collateral ligament (LCL and MCL) forces, tibiofemoral contact force, and patella shear force during the simulated weight-bearing deep knee flexion.

MATERIALS AND METHODS: A musculoskeletal model, replicating the dynamic quadriceps-driven weight-bearing knee flexion in previous cadaver studies, was simulated in three different constrained tibial geometries with a posterior cruciate-retaining arthroplasty prototype component. The model included tibiofemoral and patellofemoral

contact, passive soft tissue and active muscle elements. The soft tissues were modeled as nonlinear springs using previously reported spring stiffness parameters, and the bony attachments were also scaled to some cadaver reports. The neutral rotational alignment of the femoral and tibial components was aligned according to the femoral epicondylar axis and the tibial anteroposterior axis, respectively. Knee kinematics and ligament forces were computed during two cycles of squatting for mal-rotated conditions of the tibial component. The tibial rotational alignments were changed between 15° external rotation and 15° internal rotation in 5° increments, and forces at MCL, LCL, tibiofemoral joint and patellofemoral joint were compared among the knees with different rotational alignment.

RESULTS: For the MCL, the neutral and 15° externally rotated tibial components caused a maximum force of 67.3 N and 69.0N, respectively. In contrast, the 15° internally rotated tibial components increased forces to 285.2N as a maximum force [Fig.1]. The LCL force also increased but up to less than half of the MCL value [Fig.2]. The higher degree of constraint of the tibial component was associated with greater femoral rotational movement and higher MCL force. The tibiofemoral and patellofemoral contact forces were not influenced by malrotation of the tibial component, but the contact stresses increased because of a decreased contact area.

DISCUSSION AND CONCLUSION: In this computer simulation, excessive internal rotation in the tibial component increased MCL forces and patellofemoral and tibiofemoral contact stress. The current study suggests that increased MCL forces and patellofemoral and tibiofemoral contact stress caused by a malrotated tibial component could be one cause of patient complaints and polyethylene problems after TKA.



O13A6

Initial Results of a Modified Flexion/Extension Gap Balancing Technique Using Soft Tissue Force Measurements In TKA

Primary Author: Stefan Kreuzer

Institution: University of Texas Health Science Center Houston

Coauthors: Amir Pourmoghaddam (Memorial Bone and Joint Research Foundation), Adam M. Freedhand (University of Texas Health Science Center Houston)

INTRODUCTION: The early development of instrumentation for TKA led to two distinct surgical techniques for knee arthroplasty: the gap-balancing technique and the measured resection technique. The gap-balancing technique can lead to elevation of the joint line when the femoral component is moved anterior to avoid notching through over-resection of the posterior condyles. Shifting the resections anterior leads to a looser flexion space. To balance the flexion and extension gaps and achieve full extension

more distal femur may need to be resected which raises the joint line. With measured resection compensatory soft tissue releases may be necessary to accommodate the cuts performed by the instruments to achieve ligament balance. Regardless of technique, slight adjustments in soft tissue tension and bone resection may be required to achieve a well-balanced total knee.

OBJECTIVES: The purpose of this study was to compare a new flexion/extension gap (flex/ext) balancing technique using a force sensor plate and soft tissue distractor with a modified “balanced resection” technique (flexion only).

METHODS: For the flexion/extension gap balancing technique, a provisional distal femoral cut of approximately 5mm was performed followed by an anatomic tibial cut. To balance the flexion gap, the conventional eLIBRA instrumentation was utilized to establish femoral rotation. After the anterior and posterior femoral cuts were completed, the posterior osteophytes were carefully removed and posterior capsular release was performed. The flexion gap was measured using the eLIBRA and the extension gap was matched to the flexion gap using a soft tissue balancer with the leg in extension followed by recutting the distal femoral bone. The force sensor again was used during this step to get equal tension on the medial and lateral collateral ligaments. All cuts were measured utilizing computer navigation. The results were compared to 44 knees operated via flexion gap balancing.(flexion only). Mann-Whitney-U-test was performed to determine statistical significance. IRB approval and informed consent was obtained for all patients.

RESULTS: No differences were noted in pre and post-implantation femoral alignment and orientation of the femoral and tibial cuts between the techniques. A 10° improvement in mean arc of motion was seen in the flex/ext gap balancing technique whereas a 5.5° degree improvement was seen in the flexion only gap balancing technique.

CONCLUSION: The flexion/extension balancing technique employs a force sensor plate that appears to achieve a well aligned extremity without requiring additional soft tissue release. The results of the current study suggest that the intra-operative range of motion was significantly increased by the application of the flexion/extension balancing technique. Although the femur was prepared without using any bone landmarks, both techniques had little impact on overall alignment, femoral rotation, or distal fem-

oral cut. This technique may lead to improved long term clinical outcomes in patients undergoing total knee arthroplasty. Future studies should be conducted to evaluate this potential improvement.

O13A7

Alignment and Ligaments Balance in Total Knee Arthroplasty

Primary Author: Alberto Agueci

Institution: Conegliano Hospital

Coauthors: Cesare Mariani (Conegliano Hospital)

The Authors present their ligament tensor for evaluation of the ligaments balance during total knee arthroplasty. With the device presented, the surgeon is able to find the right orientation of the bone resections not only in knee flexion but also in extension, to optimize the distal femoral cut orientation.

To maximize the technic results,after the tibial cut and rotational femoral evaluation with the tensor, the Authors propose to perform, as first femoral step, the posterior femoral cut, before the distal one.

This procedure allows to remove the posterior femoral osteophytes that are able to falsified the ligament and posterior capsule tension during knee extension.

Clinical Outcomes of THA

O13B1

Why Total Hip Arthroplasties Fail in 2014: What Can We Learn?

Guest Faculty: Daniel J. Berry, M.D.

Institution: Mayo Clinic; Rochester, MN, USA

I. Introduction

A. THA is a great operation—arguably the most suc-

successful operative intervention, period! But there is still room for improvement.

B. Sources of THA failure:

1. Patient related problems
2. Technical surgical problems
3. Implant related problems

II. What Remains to be Fixed?

A. According to large national databases the most common reasons for reoperation are:

1. Loosening/mechanical failure
2. Dislocation
3. Wear/lysis
4. Infection
5. Periprosthetic fracture
6. Device specific problems

III. Loosening:

- A. Still the most common reason for failure
- B. Partly a legacy of past era
- C. Loosening is now less common with:
 1. Good technique
 2. Good implant choice

IV. Dislocation:

- A. Rate has declined with larger diameter heads and better approaches
- B. Further reduction awaits new technology: perfecting implant position for every patient

V. Infection:

- A. Unsolved problem: Little progress in 30 years
- B. Host factors are very important
- C. Operating room environment also plays an important role
- D. We still need innovation in this space

VI. Bearing Surfaces:

- A. Crosslinked polyethylene is performing very well at 10(+) years
- B. Exercise caution with other bearings: There is a good chance their failure rate will be higher

VII. Periprosthetic Fractures:

- A. Still unsolved
- B. More late fractures are occurring than we once recognized
- C. More early fractures are occurring with uncemented THA

VIII. New Technology Related Problems:

- A. Metal-metal failures
- B. Modular femoral neck failures
- C. Taper corrosion problems
- D. Ceramic squeak
- E. All indicate cautious adoption of new technologies

gies

IX. Early/Midterm/Late Failures:

A. Early Failures:

1. Mostly technical problems (dislocation/fracture/loosening)
2. Occasional patient problems (infection)
3. Occasional device problems

B. Midterm Failures:

1. Mostly the implant/technology
 - a. Premature loosening, wear, implant fracture, corrosion

C. Late Failures:

1. Mostly patient/use related failures
 - a. Loosening, wear, fracture, infection, instability

O13B2

Early Outcomes of Simultaneous Bilateral Direct Anterior Approach Total Hip Arthroplasty: A Retrospective Review

Guest Faculty: Cass K. Nakasone, MD

Institution: Straub Clinic & Hospital, Honolulu HI, USA

Coauthors: Trudy Hong (John A. Burns School of Medicine)

Total hip arthroplasty is one of the most common orthopedic surgeries performed. Simultaneous bilateral THA, however, a procedure where both hip joints are replaced during a single anesthetic event, is relatively uncommon. There are few reports in the literature regarding simultaneous bilateral THA done thru a direct anterior approach. The primary objective of this study is to describe the early complications encountered and short-term outcomes of a relatively large cohort of patients who underwent simultaneous bilateral THA utilizing a direct anterior approach by a single fellowship trained surgeon in a community hospital setting.

A retrospective chart review was performed on a group of 72 patients who had had simultaneous bilateral THA utilizing a direct anterior approach at the Straub Clinic & Hospital between January 2006 and December 2012. Minimum followup was 3 months. Data collected from the electronic medical records included variables such as hospital length of stay, disposition (home or short-term rehabilitation facility), days to ambulation, average distance walked on

each postoperative until discharge and early postoperative complications.

There were 39 females and 33 males. Average BMI was 26.7 (18.5 - 40.3). Sixty nine (95.8%) patients had osteoarthritis, two (2.8%) had avascular necrosis and one (1.4%) had rheumatoid arthritis. The average preoperative hemoglobin level was 14.0 g/dL. The average blood loss per hip was 210 cc (75 cc - 600 cc). The average postoperative hemoglobin levels were 10.8 g/dL.

The average hospital length of stay was 3 days (1-7). The average distanced walked on postoperative day one was 73 ft. and on postoperative day two this increased to 187 ft. For those patients still in the hospital on postoperative day three and four, the average distance walked was 219 ft. and 249 ft., respectively. 82% were discharge directly to home and 18% required transfer to a short-term rehabilitation facility before returning to a home environment.

There were no postoperative dislocations, one superficial infection, one deep infection requiring irrigation and debridement with head and liner exchange and six weeks of IV antibiotics, one periprosthetic fracture due to fall requiring revision of the stem and reduction of the fracture, one postoperative hematoma requiring irrigation and debridement and one greater trochanteric fracture not requiring surgical intervention. There were no deep vein thromboses, pulmonary emboli, myocardial infarctions, or other serious systemic complications. Thirty eight of the patients required transfusion of at least one unit of packed red cells. For those patients requiring transfusions, the average number of units transfused was 2.6.

Overall, bilateral THA done thru a direct anterior approach resulted in short hospital stays, rapid return to early ambulation with assistive devices, decreased need for short term rehabilitation facilities and few early postoperative complications.

O13B3

Outcome of Primary Total Hip Arthroplasty in Patients Over 80 Years of Age

Primary Author: Yoko Miura

Institution: Funabashi Orthopaedic Hospital

Coauthors: Kazuhiro Oinuma (Funabashi Orthopaedic

Hospital), Tatsuya Tamaki (Funabashi Orthopaedic Hospital), Hideaki Shiratsuchi (Funabashi Orthopaedic Hospital)

INTRODUCTION: It's becoming very aging society in many developed countries, and an increase of elderly numbers who undergo total hip arthroplasty is expected.

OBJECTIVE: The purpose of this study is to investigate the outcome of THAs in the elderly and find the risk and benefit.

METHODS: One hundred and three patients, 108 hips, older than 80 years, were treated with total hip arthroplasty from 2005 to 2013. The mean age was 83 years. Five patients were operated bilaterally. The female ratio was 88%. They were all operated with direct anterior approach. The preoperative diagnosis were degenerative joint disease in 98 hips, complications after proximal neck fractures in 5 hips, rheumatoid arthritis in 2 hips, aseptic necrosis in 2 hips, and femoral neck fracture 1 hips. Mean follow-up periods were 59.1 months.

RESULTS: Preoperative systemic complications such as heart disorder, cerebrovascular disorder, and diabetes were seen in 98% of patients. Cemented stems were used in 25 hips (23%) and cementless stems were used in 83 hips (77%). Mean blood loss was 347ml, and mean operative time was 56 minutes. Preoperative Japan Orthopaedic Association (JOA) scores averaged 36 points, and improved to 83.8 points postoperatively. The level of independent living at their home was maintained 90 % of patients at long term follow up.

CONCLUSIONS: In the elderly over 80 years old, even though they have various systemic complications and osteoporotic bones, satisfactory outcome could be anticipated after THA. But some reports have already mentioned that they have high risk of recurrent dislocations, infection and high mortality. We have to pay more attentions to good initial stem fixation, muscle preservation, less dislocation and less invasive operation in these elderly patients.

O13B4 The Effect of a Short Stem on Implant Stability

Primary Author: Joseph F. Fetto

Institution: NYU Hospital for Joint Diseases

Coauthors: Leali Alex (Hosp. for Spec Surg)

INTRODUCTION: Recent interest in shorter surgical incisions and alternative approaches has led to shortening the length of femoral components. Some of the shortened versions of standard length devices have produced significant, high rates of early subsidence and aseptic failure. These failures have prompted a re-examination of the fundamental purpose a stem plays in a non-cemented arthroplasty and safety of reducing stem length.

In addition to acting as an alignment device, the stem of a traditional non-cemented implant aids to achieve initial stability as a nail in a piece of wood: by friction and circumferential displacement of the material into which it is inserted. As such, the length of a stem is directly correlated with an implant's initial stability. Charnley recognized the importance of initial implant stability as an early predictor of long term success. Subsidence has become accepted as a reliable, early predictor of failure. Malchau reported that risk of revision can be determined by as early as the 1-year follow up (2).

In 2002, we reported on the positive effect of stem geometry on femoral implant stability (3). The stem, of this component, is tapered and polished, so as to discourage osseous integration of the implant below the level of the lesser trochanter. In this way, the stem of this standard component was specifically intended to act only an alignment guide. Initial stability and fixation of the prosthesis is provided by the proximal geometric "rest fit". The specific 3-dimensional design features incorporated into the proximal geometry of a standard component have also been shown to reduce distal stress transfer, post-operative proximal stress shielding, loss of proximal bone stock, diaphyseal hypertrophy and thigh pain (4).

The purpose of the present study was to examine the effect of reducing stem length on the axial stability of such an implant. It is a retrospective review of the first 69 short stem components implanted.



**ICJR Pan Pacific North American/
European Research Award
Winner**

O13B5 Primary Total Hip Arthroplasty Among Nonagenarian Patients: Patient Characteristics and Clinical Outcomes

Primary Author: Alexander Miric

Institution: Southern California Permanente Medical Group

Coauthors: Maria CS. Inacio, PhD (Southern California Permanente Medical Group), Matthew P. Kelly, MD (Southern California Permanente Medical Group), Robert S. Namba, MD (Southern California Permanente Medical Group)

INTRODUCTION: As the US nonagenarian population continues to grow, more patients aged 90 and over will become candidates for total hip arthroplasty (THA). They are likely to have a greater number of associated medical problems which may increase the risk for postoperative morbidity and mortality. The purpose of this study was to evaluate the patient characteristics and incidence of post-operative morbidity, mortality and readmission among nonagenarian patients who underwent THA.

METHODS: A retrospective analysis of prospectively collected data by a Total Joint Replacement Registry was conducted. All elective, primary THAs from 4/1/2001 to 12/31/2011 were included. Patient characteristics (age, sex, body mass index (BMI), race), co-morbidities (congestive heart failure, valvular disease, peripheral vascular disease, hypertension), general health (assessed by the American Society of Anesthesiologist Score (ASA)), and post-operative outcomes (length of stay (LOS), complications, readmission and mortality) were assessed. Individuals aged ≥ 90 years old at time of surgery were compared to those of patients aged < 80 and patients 80-89 years old. Descriptive statistics were employed.

RESULTS: 183 (0.4%) of the 43,543 primary THAs performed during the study period were among nonagenarians. The mean follow up of the cohort was 3.6 years. Nonagenarian patients were predominantly white (77.1 %), female (64.5%) and diagnosed preoperatively with osteoarthritis (92.4%).

(All data groups below in following order: patients <80, 80-89, and >90 years of age)

In comparison to patients <80 and 80-89 years old, nonagenarians had the highest prevalence of ASA scores >3 (32.7% vs. 54.2% vs. 66.1%, respectively), peripheral vascular disease (3.5% vs. 10.7% vs. 11.7%), hypertension (52.0% vs. 71.5% vs. 76.7%), and valvular disease (2.7% vs. 8.6% vs. 11.7%). The nonagenarian prevalence of congestive heart failure (2.1% vs. 7.3% vs. 3.3%) was similar to that of patients <80 and less than that of patients 80-89. Nonagenarians had the lowest BMI (29.6 kg/m² vs. 26.2 kg/m² vs. 24.9 kg/m²) and the lowest prevalence of diabetes (21.3% vs. 22.9% vs. 18.6%).

Although comparable to patients 80-89, nonagenarians had the longest LOS (mean 2.8, standard deviation (SD) = 1.5 vs. 3.3 (SD = 1.8) vs. 3.4 (SD = 1.7)), the highest 90-day readmission rate (6.2% vs. 10.5% vs. 15.0%), and the highest 90-day mortality (0.2% vs. 1.3% vs. 2.7%). However, nonagenarian patients had the lowest incidence of deep vein thrombosis (0.7% vs. 1.2% vs. 0%), and no significant differences in the incidence of infection (deep or superficial) or pulmonary embolisms were observed.

DISCUSSION AND CONCLUSION: In a large cohort of nonagenarian THA patients we found that despite advanced age and a higher prevalence of some co-morbidities, nonagenarians had a LOS and complication rates comparable to those of younger THA patients. Furthermore, postoperative mortality was within expected mortality for individuals 90 years and older. Higher readmission rates, however, highlight the benefit of close follow up during a prolonged postoperative period.

THA among nonagenarians can be performed safely with a perioperative morbidity and mortality that is acceptable to both patient and surgeon.

O13B6

Posterior Approach: Can We Improve Functional Outcome & Reduce Dislocation: A Clinical Study

Primary Author: Chandra Shekhar Yadav

Institution: All India Institute of Medical Sciences, New Delhi

Coauthors: Nishikant Kumar (All India Institute of Medical Sciences, New Delhi), Samarth Mittal (All India Institute of Medical Sciences, New Delhi), Sanjay Yadav (All India Institute of Medical Sciences, New Delhi), Ashok Kumar (All India Institute of Medical Sciences, New Delhi)

BACKGROUND: Modified posterior approach and its effect on stability and functional outcome in total hip arthroplasty.

MATERIAL & METHODS: A retrospective comparative evaluation was done to assess the functional outcome and rate of dislocation in 233 hips (Group A) operated before 2007 by convention posterior approach and 567 hips (Group B) were operated by modified posterior approach. (2007-2011) In this modified posterior approach technique, 2-3 stay sutures (non-absorbable Ethibond no. 5) are applied in the piriformis tendon, short external rotators and proximal part of Quadratus muscle. Then a conjoint- myocapsular sleeve is raised by starting cutting (with cautery) linearly over the capsule with adherent fibers of gluteus minimus to piriformis tendon, short rotators and part of quadratus to expose and dislocate the head. After inserting the definite prosthesis, upper part of sleeve (capsule, piriformis tendon) is sutured with same nonabsorbable Ethibond at the lower part of tip of greater trochanter by passing through the bone with needle or by drilling the bone; lower part of the sleeve is tied with lateral trochanteric bone. Additional stability to repair was given by closing the tendinous part of the gluteus maximus by horizontal cross mattress sutures up its attachment to the proximal femoral shaft.

RESULTS: All patients underwent cementless total hip arthroplasty; average Harris hip score at minimum 3.1 yr follow was 88.7 in Group A & 85.2 in Group B. Group B had only one dislocation while Group A had 12 dislocations (5%).

CONCLUSION: This technique provides enhanced stability and improved functional outcome.

O13B7

Clinical Outcome of Hip Resurfacing Depends on Design

Primary Author: Koen A. De Smet

Institution: Anca Clinic

Coauthors: Catherine Van Der Straeten (University Hospital Ghent), Alessandro Calistri (Anca Clinic Roma)

Surface arthroplasty or resurfacing represents a significant development in the evolution of hip replacement. A hip resurfacing (HRA) is a bone conserving alternative to total hip arthroplasty (THA) that restores normal joint biomechanics and load transfer and ensures joint stability. Metal-on-metal (MoM) bearings have been preferred for these large diameter articulations because of their lower volumetric wear and smaller particulate debris compared to metal-on-poly-ethylene bearings. Of the many engineering factors which have contributed to the success of the MoM bearing, the metallurgy, diametral clearance, sphericity and surface finish were thought to be most important. More recently, adverse reactions to metal particles and ions generated by wear and corrosion of the metal surfaces have focused the attention on the importance of coverage angle and cup positioning. Currently, the scientific consensus is that cup coverage angle, diametral clearance and metallurgy have their importance in that order. Precise understanding of manufacturing variables is imperative in obtaining clinical consistency and safety in the patient. It is important to examine femoral fixation, bone remodelling, and wear of MoM implants. For the second and third generation MoM HRA various designs and biomaterials have been used. We conducted a randomised, controlled trial comparing 9 different hip resurfacing prostheses. Clinical and radiographic outcome and whole blood, serum and urine metal ion levels are evaluated at 6 months, 1 year, 2 years and 5 years in 140 patients with 9 different HRA designs and the differences analyzed. These results and the continuous regular follow up in the one surgeon practice of 4000 resurfacings in more than 15 years, show a more clear view in the understanding of MOM resurfacing, the problems and the importance of design. The Durom prosthesis, today withdrawn from the market, may claim a metallurgic advantage and the best wear couple with its Metalul history, this in combination with the highest coverage angle of all cups, what is suggested by low ion measurements.

The good clinical outcomes of some designs prove statistically an undisputable record to keep MOM resurfacing as a preferred method in young active people. However, as discussed above, an optimal bearing alone is not sufficient to achieve a successful hip resurfacing.

Non Implanted Knee: Procedures and Techniques

O14A1

Ultrasound and Sound Sensors: Future Diagnostic Opportunities for Orthopaedics

Guest Faculty: Ray C. Wasielewski, MD

Institution: Center for Musculoskeletal Research, University of Tennessee, Knoxville, TN, USA

Coauthors: Komistek, RD; Mahfouz, MR; Debock, TJ; To, G; Fatah, EEA

Previous diagnostic modalities such as x-rays, MRI, CT and fluoroscopy have been used alone or in combination to diagnosis soft-tissue clinical conditions and bone abnormalities. These diagnostics gives the clinician data that is helpful but has yet to overcome significant limitations. Combined 3-D ultrasound and sound/vibration sensing techniques could be utilized by orthopaedic surgeons to better diagnose injuries, defects and both static and dynamic clinical conditions that may not be detected using other conventional modalities.

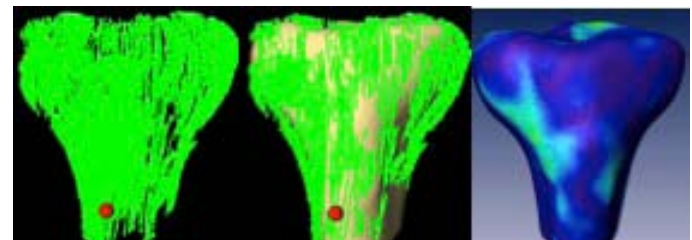


Figure 1. Example of an ultrasound scan of the human knee (left), morphing the bone to the scan data (center) and then comparing image accuracy to an MRI (right).

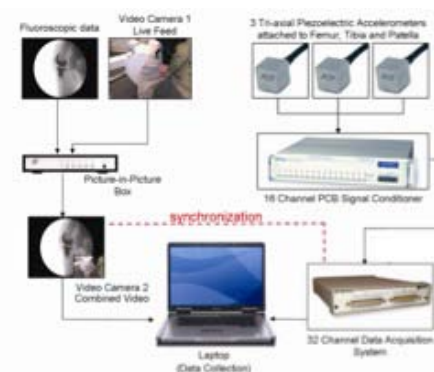


Figure 2. Data acquisition process for capturing in vivo sound of knees.

METHODS: A new technology has been developed and studied in an IRB using ultrasound to create three-dimensional (3D) bones and cartilage at the articulating surfaces, demonstrate their accuracy relative to 3-D MRI and CT (Figure 1). Using a standard ultrasound probe, radio frequency (RF) data is captured and processed in real time using a statistical signal model for bone detection and bone echo selection. This process allows for a contour to be derived for the rigid body of questions, leading to a 3D recovery of the bone. Further signal processing allows recovery of the cartilage and other soft-tissues surrounding the joint. These 3-D images were then compared to 3-D MRI derived data in patients having PSI TKA. A sound sensor has also been developed that allows for the capture of raw signals separated into vibration and sound (Figure 2). A filtering process is utilized to remove the noise and then further analysis allows for the true signal to be analyzed, correlating vibrational signals and sound to specific clinical conditions. Patients with knee injuries were studied in an IRB. X-rays and clinical examinations by the surgeon were followed by MRI to diagnose any and all intra-articular pathology prior to surgery. A sound analysis of the knee was then done pre and post operatively. We could then correlate specific intra-operative observations and corrective actions to pathologies to accurately identify each conditions pathognomonic sound patterns. This allowed for the algorithms to get smarter over time with correct diagnostic data.

RESULTS: These 3-D ultrasound and sound study data from numerous tests show that both modalities alone and in combination have considerable static and dynamic diagnostic capabilities. The JointVue ultrasound software can create 3-D images of the bones and cartilage with resolutions that are comparable to more traditional techniques, MRI and CT Scans. These tests have shown repeatedly that 3D bones can be created with an error less than 1.0 mm. Sound signals have been analyzed and correlated to specific knee and hip clinical pathology as well as complications after Total Joint Arthroplasty.

DISCUSSION: Both CT scans and x-rays emit radiation, and CT scans and MRI scans are static evaluations not conducted under the dynamic conditions when a patient is most commonly symptomatic.

With JointVue's sound algorithms becoming smarter, we will soon know the pathognomonic sounds for specific intra-articular pathologies. Much like a Holter monitor diag-

noses irregular heart beats, our sensors could be worn as an out-patient and the patient could do activities that cause the pain and the vibrations created during that painful activity could be gathered by the device. Then this data could be downloaded and analyzed to determine the cause of the patient's symptoms. Sound leading the diagnostic decision making process is important because many times a patient will have multiple intra-articular pathologies such that it is unclear as to which of these is causing the patients disability (MRI's often show multiple pathologies). The knowledge of the pathognomonic sounds created by such things as a torn menisci, osteoarthritis cartilage lesions, ACL insufficiency, joint subluxations etc. will allow the clinician to differentiate exactly what is the cause of the patient's pain. In doing so the treatment or therapy can be directed towards the actual cause of the pain rather than a more general treatment for all of the pathologies many of which may not be causing symptoms. This will, for instance, prevent many unneeded TKA surgeries and result in the most conservative procedure being done. Also, if pain is due to a ligament or tendon abnormality, PT may be indicated rather than surgery.



With ultrasound 3-D images of the shape and position of a patient's bones relative to one another in a knee joint, kinematics could be recorded in synchronization with sounds/vibrations helping corroborate a specific diagnosis. Because, while sound can often detect diagnosis, it cannot pinpoint the exact location in the joint so that ultrasound used as a adjunct could help localize the pathologic disruption or cause. Additionally, a dynamic diagnostic brace with combined kinematic and sound could help differentiate the cause of pain in a knee with multiple static MRI pathologies. For instance, in a ACL deficient knee with subluxation and OA but with pain occurring only when the sound of a torn meniscus is heard may just need a meniscectomy (not a TKA or ACL repair).

The health care system wants non-invasive disruptive technologies that avoid unnecessary surgeries or more accurately pinpoint the source of symptoms. These two new orthopaedic diagnostic techniques, ultrasound and sound, will help the treating clinician make clinical diagnoses while the patient is performing weight-bearing, dynamic activities, without the harmful radiation. Early results are promising for both of these new dynamic diagnostic techniques that could have distinct advantages in activity related pain compared to traditional techniques.

O14A2

Swing Test: A New Physical Examination Technique for Evaluating Valgus Knee Deformity

Guest Faculty: Yixin Zhou, MD

Institution: Beijing Jishuitan Hospital, Department of Orthopaedics, Beijing Jishuitan Hospital, Xicheng District Beijing, China

Coauthor: Dejin Yang (Beijing Jishuitan Hospital)

BACKGROUND: The origin of a valgus deformity affects the algorithmic and individualized approach used in total knee arthroplasty in valgus knees. We developed a new physical examination technique, the swing test, to evaluate whether valgus malalignment is present when the knee flexes.

METHODS: We performed the swing test on 44 valgus knees in 44 consecutive patients, and we conducted traditional malalignment analysis on each patient's long-film radiographs and computed tomography images to evaluate origin of valgus deformity. We did a diagnostic test to compare the results of the swing test with those of traditional malalignment analysis.

RESULTS: For the swing test, there were positive findings in 22 cases and negative findings in the other 22 cases, whereas for traditional malalignment analysis, there were positive findings in 26 cases and negative findings in 18. The sensitivity, specificity, and accuracy for the swing test were 84.6%, 100%, and 90.9%, respectively.

CONCLUSIONS: The swing test is an effective technique in evaluating whether valgus deformity exists when the knee is flexed.

O14A3

Recent Trends in the Incidence of Anterior Cruciate Ligament Injuries and Subsequent Reconstruction Rates

Primary Author: Kristina M. Funahashi

Institution: Harvard University

Coauthors: Ted T. Funahashi (Kaiser Permanente), Greg B. Maletis (Kaiser Permanente), Rick P. Csintalan (Kaiser Permanente), Yuexin X. Chen (Kaiser Permanente)

INTRODUCTION: The incidence of ACL reconstructions in the United States population has been increasing over the past decade. However, whether the rate of ACL reconstructions or the ACL injury rate in the population has been increasing has not yet been studied. This study looks at 1) the incidence of ACL injury rates in a population representative of the US population by age groups and gender, 2) analyzes the proportion of those who undergo reconstruction after injury by age group and gender, and 3) studies the proportion of those who undergo ACL reconstructions by ethnicity.

METHODS: ACL reconstruction and injury rates were extracted from a database in an integrated healthcare system reflective of the general population over the years 2007-2012. Rates of ACL injuries and reconstructions per year were obtained. Incidence rates per 100,000 members were calculated and compared for different years, genders, age, and race categories. ICD-9 coding (International Classification of Diseases, Ninth Revision, Clinical Modification) was used to query the data from the administrative system based on the procedure code 81.45 for ACL reconstructions and '717.83A', '717.83B', '844.2C', '844.2E', '844.2M', '959.7Q' for ACL injuries. Once identified, gender, age, race, and the diagnosis at the time of admission were collected.

RESULTS: From 2007-2012 there were 12,482 ACL injuries within an integrated healthcare organization (31.7% females, 68.3% males). ACL injury and reconstruction rates for both males and females have increased over the course of the study period, especially for females, with an exceptionally marked increase for females 14-17 years old. ACL reconstruction rates range from 65.3% reconstructed for age group 18-21 gradually decreasing to 19.7% for ages 50 and over. The rate of ACL reconstructions does not appear to be significantly different between genders

(50.3% reconstructed females, 50.7% males) or ethnic groups (Asian, 60.3%; Black, 52.9%, Native American, 58.3%; White, 51.2%; Hispanic, 55.7%).

CONCLUSIONS: This is the first study to report on ACL injury rates for age groups and genders across time that is representative of the general population. It is also the first to report on and compare reconstruction rates for different ethnicities. This study found that injury and reconstruction rates are increasing especially for females 14-17 years old, in which the injury rate has reached that of their male counterparts. Reconstruction rates do not appear to change significantly over the course of individual's lifetimes, with the highest rate of reconstructions at age group 18-21 and remaining above 40% until age 40 where reconstruction rates begins to decline.

O14A4

Arthroscopic Evaluation of Chondral Lesions After ACL Reconstruction: A Comparison by the Difference in Meniscus Treatment

Primary Author: Takanori Akada

Institution: Funabashi Orthopaedic Hospital Sports Medicine Center

Coauthors: Akihiro Tsuchiya (Funabashi Orthopaedic Hospital Sports Medicine Center), Izumi Kanisawa (Funabashi Orthopaedic Hospital Sports Medicine Center), Kenji Takahashi (Funabashi Orthopaedic Hospital Sports Medicine Center)

BACKGROUND: While meniscus injury in anterior cruciate ligament (ACL) deficient knee leads to increase the instability, ACL reconstruction reduced anterior tibial translation and rotational laxity to the intact state. On the other hand, meniscectomy accelerates degenerative joint changes even in ACL reconstructed knee.

PURPOSE: The purpose of this study was to evaluate the incidence of chondral lesions by second-look arthroscopy after combined meniscus injury and ACL reconstruction. **Methods:** Between January 2009 to December 2011, 101 patients (54 male and 47 female) underwent ACL reconstruction with no chondral injury. All patients underwent anatomical double bundle ACL reconstruction using hamstring tendon grafts. Patients were excluded if they had concomitant ligament injury, re-injury or contralateral

al injury, more than 3mm side-to-side difference on anterior tibial translation at the time of second-look arthroscopy, and postoperative infection. The mean age at primary ACL reconstruction was 24.4 years, the mean BMI was 22.6, and the mean period from primary ACL reconstruction to second-look arthroscopy was 16.8 months. Of 101 patients, meniscectomy was underwent in 19 patients, meniscus repair in 20 patients, and 62 patients had no meniscus injury. Cartilage status was evaluated by second-look arthroscopy and the ICRS classification. We compared the incidence of chondral lesions among three groups. Other assessments at second-look arthroscopy included Lysholm scores, muscle strength test, and single-legged hop tests.

RESULTS: Of 101 patients, chondral lesions were found in 30 patients. 14 patients were found in meniscectomy group, 7 patients in meniscus repair group, and 9 patients in no meniscus injury group. Of 20 patients underwent meniscus repair, complete healing of the repaired meniscus were found in 12 patients. Of the 12 patients, chondral lesions were found in 4 patients. The incidence of chondral lesions was significantly less in no meniscus injury group and complete healed meniscus group. No significant differences were found between the patients with and without chondral lesions in Lysholm scores, muscle strength test, and single-legged hop tests.

CONCLUSION: Chondral lesions in meniscectomy group were found at a high incidence. Complete healed meniscus led to less cartilage damage at short-term follow-up. We confirmed the importance of meniscal preservation.

	Meniscectomy	Meniscus repair	No meniscus injury
n	19	20	62
Sex (M/F)	11/8	6/14	39/23
Mean age (y)	24.3	22.6	25.1
Mean BMI	22.6	21.1	23.1
Mean period from ACLR to 2 nd -look (mo)	19.2	16.3	16.2

Meniscectomy		Meniscus repair		No meniscus injury	
GL (+)	GL (-)	GL (+)	GL (-)	GL (+)	GL (-)
14 (73.7%)	5 (26.3%)	7 (35%)	13 (65%)	9 (14.5%)	53 (85.5%)

(CL: Chondral lesion)

O14A5

Influence of Posterior Tibial Slope on Stability and Second-look Arthroscopic Findings after ACL Reconstruction

Primary Author: Heegon Park

Institution: Dankook University Hospital

PURPOSE: The purpose of this study was to analyze the influence of posterior tibial slope on the stability in clinical and second-look arthroscopic evaluation after ACL reconstruction.

MATERIALS AND METHODS: A posterior tibial slope between 0° and 4° was found in 28 patients (group A), between 5° and 9° in 64 patients (group B), and greater than 10° in 32 patients (group C). We evaluated the stability with using the Lachman test and a KT-2000 arthrometer. In second-look arthroscopy, grafted tendons were evaluated based on the tension, rupture, and synovial coverage

RESULTS: In clinical evaluation for stability, mean KT-2000 arthrometer and Lachman test at last follow-up showed no statistically significant differences depending on posterior tibial slope. In second-look arthroscopic findings showed, there was no statistically significant difference between groups A and B ($p=0.91$), but however, statistically significant were showed observed between groups A and C Ed – highlight: The word “associations” might also be used here. ($p=0.03$), and between groups B and C ($p=0.02$).

CONCLUSION: The results of this study suggest that patients who underwent ACL reconstructed patients with higher posterior tibial slope ($\geq 10^\circ$) have more lax tension in second-look arthroscopy, but not in clinical stability tests.

O14A6

In Vivo Evaluation of Gold and Hydroxyapatite Nano-grafts for Anterior Cruciate Ligament (ACL) Reconstruction

Primary Author: Richard A. White

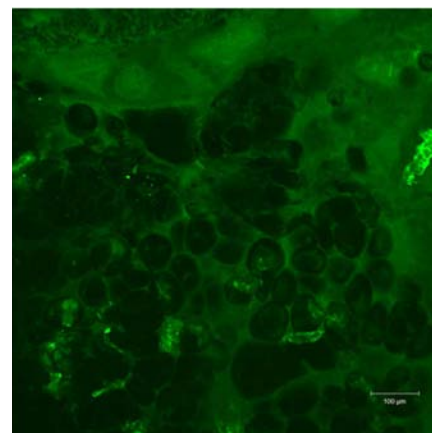
Institution: University of Missouri

Coauthors: Sarah Smith (Missouri), David Grant (Missouri), Sheila Grant (Missouri)

INTRODUCTION: A novel graft material for anterior cruciate ligament reconstruction (ACL) derived from extracellular matrix and conjugated with gold and hydroxyapatite nanoparticles has shown enhanced biocompatibility and cellular integration in green fluorescent protein (GFP) expressing swine.

METHODS: Nano-grafts were created from the decellularized extracellular matrix of either porcine diaphragm tendon or human anterior tibialis and covalently cross-linked with gold (AuNP) and hydroxyapatite (nano-HAp) nanoparticles. A set of three allograft and three xenograft scaffolds was implanted into twelve GFP pigs. Each set contained samples without nanoparticles, with AuNP, and with both AuNP and nano-HAp. Four pigs were sacrificed at 1, 3, and 6 months. Explanted scaffolds were histologically scored for cellular infiltration, foreign body giant cells, vascularity, connective tissue organization, fibrous encapsulation, and scaffold degradation. Cellular integration was assessed by direct visualization of GFP using confocal microscopy.

RESULTS: Histology results for one-month scaffolds indicate little to no foreign body giant cells. The nano-grafts had slightly higher vascularization compared to scaffolds without nanoparticles. Nano-grafts displayed less encapsulation compared to crosslinked scaffolds indicating enhanced biocompatibility. No trends were seen for other scoring categories. Confocal microscopy images showed evidence of cellular integration of host tissue into allograftic gold nano-grafts by way of GFP cellular highways



CONCLUSION: Nano-grafts displayed enhanced biocompatibility and cellular integration compared to grafts without nanoparticles. Funding for the project was awarded by a grant from the Coulter Foundation, in conjunction with the University of Missouri.

O14A7 Patellar Tendon Donor-Site Healing During Six and Twelve Months after Anterior Cruciate Ligament Reconstruction

Primary Author: Hamed Yazdanshenas

Institution: UCLA/Charles R. Drew University of Medicine and Science

Coauthors: Firooz Madadi (SBMU), Firoozeh Madadi (SBMU)

PURPOSE: The most prevalent lesion in knee trauma that may go undiagnosed is the Anterior Cruciate Ligament rupture (ACL). Even though in some situations, the rupture can be left untreated; in the majority of cases, treatment is necessary. The most acceptable method of treatment is the Bone-Patellar Tendon-Bone Graft. This study is conducted to evaluate the recovery process of the graft donor site.

METHODS: This study is a cohort observational study that evaluates the graft donor site (the patellar tendon) recovery in 23 patients with ACL rupture. In all cases, ultrasonography was used to evaluate the donor site 6 months after the patellar tendon graft surgery.

RESULTS: The results showed that in 70 percent of the cases, the healing process was completed after 6 months. The patellar tendon of the recovering knee had a similar ultrasound as the patellar tendon of the normal knee after 6 months; therefore, it was possible to harvest graft material from the recovering knee again. In the remaining 30 percent of the cases, increased width and diameter of the tendon were seen, which are known indicators of the healing process.

CONCLUSION: According to these results, reuse of the patellar tendon for reconstruction of the ACL is feasible after 6 months. This finding is of paramount importance in patients who are at risk of repetitive ACL injuries, such as athletes.

KEYWORDS: Anterior Cruciate Ligament (ACL), High Tibial Osteotomy (HTO), Medial Collateral Ligament (MCL)

Hip Infection

O14B1 Infected THR: 2014

Guest Faculty: Arlen D. Hanssen, MD

Institution: Mayo Clinic, Rochester, MN, USA

1. **Antibiotic Suppression:** rarely indicated (Success is 1/3). Indications include: Prosthesis removal is not feasible, low virulence microorganism, microorganism is susceptible to an oral antibiotic, antibiotic tolerated without serious toxicity, prosthesis is well-fixed.
2. **Debridement with Prosthesis Retention:** Success possible in Type II and Type IV infections. Success related to duration of symptoms (eg. *S. aureus* < 48 hours). Do not attempt in Type III (chronic) infections: universal failure. Treatment should be prompt and considered emergent once the diagnosis has been confirmed.
3. **Resection Arthroplasty:** usually a temporizing procedure; occasionally is definitive.
4. **Arthrodesis:** rare
5. **Disarticulation:** also extremely rare; reserved for life-threatening infection.
6. **Insertion of a New Prosthesis**

Direct Exchange: Requires careful selection process (75-80% success). Most series are highly selected cases.

- a. Absence of wound complications after initial THR
- b. Good general health
- c. Methicillin-sensitive *S. epidermidis*, *S. aureus*, and *Streptococcus* species
- d. An organism that is sensitive to the antibiotic mixed into the bone cement

Limited opportunity in current era due to increasing multi-drug-resistant organisms and many current revisions use cementless implants.

Delayed Reconstruction (2-stage): Preferable approach with >90% success for all patients including those excluded for direct exchange.

Results of Reimplantation:

	Spacers/Beads	Prosthesis Fixation	Success
Direct-Exchange	--	Plain cement	60%
Direct-Exchange	--	Ab-PMMA	83%
Two-Stage	no	Plain cement	82%
Two-Stage	no	AbPMMA	90%
Two-Stage	yes	Uncemented	92%
Two-Stage	yes	Ab-PMMA	92%

Future directions include accurate prediction of specific risk factors, improved imaging studies and bacterial genetic detection technology for diagnosis, improvement in antibiotics with more oral treatment and less intravenous therapy, use of new staging systems for patient outcome with various treatment options, and technological advances in local antibiotic delivery systems.

O14B2

Partial Radical Debridement: Heresy or Cautiously Optimistic?

Guest Faculty: Adolph V. Lombardi Jr., MD, FACS

Institution: Joint Implant Surgeons, Inc.; The Ohio State University Wexner Medical Center; Mount Carmel Health System, New Albany, Ohio

The common, recommended treatment for infected total hip arthroplasty (THA) is two-staged exchange including removal of all components. However, removal of well-fixed femoral stems can result in bone damage and compromised fixation. We recently reported on an alternative treatment of partial two-stage exchange used in selected cases, in which the well-fixed femoral stem was left and only the acetabular component was removed, the joint space was débrided thoroughly, an antibiotic-laden polymethylmethacrylate spacer was molded using a bulb-type syringe and placed in the acetabulum, intravenous antibiotics were administered during the interval, and delayed reimplantation was performed. In 19 patients treated with this technique from 2000 to January 2011, 89% were free of infection at a mean follow-up of 4 years. During the study period, this represented 7% (19 of 262) of the patients whom we treated for a chronically infected THA. Two patients (11%), both with prior failure of two-staged

treatment of infection, failed secondary to recurrence of infection at an average of 3.3 years. There were no patient deaths within 90 days. Postoperative Harris hip score averaged 68 (range, 31-100). Since then, disposable silicone molds (Stage One Select Hip Spacer Molds, Biomet, Inc.; Warsaw, Indiana, USA) have become available to fabricate the spacers in separate femoral and head units. The head spacer mold, which can incorporate various taper adapter options, greatly facilitates the technique of partial two-stage exchange. We are currently reporting our early experience using disposable silicone head spacer molds for partial two-stage exchange in 7 patients with infected THA. Follow-up after reimplantation averaged 1.5 years (range, 4 months to 3 years). One patient expired 2 years after reimplantation with no recurrence of infection. No patients were lost to follow-up. One patient evaluated at 4 months postoperative was noted to have a 7 cm fluid collection in the hip and redness at the incision. Her serum ESR was 87 mm/hr (normal, 0-30 mm/hr) and CRP was 57.2 mg/L (normal, 0.0-9.9 mg/L). Radical débridement was recommended; however, the patient has declined to schedule. There have been no other complications or further surgical procedures. Eradication of infection has been successful in 6 of 7 patients (86%). The mean postoperative Harris hip score at most recent evaluation was 71.8 (range, 44-90). As 89% and 86% of patients in these two series were clinically free of infection at follow-up, we believe partial two-stage exchange may represent an acceptable option for patients with infected THA when femoral component removal would result in significant bone loss and compromise of reconstruction. Further study is required on this approach. Eradication of periprosthetic joint infection after THA remains an ongoing challenge.

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O14B3

Treatment of the Infected Total Hip Replacement

Guest Faculty: Harold E. Cates, MD

Institution: Center for Musculoskeletal Research, University of Tennessee, Knoxville, TN, USA

Total Hip Replacement infection is a serious complication occurring in 0.3 – 1.3% of total primary hips and up to 3% of revision hip arthroplasties. Successful treatment is enhanced with an accurate diagnosis, tailored antibiotics and appropriate surgical intervention. Surgical treatment options are reviewed relative to chronicity, organism(s) and host factors. Specific surgical techniques to optimize outcome are demonstrated. Special emphasis is placed on a 2-stage articulating antibiotic spacer techniques. The timing of reimplantation is also discussed.

O14B4

Use of Massive Structural allografts in Revision of infected Total hip Replacement

Primary Author: Vijay Kumar

Institution: All India Institute of Medical Sciences

Coauthors: Bhavuk Garg (AIIMS), Rajesh Malhotra (AIIMS)

INTRODUCTION: Patients with infected hip replacement are treated with 2 stage revision surgery. These patients often present with large bone defects at the time of second surgery. Structural Allografts are often required to address these bone defects. There is considerable apprehension about using massive skeletal allografts in these situations due to the fear of infection.

PATIENTS AND METHODS: 12 patients with infected THA were treated with a two-stage protocol. In the first stage, the prosthesis was removed together with all necrotic tissues and cement material if present. A custom-made mold of gentamicin cement containing 1 g of gentamicin was then inserted. Systemic antibiotics were used during the interval period. In the second stage revision THR, the patients had femoral reconstruction using bulk allograft bone.

RESULTS: The mean follow-up was 6 (4-9) years. There

was no failure in 11 patients, whereas one patient presented with recurrent infection and underwent a Girdlestone resection arthroplasty as definitive treatment. The mean Harris Hip Score improved from 34 points preoperatively to 76 points at the last review. There was no loosening or osteolysis around the femoral stems and acetabular cup at the time of final follow up in the 11 cases where the procedure was successful.

CONCLUSION: Our results support the use of massive allografts in staged reconstructions of infected THAs complicated by considerable bone loss.

O14B5

A Functional Antibiotic Spacer Provides Patients With Similarly Satisfying Treatment Options For Infection

Primary Author: Aidin E. Pour

Institution: University of Michigan

Coauthors: Joseph P. Ward (University of Michigan), Brian R. Hallstrom (University of Michigan), Greg A. Erens (Emory University), Thomas L. Bradbury (Emory University), James R. Roberson (Emory University)

PURPOSE: Two-stage revision is the gold standard treatment for chronic periprosthetic infection of the hip or knee. Implantation of a functional antibiotic spacer allows patients the option of two stage revision or living with the spacer in place. Some patients may be satisfied with the activity level that they attain with the functional antibiotic spacer and may avoid the morbidity of a second surgery.

METHODS: We retrospectively examined the outcomes of 30 joints in 27 patients treated for chronic periprosthetic infection of the hip or knee at a mean follow-up of 27 months (range 11-46 months). Comparing the patients treated with two-stage revision to those patients living with a functional antibiotic spacer, we used University of California Los Angeles activity scores, modified Harris hip scores, and patient satisfaction measures to answer two main questions: (1) Is there a significant difference in activity level? (2) Is there a significant difference in patient satisfaction? Patient satisfaction was measured on a 1-100 scale with 100 being completely satisfied.

RESULTS: There were no statistically significant differ-

ences in the American Society of Anesthesiologists scores between the groups—mean 2.69 in the two-stage group and mean 3.00 in the spacer group (p value 0.255). Statistically significant differences were found between the groups for University of California Los Angeles activity scores—mean 5.3 in the two-stage group and mean 2.8 in the spacer group (p value 0.027). There were no statistically significant differences in modified Harris hip scores—mean 55.6 in the two-stage group and mean 41.6 in the spacer group (p value 0.34). In the subgroup analysis of the modified Harris hip score questions, there was a statistically significant difference in the need for support when ambulating—mean 4.21 in the two-stage group and mean 2.45 in the spacer group (p value 0.024)—and in the distance that can be walked—mean 6.15 in the two-stage group and mean 2.0 in the spacer group (p value 0.005). No statistically significant differences were found in patient satisfaction measures—mean 70.0 in the two-stage group and mean 76.6 in the spacer group (p value 0.65)—though the mean satisfaction measure was higher in the spacer group.

CONCLUSION: Patients living with a functional antibiotic spacer are less active than patients undergoing a two-stage revision for chronic periprosthetic infection of the hip or knee. Specifically, patients living with a functional antibiotic spacer need more support when ambulating and ambulate shorter distances than patients, who undergo two-stage revision surgery. Despite the decreased activity level, patients living with a functional antibiotic spacer are just as satisfied with the outcome of their joint as those patients treated with a two-stage revision. Patients with modest activity goals may be satisfied to live with a functional antibiotic spacer and to avoid a second surgery.

O14B6

The Effect of the Full-Coating Nonmodular Stem Used in Two-Stage Revision for Infected Total Hip Arthroplasty

Primary Author: Bin Shen

Institution: Department of Orthopaedic Surgery, West China Hospital, West China Medical School, Sichuan University

Coauthors: Qiang Huang (Department of Orthopaedic Surgery, West China Hospital, West China Medical School, Sichuan University), Jing Yang (Department of Orthopaedic Surgery, West China Hospital, West China Medical School, Sichuan University), Zongke Zhou (Department of Orthopaedic

paedic Surgery, West China Hospital, West China Medical School, Sichuan University), Pengde Kang (Department of Orthopaedic Surgery, West China Hospital, West China Medical School, Sichuan University), Fuxing Pei (Department of Orthopaedic Surgery, West China Hospital, West China Medical School, Sichuan University)

BACKGROUND: The purpose of the present retrospective study was to determine the cure rate of infection and mid-term outcomes of the full-coating nonmodular stem used in two-stage revision for infected THAs after a minimum 5-year follow-up.

METHODS: We analyzed the clinical data of 33 patients (33 hips) who had a two-stage revision THA using full-coating non-modular for late infection. Remote fixed full-coating non-modular prostheses were used in femoral sides. At follow-up Harris Hip Score and X-ray were used to perform clinical and radiological evaluations.

RESULTS: At a minimum 5-year follow-up of 33 patients no reinfection and loosening was found. Radiolucent line adjacent to the acetabular component was seen in zone 1 of DeLee and Charnley on three radiographs (1%) and in zone 2 on four radiographs, no radiolucent lines were seen in zone 3. There are 30 patients gained stable bone ingrowth. Allogenic cortical bone plate's allografts were used in 10 hips for femoral sides. All granular bones fused well with the host bones 12 months after the surgery.

Conclusion Using full-coating non-modular stem in two-stage revision for treating infected THAs can gain satisfactory outcomes. Under well control of the infection during the first-stage, impaction using allogeneic cortical bone plates or granular bone is safe and effective in the second-stage.

O14B7

Results of Revision Total Hip Arthroplasty in Treatment of Infected Hip Arthroplasty Due To Gram Negative Infections

Primary Author: Rajesh Malhotra

Institution: All India Institute of Medical Sciences

Coauthors: Bhavuk Garg (AIIMS), Vijay Kumar (AIIMS)

INTRODUCTION: Periprosthetic infections are usual-

ly caused by gram positive organisms. However, infections caused by gram negative bacteria are on the rise. The treatment of patients with infected hip arthroplasty due to gram negative bacteria is challenging. We report the treatment outcome of two-stage revision THA for infected hip arthroplasty, including hemiarthroplasty, using an antibiotic-impregnated cement spacer for the interval between the first and second stages ;

MATERIAL AND METHODS: The records of all patients presenting with infected hip arthroplasty were reviewed. The outcome of patients with gram-negative infections were compared with patients with gram positive infections. All patients in whom an organism could not be isolated were excluded from the study. All patients were treated with a 2- stage revisions. The first stage operation involved complete debridement, removal of infected prosthesis, implantation of cement spacer with antibiotics, and concomitant administration of 3 weeks of intravenous (IV) and 1 month of oral antibiotic. After eradication of infection, it was converted to THA in the second stage.

RESULTS: 70 hips with infected hip replacement were treated in 2 stages using an antibiotic impregnated spacer between Jan 2006 and Jan 2011. Out of these 70 hips, 45 had a gram positive infection whereas 25 patients suffered from gram negative infection. The mean duration of follow-up was 40 months (range 28-60 months). Average Harris hip score improved from 38 before surgery to 90 at final follow-up in the gram positive group and from 28 to 84 in the gram negative group. The mean interval between the first and second stages was 10.1 weeks (range 6-19 weeks) in gram- positive group and was 16 weeks (range 10-24 weeks) in gram-negative group. Of the 45 hips with gram-positive infection, 41 were successfully converted to THA whereas resection arthroplasty was done in 4 cases. In the 25 hips with gramnegative infection, 18 hips were successfully revised to THA whereas resection arthroplasty was done in 7 hips. 5 patients with a gram positive infection and 8 patients with gram negative infection required more than one debridement before conversion to THA. There was a recurrence of infection in 2 patients with gram-positive infection and 4 patients with gram- negative infection.

DISCUSSION: Gram negative periprosthetic infections have a poorer outcome compared to gram positive infection and the infection is difficult to control in patients suffering from gram negative infection.

Knee Mechanics & Design

O15A1

Mechanics of the Knee: In Vivo Kinetics, Kinematics and Sound

Guest Faculty: Richard D. Komistek, PhD

Institution: Center for Musculoskeletal Research, University of Tennessee, Knoxville, TN, USA

INTRODUCTION: Understanding the in vivo mechanics of the knee is very important to knee implant development and the ability to predict longevity of an implant under various loading conditions. Throughout the past 20 years, our research group has utilized in vivo fluoroscopy as the main input to mathematical models developed using Kane's Dynamics to predict the in vivo forces and stresses of knee implants during various activities. More recently, a sound sensor was developed to analyze in vivo vibrations at the bearing surface interface and the sounds associated with each dominant frequency propagated during this interaction. Therefore, the objective of this study was to assess the in vivo mechanics of the knee at both femorotibial and patellofemoral interfaces.

METHODS: Inverse dynamic mathematical models were developed, using Kane's Dynamics, for the human lower extremity to assess the bearing surface interaction in the knee joint. Under fluoroscopic surveillance, patients were asked to perform normal gait and deep flexion maneuvers to maximum flexion. The three-dimensional position and orientation of the femoral, tibial and patellofemoral components were defined using in vivo fluoroscopy data, with respect to the Newtonian reference frame, transformed into relative reference frames, defined using temporal functions and then input into the mathematical model. Sound sen-

sor data, captured at 10,000 Hz, were also utilized to determine findings of interest that were further assessed using fluoroscopy and the mathematical model.

RESULTS: The maximum knee force for each subject varied considerably both at the femorotibial and patellofemoral interfaces. During gait, the maximum femorotibial force ranged from 2.1 to 3.2 times Body Weight (BW), but were significantly greater during a deep knee bend, ranging from 2.5 to 4.5 times BW. During gait, the patellofemoral forces did not increase significantly since knee flexion remains less than 30 degrees during stance-phase of gait, but during a deep knee bend the maximum patellofemoral force ranged from 2.5 to 4.0 times BW. The quadriceps force remained 1.2 to 2.0 times greater than the patellofemoral ligament during deep flexion maneuvers. Sounds at the knee resembled clicking, grinding and cracking.

CONCLUSION: Determination of in vivo forces at the knee is critical to understand implant longevity and the viability of implant success. Temporal force profiles derived at the knee joint can be used in knee simulators and finite element analyses to determine in vivo stresses and predict how successful a knee implant may be throughout a patient's lifetime. Implanted knee forces are generally much higher than normal knee forces and can vary considerably from patient to patient and implant to implant, leading to the assumption that knee kinematics does play a role in knee implant failure and may be a main reason why one implant last longer than another.

O15A2

The Bi-surface Knee: Unique Design for Deep Flexion

Guest Faculty: Masao Akagi, MD, PhD

Institution: Department of Orthopaedic Surgery, Kinki University Faculty of Medicine, Osaka-Sayama City, Osaka, Japan

Coauthors: Shinichiro Nakamura, MD (Department of Orthopedic Surgery, Kyoto University, Graduate School of Medicine, Sakyo-ku, Kyoto, Japan); Shigeki Asada, MD (Department of Orthopaedic Surgery, Kinki University Faculty of Medicine, Osaka-Sayama City, Osaka, Japan); Shigeshi Mori, MD (Department of Orthopaedic Surgery, Kinki University Faculty of Medicine, Osaka-Sayama City, Osaka, Japan)

The Bi-Surface Knee (Kyocera Medical, Osaka, Japan), which has a unique ball-and-socket joint in the posterior intercondylar region and whose femoral component is made from alumina ceramic, was designed to achieve deep knee flexion necessary in Japanese life-style and to mimic normal knee kinematics after surgery. The ball-and-socket joint (the ball in the femur and the socket in the tibia, respectively) facilitates the rollback motion of the femur and provides posterior stability like the post-cam mechanism in the posterior stabilized (PS) knee, allows the axial rotation of the knee, and provides a wide contact area for the tibial polyethylene insert in deep flexion position.

A review of the clinical results of a minimum 10-year follow-up (type 1 and type 2 between 1989 and 1997, 507 total knee arthroplasties in 371 patients, mean follow-up years of 11.7) showed that the knee score was improved from 38.9 ± 17.4 points preoperatively to 93.3 ± 7.8 points at the latest follow-up ($p < 0.001$). The functional score was improved from 34.9 ± 19.3 points to 52.7 ± 24.1 points ($p < 0.001$). The mean range of flexion was improved from $118.7 \pm 21.7^\circ$ to $124.2 \pm 20.8^\circ$ ($p < 0.001$). Kaplan-Meier survivorship at 10-year was 95.9% with any operation or radiographic failure as the end-point. The corresponding rate was 97.4% with revision of any component as the end-point. No ceramic component fracture occurred. This study demonstrated that good range of flexion was maintained for a long time after total knee arthroplasty with excellent durability.

At present, type 5 Bi-surface knees (CS and PS knee with some kinds of tibial geometries) are available. For more than 20 years, this unique knee has been used in Japan and a number of improvements of the surface geometry have been made to better knee stability and to introduce asymmetry in the femoral component, to avoid debonding in the femoral component (noted in type 3 and 4) and to mimic physiological knee motion. Type 5 PS knee has a small post anterior to the socket and a shallow box in the femoral intercondylar region to improve medial-lateral stability provided by the intercondylar eminence and guidance of the ball to the socket. The type 5 tibial insert has a lateral flat surface, which allow the lateral condylar posterior subluxation in full squatting. Type 5 Bi-surface knees are supposed to be promising implants to balance knee kinematics, stability and durability. However, further improvements for its design seem to be required so that this unique knee will be used from now on and worldwide.

O15A3

Rotational Alignment of the Tibial Component in TKR: The Effect of Implant Design and Surgical Experience

Primary Author: SK Ismaily

Institution: The Institute of Orthopedic Research and Education, Baylor College of Medicine, and Houston Methodist Hospital, Houston, Texas, and Duke University Medical Center, Durham, NC, USA

Coauthors: A Suarez, R. Patel, SJ Incavo, MP Bolognesi, and PC Noble

INTRODUCTION: Correct rotational placement of the tibial component in TKA is especially challenging, primarily because the anatomic landmarks on the tibia are highly variable and are poorly correlated with the motion axis of the knee. This has led to a proliferation of tibial implant designs of different shape (symmetric vs. asymmetric designs) and number of sizes (7 to 18), to fit the resected surface of the tibia without cortical overhang. As symmetric trays provide better fit when they internally rotated, a recent approach to implant design has been to create anatomic profiles using statistical atlases oriented to match the flexion-extension plane of the knee. Although this approach has theoretical advantages, it is not known whether it leads to measurable benefits in clinical practice.

This study was performed to answer the questions:

1. Is correct placement of the tibial component influenced by its shape and asymmetry?
2. How is component placement affected by surgical experience?

METHODS: CAD models of the tibial trays of 7 popular TKA designs were prepared by reverse engineering. Four designs were symmetric (medial-lateral), two were asymmetric (fixed geometric shapes), and one was anatomic (derived by statistical analysis of anatomic atlases). Computer models of ten tibias (7 males, 3 females), were selected from a large anatomic collection to span the normal variation of the tibia. The proximal surface of each computer model was resected perpendicular to the canal axis, 5mm distal to the medial plateau, with a posterior slope of 5 degrees.

31 volunteers (16 experienced joint surgeons and 15 orthopedic trainees) performed 70 virtual fitting exercises each

by selecting the optimum size of each design and positioning it on the resection plane to provide the best combination of rotation and coverage. Each implantation was analyzed to determine: (i) the rotational alignment of the tray with respect to the neutral axis as defined by Berger et al, (ii) tibial coverage, defined as the percentage of the exposed area of the tibia covered by the tray, and (iii) cortical overhang/under-coverage, measured in seven anatomic regions encompassing the circumference of the tray. Differences between each of these parameters were statistically evaluated as a function of study participant (surgeon/trainee) and tray design (symmetric/asymmetric/anatomic) using ANOVA and Fisher's PLSD test for post-hoc comparisons between groups.

RESULTS: 2,170 virtual implantations were performed in this study. Across all participants and component designs, the tibial components were placed in an average of $5.29 \pm 0.07^\circ$ of external rotation relative to the Berger axis (Figure 1). There was no difference between the average rotation of the symmetric and asymmetric designs ($5.04 \pm 0.09^\circ$ vs. $5.07 \pm 0.12^\circ$), however, the anatomic components were placed in $6.71 \pm 0.19^\circ$ of external rotation, significantly more than both the symmetric and asymmetric designs ($p < 0.0001$). Overall, 147 (6.8%) of trays were placed in internal rotation. There was no significant difference in the incidence of malrotation of the symmetric vs asymmetric components ($7.8 \pm 0.8\%$ vs. $6.8 \pm 1.0\%$; $p = 0.385$). These values were approximately three times larger than seen with the anatomic design ($2.6 \pm 0.9\%$; $p = 0.0010, 0.0164$).

Tibial coverage was $75.9 \pm 0.1\%$ overall, and was slightly smaller with the symmetric designs ($74.2 \pm 0.1\%$), compared to both the asymmetric ($77.8 \pm 0.2\%$; $p < 0.0001$), and anatomic components ($78.9 \pm 0.0\%$; $p < 0.0001$). The asymmetric and anatomic designs left significantly less uncovered bone in all regions ($p < 0.0001$), except for the antero-medial corner.

For all tray designs, surgeons placed components in approximately 2.3° more external rotation than the trainees, independent of the implant design ($p < 0.0001$ for all comparisons). 8 of the 147 cases of internal rotation were performed by surgeons (incidence: 0.7%), vs. 139 by trainees (13.2%; $p < 0.0001$) (Figure 2). The influence of tray design was most dramatic in the hands of the trainees, where 15.0% of symmetric and 13.7% of asymmetric components were internally rotated, compared to only 5.3% of

the anatomic design ($p=0.0018$, 0.0138). Differences in tibial coverage achieved by trainees and surgeons were minimal ($74.7\pm4.1\%$ vs. $73.8\pm3.9\%$).

DISCUSSION:

1. Our study demonstrates that the risk of component mal-rotation is strongly affected by implant design and surgical experience.
2. Overall, there was no significant difference between the performance of asymmetric and symmetric components in terms of any of the parameters examined. Conversely, components of the anatomic design were rarely placed in internal rotation and had slightly greater tibial coverage than any of the other implants studied.
3. Trainees placed trays of all designs in less external rotation than experienced joint surgeons, and prioritized coverage of the exposed tibial surface, especially when positioning symmetric components. This lead to a dramatic increase in mal-rotated components for only a small gain in tibial coverage.

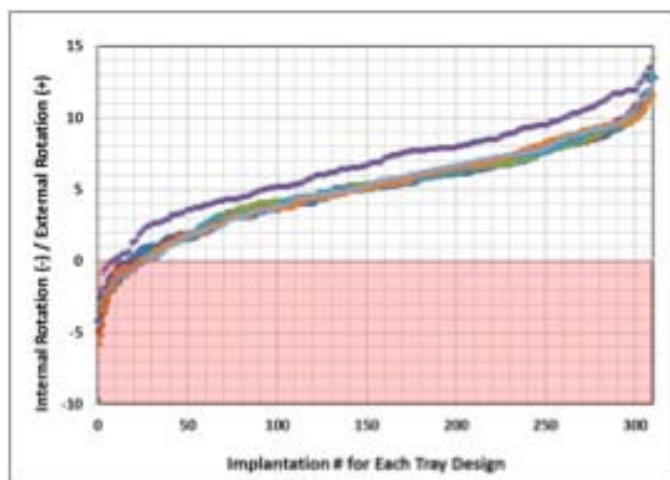


Figure 1 – Distribution of rotational values for each tray design, ordered from greatest internal rotation to greatest external rotation

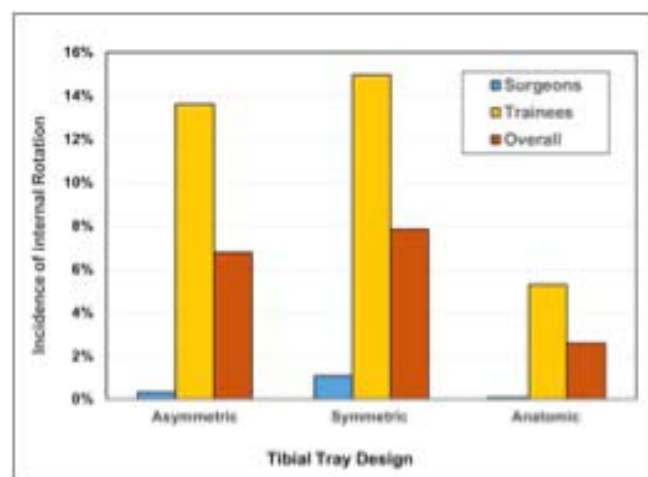


Figure 2 – Incidence of internal rotation for surgeons and trainees as a function of tibial tray design.

O15A4

Fluoroscopic Evaluation of TKA; Treadmill Gait vs. Mobile Fluoroscopy

Primary Author: Trevor F. Grieco

Institution: University of Tennessee

Coauthors: Adrija Sharma (University of Tennessee), William R. Hamel (University of Tennessee), Matthew A. Young (University of Tennessee), Douglas A. Dennis (Colorado Joint Replacement), Richard D. Komistek (University of Tennessee)

BACKGROUND: Researchers began evaluating TKA kinematics with either cadavers or motion analysis systems. Over the past few decades fluoroscopy has been utilized to accurately determine in vivo kinematics more accurately, but limitations do remain with those studies. Previous fluoroscopic studies were conducted using stationary fluoroscopy, which limits the activities that can be analyzed and restricts the patient from performing these activities more normal-like. A treadmill has been introduced for these fluoroscopic studies, but it is assumed that knee kinematics, walking on a treadmill, are not the same as the kinematics of the knee walking on the ground. More recently, a mobile fluoroscopy unit has been developed that can be used for unrestricted fluoroscopic surveillance of a joint. In this study the in vivo tibiofemoral kinematics of patients walking on a treadmill under stationary fluoroscopic surveillance are compared to the kinematics of the patient walking naturally under mobile fluoroscopic surveillance in order to show the difference between walking on a tread-

mill and walking naturally.

METHODS: Ten TKA patients were analyzed under fluoroscopic surveillance while performing multiple gait cycles. The patients were first analyzed under stationary fluoroscopy on a treadmill, and were then analyzed under mobile fluoroscopy as they walked naturally across the lab. CAD models of implanted components were obtained from the manufacturer, and 3D tibiofemoral kinematics were obtained using 2D to 3D registration at key phases of the gait cycle. The gait cycle was analyzed from heel strike to toe off in increments of 10% with respect to the total time of the gait cycle.

RESULTS: Interestingly, as has been hypothesized, patients walking on a treadmill performed what can be described as a “lazy gait”, where they would drop their foot as the treadmill moved, rather than extending their foot at heel-strike as they would routinely do on normal ground. Due to the lazy gait pattern, the kinematic patterns were quite different for treadmill gait compared to walking on the ground while under surveillance of the mobile fluoroscopy unit. Patients walking on the ground exhibited more axial rotation and the attenuation of condylar translation, which was absent during treadmill gait.

CONCLUSIONS: There are distinct differences in tibiofemoral kinematics when walking on a treadmill versus walking naturally. As stated previously, the treadmill induces a “lazy gait” and more closely resembles stomping rather than walking leading to less dynamic kinematics, namely reduction in axial rotation due to a pivoting of the lateral condyle. The mobile fluoroscopy unit allows for more normal-like analyses to be conducted and leads to kinematic patterns that are probably more similar to daily motion exhibited by the patient.

O15A5

Influence of Femoral Block on Quadriceps Strength Recovery (QSR) After Total Knee Replacement

Primary Author: Michele Angers

Institution: CHU de Quebec, Laval University

Coauthors: Stephane Pelet (CHU de Quebec), Etienne L. Belzile (CHU de Quebec), Jessica Vachon (CHU de Quebec)

INTRODUCTION: Total knee replacement (TKR) is a frequent and effective surgery for knee osteoarthritis. Post-operative pain is under concern and can be relieved by different methods, including femoral block (FB). The efficacy of FB on pain relief was associated with the absence of clinical impact when measured with the range of motion (ROM). Recent studies suggest that the quadriceps strength is the best indicator of functional recovery after TKR. The goal of this study is to compare the quadriceps strength recovery after TKR according to the kind of analgesia (patient control analgesia (PCA) with or without FB) Hypothesis: the FB delays the QSR at short and mid-term follow-up.

METHODS: Prospective randomized trial with single-blind assessment involving 135 patients admitted for TKR in an academic center. Randomization into one of the three following groups: A) Continuous FB 48h + PCA B) Single-shot FB and PCA C) PCA alone. Groups were comparable for demographic and surgical data. The FB was realised and controlled (electric stimulation) by an expert anesthesiologist before the surgery. Follow-up standardised in all groups with blinded assessors. Quadriceps strength measured with a validated dynamometer at 6 weeks, 6 and 12 months. Secondary outcomes included clinical evaluation (ROM, pain, stability) and functional scores (SF-36, WOMAC). Multivariate analysis (Kruskal-Wallis, Mann-Whitney) for main outcomes and Spearman factor for correlation. Sample size calculated for alpha 5% and study power 80%.

RESULTS: 111 patients available for 6 weeks follow-up (A-B-C:40-38-33) and 104 (36-36-32) at 6 and 12 months. Two patients in group B excluded for direct fall in the first postoperative week with extensor mechanism rupture and peri-prosthetic femoral fracture. QSR is significantly decreased in patients with FB at all times (mean, 95% IC): 6 weeks (A 51.3%, 44.1-58.5; B 62.2%, 55.2-69.2; C 77.4%, 70.7-84.1; $p<0,05$), 6 months (A 65.4%, 57.9-72.9; B 82.1%, 74.2-90; C 95.7%, 88.5-102.9; $p<0,05$) and 12 months (A 87.8%, 82.1-93.5; B 97.8%, 89-106.6; C 104.8%, 96.1-113.5; $p<0,05$). No significant difference between continuous or single-shot FB. Higher ROM in group C at all times (p 6 weeks = 0,046; p 6 months = 0,159; p 12 months = 0,026). No correlation between ROM and QSR ($\rho=0,07$; $p=0,23$). Better functional results in the group C at all times ($p<0,05$), with good correlation to QSR ($\rho=0,177$; $p=0,032$). Slight difference in analgesic effect of FB ($p=0,14$).

CONCLUSION: Femoral block has a negative influence on QSR at short and mid-term follow-up and delays the rehabilitation after TKR. QSR is actually the most sensitive indicator of functional recovery after TKR and is better related to functional tests than ROM. This can explain the harmlessness of FB in previous studies. FB should not yet be recommended for analgesia after TKR.

O15A6

Antero-posterior TKA Stability During Stair Descent

Primary Author: Rupal Patel

Institution: Virginia Commonwealth University

Coauthors: Stephen Incavo (The Methodist Hospital, Houston, TX), Philip Noble (The Methodist Hospital, Houston, TX), Kyle Borque (The Methodist Hospital, Houston, TX), Jonathan Gold (The Methodist Hospital, Houston, TX), Sabir Ismaili (The Methodist Hospital,

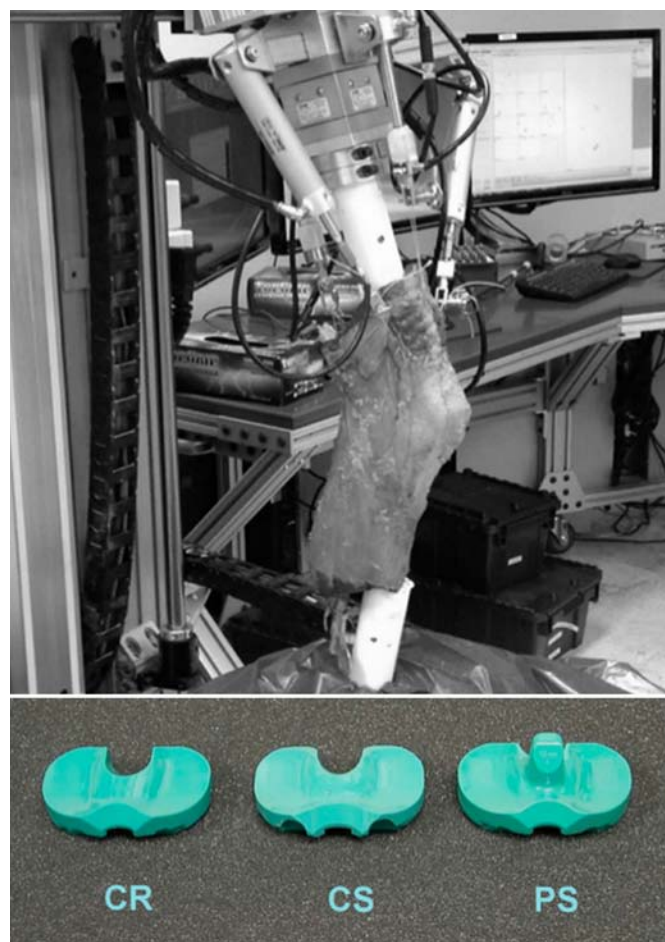
INTRODUCTION: Increasing attention to the functional outcome of total knee arthroplasty (TKA) has demonstrated that many patients experience limitations when attempting to perform demanding activities that are normal for age-matched peers, primarily because of knee symptoms. Episodes of instability following TKA are most commonly reported during activities in which significant transverse or torsional forces are supported by the joint with relatively low joint compression forces, including stair-descent and walking on sloped or uneven surfaces. This study was performed to examine the influence of conformity between the femoral and tibial components on the Antero-Posterior (AP) stability of knee during stair descent.

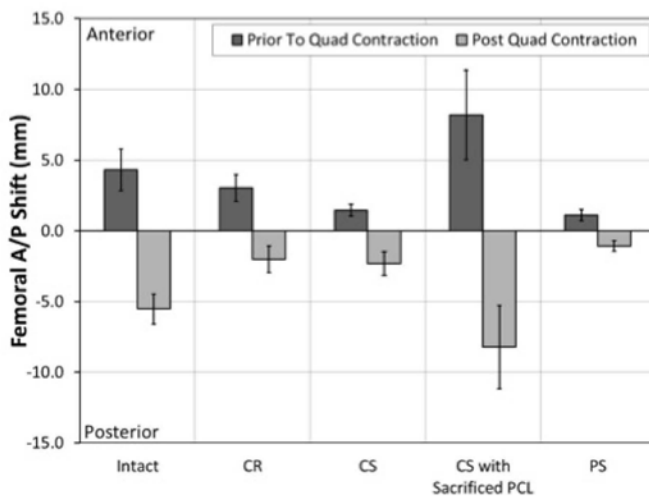
METHODS: Six cadaveric knees were loaded in a six degree-of-freedom joint simulator, with the application of external forces simulating the action of the quadriceps and hamstring muscles and the external loads and moments occurring during stair descent, including the stages of terminal swing phase, weight-acceptance phase (prior to and after quadriceps contraction) and mid-stance. During these manoeuvres, the displacement and rotation of the femur and the tibia were measured with a multi-camera high resolution motion analysis system (Fig. 1). Each knee was tested in the intact and ACL deficient condition – and after implantation of total knee prosthesis with Cruciate-Retaining (CR), Cruciate-Sacrificing with an intact PCL (CS +

PCL), Cruciate-Sacrificing with an absent PCL (CS-PCL) and Posterior-Stabilizing (PS) tibial inserts (Figs 2 and 3).

RESULTS: Loading of the knee during stair descent caused the femur to displace anteriorly by 4.31 ± 1.47 mm prior to quadriceps contraction. After TKA, anterior displacement ranged from 1.11 ± 0.41 mm (PS) to 8.19 ± 3.17 mm (CS-PCL). Intermediate values were 1.46 ± 0.42 mm (CS + PCL) and 3.03 ± 0.94 mm (CR). Quadriceps contraction was able to restore the femoral AP position (5.53 ± 1.08 mm posterior motion) in the intact knee, but larger quadriceps force were required for the other designs (8.22 ± 2.94 mm CS-PCL, 2.32 ± 0.83 mm CS + PCL, 2.02 ± 0.94 mm CR design, and 1.08 ± 0.38 mm with the PS).

CONCLUSION: Pain during high demand activities such as stair descent is a common complaint of patients after TKA, and this may be due to AP instability and extra-physiologic quadriceps demand. The only designs that restored antero-posterior knee stability were a PS insert or a CS insert with an intact PCL. The CS design without a PCL demonstrated the worst AP stability, despite the fact that these inserts are designed to be used without a PCL.





O15A7 Prediction of In-Vivo Contact Forces In the Implanted Knee

Primary Author: Adrija Sharma

Institution: University of Tennessee, Knoxville, TN, USA

Coauthors: Richard D. Komistek (University of Tennessee, Knoxville, USA), Darryl D. D'Lima (Scripps Clinic, LaJolla, California, USA), Clifford W. Colwell (Scripps Clinic, LaJolla, California, USA)

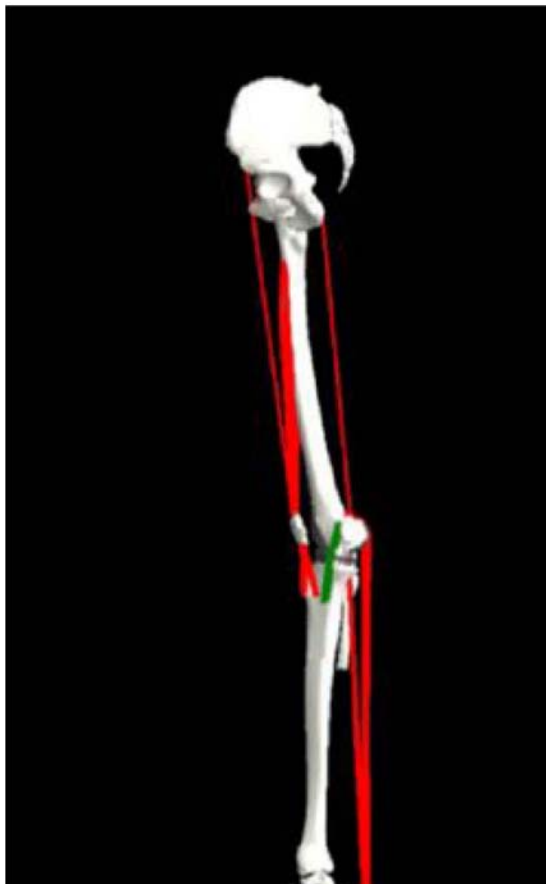
INTRODUCTION: Telemetric knee implants have provided invaluable insight into the forces occurring in the knee during various activities. However, due to the high amount of cost involved only a few of them have been developed. Mathematical modeling of the knee provides an alternative that can be easily applied to study high number of patients. However, in order to ensure accuracy these models need to be validated with in-vivo force data. Previously, mathematical models have been developed and validated to study only specific activities. Therefore, the objective of this study was compare the knee force predictions from the same model with that obtained using telemetry for multiple activities.

METHODS: Kinematics of a telemetric patient was collected using fluoroscopy and 2D to 3D image registration for gait, deep knee bend (DKB), chair rise, step up and step down activities. Along with telemetric forces obtained from the implant, synchronized ground reaction forces (GRF) were also collected from a force plate. The relevant kinematics and the GRF were input into an inverse dynam-

ic model of the human leg starting from the foot and ending at the pelvis (Figure 1). All major ligaments and muscles affecting the knee joint were included in the model. The pelvis and the foot were incorporated into the system so as to provide realistic boundary conditions at the hip and the ankle and also to provide reference geometry for the attachment sites of relevant muscles. The muscle redundancy problem was solved using the pseudo-inverse technique which has been shown to automatically optimize muscle forces based on the Crowninshield-Brand cost function. The same model, without any additional changes, was applied for all activities and the predicted knee force results were compared with the data obtained from telemetry.

RESULTS: Comparison of the model predictions for the tibiofemoral contact forces with the telemetric implant data revealed a high degree of correlation both in the nature of variation of forces and the magnitudes of the forces obtained. Interestingly, the model predicted forces with a high level of accuracy for activities in which the flexion of the knee do not vary monotonically (increases and decreases or vice-versa) with the activity cycle (gait, step up and step down). During these activities, the difference between the model predictions with the telemetric data was less than 5% (Figure 2). For activities where flexion varies monotonically (either increases or decreases) with activity (DKB and chair rise) the difference between the forces was less than 10%.

DISCUSSION: The results from this study show that inverse dynamic computational models of the knee can be robust enough to predict forces occurring at the knee with a high amount of accuracy for multiple activities. While this study was conducted only on one patient with a telemetric implant, the required inputs to the model are generic enough so that it is applicable for any TKA patient with the mobility to conduct the desired activity. This allows kinetic data to be provided for the improvement of implant design and surgical techniques accessibly and relatively inexpensively.



Dysplasia of the Hip

O15B1

The 3-D Anatomy of the Dysplastic Hip. Consequences for THA

Guest Faculty: Jean-Noël Argenson, MD, PhD

Institution: The Institute for Locomotion, Aix-Marseille University, Department of Orthopaedic Surgery, Marseille, France

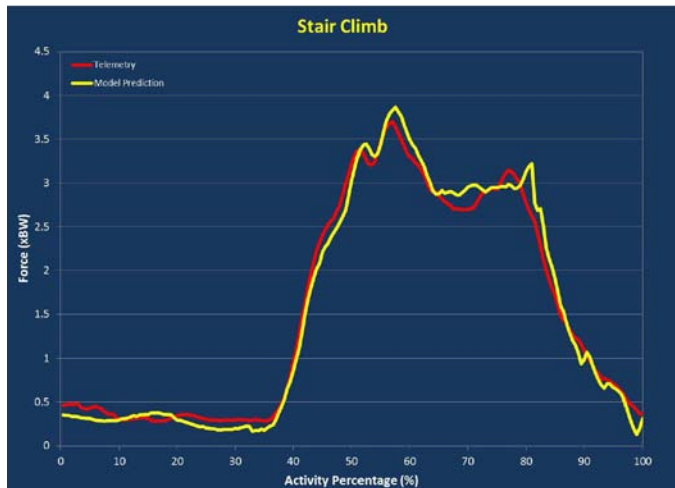
Coauthors: Xavier Flecher, MD, Sebastien Parratte, MD, Jean-Manuel Aubaniac, MD

Total hip arthroplasty for osteoarthritis following developmental dysplasia of the hip (DDH) is challenging due to the modified anatomy of the proximal femur and the acetabulum.

We studied the three-dimensional morphologic parameters of 247 hips from 218 adult's patients with osteoarthritis following dysplasia or congenital dislocation, using X-rays and CT. A cohort of 310 primary osteoarthritic hips studied with the same protocol was used as a control group. According to the classification of Crowe et al 32 of the 78 dislocated hips were graded as class I, 26 as class II and 20 as class III or IV. The 169 hips graded as dysplasia had no subluxation.

The anteroposterior diameter of the acetabulum was smaller in patients with DDH, specially for completely dislocated hips. The intramedullary femoral canal had reduced mediolateral and anteroposterior dimensions for all groups compared to primary osteoarthritis. The individual variability was important when measuring the CT-scan canal flare index, despite the subluxation class considered. The extramedullary parameters showed a decrease in femoral neck shaft angle for high subluxation and an increase for low grades specially in class II. The proximal femur had more anteversion than in the control group with individual variations ranging from 1° to 52° for dysplasia and from 2° to 80° for congenital dislocation.

The importance of the dislocation may reflect the difficulty to achieve hip center location in the true acetabulum, but the large individual morphologic variability showed that the femoral prosthesis cannot be chosen on the single



basis of the severity of the subluxation. Preoperative CT evaluation may have a role for THA in the DDH patient, allowing measurement of the true acetabulum anteroposterior diameter and assessment of the individual femoral anteversion for femoral prosthesis selection.

O15B2

THA with Shortening Subtrochanteric Osteotomy for High Hip Dislocation: Techniques and Results

Guest Faculty: Daniel J. Berry, MD

Institution: Mayo Clinic, Rochester, MN, USA

I. INTRODUCTION

Management of high dislocation has progressed substantially in the last decade. Most prefer to place the socket in an anatomic position and then shorten the femur to allow reduction of the hip and avoid excessive tension on the sciatic nerve. Shortening the femur through a subtrochanteric osteotomy has the benefits of maintaining a fairly normal femoral geometry and avoiding greater trochanteric osteotomy.

II. TECHNIQUE

- A. The hip is approached usually using a posterior approach. A femoral neck osteotomy is performed. Preliminary preparation of the femur is performed. A transverse subtrochanteric osteotomy (usually about 10 cm distal to tip of greater trochanter) is made allowing the proximal segment of the femur to be translocated anteriorly exposing the acetabulum. A small cup is placed in the native socket.
- B. The femoral subtrochanteric osteotomy: An intercalary segment of bone of appropriate length (usually 4-5 cm) is removed. Final femoral preparation is performed for stabilization of the osteotomy with the intramedullary implant. Rigid fixation of both the proximal and distal fragments and the implant must be obtained.
- C. Details of the technique will be discussed during the presentation and are published in JBJS (see refs below).
- D. Technique tips: (1) Prophylactic cerclage of proximal and distal segments. (2) Judge length of bone-resection based on preop plan and intraoperative findings. (3) Pay attention to sciatic nerve

tension. (4) Don't underestimate challenges of cup fixation.

III. RESULTS

- A. Mayo Clinic:
 1. 28 hips
 2. Osteotomy healed 26/28
 3. Implants stable 26/28
 4. HHS 43.89
- B. Favorable results also reported from other centers

IV. CONCLUSIONS

- A. Elegant technique
- B. Preserves abductor attachments and proximal femoral anatomy

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O15B3

Arthroscopic Surgical Outcomes Of Mild Dysplasia Versus Focal Pincer Femoroacetabular Impingement: A Multicenter Case Control Study

Primary Author: Dean K. Matsuda

Institution: Kaiser West Los Angeles Medical Center

Coauthors: Joshua Sampson (Wayne State University), Monti Khatod (Kaiser West Los Angeles), Nicole A. Matsuda (Westchester High School), Raoul Burchette (Kaiser Research and Evaluation)

INTRODUCTION: Recent studies have shown successful outcomes from arthroscopic surgery for femoroacetabular impingement (FAI) and comparatively poor outcomes for dysplasia. But dysplasia often occurs with cam FAI. At present, there have been no studies investigating outcomes from this common clinical setting. The purpose of

this study is to determine the comparative outcomes of arthroscopic surgery for mild dysplasia and focal pincer FAI in patients with concurrent cam FAI.

METHODS: An IRB-approved multicenter retrospective review of prospectively collected data was performed comparing a mild dysplasia cohort (CEA 16-24 degrees) consisting of 7 patients (4 female) of mean age 38.4 years with a focal pincer cohort (CEA 25-39 degrees) consisting of 78 patients (40 female) of mean age 51.3 years in patients with cam FAI that underwent arthroscopic surgery between March 2009 and June 2010 with successful completion of pre- and post-operative nonarthritic hip score (NAHS) and 5-point Likert satisfaction instrument with minimum 2 year follow-up. Complications, revision surgeries, and conversion arthroplasties were recorded. Multivariate linear regression analysis was performed. A nested case control analysis with 2:1 ratio matched controls to dysplasia patients was then performed. Statistical significance was set at $P < 0.05$.

RESULTS: The dysplasia cohort had a mean change in NAHS of +16.8 at 3 months, +11.7 at 12 months, and -2.3 at 24+ months. Mean satisfaction was 2.7. There were no complications, no revision surgeries, and 2 conversion arthroplasties (29 %). The focal cohort had a mean change in NAHS of +12.7 at 3 months, +21.8 at 12 months, and +22.4 at 24+ months. Mean satisfaction was 3.7. There was 1 complication (1.3 %), 1 revision FAI surgery (1.3 %), and 8 conversion arthroplasties (10.3 %). The nested case control analysis confirmed a comparative poorer outcome for the dysplasia cohort (- 24.7 point difference in 24 month change in NAHS, P The dysplasia cohort demonstrated significantly less improvement in NAHS ($P = 0.002$) and trends toward less satisfaction ($P = 0.12$) and higher hip arthroplasty conversions ($P = 0.15$) than the focal cohort.

DISCUSSION AND CONCLUSION: This is the first study to investigate outcomes from arthroscopic surgery for dysplasia in the common setting of concurrent cam FAI. Compared to patients with focal pincer FAI, patients with mild dysplasia have poorer outcomes following arthroscopic surgery. Moreover, early clinical improvement tends to quickly deteriorate in these patients.

O15B4

Outcomes of Acetabular Component Fixation After Total Hip Arthroplasty in Developmental Dysplasia of The Hip

Primary Author: Kurato Jonishi

Institution: Funabashi Orthopedic Hospital

Coauthors: Kazuhiro Oinuma (Funabashi Orthopedic Hospital), Hideaki Shiratsuchi (Funabashi Orthopedic Hospital)

BACKGROUND: In total hip arthroplasty (THA) for patients with developmental dysplasia of the hip (DDH), reduction of the bony coverage of the cup tends to cause a superolateral acetabular defect, and the cup tends to become positioned superiorly in the acetabulum.

MATERIALS AND METHODS: One hundred ninety-three patients with DDH (Crowe type II-IV) who underwent primary THA between 2008 and 2012 were reviewed retrospectively. Patients who underwent THA with trochanteric osteotomy were excluded. All patients received a direct anterior approach (DAA), and we set the target cup positioning for the true acetabulum. In the acetabular procedure, the joint capsule was excised, and the true acetabulum was reamed internally after resection of the femoral head. The cup was fixed by a press-fit technique with screw fixation, and bone chips or bulk bone was grafted into the superolateral defect after cup fixation was confirmed. We evaluated the cup position to the true acetabulum, cup center-edge angle (the angle between a vertical line to the cup center and a line from the lateral acetabular edge to the cup center), and prosthesis survival (endpoints of time to cup loosening or revision performed). In defining the true acetabulum, we centered the cup in Zone 1, depending on the approximate femoral head center as described by Pagnano et al.

RESULTS: Subjects were 23 men (29 joints) and 141 women (164 joints), mean age was 55.8 (34–81) years, and mean follow-up time was 3.4 (1–5) Years. Crowe type was type II in 114 joints, type III in 56 joints, and type IV in 23 joints. The average Japanese Orthopedic Association hip score before surgery was 43.1 points, which increased to 93.9 points at final follow-up. In terms of joint cup positioning, 187 were positioned in the true acetabulum (Zone 1) and 6 were positioned superior. The mean cup center-edge angle was $3.4 \pm 9.2^\circ$ (-26.6–28.4), with 73 joints un-

der 0°, but all of which were positioned in the true acetabulum. The survival rate was 100% for both the loosening and revision end points.

DISCUSSIONS: The superolateral bone defect increased and bony coverage of the cup was reduced when the cup was placed in the true acetabulum for THA patients with DDH. Although the cup center-edge angle was < 0°, the findings suggest that the press-fit and screw-fixed cups were fixed strongly over the short term.

O15B5

Results of Total Hip Arthroplasty in Arthritis Secondary to Developmental Dysplasia of Hip

Primary Author: Rajesh Malhotra

Institution: All India Institute of Medical Sciences

Coauthors: Vijay Kumar (AIIMS), Bhavuk Garg (AIIMS)

INTRODUCTION: The patients with developmental dysplasia of hip present at a younger age with arthritis of hip and have anatomic abnormalities like excessive anteversion, shortening and reduced horizontal and vertical offset which result in technical difficulties at THR

We report the difficulties encountered during surgery, and the long term results of patients who had arthritis secondary DDH and a technically difficult primary hip arthroplasty using the modular S-ROM stem.

METHOD: 18 patients underwent surgery by the senior author using the S-ROM femoral stem were entered into the prospective trial. The average age of the patient at surgery was 45 (range 23–74 years). They were followed up for an average of 5 years (range 3–8 years), clinical scores recorded by a clinician other than the surgeon and radiographs were examined by an independent radiologist.

RESULTS: 5 patients required a significant autologous bone graft while 3 patients required femoral shortening at the time of their THR.

The average pre-op Harris Hip Score was 37, at 1 year it was 86, and at 5 years 81. The WOMAC average score (the lower the score the better the outcome) was 27 at 2 years and 23 at 5 years.

None of the S-ROM stems were loose or needed revision, at latest follow-up. 2 hips had osteolysis in Gruen zone 1, one hip had osteolysis in zone 7, and one hip had osteolysis in zone 1 and 7. There was no evidence of osteolysis around or distal to the sleeve.

CONCLUSION: The S-ROM stem used in primary THR shows excellent results at 5 years in patients with anatomical abnormality related to severe DDH. S-ROM stem/sleeve modularity allows femoral component anteversion independent of the position of best fit in the proximal femur, and helps overcome the technical difficulty in these patients.

O15B6

Definition of Shallow Dysplastic Hip and Reconstruction by using Additional Bulk Bone in Total Hip Arthroplasty

Primary Author: Masaaki Maruyama

Institution: Dept. of Orthop. Surg., Shinonoi General Hospital

Coauthors: Keiji Tensho (Department of Orthopedic Surgery, Shinshu University School of Medicine), Shinji Wakabayashi (Department of Orthopedic Surgery, Matsumoto Medical Center, Chushin Matsumoto Hospital), Kenji Hisa (Department of Orthopedic Surgery, IMS Miyoshi General Hospital)

BACKGROUND: There is no distinct definition of shallow acetabulum in dysplastic hip and no report of additional type of bulk bone grafting method (Ad-BG). The purpose of this study was to define the shallow acetabulum and to evaluate the clinical and radiographic results of primary total hip arthroplasty (THA) with Ad-BG.

MATERIALS AND METHODS: With modification of Crowe's classification, shallow dysplasia was defined and classified (Fig. 1). Between October 1999 and August 2008, 120 hips of 302 THAs for dysplastic hip were defined as shallow and Ad-BG was done in 96 hips (80%). For 24 hips with shallow dysplasia, THA were performed by using conventional type of interpositional bulk bone graft (Ip-BG) (8 hips) or without bone graft by using rigid lateral osteophyte. All patients were followed clinically using the Japanese Orthopaedic Association (JOA) score and also Merle d'Aubigne and Postel (M&P) scores

in a prospective fashion, and radiographs were analyzed retrospectively. The criteria used for determining loosening were migration or total radiolucent zone between the prosthesis (or cement) and host bone. The mean followup periods were 8.0 ± 2.3 (5.0-13.5) years. Operative technique. Resected femoral head was sliced with thickness of 1-2 cm, and then a suitable size of the bulk bone block was placed on the lateral cortex of the ilium and fixed by polylactate absorbable screws. Autogenous impaction morselized bone grafting with or without hydroxyapatite granules was performed in conjunction with a cemented socket. The same surgeon assisted by his colleagues operated all of the cases.

RESULTS: No acetabular components were revised except for a case with shallow and Crowe type IV acetabulum. The mean JOA and M&P score for the hips improved from preoperative 39 and 6 points to postoperative 93 and 17 points respectively. Radiographically, the Ad-BGs in most of the cases were remodeled and recognized reorientation within 2 years postoperatively.

CONCLUSIONS: The authors report very good results of acetabular reconstruction with the use of Ad-BG technique in conjunction with impaction morselized bone graft for shallow hip in primary THA. Osteointegration and good clinical outcome were achieved in most of cases. However longer term outcome should be the subject of further investigation.

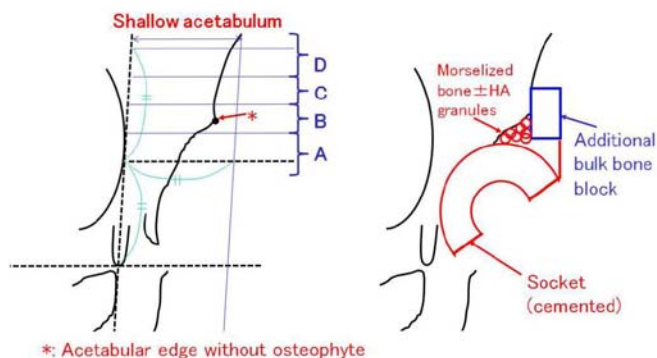


Fig. 1 Definition of shallow acetabulum for dysplasia and operative technique with additional bulk bone grafting

O15B7 Navigation of Cup Position and Leg Lengthening in THA for Dysplastic Hip Osteoarthritis

Primary Author: Hirotugu Ohashi

Institution: Osaka Saiseikai Nakatsu Hospital

Coauthors: Hirotake Yo (Osaka Saiseikai Nakatsu Hospital), Ryo Sugama (Osaka Saiseikai Nakatsu Hospital)

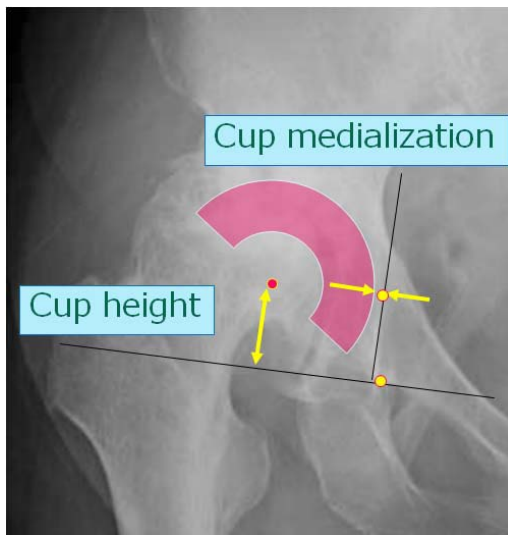
INTRODUCTION: Osteoarthritis of the hip secondary to developmental dysplasia represents acetabular hypoplasia, supero-lateral subluxation, and leg-length discrepancies. We have developed an imageless navigation system in THA focusing on dysplastic hips. The cup position and the leg lengthening are planned based on preoperative templating. The navigation system provides cup inclination and anteversion as well as cup position and leg lengthening. The aim of this study was to investigate the following questions: (1) How accurate are the values of cup orientation, cup position, and leg lengthening? (2) What factors influence the accuracy? (3) Can the post-operative leg length discrepancy be compensated by using the navigation system compared to that without navigation?

MATERIALS AND METHODS: Eighty THA of 71 patients were performed for dysplastic hips. According to Crowe classification, 58 hips were categorized in type I, 18 hips were in type II, and 4 hips were in type III. The sample consisted of 10 men and 61 women with a mean age of 59.9 years. We used two approaches, direct anterior approach in supine position (34 hips), and direct lateral approach in lateral position (46 hips). During operation, the cup height, the cup medialization, the cup inclination, and anteversion were recorded by the navigation system. The leg lengthening was navigated. After operation, the cup inclination and anteversion were measured on CT images. The cup height, the cup medialization and the leg lengthening were measured on AP radiographs (Figure). The leg lengthening was measured on radiographs before and after operation. To investigate the efficacy for the compensation of the post-operative leg length discrepancy, 38 hips operated with navigation system were compared to 33 hips operated without navigation system. All were unilateral cases and the leg length equalization was aimed.

RESULTS: The absolute difference between the navigated and the measured angle was 4.3 ± 3.1 degrees in cup incli-

nation, and 5.5 ± 3.8 degrees in cup anteversion. The absolute difference between the navigated and the measured distance was 4.5 ± 4.0 mm in cup height, 3.0 ± 2.5 mm in cup medialization, and 3.7 ± 3.0 mm in leg lengthening. The accuracy was not influenced by the Crowe classification and the patient positions. The absolute post-operative leg length discrepancy was 3.9 ± 3.3 mm with navigation and 6.6 ± 4.8 mm without navigation ($p=0.0078$) (Table).

DISCUSSION: Our imageless navigation system is unique since it realizes to navigate cup orientation as well as cup position and leg lengthening according to the 2D templating. We found that the accuracy of cup position and leg lengthening was acceptable for clinical use, and was not influenced by the Crowe classification and the patient positions. The compensation of the leg length discrepancy was more accurately by using the navigation system. These results indicated this navigation system can improve the accuracy of cup orientation, cup position and leg lengthening in THA for dysplastic hips.



Leg length discrepancy before and after THA with or without navigation system

	With Navigation	Without Navigation	
Patients	N=38 (M: 5, F: 33)	N=33 (M: 3, F: 30)	
Age	60.5 ± 6.1	75.4 ± 3.7	
Pre-operative LLD	-9.8 ± 7.0 mm	-8.8 ± 7.0 mm	$p=0.5710$
Post-operative LLD	1.1 ± 5.0 mm	4.3 ± 7.0 mm	$p=0.0295$
Absolute value of post-operative LLD	3.9 ± 3.3 mm	6.6 ± 4.8 mm	$p=0.0078$

(LLD: leg length discrepancy)

Femoral & Tibial Component Rotation: How to get it Right

O16A1

Why Gap Balancing is the Best Technique for Total Knee Arthroplasty

Guest Faculty: Douglas A. Dennis, MD

Institution: Adjunct Professor, Dept. of Biomedical Engineering, University of Tennessee; Adjunct Professor of Bioengineering, University of Denver; Assistant Clinical Professor, Dept. of Orthopaedics, University of Colorado School of Medicine, Denver, CO, USA

INTRODUCTION: Multiple differing surgical techniques are currently utilized to perform total knee arthroplasty (TKA). Stability of TKA is dependent on precise rotation of the femoral component. Femoral component malrotation has been associated with numerous adverse sequelae including patellofemoral and tibiofemoral instability, knee pain, arthrofibrosis, and abnormal knee kinematics. Controversy exists regarding the best method to determine femoral component rotation. Some favour a measured resection technique in which bone landmarks (femoral epicondyles, posterior femoral condyles, or the anteroposterior axis) are the primary determinants of femoral component rotation. Others recommend gap balancing in which the femoral component is positioned parallel to the resected proximal tibia with each collateral ligament equally tensioned. [1] This report describes two studies comparing the two techniques to determine which method provides superior coronal plane stability.

METHODS: 212 patients underwent a TKA utilizing a computer navigation system in Study 1 (Ci Navigation System; Depuy, Warsaw, IN). The transepicondylar, anteroposterior, and the posterior condylar axes were registered. CAS optimized femoral rotation (gap balancing) was then compared to use of the anatomic bony landmarks (i.e., measured resection technique) to evaluate the accuracy of these landmarks in determining rotation of the femoral component. [2]

In a 2nd study, 40 TKA were performed using a measured

resection technique (20 PCL-retaining and 20 PCL-substituting) and compared with 20 PCL- substituting TKA implanted using gap balancing. All 60 TKAs were judged clinically successful and were analyzed fluoroscopically. Kinematics were determined using a 3-D model fitting technique while performing a deep knee bend. Coronal plane instability was then evaluated by determination of the incidence and magnitude of femoral condylar lift-off. [3]

RESULTS: In the 1st study, use of the epicondylar axis to determine femoral rotation placed the component a mean 0.9° externally rotated (range, 13° internal to 15° external) vs. gap balancing, with the flexion gap balanced (+/- 3°) only 43% of the time. The posterior condylar axis was a mean of 0.4° internally rotated (range, 16° internal, 11° external) vs. gap balancing, with the flexion gap balanced 58% of the time. The anteroposterior axis was a mean of 1.9° externally rotated (range 14° internal, 16° external) vs. gap balancing, with the flexion gap balanced 40% of the time.

In the 2nd study, the incidence of femoral lift-off greater than 0.75 mm was 80% (maximum, 2.9 mm) and 70% (maximum 2.5 mm) for the PCL-retaining and substituting TKA groups performed using measured resection versus 35% (maximum 0.88 mm) for the gap-balanced group. Lift-off greater than 1 mm occurred in 60% and 45% of the PCL-retaining and -substituting TKA using measured resection versus none in the gap-balanced group. Mean femoral condylar lift-off values for the PCR and PS TKA groups performed using a measured resection technique were 1.45mm and 1.11mm respectively versus 0.67mm for those implanted using gap balancing.

CONCLUSION: The current analyses demonstrate superior coronal plane stability in those subjects who received a TKA using gap balancing. A wide range of error was encountered with use of measured resection technique. The authors hypothesize that these findings are related to surgeon inability to precisely identify critical bone landmarks when deciding correct femoral component rotation using a measured resection methodology. Superior coronal stability should result in improved functional performance and reduced polyethylene wear.

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O16A2

Balancing the Gaps in TKA – The Basic Principles

Guest Faculty: Alfred J. Tria Jr., MD

Institution: St. Peter's University Hospital, Somerset, NJ, USA

TKA requires balancing of the flexion and extension spaces throughout the entire operative procedure. The chart below summarizes the steps that are required for each of the nine possibilities the surgeon may encounter.

		Extension		
		tight	perfect	loose
Flexion	tight	More tibia	D-size slope	Move-femur ↓ D-size slope
	perfect	More femur	OK	Move-femur ↓ D-size
	loose	Up-size more femur	Up-size More femur	↑ poly

There is often more than one solution for the imbalance and the choice should be made by the ease of application.

O16A3

Prospective Comparison of Flexion Stabilities after TKA Using the Measured Resection and Balanced Gap Techniques.

Primary Author: Ha-Sung Kim

Institution: Center for Joint Disease, Chonnam National University Hwasun Hospital

Coauthors: Eun-Kyoo Song (Center for Joint Disease, Chonnam National University Hwasun Hospital) ,Jong-

Keun Seon (Center for Joint Disease, Chonnam National University Hwasun Hospital)

INTRODUCTION: There are two techniques of achieving soft gap balancing in TKA; a measured resection technique and a balanced gap technique. In this prospective comparative study, the authors evaluated rotational alignments of femoral components and flexion stabilities after TKA performed using the measured resection or gap balanced techniques. In addition, functional outcomes obtained using the two techniques were compared after a minimum follow-up of 2 years.

METHODS: Seventy-two consecutive patients, who were awaiting unilateral TKAs, were allocated alternatively to either the TKA using by measured resection or a using-by balanced gap techniques. Eight patients were excluded from this study (2 patients due to refusal to participate study and 4 patients due to loss of follow-up). This left sixty-four TKAs (32 TKA by measured resection and 32 by balanced gap) with a minimum of 2 years. At final follow-up, valgus and varus laxities at 90 degrees of knee flexion were measured on radiographs taken under valgus-varus stress, and total flexion laxity was determined by summing valgus and varus laxities. In addition, the rotations of femoral components from the transepicondylar axis were also measured on flexion radiographs. To compare clinical outcomes, range of motion, HSS scores, and WOMAC scores at final follow-up were evaluated and compared between two groups.

RESULTS: Mean varus laxities were 4.3° in the measured resection group and 3.7° in the balanced gap group, and mean valgus laxities were 3.2° and 3.4°, respectively without statistical significance. Mean total laxities were similar in the two groups (7.5 vs. 7.0, $p=0.37$). However, the number of patients with valgus-varus imbalance greater than 3° was significant more in measured resection group than balanced gap group. And mean femoral component rotations were significantly different in the two groups (measured resection; 0.8° external rotation from transepicondylar axis and balanced gap; 1.5° external rotation ($p=0.04$)). The average HSS scores were 86 points in the measured resection group, and 90 points in the balanced gap group, which showed no significant difference. Moreover, no significant inter-group differences were evident for range of motion and WOMAC scores ($p=0.73$, $p=0.640$).

CONCLUSION: This study demonstrated that both mea-

sured resection and balanced gap techniques can achieve good functional outcomes in TKA. However, the balanced gap techniques have an advantage in flexion stability than measured resection in TKA.

O16A4 Kinematic Consequences of Excessive Internal Tibial Component Rotation

Primary Author: Marc Bandi

Institution: Zimmer GmbH

Coauthors: Iris Sauerberg (Zimmer GmbH), John Kyle P. Mueller (Zimmer Inc), Eik Siggelkow (Zimmer GmbH)

INTRODUCTION: Excessive internal rotation of the tibial component of a total knee arthroplasty (TKA) is a common challenge in joint implantation. It is the result of a combination of several factors, including the natural tendency to deal with the asymmetry of the tibial surface by attempting to maximize coverage with the tibial tray. The clinical consequences of this degree of surgical variation are well known in the form of anterior knee pain and stiffness. However, little is reported regarding the underlying biomechanical consequences. The goal of this study was to quantify the kinematic effect of excessive internal rotation of the tibial component.

MATERIAL AND METHODS: Four specimen-specific numerical knee models (Abaqus/Explicit, Simulia) were used to simulate knee function. With ethical approval, the models were created from post-mortem human specimens by co-registered CT and MRI scans and robotic calibration. The models are validated and applicable for studying implant positioning. Virtual TKA was performed using contemporary cruciate-retaining (CR), posterior-stabilized (PS) and ultra-congruent (UC) designs. Each design was virtually implanted in each knee with the tibial baseplate in both neutral rotation (posterior cruciate ligament – medial third of tibial tubercle) and internal mal-rotation (15°). A lunge motion was simulated in each configuration by applying loads measured in-vivo. Tibiofemoral kinematics was expressed by the antero-posterior (AP) motion of the lowest points of the medial and lateral femoral condyles. Regarding patellofemoral kinematics, the lateral offset of the tibial tubercle with respect to the trochlear groove (TTTG) was measured along the medial-lateral axis of the femoral component.

RESULTS: Compared to a neutral alignment, 15° of internal tibial baseplate mal-rotation decreased differential rollback (lateral rollback versus medial rollback during lunge) by 152% (3.2 mm to -1.7 mm) for the CR (see Figure 1 for examples), by 94% (2.9 mm to 0.2 mm) for the PS and by 82% (2.4 mm to 0.4 mm) for the UC design. Mal-rotation also increased the average TTTG by 10.1 mm \pm 0.9 mm (-3 mm to +7.1 mm) for the CR (Figure 2), by 8.8 mm \pm 0.5 mm (-1.9 mm to +6.9 mm) for the PS and by 10.4 mm \pm 0.4 mm (-2.8 mm to +7.6 mm) for the UC design.

DISCUSSION AND CONCLUSION: Excessive internal tibial baseplate rotation caused kinematics to deviate from normal. It nearly eliminated differential rollback in all designs. In the CR design it even resulted in a larger medial rollback. This pattern contrasts normal kinematics and may cause anterolateral overstuffing and consequently pain. Dejour et al. found a TTTG greater than 20 mm for individuals with a history of patella dislocation in 56% of the cases. In our study, internal tibial baseplate mal-rotation increased the TTTG towards this threshold, thus suggesting an increased risk related to the patella function. In conclusion, our results help understanding the biomechanical consequences of excessive internal rotation of the tibial baseplate. They demonstrate that mal-rotation leads to tibiofemoral and patellofemoral kinematic aberrations that could contribute to patella mal-tracking and anterior pain.

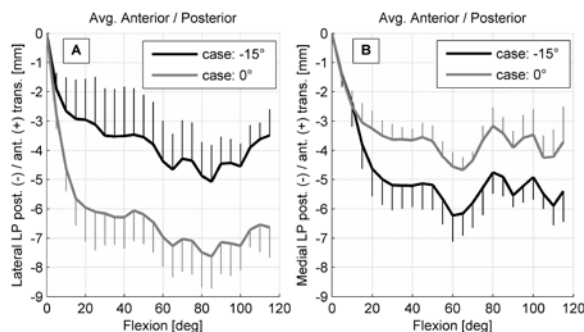


Figure 1: A) Lateral rollback and B) medial rollback (average / standard deviation) of CR designs with neutrally (0°) and internally rotated (-15°) tibial baseplates

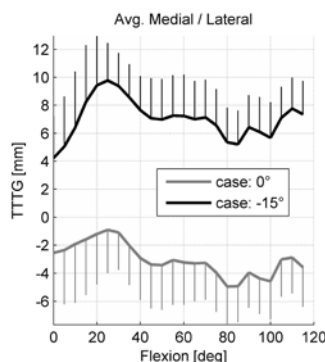


Figure 2: TTTG (average / standard deviation) of CR designs

O16A5 Differences of Sizing and Rotational Landmarks of Distal Femur Between Southern Chinese and Caucasian

Primary Author: Zongke Zhou

Institution: Orthopaedic Department, West China Hospital of Sichuan University, Chengdu, China

Coauthors: Chengpei Zhou (Orthopaedic Department, West China Hospital of Sichuan University, Chengdu, China), Bin Shen (Orthopaedic Department, West China Hospital of Sichuan University, Chengdu, China), Jing Yang (Orthopaedic Department, West China Hospital of Sichuan University, Chengdu, China)

BACKGROUND: The purpose of this study was to investigate the exact sizing and rotational landmarks of the distal femur collected from a large group of healthy Southern Chinese using three dimensional computer tomographic measurements, and to correlate the measurements to the known dimensions from Caucasian.

METHODS: This study evaluated distal femoral geometry in 125 healthy Southern Chinese, included 58 women (96 knees) and 67 men (154 knees) who had a mean age of 35.2 \pm 8.11 years a mean height of 165.5 \pm 7.94 cm, a mean weight of 61.7 \pm 9.56 kg. The articular surface width from medial to lateral transepicondylar (ML), anterior-posterior dimension (AP), the dimensions from medial/lateral epicondyle to posterior condylar (MEP/LEP), were measured. A characterization of the aspect ratio (ML/AP) was made for distal femur. The angles between the tangent line of the posterior condylar surfaces, the Whiteside line, the transepicondylar line, and the trochlear line were measured. The sulcus angle, the hip center-femoral shaft angle were also measured. Known dimensions from Caucasian were compared with the morphologic data. In analyzing the data, best-fit lines were calculated with use of least-squares regression. The dimensions are summarized as the mean and standard deviation. The differences of rotational landmarks and sizing between the Southern Chinese and Caucasian were assessed with use of the Student t test. A p value of <0.05 indicated a significant effect.

RESULTS: ML and AP were larger values in Southern Chinese male than female (ML: 70.38 \pm 3.09 vs. 62.09 \pm 2.52mm, P<0.001; AP: 63.68 \pm 2.82 vs. 57.83 \pm 2.91mm, P<0.001). The results showed that South-

ern Chinese knees were generally smaller than Caucasian (ML: 67.27 ± 4.95 vs. 76.8 ± 7.2 mm, $P < 0.001$). The femoral aspect ratio of Southern Chinese was significantly smaller than Caucasian (1.09 ± 0.04 vs. 1.28 ± 0.06 , $P < 0.001$). In addition, we found a gradually decreased in the aspect ratio with an increasing anteroposterior dimension in the distal femur of Southern Chinese, as same to most other studies. The transepicondylar axis was found to be a reliable landmark to properly rotate the femoral component, so we chose the femoral condylar MEP and LEP evaluate posterior condylar offset, the values were respectively 28.62 ± 2.18 mm and 22.50 ± 2.19 mm. From this study, most of the angles were different from Caucasian. Anteroposterior line minus epicondylar line angle was $90.14 \pm 1.30^\circ$ (Caucasian $90.33 \pm 2.44^\circ$, $P > 0.05$), anteroposterior line minus posterior condylar line angle was $83.18 \pm 1.94^\circ$ (Caucasian $86.82 \pm 2.71^\circ$, $P < 0.001$), epicondylar line minus posterior condylar line angle was $7.00 \pm 1.70^\circ$ (Caucasian $3.60 \pm 2.02^\circ$, $P < 0.001$), trochleoepicondylar angle was $12.45 \pm 2.34^\circ$ (Caucasian $4.95 \pm 2.15^\circ$, $P < 0.001$), sulcus angle was $147.40 \pm 4.69^\circ$ (Caucasian $139.6 \pm 6.96^\circ$, $P < 0.001$). The angle between mechanical and anatomic axis of the femur was $5.92 \pm 0.47^\circ$ (Caucasian $6.33 \pm 2.42^\circ$, $P < 0.001$).

CONCLUSION: Modified knee implants were asked for Southern Chinese patients with smaller sizing of distal femur and the aspect ratio (ML/AP). We should pay more attention to knee implant design and operation technology owing to the angles were different from Caucasian from this study, most of the angles were different from Caucasian. The Proper rotational alignment of the femoral component is critical for the outcome of total knee arthroplasty.

O16A6

The Tibial Centroid Axis: A Reliable Reference for Rotational Orientation of the Tibia Plateau in Knee Surgery

Primary Author: Anthony Leong

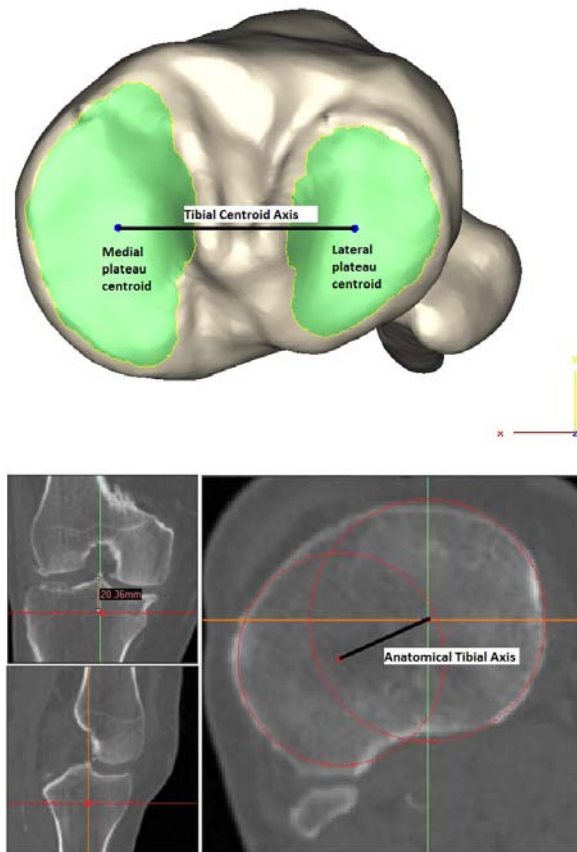
Institution: Imperial College London

Coauthors: Charison Tay (Imperial College London), Evelyn Thangaraj (Imperial College London), Gareth Jones (Imperial College London), Cobb Justin (Imperial College London)

There are few reliable frames of reference for rotational orientation of the tibial plateau in knee surgery. The most

reliable one today is the Anatomical Tibial Axis (ATAx). Constructed using a pair of best fit circles to the cortex of the inferior portions of the medial and lateral tibial plateaus, the ATAx is more reliable than any other axes relying on fixed bone landmarks on the tibia. Apart from the ATAx, there is no other reliable alternative in the literature. However, many surgeons still rely on tibial landmarks in order to determine the correct rotational alignment of a tibial prosthesis. Axes based on these fixed bone landmarks vary significantly between themselves, and in total knee replacement this results in a significant variance in rotational mismatch between the femoral and tibial components. Rotational misalignment is a leading cause of poor functional outcome and early component failure. Indeed, some total knee prostheses require a relatively greater degree of rotational accuracy such as in highly congruent fixed bearing prostheses, where there is additional rotational constraint between the tibial inlay and femoral component. Our aim in this study was therefore to develop an alternate reliable way of referencing tibial plateau rotation based on an axis derived from the centroids of the medial and lateral tibial plateau. We obtained CT scans of 60 tibias from patients who had previously given consent for their use in orthopaedic research. Osteoarthritis (OA) severity ranged from Ahlback grade 0-3, and Kellgren-Lawrence grade 0-3. The CT images were segmented into three-dimensional computer models with Mimics and 3-matics Software (Materialise, Belgium). In 3-matics, tibias were aligned to a common frame of reference, vertically to the mechanical axis, and axially to the ATAx. Centroids were derived for both the medial and lateral plateaus. We named the line joining the two centroids the Tibial Centroid Axis (TCAx). We found the TCAx very nearly parallel to ATAx, internally rotated by only $1^\circ \pm 4^\circ$ (2 SDs). The TCAx was externally rotated relative to an axis attached to the posterior condyles by $6^\circ \pm 7^\circ$ (2 SDs), and externally rotated relative to an axis involving the lateral tibial spine and tibial tuberosity by $80^\circ \pm 14^\circ$ (2 SDs). These results were similar to a previous study, which also confirmed the unreliability of axes derived from fixed bone landmarks. The TCAx has an advantage over the ATAx. The ATAx is subject to parallax errors in the axial view as its medial coordinate is positioned 20mm inferiorly to the lateral coordinate. This is aggravated when there is a change in the longitudinal frame of reference in the sagittal plane. The TCAx however cannot be used when there is severe destruction and deformation of the tibial plateau surface. We conclude therefore that the TCAx is an alternate and equally reliable reference for rotational orientation of the tibia plateau in both normal

and moderately osteoarthritic knees.



O16A7 Joint Gap Assessment with a Tensor is Useful for Selection of the Insert Thickness in Unicompartmental Knee Arthroplasty

Primary Author: Koji Takayama

Institution: Department of Orthopaedic Surgery, Kobe University Graduate School of Medicine

Coauthors: Tomoyuki Matsumoto (Department of Orthopaedic Surgery, Kobe University Graduate School of Medicine), Hirotugu Muratsu (Department of Orthopaedic Surgery, Steel Memorial Hirohata Hospital, Japan), Atsuo Uefuji (Department of Orthopaedic Surgery, Kobe University Graduate School of Medicine)

BACKGROUND: The success of unicompartmental knee arthroplasty (UKA) relies on proper soft-tissue tensioning to obtain a balanced extension-flexion gap; however the soft tissue balance during UKA is still dependent on surgeons' subjective feeling and experience. Recently, a tensor that is designed to assess soft tissue balance during

UKA has been developed. Using the tensor, joint component gap can be quantitatively assessed with femoral component placement through entire range of motion (ROM). The purpose of this study was to compare the component gap throughout the ROM among different distraction forces in UKA and examine the correlation between the component gap and the insert thickness.

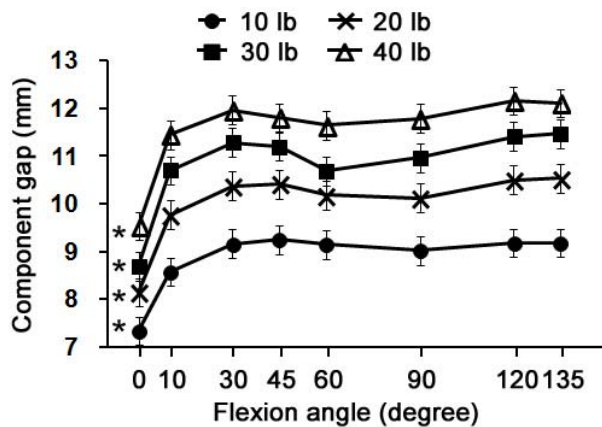
METHODS: Thirty cases of 29 patients (19 female and 10 male) were included in the study. The mean age was 71.8 ± 8.5 years old (range: 58-85), and the average coronal plane femorotibial angle (FTA) was 181.2 ± 3.2 degree pre-operatively. All the patients received a conventional medial Zimmer Unicompartmental High Flex Knee System (Zimmer Inc, Warsaw, Ind). Using a tensor under 10, 20, 30, and 40 lb distraction forces, after femoral component placement, the component gaps were assessed throughout the ROM. The correlations between the component gap and the insert thickness selected were examined.

RESULTS: The 'component gaps' increased in proportion to the increase of distraction force and showed similar gap kinematics with four different distraction forces. The 'component gap' decreased significantly during full extension (10 to 0 degree of knee flexion) with each distraction force (p The mean value of the insert thickness was 9.0 ± 1.0 mm. The insert thickness was strongly correlated with the 'component gap' of 10, 30, 45 degree of knee flexion with over 20 lbs distraction force. (20lbs distraction force; $r=0.803, 0.845, 0.802$, 30lbs distraction force; $r=0.870, 0.883, 0.831$, 40lbs distraction force; $r=0.819, 0.860, 0.829$ at 10, 30, 45 degree flexion, respectively) (Fig 2).

DISCUSSION: The insert thickness in UKA was strongly correlated with the 'component gap' of 10 degree to mid-range of knee flexion compared to at full extension. These results suggested that the 'component gap' not at full extension but at 10 degree to mid-range of knee flexion with this tensor assisted surgeons to make the selection of insert thickness during UKA. In addition, the insert thickness in UKA was also strongly correlated with the 'component gap' at over 20lbs compared to 10lbs. These results indicated the 'component gap' of 10 degree of knee flexion to mid-range of flexion with at least 20lbs distraction force is necessary to have a strong correlation with the insert thickness.

CONCLUSION: Component gaps increased in phase with the the distraction force. However, with the use of the

tensor, surgeons may predict appropriate thickness of the insert referring to the value of 10 degree of knee flexion to mid-range of flexion with at least 20lbs distraction force.



The correlation between the insert thickness and the component gap

Flexion	The correlation coefficient (r)			
	10 lb	20 lb	30 lb	40 lb
0°	0.46*	0.49*	0.53**	0.59**
10°	0.79**	0.80**	0.87**	0.82**
30°	0.71**	0.85**	0.88**	0.86**
45°	0.69**	0.80**	0.83**	0.83**
60°	0.73**	0.74**	0.81**	0.79**
90°	0.58**	0.66**	0.71**	0.67**
120°	0.45*	0.47*	0.55**	0.40*
135°	0.39*	0.41*	0.37	0.26

* p<0.05, ** p<0.01

decade we have utilized a less invasive modification to the direct lateral approach (LIDL). Essentials are avoidance of dissection into the vastus lateralis insertion, a limit of 1-2 cm proximal dissection into the gluteus medius, and an effort to spare the majority of the gluteus minimus insertion. Virtues of the direct lateral approach are excellent visualization of the acetabulum and proximal femur for appropriate component alignment and orientation. We previously reported less blood loss and a shorter hospital stay with the LIDL approach compared with the standard direct lateral [1]. While touted as safer with respect to minimizing dislocation, the LIDL approach has been reported to require a slightly prolonged rehabilitation to eliminate postoperative limp. The soft-tissue dissection still requires removing and repairing the abductor musculature. Direct anterior approaches have gained popularity as minimally invasive methods for performing primary total hip arthroplasty. The anterior interval is both intermuscular and internervous, so the anterior approach has the potential advantage of requiring little or no muscle dissection and is a true minimally invasive alternative. Some studies have reported high intraoperative and postoperative complication rates, increased transfusion risk, and questionable clinical benefits with direct anterior approaches. However, in an earlier study from our center, we found significantly improved early recovery of patients who underwent THA via the ASI approach versus LIDL, with a higher rate of hospital discharge directly to home as well as improved Harris hip scores and lower-extremity activity scale scores at six weeks [2]. While there were complications associated with this approach, the rate was not significantly higher (with the number of patients studied) than the rate with the LIDL approach. We wanted to determine if the early clinical benefits of the ASI approach remained with longer follow-up. Therefore, we reviewed our primary THA experience with a single, short tapered titanium femoral component, and compared outcomes between THA performed with an LIDL versus ASI approach.

THA Surgical Approach

O16B1

Does Early Functional Advantage of the Direct Anterior Approach – Continue in Follow-up?

Guest Faculty: Adolph V. Lombardi Jr., MD, FACS

Institution: Joint Implant Surgeons, Inc.; The Ohio State University Wexner Medical Center; Mount Carmel Health Systems; New Albany, Ohio, USA

Numerous variations of the direct lateral or anterolateral abductor splitting approach have been described, with the essence of all being a partial release of the confluence of the vastus lateralis and gluteus medius and minimus from the anterolateral attachment to the femur. For more than a

A query of our practice registry revealed 240 patients (281 hips) who underwent primary cementless THA with a short, tapered femoral component between January 2006 and February 2008. A high offset option was utilized in 54%. Age averaged 62.7 years and BMI averaged 29.4 kg/m². The ASI approach was utilized in 143 THA, and the LIDL approach was used in 138 THA. Disease profiles, gender, age, BMI, and preoperative clinical scores were similar between approach groups.

Follow-up averaged 4.6 years. Stem length averaged 107.2mm (95-120). Harris hip scores improved by an average 33.7 points, from 50.3 preoperatively to 84.0 at most recent, with no differences between approach groups. Six stems (2.1%) have been revised: 2 LIDL (both infection) and 4 ASI (1 infection, 2 periprosthetic femoral fracture, and 1 well fixed with loose cup revised for inability to dissociate femoral head from trunnion) ($p=NS$). Operative times were longer for with ASI than LIDL (72.4 versus 65.5 minutes, ($p=0.0001$), likely a reflection of more established experience with the LIDL at time of study. While length of stay, estimated blood loss and transfusion needs were similar, mean hemoglobin level at discharge was lower in ASI than LIDL patients (10.2 versus 10.9 g/dl; $p=0.0003$). Mean length of stay was similar between approach groups, at 1.9 days for the ASI group and 2.0 days for the LIDL.

In this series, good results with a low rate of stem revision were achieved with a short, tapered titanium femoral component with proximal, porous plasma-sprayed coating, using either a less invasive direct lateral or direct anterior approach. Patients treated with the LIDL approach had equivalent clinical and functional results compared with patients treated with the ASI approach.

Berend KR, Lombardi AV Jr. Total hip arthroplasty via the less invasive anterolateral abductor splitting approach. *Seminars in Arthroplasty*. 15(2):87-93, April 2004.

Berend KR, Lombardi AV Jr, Seng BE, Adams JB. Enhanced early outcomes with the anterior supine intermuscular approach in primary total hip arthroplasty. *J Bone Joint Surg Am*. 2009 Nov;91 Suppl 6:107-20.

O16B2

Revision Total Hip Arthroplasty Via Direct Anterior Approach

Primary Author: William J. Hozack

Institution: Rothman Institute, Thomas Jefferson University

Coauthors: Erik N. Hansen (UCSF), David Tarity (Thomas Jefferson University)

INTRODUCTION: The direct anterior approach for total hip arthroplasty (THA) has gained recent popularity due to documented benefits of decreased tissue damage and im-

proved early clinical and functional outcomes. Yet, one of the reported drawbacks is that it is less extensile compared to other approaches and is therefore not conducive to revision surgery. Very little literature has been published on the topic of revision THA via the direct anterior approach.

METHODS: A consecutive series of 62 patients (64 hips) who had undergone revision total hip arthroplasty through the direct anterior approach was reviewed. Data analyzed included demographic information, surgical indications and implants, intraoperative technique, and complications.

RESULTS: The interval between index and revision surgery averaged 2 years (range 1 week to 13 years). The indication for revision surgery included periprosthetic fracture (femur- 6, 9%; acetabulum- 1, 2%), instability (5, 8%), infection (2, 3%), aseptic loosening (femur- 8, 13%; acetabulum- 1, 2%; both- 1, 2%), leg length discrepancy (1, 2%), adverse reaction to metal debris (ARMD) (33, 52%), ARMD and infection (1, 2%), polyethylene wear (1, 2%), failed hip resurfacing (1, 2%), and painful hip arthroplasty (3, 5%). Of the 54 femoral stem revisions, the majority (43, 80%) were revised to a primary anatomic or wedge taper stem, while 11 (20%) were revised to a conical tapered revision prostheses. In 2 cases, an extended trochanteric osteotomy was performed, and there was one case of a femoral shortening osteotomy. All 8 acetabular revisions were to another hemispheric cup with only one case requiring augments. There were no intraoperative complications, such as cortical perforation or periprosthetic fracture. Additional surgery was necessary in 6 patients (9%) due to aseptic loosening (3), instability (1), and infection (2).

Conclusion: For a multitude of indications, revision THA via the direct anterior approach is feasible and safe. Understanding the techniques for extension of this approach is critical for the success of the operation.

O16B3

Multicenter, Retrospective Review of Early Complications After Total Hip Arthroplasty by Anterior Approach

Primary Author: Steven L. Barnett

Institution: Orthopaedic Specialty Institute

Coauthors: Robert S. Gorab (Orthopaedic Specialty Institute), William G. Hamilton (Anderson Orthopaedic Clinic), Joel M. Matta (Saint John's Health Center), Jay

J. Patel (Orthopaedic Specialty Institute), Leera Choi (Orthopaedic Specialty Institute)

INTRODUCTION: The objective of this study is to report the early 90 day postoperative complications after total hip arthroplasty (THA) by anterior approach (AA) in a large multicenter retrospective review.

METHODS: Retrospective case review was performed on 5090 consecutive primary THAs in 4473 patients, who had undergone THA by AA between August 2006 and July 2013 by 5 surgeons in 3 sites. The complications were recorded in the 90 day postoperative period by chart review.

RESULTS: The series consisted of 52.9% females, mean body mass index of 27.5, and mean age of 63.6 years. The most common diagnosis was osteoarthritis (91.2%). The surgical complication rate was 1.93% (98 cases), with 29 (0.57%) intraoperative calcar fractures, 15 (0.29%) superficial infections, 12 (0.24%) dislocations, 8 (0.16%) hematomas, 9 (0.14%) intraoperative greater trochanter fractures, 5 (0.10%) deep infections, 3 (0.06%) cellulites, 3 (0.06%) intraoperative femoral shaft fractures, 3 (0.06%) postoperative greater trochanter fractures, 2 (0.04%) sciatic nerve palsies, 2 (0.04%) postoperative calcar fractures, 2 (0.04%) periprosthetic fractures, 1 (0.02%) peroneal nerve palsy, and 1 (0.02%) intrapelvic bleed. The medical complication rate, measured at two of the sites, was 1.06% (54 cases). These include 12 (0.24%) deep vein thromboses, 14 (0.28%) cardiac arrhythmias, 5 (0.10%) myocardial infarctions, 5 (0.10%) hematologic disorders, 4 (0.08%) pulmonary embolisms, 3 (0.06%) gastrointestinal disorders, 3 (0.06%) pneumonias, 1 (0.02) asthma, and 1 (0.02%) stroke. The estimated blood loss demonstrated 67.1% of patients with less than 1 unit blood loss and 29.4 % lost between 1 and 2 units.

CONCLUSION: This multicenter study of 5090 consecutive AA THAs demonstrates a low rate and acceptable range of complications.

O16B4

Anterior vs. Posterior Approach for Total Hip Arthroplasty: a Systematic Review and Meta-analysis

Primary Author: Brendan T. Higgins

Institution: Dartmouth Hitchcock Medical Center

Coauthors: Timothy J. Lin (Dartmouth Hitchcock Medical Center), Daniel R. Barlow (Geisel School of Medicine at Dartmouth), Nathan E Heagerty (The Dartmouth Institute for Health Policy and Clinical Practice)

BACKGROUND: Total hip arthroplasty (THA) is a cost-effective treatment that improves pain, function and quality of life among patients with hip osteoarthritis. Multiple approaches to THA are commonly practiced with no consensus as to which yields the best clinical, radiographic and surgical outcomes. Recently, there has been renewed and increased interest in the anterior approach to THA due to the belief that because the anterior approach utilizes an inter-muscular and inter-nervous plane, it may result in decreased pain, faster recovery and improved hip stability.

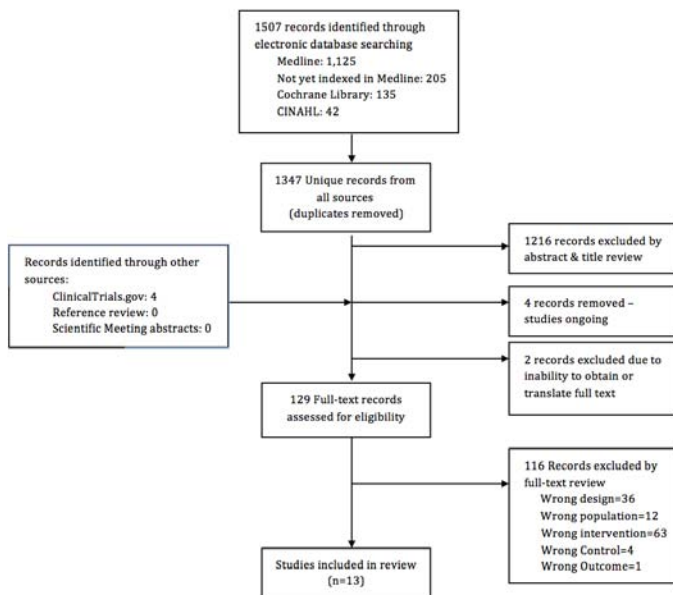
OBJECTIVE: To compare clinical, radiographic and surgical outcomes among patients undergoing primary THA performed by either the anterior or posterior approach.

METHODS: We searched MEDLINE, Cochrane Library, CINAHL and ClinicalTrials.gov from inception through October 2013 for studies comparing the anterior versus posterior approach in patients undergoing primary THA. We also reviewed reference lists, abstracts from the annual meetings of the American Academy of Orthopaedic Surgeons and the American Association of Hip and Knee Surgeons, and contacted experts in the field of THA. Two reviewers independently assessed study quality and extracted data. We pooled patient reported pain and function outcomes qualitatively. We generated forest plots using random effects to pool weighted mean differences for continuous outcomes and pooled Peto odds ratios and risk ratios using fixed and random effects respectively for dichotomous outcomes.

RESULTS: Of 1,507 records screened, we included two randomized trials, three prospective comparative studies and eight retrospective comparative studies, totaling 1,335 participants. (See Figure 1 for our study selection flow diagram.) Six studies reported post-operative pain and function: the anterior approach was significantly favored in 3 studies at short-term follow-up (6 weeks to 3 months); however there were no significant differences between approaches in any study at any subsequent time point (6 month to 2 years). Pooled estimates suggested that length of stay, post-operative dislocations and percentage of patients discharged to home favored the anterior approach, while operative time and estimated blood loss favored the

posterior approach. However, individual study findings varied widely and none of the pooled differences were statistically significant. Rates of intra-operative fractures and post-operative blood transfusions were similar for both approaches. With regard to radiographic outcomes, acetabular cup position and leg length discrepancy were improved using the anterior approach.

Figure 1: PRISMA study selection flow diagram



CONCLUSIONS: Overall, the studies included in our review demonstrate poor methodological quality. Current evidence comparing outcomes following anterior versus posterior THA does not demonstrate clear superiority of either approach. Until more rigorous, prospective, randomized evidence is available, we recommend choice of surgical approach for THA be based on patient characteristics, surgeon experience, and surgeon and patient preference.

O16B5

Tranexamic Acid for Reduction of Blood Loss in Direct Anterior Total Hip Arthroplasty (DA THA)

Primary Author: Sherif Dabash

Institution: Cleveland Clinic Florida

Coauthors: Juan Suarez (Cleveland Clinic Florida), Preteesh Patel (Cleveland Clinic Florida), Leticia Barksdale (Cleveland Clinic Florida), Ahmed Attia (Cleveland Clinic Florida), Eric Slotkin (Cleveland Clinic Florida), Caleb

szubski (Cleveland Clinic Florida)

BACKGROUND: Direct anterior total hip arthroplasty (DA THA) can be associated with substantial blood loss that may lead to increased morbidity and the need for allogeneic blood transfusions. Multiple blood conservation strategies have been developed to decrease transfusion risks and requirements in patients undergoing hip replacement surgery. Anti-fibrinolytic compounds such as tranexamic acid (TXA) administered systemically during the perioperative period have demonstrated promising results. This study aimed to retrospectively review the effectiveness of tranexamic acid alone and in conjunction with the use of a bipolar sealer in reducing allogeneic blood transfusions in direct anterior total hip arthroplasty.

METHODS: This retrospective study reviewed 173 patients who underwent a unilateral direct anterior total hip arthroplasty performed by two fellowship trained, board certified orthopedic surgeons during a one year period. The patients enrolled in this study and were divided into 3 groups: TXA + bipolar sealer (49 patients), TXA alone (63 patients), and control group utilizing neither TXA nor bipolar sealer (61 patients). Primary end points included change in hemoglobin, post-operative drain output, and rate of transfusion. Secondary end points were length of stay. Paired univariate analysis was performed.

RESULTS: Statistical analysis of the data demonstrated the use of TXA alone or in combination with a bipolar sealer resulted in decreased transfusion rates, post-operative drain output, and calculated blood loss. However, the addition of a bipolar sealer in combination with TXA did not demonstrate any significant difference on all parameters measured compared to TXA alone. The two treatment groups receiving TXA also benefited from a significantly decreased hospital length of stay compared to controls.

CONCLUSION: Our study verifies that the use of systemic tranexamic acid reduces perioperative blood loss and transfusion requirements in direct anterior total hip arthroplasty. However, the additional use of a bipolar sealer did not demonstrate any added benefit. Based on these findings, we recommend the use of systemic tranexamic acid for blood conservation during direct anterior total hip arthroplasty.

O16B6 Management of Blood Transfusion in Simultaneous Bilateral Total Hip Arthroplasty Using the Direct Anterior Approach

Primary Author: Xiangfeng Li

Institution: Funabashi Orthopaedic Hospital

Coauthors: Kazuhiro Oinuma (Funabashi Orthopaedic Hospital), Tatsuya Tamaki (Funabashi Orthopaedic Hospital), Youko Miura (Funabashi Orthopaedic Hospital), Hiroyuki Yoshii (Funabashi Orthopaedic Hospital), Hidetaka Higashi (Funabashi Orthopaedic Hospital)

INTRODUCTION: Simultaneous bilateral total hip arthroplasty (THA) is actively performed for suitable cases in our hospital because it is associated with a shorter hospitalization, faster rehabilitation and lower total cost. Bilateral THA patients require more autologous and allogeneic blood transfusion than unilateral THA patients. However, because of the improvement in surgical techniques, we have frequently experienced cases that do not require autologous blood transfusion and only need intraoperative blood salvage.

OBJECTIVE: The purpose of this study was to investigate the current situation of perioperative blood transfusion in bilateral THA cases in our hospital and consider the appropriate management of the same. **Subjects and Methods:** From July 2010 to January 2014, 318 patients (35 males, 283 females, 636 hips) underwent simultaneous bilateral THA using the direct anterior approach (DAA) in our hospital. As preoperative diagnoses, 588 hips had osteoarthritis (OA), 26 hips had idiopathic osteonecrosis of the femoral head, 16 hips had rheumatoid arthritis, 4 hips had ankylosis, and 2 hips had rapidly destructive coxarthrosis. The mean age of the patients was 58.7 (27–80) years, and mean body mass index (BMI) was 23.9 (16.2–54) kg/m². Intraoperative blood salvage was required for all patients. Operative time, intraoperative blood loss, rates of autologous blood donation and allogeneic blood transfusion, fluctuations in perioperative hemoglobin (Hb), and complications were considered.

RESULTS: Mean operative time was 91 min and mean intraoperative blood loss was 441 (50–1880) ml. Of the 318 patients, autologous blood transfusion (200–400 ml) was needed in 256 (80.5%) patients along with intraoperative blood salvage. The remaining 62 (19.5%) patients only

needed intraoperative blood salvage. No patient required allogeneic blood transfusion. Mean preoperative Hb was 12.5 (9.6–16.8) g/dl, and mean postoperative Hb at 1 and 5 days after the surgery was 10.3 (7.0–13.6) g/dl and 9.4 (6.5–12.3) g/dl, respectively. Among patients with BMI 30, the rate of autologous blood transfusion was 100% and 56%, respectively. Mean intraoperative blood loss was 205 ml in 475 hips with primary OA or Crowe classification type I acetabular dysplasia, 274 ml in 109 hips with Crowe classification type II–IV acetabular dysplasia, and 291 ml in 25 hips with a history of osteotomy.

DISCUSSION: In the current situation of bilateral THA in our hospital, allogeneic blood transfusion was avoided by either intraoperative blood salvage alone in 19.5% patients or a combination of intraoperative blood salvage with autologous blood transfusion in 80.5% patients. Our results suggest that autologous blood transfusion can also be avoided by intraoperative blood salvage alone in patients with high BMI and mild acetabular dysplasia without a history of osteotomy.

O16B7 A Posterior Surgical Hip Dislocation Through a Modified Posterolateral Approach: Assessment of Femoral Head Perfusion Using Gadolinium Enhanced MRI

Primary Author: Peter Keyes Sculco

Institution: Hospital for Special Surgery

Coauthors: Lazaro E. Lionel (HSS), Craig E. Klinger (HSS), David Helfet (HSS), Edwin Su (HSS), Dean Lorch (HSS), Jackie Birnbaum (HSS), Jonathan Dyke (HSS)

BACKGROUND: The posterolateral approach is the most commonly performed surgical approach to the hip joint but does not preserve femoral head blood supply. The objective of this study is to determine whether proposed alterations to the posterolateral approach can reliably protect the deep branch of the medial femoral circumflex artery and preserve intra-osseous femoral head perfusion.

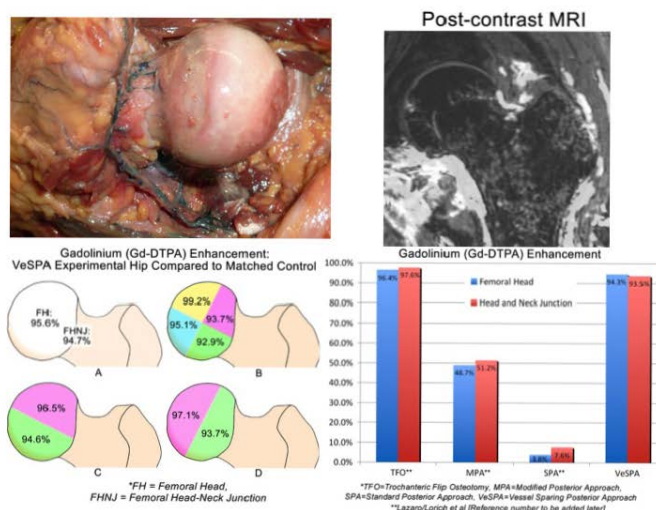
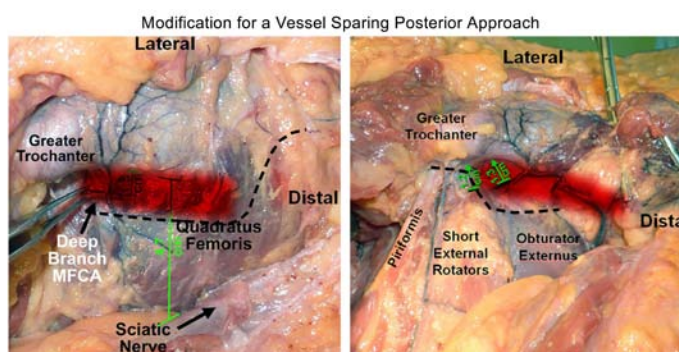
METHODS: In 8 fresh-frozen human cadaveric pelvis specimens, a surgical hip dislocation was performed through the posterolateral approach with standardized modifications designed to preserve femoral head blood supply. Modification includes quadratus femoris, conjoin

tendon and obturator externus tenotomy 2.5 cm posterior to greater trochanteric insertion and t-shaped capsulotomy originating below cut edge of obturator externus tendon. After surgical dislocation, the Medial Femoral Circumflex Artery was cannulated, injected with Gadolinium contrast, and Magnetic Resonance Imaging was performed to assess femoral head perfusion. The contralateral hip was injected and utilized as a non-operative control. Polyurethane compound was then injected into the cannulated MFCA and gross dissection performed in order to validate MRI findings and assess vessel integrity after the surgical approach.

RESULTS: Compared to the non-operative control, the operative hip underwent the proposed vessel sparing posterior surgical hip dislocation retained an average of $95.6\% \pm 9.7\%$ SD perfusion to the femoral head and $94.9\% \pm 5.4\%$ SD perfusion to the femoral head-neck junction compared to the non-operative control. In all eight specimens gross dissection after injection of polyurethane compound confirmed latex filled intact superior and inferior retinacular arteries entering the femoral head.

CONCLUSION: The results in this study suggest that the described surgical modifications to the posterolateral approach maintain superior and inferior retinacular arterial supply to the femoral head after surgical hip dislocation.

CLINICAL RELEVANCE: This surgical approach may have clinical application in hip resurfacing arthroplasty and potentially decrease the risk of post-operative osteonecrosis and femoral neck fracture. While it may also have a role in hip preservation and offer an alternative to the trochanteric femoral osteotomy, additional in vivo studies are required to further validate its efficacy before it can be recommended for widespread clinical use. Further potential applications include cartilage restoration and the treatment of avascular necrosis that may benefit from a vessel sparing posterolateral surgical hip dislocation.



When Things Go Wrong?

O17A1 Extensor Mechanism Reconstruction Following TKA

Guest Faculty: Arlen D. Hanssen, MD

Institution: Mayo Clinic, Rochester, MN, USA

Extensor mechanism disruption associated with TKR is an uncommon but potentially disastrous complication. Simple suture fixation has been reported to be insufficient while autograft and allograft tendon reconstruction techniques have had variable results especially with long-term followup. A simple, straightforward technique using synthetic mesh has been utilized since 1995, for both quadriceps and patellar tendon disruptions associated with TKR appears reliable and is very cost effective.

The surgical technique includes the use of a knitted monofilament high-density polypropylene graft to reconstruct the extensor mechanism and facilitate fixation of adjacent host tissue into the graft. The graft is placed within an intramedullary position in the tibia located behind the tibial tubercle and in front of the tibial prosthesis. Graft fixation

is accomplished with the use of bone cement and a transfixion cancellous bone screw into the tibial plateau. One of the most important aspects of this reconstruction is to adequately immobilize the two halves of the extensor mechanism on the ventral and dorsal surfaces so that the extensor mechanism can be drawn distally and allow the vastus medialis (VM) to also overlap the underlying mesh and vastus lateralis (VL).

Once the quadriceps is mobilized, the mesh graft is passed from inside-out through a portal in the lateral retinacular tissues. The graft is then secured to the ventral surface of the VL lateralis with a Krackow #5 nonabsorbable suture which creates the base for attachment of the VM in a distally and laterally tensioned position. The final construct is then a “pants-over-vest” advancement so that the mesh is sandwiched between the VM and VL.

Postoperative rehabilitation starts with the use of a long leg cast for 10-12 weeks followed by progressive ROM with a brace over the next 3 months. This session will demonstrate the steps of the surgical technique with tips and pitfalls associated using this reconstructive method.

Browne JA, Hanssen AD. Reconstruction of patellar tendon disruption after total knee arthroplasty: results of a new technique utilizing synthetic mesh. *J Bone Joint Surg Am.* 2011 Jun 15;93(12):1137-43.

O17A3 **Knee Arthrodesis is Best Option Following Failed 2 Stage Reimplantation TKA**

Primary Author: Gwo-Chin Lee

Institution: University of Pennsylvania

Coauthors: Chancellor Gray (University of Pennsylvania), Chia Wu (University of Pennsylvania)

BACKGROUND: A two-stage reimplantation procedure is a well-accepted procedure for management of first-time infected total knee arthroplasty (TKA). However, there is a lack of consensus on the treatment of subsequent reinfections.

QUESTIONS/PURPOSES: The purpose of this study was to perform a decision analysis to determine the treatment method likely to yield the highest quality of life for a

patient after a failed two-stage reimplantation.

METHODS: We performed a systematic review to estimate the expected success rates of a two-stage reimplantation procedure, chronic suppression, arthrodesis, and amputation for treatment of infected TKA. To determine utility values of the various possible health states that could arise after two-stage revision, we used previously published values and methods to determine the utility and disutility tolls for each treatment option and performed a decision tree analysis using the TreeAgePro 2012 software suite (Williamstown, MA, USA). These values were subsequently varied to perform sensitivity analyses, determining thresholds at which different treatment options prevailed.

RESULTS: Overall, the composite success rate for two-stage reimplantation was 79.1% (range, 33.3%-100%). The utility (successful outcome) and disutility toll (cost for treatment) for two-stage reimplantation were determined to be 0.473 and 0.20, respectively; the toll for undergoing chronic suppression was set at 0.05; the utility for arthrodesis was 0.740 and for amputation 0.423. We set the utilities for subsequent two-stage revision and other surgical procedures by subtracting the disutility toll from the utility each time another procedure was performed. The two-way sensitivity analysis varied the utility status after an additional two-stage reimplantation (0.47–0.99) and chance of a successful two-stage reimplantation (45%–95%). The model was then extended to a three-way sensitivity analysis twice: once by setting the variable arthrodesis utility at a value of 0.47 and once more by setting utility of two-stage reimplantation at 0.05 over the same range of values on both axes. Knee arthrodesis emerged as the treatment most likely to yield the highest expected utility (quality of life) after initially failing a two-stage revision. For a repeat two-stage revision to be favored, the utility of that second two-stage revision had to substantially exceed the published utility of primary TKA of 0.84 and the probability of achieving infection control had to exceed 90%.

CONCLUSIONS: Based on best available evidence, knee arthrodesis should be strongly considered as the treatment of choice for patients who have persistent infected TKA after a failed two-stage reimplantation procedure. We recognize that particular circumstances such as severe bone loss can preclude or limit the applicability of fusion as an option and that individual clinical circumstances must always dictate the best treatment, but where arthrodesis is practical, our model supports it as the best approach.

O17A5

The Treatment of 50 Deep Infections With or Without Resistant Organisms

Primary Author: Tomoyuki Matsumoto

Institution: Kobe University Graduate School of Medicine

Coauthors: Kazunari Ishida (Kobe Kaisei hospital), Nobuhiro Tsumura (Hyogo Rehabilitation Center Hospital), Hirotugu Muratsu (Steel Memorial Hirohata Hospital), Kanto Nagai (Kobe University Graduate School of Medicine), Yuichi Hida (Takatsuki General Hospital)

INTRODUCTION: There has been an increase in the prevalence of infections caused by methicillin-resistant organisms, causing difficulty in the treatment of prosthetic joint infection. A multicenter study was performed to review 50 patients with deep infection with or without a resistant organism such as methicillin-resistant *Staphylococcus aureus* at the total knee arthroplasty site.

METHODS: Seventy-one consecutive patients (71 knees) who had an infection after TKA between 2000 and 2010 were retrospectively reviewed. Based on a relatively good clinical course, superficial infections were excluded from the study. The remaining 50 patients with deep infections, including 38 men and 12 women with a mean age of 71.1 ± 7.7 years, were included in the study. Thirteen patients with early deep infections and 4 with acute hematogenous infections were treated with debridement, antibiotic therapy, and retention of the prosthesis with revision of the polyethylene insert. Thirty-three patients with late chronic infections were treated with challenging prosthesis retention for unloosened prosthesis or 2-stage exchange arthroplasty for a loosened prosthesis. The mean follow-up duration was 4.7 years (range, 2.0–12.6 years). The success of treatment was assessed in each type of infection depending on the following 3 classifications: (1) whether the prosthesis was retained or removed at the first treatment, (2) whether the treatment resulted in a functional prosthetic knee or antibiotic-impregnated cement spacer/arthrodesis/amputation as the final treatment, and (3) the number of operations needed until the infection was eradicated. The success also was assessed and compared between the 2 subcategories, MRSA/MRSE or non-MRSA/MRSE, in each type of infection.

RESULTS: The initial course of treatment was successful in 6 of 13 knees (46%) with early deep infection, 1

of 4 knees (25%) with acute hematogenous infection, and 21 of 33 knees (64%) with late chronic infection. At the last evaluation, all 13 knees (100%) with early deep infection, 3 of 4 knees (75%) with acute hematogenous infection, and 25 of 33 knees (76%) with late chronic infection maintained functioning total knee prostheses. Infection control after the first treatment improved further by repeated debridement and repeated 2-stage exchange arthroplasty, with a mean of 2.5 operations in early deep infections, 3.3 operations in acute hematogenous infections, and 3.2 operations in late chronic infections. No significant differences in resultant functional knees and mean number of operations were observed between 7 patients with resistant and 6 patients with nonresistant early deep infections. However, 24 patients with nonresistant chronic infections showed significantly improvements in resultant functional knees (24/24 [100%]) and fewer mean number of operations (2.8 times) compared to 9 patients with resistant chronic infections (1/9 [11%] and 4.3 times, respectively). The remaining 8 patients with resistant chronic infections (89%) resulted in arthrodesis (3 patients), underwent above-the knee amputation (1 patient), or underwent spacer arthroplasties (4 patients).

CONCLUSIONS: Although patients with resistant early deep infections showed good results similar to those with nonresistant early infections, those with resistant late chronic infections exhibited a significantly inferior success rate, compared with nonresistant chronic infections.

O17A6

Surgical Site Infection Rates in Total Knee Arthroplasty Comparing Traditional vs. Single Use Instrumentation

Primary Author: Lawrence Morawa

Institution: Wayne State University Department of Orthopaedics

Coauthors: Geoffrey Siegel (M.D. Wayne State University Department of Orthopaedics, Dearborn MI), Neil Patel (M.D. Wayne State University Department of Orthopaedics, Dearborn MI), Kelli Crawford (PA-C, Wayne State University Department of Orthopaedics, Dearborn MI)

SUMMARY: Single-use instrumentation may provide a benefit to the patient by potentially decreasing the risk of infection and reducing the overall hospital costs.

INTRODUCTION: Surgical Site Infections (SSI) are a significant and common complication in Total Knee Arthroplasty (TKA). Historical controls state that infections cost a hospital a mean of \$25,546±\$39,875 (Range: \$1783-\$134,602). The purpose of this study was to evaluate if traditional vs. single-use instrumentation had an effect on SSIs.

METHODS: A retrospective study was performed comparing 90-day peri-operative SSI rates of TKA's performed by a single surgeon at a large community hospital comparing single-use and traditional TKA instrumentation trays. The surgeon performed TKA using a similar navigated procedure, staff, and operating room setting for both groups. The groups received similar post-operative care management. A cost-analysis breakdown was performed for each type of instrumentation.

RESULTS: Between Jan 2005 and Dec 2012, the primary surgeon performed 169 traditional and 449 single-use instrumentation TKA's. The groups were similar in demographics (age, gender, height, weight). Total OR Time was, on average, 30 minutes less when single-use instrumentation was used. SSIs for the traditional group (n=5) compared to single-use group (n= 1) (p<0.01). Single-use instrumentation added \$490, however it saved between \$480-600 per case depending on the number of extra instrument trays that needed to be opened.

CONCLUSION: SSIs continue to affect patients and hospitals. Patients in the single-use group had 0.22% infections compared to the traditional instrumentation (2.96%). Single-use instrumentation may provide a benefit to the patient by potentially decreasing the risk of infection and reducing the overall hospital costs. A larger prospective-randomized trial is warranted.

Reference:

1. Stone PW et al. Systematic review of economic analyses of health care-associated infections. *Am J Infect. Cont.* 2005; Nov;33(9):501-9.

O17A7

Total Knee Arthroplasty after Lower Extremity Amputation

Primary Author: Derek F. Amanatullah

Institution: Mayo Clinic

Coauthors: Derek F. Amanatullah, Robert T. Trousdale, Rafael J. Sierra

BACKGROUND: Below knee amputation protects the ipsilateral knee from osteoarthritis and overloads the contralateral knee predisposing it to symptomatic osteoarthritis. We report the clinical and patient reported outcomes of total knee arthroplasty (TKA) in the amputee population.

METHODS: We retrospectively reviewed the records of 13 patients treated with a TKA after lower extremity amputation with a minimum of two years of clinical or radiographic follow-up. The average clinical follow-up was 6.8 ± 4.8 years. Twelve of the 13 TKAs were performed on the contralateral side of the amputated limb while only one was performed on the ipsilateral side of the amputated limb. This represents 0.044% of all TKAs, while TKA after ipsilateral lower extremity amputation represents 0.004% of all TKAs. Complications were recorded from the clinical and operative record. Pre-operative and postoperative Knee Society Scores (KSS) were calculated from clinical examinations and patient surveys. The pre-operative, post-operative, and the latest radiographs of all knees were reviewed for loosening and implant failure.

RESULTS: There were no reported post-operative complications in our series with TKA after ipsilateral or contralateral lower extremity amputation. KSS improved from was 30.4 ± 11.8 pre-operatively to 88.5 ± 4.2 post-operatively for TKA after contralateral lower extremity amputation. The KSS improved from 37 to 90 for the patient with a TKA after ipsilateral below knee amputation. Three (23.1%) patients with TKA after contralateral lower extremity amputation had aseptic loosening of their components at final follow-up. One of the patients with aseptic loosening required revision TKA (7.7%).

CONCLUSIONS: TKA after lower extremity amputation is rare, especially on the ipsilateral extremity. TKA after lower extremity amputation provides excellent functional and clinical outcomes whether on the ipsilateral or contralateral extremity. Early aseptic loosening is the most common mechanism of implant failure in the amputee population, and this risk is more than 2.5 times greater than the reported risk of early aseptic loosening in the non-amputee population. Augmentation of tibial fixation with a cemented stem may be advisable during primary TKA in the amputee population. Level of Evidence: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.

Shoulder Arthroplasty

O17B1

Extending the Indications for Reverse TSA

Guest Faculty: Edwin E. Spencer Jr., MD

Institution: Knoxville Orthopaedic Clinic, Knoxville, TN, USA

The reverse TSA was first introduced in the US in 2004 and has enjoyed a remarkable increase in its use. The initial indications were adopted from the Europeans who had much more experience. These essentially included cuff tear arthropathy and failed rotator cuff repairs in elderly patients. As the US experience grew, so did the indications. These extended indications will be discussed in this talk and include proximal humeral nonunions and malunions, fracture, bone loss on the humeral and glenoid sides, failed RCR's, and revisions where the deficits can include osseous and soft tissue lesions. The reverse TSA allows the surgeon to compensate for many deficiencies including bone loss, cuff insufficiency and even instability.

As the indications have expanded, the complications have however increased. Some complications are design specific and some are unique to the procedure itself. Designers have sought to understand these complications and more recent iterations allow the surgeon to circumnavigate some of these. We will discuss how to maximize function and mitigate complications especially in extended situations.

O17B2

Patient Specific Instrumentation for Shoulder Arthroplasty

Guest Faculty: John W. Sperling, MD, MBA

Institution: Mayo Clinic, Rochester, MN, USA

A primary goal of shoulder arthroplasty is to place the components in anatomic version. However, traditional instrumentation does not accommodate glenoid wear patterns. Therefore, many investigators have attempted to use computer modeling or CT based algorithms to create custom targeting guides to achieve this goal.

There are some recent studies investigating the use of cus-

tom guides. Iannotti et al. published in JBJS-American in 2012 on the use of patient specific instrumentation. There were 31 patients included in the study. The authors found that the planning software and patient specific instrumentation were helpful overall, but particularly of benefit in patients with retroversion in excess of 16 degrees. In this group of patients, the mean deviation was 10 degrees in the standard surgical group and 1.2 degrees in the patient specific instrumentation group.

Potts et al. presented at the International Congress of Elbow and Shoulder Surgery in 2013 on 18 cadaveric shoulders that had placement of components with patient specific instrumentation that were evaluated with post-operative CT scans. The custom guides were more accurate in version and inclination than traditional instrumentation. Throckmorton presented a study at the AAOS in 2014 on 70 cadaveric shoulders. There was one high volume surgeon (>100 shoulder arthroplasties a year), two middle volume surgeons (20-50 shoulder arthroplasties a year), and two low volume surgeons (less than 20 shoulder arthroplasties per year). Overall, the custom guide was significantly more accurate than standard instrumentation. The custom guides were found to be especially more accurate among specimens with associated glenoid wear. There were no strong trends to indicate consistent differences between high, medium, and low volume surgeons. The authors concluded that custom guides have narrower standard deviation and fewer significant errors than standard instrumentation.

Custom guides continue to evolve for use in shoulder arthroplasty including some guides that allow the surgeon to decide intra-operatively between anatomic shoulder arthroplasty and reverse arthroplasty. Additional studies will be necessary to further define the role of patient specific instrumentation in practice.

O17B3

A Comparison of Reverse Shoulder Arthroplasty Functional Outcomes With Two Different Glenosphere Sizes

Primary Author: Vani J. Sabesan

Institution: Orthopedic Surgery Western Michigan University School of Medicine

Coauthors: Mark Callanan (Harvard Combined Ortho-

paedic Residency Program), Vinay K. Sharma (Department of Orthopaedic Surgery, Western Michigan University School of Medicine), J. Michael Wiater (Department of Orthopaedic Surgery, Beaumont Health System)

INTRODUCTION: Studies have shown that RSAs successfully improve pain and functionality, however variability in range of motion and high complication rates persist. As a result, consistent effort has been dedicated to optimizing the performance of RSAs by improving the biomechanics and design. Biomechanical and computer simulations studies have shown that increasing the glenosphere size and the diameter of the glenosphere improves shoulder range of motion. The purpose of this study was to evaluate the in vivo effect of glenosphere design on clinical outcomes for patients treated with a RSA.

METHODS: A matched cohort of 32 patients (>2 years follow up) with 16 patients treated with a 36-size glenosphere and 16 patients treated with a 42-size glenosphere were included in this study. Radiographic and clinical outcomes were compared between groups.

RESULTS: There was a trend toward significant increased forward elevation for patients treated with a 42-size glenosphere ($p=0.07$), however no significant difference in external rotation or strength was demonstrated between groups ($p=0.24$, $p=0.51$). The complication rates including scapular notching were similar for both size glenospheres.

DISCUSSION: Although theoretical advantages have been demonstrated for increased glenosphere size in previous studies, there was no significant difference in the prevention of notching, complications or external rotation with an increased glenosphere size in this study. There may be a significant improvement in forward elevation which can be attributed to increased center of rotation offset but further research is needed to validate true clinical improvements without increased complications for a larger glenosphere.

O17B4

Reverse Shoulder Arthroplasty with Patient Specific Glenoid Implant Positioning Guides: Our Initial Experience

*Primary Author: Srivatsa Subramanya
Institution: Sydney Ortho Clinic*

Coauthor: Jonathan A. Herald (Sydney Ortho Clinic)

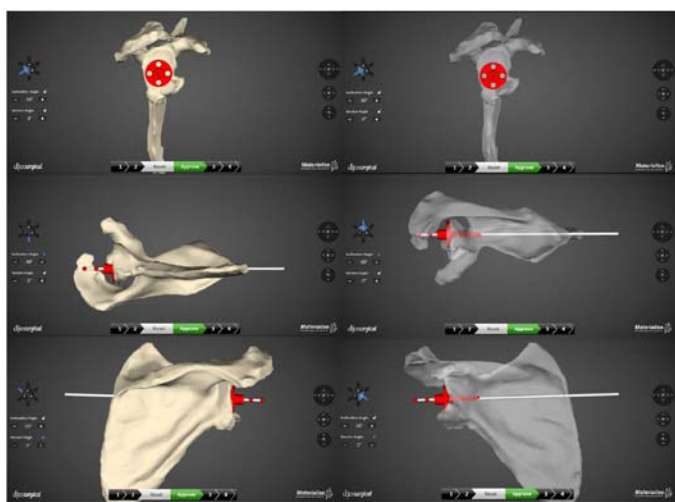
INTRODUCTION: Reverse shoulder arthroplasty has emerged as the treatment of choice for rotator cuff tear arthropathy, over the last decade. The long term success and survival of the implant depends largely on proper positioning and stable fixation of the glenoid component. There are many studies suggesting the ideal position of the base plate and screws with respect to the glenoid. However, achieving this ideal position remains a challenge to the operating surgeon. Various methods have been suggested to improve the initial fixation of the glenosphere intra-operatively. However, none of them have been reproducible on a consistent basis. Following with the success of navigation in hip and knee arthroplasty, computer navigation has been recently introduced for shoulder arthroplasties. Even though initial results have been promising, computer navigation can sometimes prove time consuming and frustrating, and has complications like unintentional or unrecognized movement or loosening of a tracking device, inaccurate or irreproducible registration of anatomic landmarks, or display of illogical numerical data. Results from knee arthroplasties suggest that these difficulties can be overcome by using patient specific instruments.

PATIENTS AND METHODS: Reverse shoulder arthroplasty was performed in seven patients using the patient specific glenoid implant positioning system. This system allows pre operative determination of the glenoid implant position on a virtual 3D model of the scapula reconstructed from pre operative CT images. The desired position of the glenoid base plate can be planned on the software by means of a virtual pin guide, which ultimately determines the position of the implant. The location of the implant and the base plate post can be virtually visualized on the glenoid and the location (of the pilot hole) and position (Version in the axial plane and inclination in the coronal plane) can be adjusted as per the surgeon's desire (figure 1). Using this data, glenoid positioning drill guides are ergonomically designed, thus customized to the patient's anatomy. CT scan was performed in all patients at the end of 2 weeks after surgery. Version and inclination of the glenoid component was measured and the images were compared to that of the pre operative virtual model.

RESULTS: The mean native version of the glenoid was 5.20 of retroversion (range -0.650 to -14.380, SD - 5.3) and mean native tilt was 12.250 of superior tilt (range 8.07 to 18.240, SD: 4.04). The mean version of the glenoid com-

ponent as chosen in the pre operative planning was 1.270 (range: -10 to 30. The mean inclination chosen was 9.190 (range: -80 to 100 of inferior tilt). Post operatively, we achieved a mean version of -0.360 (range: -3.10 to 2.30, SD: 2.01) and mean inclination of -9.190 (range -7.10 to -110, SD: 1.29). The base plate had good contact with the reamed glenoid face both in axial and coronal views in all cases.

CONCLUSION: Patient specific glenoid implant positioning guides appear to be effective in achieving accurate placement of the glenoid component in reverse shoulder arthroplasty. It may help to overcome the problems native to computer navigation.



O17B5 A Novel Method for Wear Testing of Reverse Shoulder Arthroplasty Systems

Primary Author: Hani Haider

Institution: Dept. of Orthopaedic Surgery and Rehabilitation, University of Nebraska Medical Center

Coauthors: John Sperling (Mayo Clinic Department of Orthopaedic Surgery, Rochester, MN), Thomas Throckmorton (University of Tennessee-Campbell Clinic Department of Orthopaedic Surgery)

As reverse total shoulder arthroplasty systems expand with longer durations in vivo, so does the concern and potential complications of wear, debris and osteolysis. Despite other attempts, no wear testing method has emerged to compare implants across systems and labs. The main reasons may have been the diverse sources of forces and motions

used in testing, widely different wear amounts which resulted, and the general lack of dedicated shoulder simulators. In this study we propose a shoulder wear test method using a novel adaptation of a hip simulator. By harnessing force-motion data from telemetrized shoulder implants from the Bergman's laboratory in Berlin, we synthesized those results to devise a wholistic multi-axis simulation regime for reverse shoulders. The alignment and motions of the humeral bearing surface and the glenosphere were kept anatomically correct (relative to each other) and yielded a physiologically realistic wear-inducing articulation. However, we opted to orient the implant system with novel fixtures on an AMTI (hip) simulator such that the machine's main compressive force was aligned with the shoulder constructs in a way that mimicked the average resultant shoulder force from the in vivo telemetry data in both magnitude and nominal direction. Aligned thus, a patient with a shoulder installed would neither stand, nor lie down, but be oriented in a composite angle relative the simulator original axes. Each anatomic shoulder motion was achieved by unique computed combinations of the three simulator motion actuators simultaneously, none of which were aligned anatomically for the shoulder on its own. The maximum ranges of cyclic shoulder motion achieved with the constraints of the simulator were 38°-79° of forward elevation repeated in two separate (15° and 45°) elevation planes. The change of elevation plane inherently involved abduction-adduction motion, and simultaneously also involved variation of internal-external rotation within a 57° range. Each elevation rise (twice per cycle) was also accompanied by a sinusoidally rising and falling compressive load in the range 50N-1700N. The testing method was carried through 2.5 million of the above (double-elevation) cycles and gravimetrically measuring wear of twelve 36mm size RTSA systems. We compared six systems having vitamin E-infused highly cross-linked polyethylene bearings (100 kGy radiation) to six controls with a conventional highly cross-linked polyethylene of half the radiation dose. Significant wear resulted for the control bearing material (average 17.9±0.851 mg/MC) which was no less than most hip and knee simulations. Multiply (and statistically significantly, p We present here a novel method for polyethylene wear testing in RTSA. Significant differences in wear rates resulted under physiologically realistic cyclic motion and forces with strong discrimination between two systems whose bearing materials were known to be different in resilience to wear. Using custom fixtures to utilize a standard commercially available joint simulator suggests efficacy of the test method and utility across different labs.

Acknowledgement: The authors would like to thank Biomet for their financial support in the design as well as for the experimental testing of this method.

O17B6 **Effect of Lateralized Offset on Shoulder Rotation After Bony Increased Offset Reverse Shoulder Arthroplasty**

Primary Author: Kyu-Hak Jung

Institution: Gil Hospital, Gachon University, Incheon, Korea

Coauthors: Young-Kyu Kim (Gil Hospital, Gachon University, Incheon, Korea), Won-Su Son (S Jungang Hospital, Jeju, Korea), Eui-Chul Lee (Gil Hospital, Gachon University, Incheon, Korea), Seung-Kyun Cho (Gil Hospital, Gachon University, Incheon, Korea)

PURPOSE: Bony increased offset reverse shoulder arthroplasty(BIO-RSA) produce more improved shoulder external rotation than conventional reverse shoulder arthroplasty(CRSA). The reasons of improved shoulder rotation may cause by tensioning of remained rotators and increasing free range of motion without posterior impingement. We evaluated the correlation between remained rotators and shoulder rotation, and the effect of lateralized offset on shoulder rotation in BIO-RSA.

MATERIALS AND METHODS: The records of 47 patients with diagnosis of CTA or irreparable massive cuff tear who had received either CRSA or BIO-RSA from September 2007 to December 2012 were reviewed. 21 CRSAs and 26 BIO-RSAs were performed. The mean follow-up was 30.2 months(range, 14-65). The mean age was 70.6 years(range, 60-81). Graded by remained tendon of IS, TM (grade 1; less than half of IS, grade 2; entire TM, grade 3; more than half of TM, grade 4; less than half of TM). According to grade of remained external rotators, grade 1~4 were 8(17.0%), 15(31.9%), 17(36.2%), 7(14.9%), respectively. Remained rotators grade was no significant difference between both RSAs. We compared pre-, postoperative, and increments of shoulder rotation between both RSAs. And, we evaluated the correlation between grade of remained rotators and increments of shoulder rotation in each RSA.

RESULTS: Correlation between grade of remained rota-

tors and pre-, postoperative external rotation was statistic significant($P<0.05$). The improvement of external rotation range was 3.3° (-25° to $+25^{\circ}$) in CRSAs versus 14.2° (-30° to $+60^{\circ}$) in BIO-RSAs, which was significant difference ($P<0.05$). In CRSA, increments of external rotation was 5° in grade 1, 1.3° in grade 2, 6.9° in grade 3, -1.6° in grade 4. There was no significant correlation between increments of external rotation and grade of remained rotators($P>0.05$). In BIO-RSA, there was 20.8° in grade 1, 16.3° in grade 2, 10.8° in grade 3, 4.5° in grade 4 with significant correlation between increments of external rotation and grade of remained rotators ($P<0.05$).

CONCLUSION: Grade of remained rotators was correlated with pre-, postoperative shoulder external rotation. In BIO-RSA, increments of external rotation were correlated with remained rotator grade. Remained rotators may affect the shoulder rotation by tensioned rotator after bony-increased lateral offset of BIO-RSA. But, further evaluation of the other effects on shoulder rotation still needs. TKA Design & Instrumentation

TKA Design and Instrumentation

O18A1 **Patient-Specific Instrumentation In Simultaneous Bilateral Total Knee Arthroplasty-Is There An Advantage?**

Guest Faculty: Fred D. Cushner, MD

Institution: ISK Institute, New York, NY; NS - LIJ Orthopedic Institute, New York, NY, USA

Coauthors: Ajit J. Deshmukh (NYU Hospital For Joint Diseases), Orry Erez (Maimonides Medical Center), Parthiv A. Rathod (NYU Hospital For Joint Diseases), Laura M. Young (NSLIJ Southside Hospital), Bridgit Vomero (NSLIJ/ Lenox Hill Hospital)

BACKGROUND: Technological advancements in TKA, such as patient-specific instrumentation (PSI), may have the potential to influence operating room efficiency and

early surgical recovery. No study has specifically assessed outcomes of PSI in simultaneous bilateral TKA.

QUESTIONS/PURPOSES: We compared simultaneous bilateral TKA performed with and without the use of PSI in terms of (1) surgical time; (2) blood loss and transfusion requirements; (3) inpatient length-of-stay (LOS) and lastly; (4) early thromboembolic events and complication rates.

METHODS: In this retrospective cohort study of 52 patients with 104 simultaneous bilateral primary TKAs (20 patients with non-PSI TKAs and 32 patients with PSI TKAs), we assessed surgical time by calculating the total tourniquet time and total operating room (OR) time. Blood loss was measured by measuring the maximum hemoglobin reduction and postoperative day (POD)-3 hemoglobin concentration. Blood transfusions were noted. Inpatient LOS was assessed in days with the day after surgery counted as the first day and the day of discharge counted as the last day. All thromboembolic episodes, reoperations and complications were noted up to 3 months postoperatively. Statistical analysis was performed using independent t-tests and chi-square test (with Fisher's exact test).

RESULTS: The total tourniquet time was 8.7 minutes lower and total OR time was 19.5 minutes shorter with the PSI technique, however these were not statistically significant. Blood loss, as measured by hemoglobin concentration on POD-3, maximum hemoglobin reduction and blood transfusion requirement, was similar between groups. Similarly, inpatient LOS, thromboembolic event rate and early complication rate remained comparable between groups.

CONCLUSIONS: Although there was a trend towards lower surgical time and blood loss with the use of PSI, these did not reach statistical significance and both groups were comparable in terms of all other perioperative outcome measures we studied. Further research is called for, if others agree that these differences are worth pursuing.

O18A2

Component Rotation in Kinematic Alignment: It's Just Plane Simple

Guest Faculty: Stephen M. Howell, MD

Institution: University of California, Davis, Sacramento, CA

Incorrect internal-external rotation of the femoral and tibial components contributes to dissatisfaction in knee function after total knee arthroplasty (TKA). [12] In mechanically aligned TKA, setting femoral component rotation to reference lines parallel to the anteroposterior axis of the trochlear groove, parallel to the transepi-condylar axis, or 3° externally rotated to the posterior condylar line of the femur causes a ≥ 2 mm instability in a compartment between 0° and 90° of flexion that is uncorrectable by a collateral ligament release in 42 to 80 percent of knees. [4]

Kinematically aligned TKA has gained interest because function, coronal limb and knee alignment, contact kinematics, and implant survivorship at 3 years are better than that mechanically aligned TKA. [2,6-8] The goal of kinematically aligned TKA is to set the anteroposterior axis of the femoral component and tibial component parallel to the sagittal kinematic plane. [4,6] Because the sagittal kinematic plane is perpendicular to the two parallel transverse axes in the femur that determine the flexion and extension path of the tibia and patella, setting the components parallel to this plane avoids instability in a compartment between 0° and 90°, minimizes the need for ligament release, and maintains stability in the tibiofemoral and patellofemoral joint. [1,3-6,9]

Kinematically aligned TKA sets the rotation of the femoral component by removing cartilage and bone from the posterior femoral condyles, after correcting for wear and kerf that equals the thickness of the posterior condyles of the femoral component. [10] The rotation of the tibial component is set by positioning the anteroposterior axis of the tibial trial parallel to the major axis of the nearly elliptical boundary of the articular surface of the lateral tibial condyle (Figure 2). [8,11]

A study of 71 consecutive patients showed the range of rotation from the sagittal kinematic was -3° internal to 2° external for the femoral component, and -11° internal to 12° external for the tibial component. The average Oxford knee score was 42, and WOMAC score was 89. Kinematically aligned TKA performed with generic instruments achieves a range or rotation of the femoral and tibial components from the sagittal kinematic plane that results in high function scores.

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O18A3

Long-Term Analysis of In Vivo Bearing Mobility in Rotating Platform TKA

Primary Author: Michael T. LaCour

Institution: University of Tennessee Knoxville

Coauthors: Richard D. Komistek (University of Tennessee Knoxville), Douglas A. Dennis (Porter Adventist Hospital, Denver, CO), Mathew R. Anderle (University of Tennessee Knoxville), Adrija Sharma (University of Tennessee Knoxville)

BACKGROUND: There is limited information available that analyzes bearing mobility in a Posterior Stabilized, Rotating Platform Total Knee Arthroplasty at a postoperative interval greater than three years.

QUESTIONS/PURPOSES: The objective of this study was to evaluate polyethylene bearing rotation and overall kinematic performance of a PS-RP TKA at a postoperative duration of up to ten years.

METHODS: In vivo three-dimensional (3D) kinematics were evaluated for nine subjects at 3 months, 15 months, 5 years, and 10 years following primary implantation with a PS-RP TKA. Each subject performed a deep knee bend activity, and 3D kinematics were reconstructed from multiple fluoroscopic images using a 3D-to-2D registration technique. Once complete, femoral component-tibial component, femoral component-polyethylene bearing, and polyethylene bearing-tibial component axial rotation patterns were analyzed, as well as the medial and lateral condyle contact positions, range-of-motion, and the presence of femoral condylar lift-off.

RESULTS: In general, the femur rotated externally with respect to the tibia from full extension to maximum knee flexion, and from full extension to maximum knee flexion, subjects consistently experienced posterior femoral translation of the lateral condyle and slight anterior movement of the medial condyle relative to the tibia. The polyethylene bearing experienced similar rotational patterns atop the tibial tray, and this bearing rotation was maintained at 10 years postoperatively. There was no statistical difference between postoperative periods for any aforementioned kinematic parameter except for femoral component-polyethylene bearing axial rotation, which was reduced at the 10 year interval evaluation versus other assessment periods ($p = 0.0006$). The lack of statistical difference between postoperative evaluation periods indicates sustained overall implant kinematic performance.

CONCLUSIONS: This study demonstrates that the mobility of the polyethylene bearing is maintained and that the overall kinematic performance of mobile bearing implants is not negatively affected ten years postoperatively. Reduced femoral component-polyethylene bearing rotation at 10 year follow-up duration suggests a reduced amount of slip within the system at longer postoperative time periods, implying that the majority of axial rotation occurs at the PE bearing-tibial tray articulation.

O18A4

Improved Spine Strength and Wear Performance with Grafted-Vitamin E Polyethylene

Primary Author: Kimberly D. Mimnaugh

Institution: Zimmer, Inc.

Coauthors: James Wernle (Zimmer, Inc.), Melinda Peiserich (Zimmer, Inc.), Alicia Rufner (Zimmer, Inc.)

INTRODUCTION: Conventional UHMWPE (CP) exhibits increased initial mechanical properties but has been associated with wear, oxidation, and osteolysis; whereas highly crosslinked UHMWPE (HXPE) exhibits a reduction in wear, but at the expense of mechanical properties. Oxidation of HXPE may occur through lipid absorption, prompting use of Vitamin E-grafted highly crosslinked polyethylene (VE-HXPE) to improve the oxidation resistance while maintaining mechanical properties. Fractures of the spine in posterior stabilized (PS) TKA components is a clinical concern. Component design, surgical placement and component material are contributing factors. The objectives of this study were to compare static mechanical properties, spine fatigue strength and wear performance of CP and VE-HXPE.

METHODS: VE-HXPE - Vitamin E blending resin was compression molded into blocks and electron-beam cross-linked >100kGy. CP - GUR1050 UHMWPE bar stock was subjected to gamma sterilization at 37 kGy. Tensile Yield Strength (TYS): ASTM D638 type V tensile specimens were punched from machined sheets of VE-HXPE and CP material. The tensile specimens were tested on an Instron machine per ASTM D638 at 0.5in/min until yield. Tensile specimens were aged according to ASTM F2003 in 5 atm of oxygen at 70°C for 2 week intervals up to 24 weeks. Spine Fatigue (SF): Equivalent, mid-size articular surfaces of two PS designs (Design A/VE-HXPE vs. Design B/CP) were compared in a combined axial/shear fatigue loading condition. Horizontal impact loads to the spine were applied through femoral components placed in 7 degree hyperextension with the median fatigue strength determined at 5 million combined anterior and posterior impact cycles (Mc).

WEAR/PARTICLES: Mid-size articular surfaces (Design A/VE-HXPE vs. Design B/CP) were articulated against corresponding femoral components for 5.0 Mc according to ISO14243-3 in bovine serum lubricant (protein content of 20g/l), which was changed every 0.5Mc. Polyethylene wear was measured gravimetrically using load soak controls. Particles were isolated from the salvaged serum lubricant on three stations per design/material using acid digestion and 0.05µm pore sized polycarbonate membranes for filtration. Particles were imaged and concentra-

tion/size distribution were determined per ASTM F1877 and ISO17853.

RESULTS: TYS: Average TYS of the VE-HXPE was 16% greater (p SF: The VE-HXPE in Design A showed a median fatigue strength of 408lbs compared to 372lbs for Design B, an increase of 10%.

WEAR: The VE-HXPE in Design A displayed an overall 96% reduction in wear rate compared to CP in Design B. Further, the CP/Design B produced twice as many particles within the sample size analyzed compared to the VE-HXPE/Design A.

CONCLUSIONS: The use of grafted VE-HXPE offers a 16% improvement in tensile strength after 24 weeks of aging, a 10% improvement in the strength of the PS spine, and 96% reduction in overall wear performance when compared to conventional polyethylene.

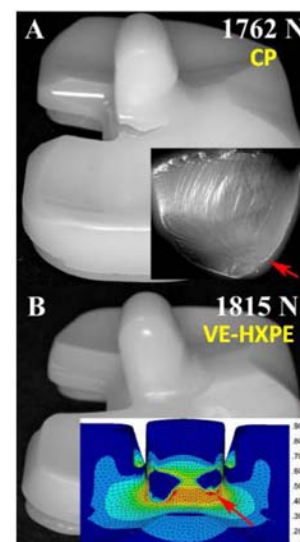


Figure 1. Posterior spine fracture of CP at 1762 N (A) vs. run-out of VE-HXPE at 1815 N (B). Typical anterior fracture.

Table 1. Tensile yield strength, wear and fatigue results for the CP and VE-HXPE materials.

Design / Material	Tensile Yield Strength (Normalized)	Wear Rate Average (mg/Mc)	Post Fatigue Strength (N)
Design B CP	1.0±0.014	14.67	1655
Design A VE-HXPE	1.16±0.24	0.56	1815
P value	p<0.0005	p<0.0005	p=0.125 / p=0.0313

O18A5

Comparison of Cruciate-Retaining Fixed-Bearing Versus Posterior-Stabilized Mobile-Bearing Total Knee Arthroplasty – A Prospective, Randomized Study

Primary Author: Hiroshi Takagi

Institution: Dept. of Orthopaedic surgery Showa Univ. Fujigaoka Hosp.

Coauthors: Shin Kato (Dept. of Orthopaedic surgery Showa Univ. Fujigaoka Hosp.), Masahiko Maekawa (Dept. of Orthopaedic surgery Showa Univ. Fujigaoka Hosp.), Atsushi Sato (Dept. of Orthopaedic surgery Showa Univ. Fujigaoka Hosp.), Soshi Asai (Dept. of Orthopaedic surgery Showa Univ. Fujigaoka Hosp.)

INTRODUCTION: There are many concepts and designs of total knee prostheses for improving range of knee motion and clinical outcome. Most previous clinical studies have found insufficient evidence the superiority of one specific prosthetic type. The purpose of this study was to compare clinical outcome and range of knee motion of two types of total knee prostheses with a different concept and design.

MATERIAL AND METHOD: A prospective, randomized comparison of posterior cruciate-retaining fixed-bearing (CR-f) type and posterior-stabilized mobile-bearing (PS-m) type total knee arthroplasty (TKA) was conducted in 48 patients of 48 knees (mean age, 75.9years) for varus alignment osteoarthritis knee. All procedures were performed by the same surgeon's group. Twenty-four knees were implanted CR-f type that was 3D Knee (DJO Surgical, Austin, TX, USA). 3D knee has a curved and symmetric tibial articular surface which is relatively more conforming in extension than flexion, but still allows some AP translation and axial rotation in extension. The remaining 24 knees were implanted PS-m type that was PFC-sigma RP-F (DePuy, Warsaw, IN). The posterior condyle of the RP-F femoral component has a reduced sagittal radius of curvature to allow for increased flexion and to increase the contact area. At the time of each follow-up (minimum duration of follow-up, two years; mean, 2.3 years), the patients were assessed clinically and radiographically with use of the knee-rating systems of the Knee Society and the Hospital for Special Surgery. Non-weight-bearing range of knee motion were determined in both groups.

RESULTS: The knees of CR-f group had a mean non-weight-bearing range of motion of 116°. The knees of PS-m group had a mean non-weight-bearing range of motion of 122°. Improvement of range of motion of CR-f group was -1.6° and PS-m group was 10.6°. It was significantly superior in the PS-m group. The mean postoperative Hospital for Special Surgery knee score was 84 points in CR-f group and 87 points in PS-m group. There were no significant differences between the CR-f group and PS-m group in postoperative knee scores [Fig.1]. No knee had aseptic loosening, revision, or osteolysis.

CONCLUSION: When the implant of CR-f type and PS-m type with a different concept and design were used at random for varus alignment osteoarthritis knee, there was no difference in clinical and radiographic results. But improvement of range of motion was significantly superior in the PS-m group.

	CR-f group	PS-m group	
HSS score	83. 9 ± 6. 4	86. 9 ± 7. 0	N.S.D.
Extension (°)	-0. 6 ± 2. 2	-0. 8 ± 2. 8	N.S.D.
Flexion (°)	116 ± 16. 3	122 ± 16. 0	p < 0.05
Improvement of ROM (°)	-1. 6 ± 15. 4	10. 6 ± 21. 4	p < 0.05
FTA (°)	173. 7 ± 1. 3	174. 3 ± 1. 4	N.S.D.

Fig.1

O18A6

Introducing Monitored Real-Time Patient Specific Technique for Total Knee Arthroplasty

Primary Author: Bernard N. Stulberg, MD

Institution: Cleveland Clinic, Cleveland OH 44113 USA

Coauthors: Jayson D. Zadzilka, Cleveland Clinic, Cleveland, OH, USA; Laurent D. Angibaud, Exactech, Gainesville, FL, USA

INTRODUCTION: On one hand, Computer Assisted Orthopedic Surgery (CAOS) focused on improving the accuracy of alignment of the components. However, there was minimal adoption of these technologies, as costs have been high and measured improvement in outcomes has not been demonstrated.

On the other hand, patient specific guide (PSG), involving preoperative three dimensional imaging and engineering of patient specific guides have been more actively embraced

by the orthopaedic community – with industry embracing the technology and promoting it vigorously. This has increased interest in the use of three dimensional technologies – with reported use by up to 14% of orthopedists in the US- despite the fact that scientific evidence has been mixed. The next generation is merging these two technologies, taking the best features of both to give the surgeon control of the patient specific total knee arthroplasty process. Sophisticated morphing technology coupled with innovative instrumentation (GPS Guide) now allows monitored real time PSG without the burden of expensive pre-operative imaging modality. Such technology allows the surgeon a means to fully understand the knee deformity being addressed, make per-operative decisions based on quantitative information that is accurate and easy to assess, and to resect and position parts as planned, confirming position easily. Additional ability to perform and monitor balancing is available if desired.

OBJECTIVES: The objective was to compare two groups of patients using a computer-assisted guidance system with a free hand method (Group I) and with the monitored GPS Guide (Group II).

METHODS: From April 2012 to August 2013, a total of eighty-two TKAs were performed using the computer-assisted system, fifty-one using a free hand method and thirty-one using the monitored GPS Guide.

RESULTS: For both groups, 100% of the knees were aligned to $\pm 2^\circ$ from the targeted values for the femoral flexion/extension, femoral and tibial varus/valgus, and $\pm 3^\circ$ for the tibial slope. The operative time under guidance was 42 minutes and 38 minutes for the free hand method group and the monitored GPS Guide, respectively. Among the two groups, the average clinical ROM at the most recent follow-up for CR TKA was 107° vs. 112° for PS TKA which was not significantly different.

CONCLUSIONS: These cases validated the integrity of the instruments and software of the monitored GPS Guide intended to easily position femoral resection pins through a single, navigated instrument. Pin accuracy and cutting efficiency are easily documented, and proper femoral position in all planes is controlled (see Figures 1 & 2). No additional imaging is needed, and the surgeon controls all aspects of decision making directly, monitored real-time patient specific TKA. It can easily be integrated for a balanced gap approach to implant positioning. This represents

the newest application of three dimensional technologies and continues the field moving toward technologies that allow the surgeon to directly control all aspects of patient specific TKA.

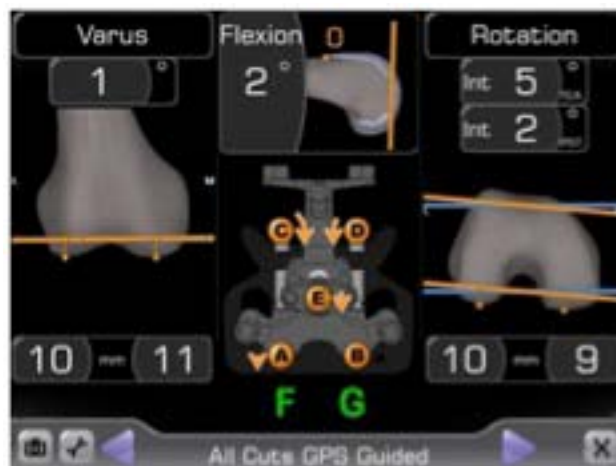


Figure 1: Screen shot before the femoral guide was adjusted to achieve the desired outcome

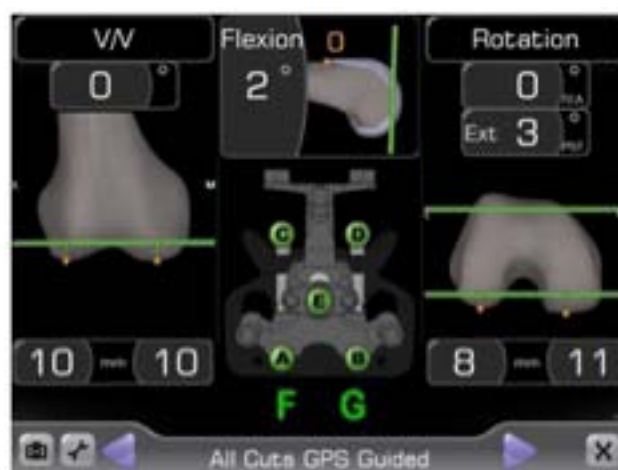


Figure 2: Screen shot after the femoral guide was adjusted to achieve the desired outcome

O18A7 Better Fit and Less Surgical Compromise During Total Knee Arthroplasty with an Anatomic Designed Tibial Component

Primary Author: Yifei Dai
Institution: Zimmer Inc

Coauthors: Kim Bertin (Hofmann Arthritis Institute), Samih Tarabichi (American Hospital), Ashok Rajgopal (Medanta Bone and Joint Institute), Jeffrey Bischoff (Zimmer Inc)

INTRODUCTION: Accurate rotational alignment, mini-

mal overhang, and good coverage are three competing objectives during total knee arthroplasty (TKA) and often lead to compromises in tibial component fit. This study compared the fit and incidence of compromise between contemporary anatomic and non-anatomic tibial designs.

METHODS: Six contemporary tibial designs (A:anatomic, B:asymmetric, C-F:symmetric) were digitally placed on 479 resected tibiae, including: 1) 97 Indian; 2) 126 Japanese; 3) 82 Korean and 10 Chinese; and 4) 164 Caucasian. Each placement selected largest possible component size, while ensuring <1mm overhang and proper alignment ($\leq 5^\circ$ mal-alignment). When a compromise on either alignment or overhang was required (due to smaller-sized component unavailable), the design was flagged as invalid for that bone. Tibial coverage was compared between ethnicities and correlated with component size for each design. Each design was placed again on 150 resections (randomly selected from the dataset), maximizing coverage without attention to rotation. Downsizing (compromise of component size due to adherence to proper alignment) was identified if predicted component size in the placement with proper alignment was smaller than that in the placement maximizing coverage. The degree of mal-alignment while maximizing coverage, the incidence of downsizing, and differences in coverage and distance to cortex between the two placements were compared across designs. Statistical significance was defined at $p < 0.05$.

RESULTS: Design A exhibited higher average coverage (92%) than other designs in all ethnicities (85-87%) ($p < 0.01$). Coverage generally decreased with reduced component size (Fig.1A,B), with 3% (Design A in Asian) to 13% (Design B in Caucasian) differences between the largest and smallest component sizes. Most bones without a valid component size were Asian (1-5% bones, Designs B-F), while for Caucasian bones they were limited to Design F (1%) (Fig.1C). Caucasian had slightly higher coverage ($< 1.5\%$) than Asian in Designs C and D ($p \leq 0.01$). Enforcing proper alignment significantly compromises coverage in Designs B-F (up to 20%, Fig.2A) and posterior medial cortical support ($p < 0.01$). In contrast, Design A has better posterior-medial cortical support with proper alignment than the other designs ($p \leq 0.03$). Designs B-F required downsizing on 39-60% of bones due to $> 5^\circ$ rotation, with components internally rotated beyond 10° on $> 30\%$ of bones (Fig.2B,C). In contrast, Design A required downsizing on only 3% of the bones, caused by small mal-rotations ($\leq 10^\circ$). Designs B-F required downsizing of ≥ 2

sizes on 2-11% of bones; while a single downsizing was sufficient for Design A.

DISCUSSION: The anatomic design has the highest and most consistent coverage ($< 3\%$ variation) across all ethnicities/sizes. It also has fewer incidences of downsizing, reduced propensity for mal-alignment, and better posterior-medial cortical support than the non-anatomic designs investigated. In contrast, in the non-anatomic tibial component designs, smaller component sizes had up to 13% decreased coverage relative to larger component sizes, and ensuring proper rotation alignment considerably compromised coverage and cortical support. This result, in conjunction with the majority of the bones without a valid component size being Asian, suggests that many non-anatomic designs do not fully accommodate variations in bone anatomy, thus forcing a compromise.

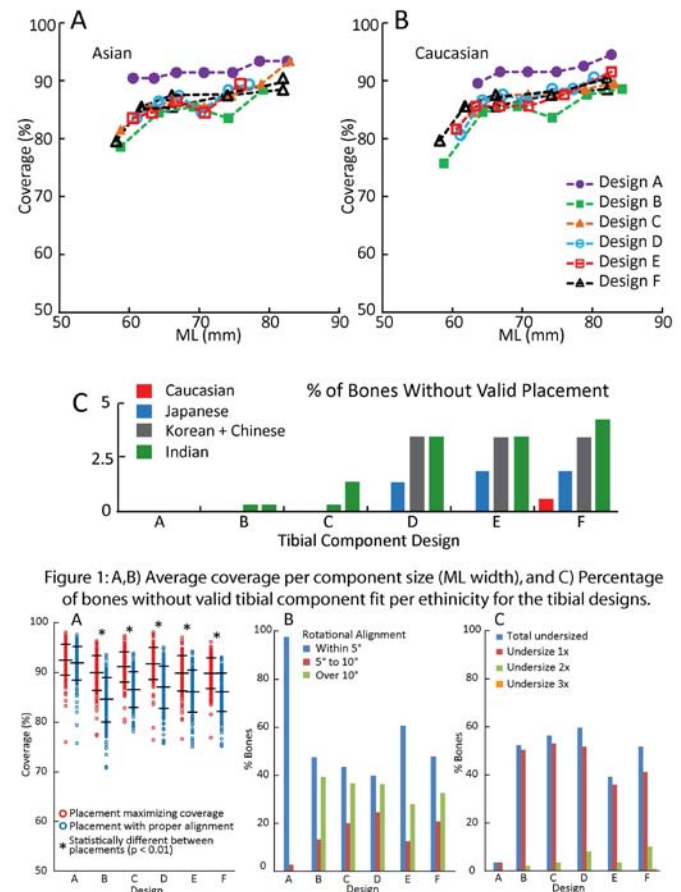


Figure 1: A,B) Average coverage per component size (ML width), and C) Percentage of bones without valid tibial component fit per ethnicity for the tibial designs.

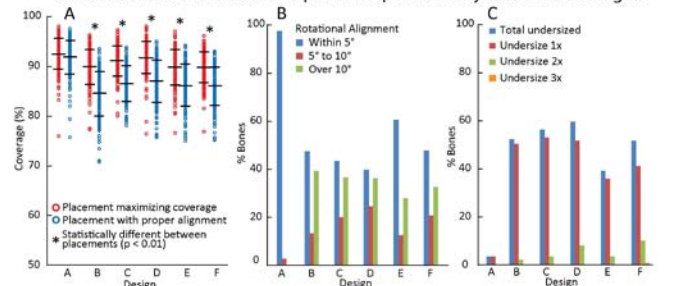


Figure 2: A) Coverage per design for the two placements (mean and standard deviation indicated). B) Percentages of bones that require component rotation to maximize coverage for each design. C) Percentage of bones with tibial component downsized, and extent of downsizing, for each design.

THA Bearing Mobility & Surface Interaction

O18B2

Mobile Bearing Hips: What are the Indications for them in 2014?

Guest Faculty: Robert L. Barrack, MD

Institution: Washington University School of Medicine, St. Louis, MO, USA

The design goals of any type of hip bearing are generally the same which are to minimize wear, maximize stability and range of motion, and maintain simplicity and flexibility in the application. One aspect of minimizing wear and decreasing complication rates is providing a wider safety margin so that bearings are tolerant of wider range of component positioning. Hard on hard bearings suffer from susceptibility to edge loading when components are not ideally positioned. Traditional hip replacement with metal on polyethylene or ceramic on polyethylene is more tolerant of edge loading particularly with highly crosslinked polyethylene. A major persisting problem with traditional hip replacement however is dislocation which now accounts for a very high percentage of revision procedures following primary and particularly revision hip replacement.

Mobile bearing hips were introduced with the goal of improving stability while maintaining low wear and increased margin for error in insertion. Potential advantages include low wear rate, increased range of motion, increased stability, and more tolerance of component malposition. This is not a new concept and was actually introduced in France almost 40 years ago. The American version of dual mobility was the bipolar hemiarthroplasty in which there was mobility between the femoral head and the polyethylene liner as well as an articulation between the metal outer bearing of the bipolar which was mobile but articulated against articular cartilage. A later version of the dual mobility concept was the tripolar prosthesis configuration in which the bipolar mated against a polyethylene liner rather than against articular cartilage. This design potentially improved stability and reduced dislocations, however it suffered from thin polyethylene at both interfaces and the use of conventional polyethylene in most of the small bipolar components which were from trauma product lines and

rarely if ever incorporated crosslinked polyethylene. The tripolar concept was later modified by incorporating a constrained feature which was useful particularly for revisions for dislocation and in the absence of functional abductor mechanism. While providing stability in most cases, the constrained tripolar suffered from complications of its own including decreased range of motion, impingement, and complications of the multiple modular interfaces.

The French version of the dual mobility concept was to reverse the materials involved and utilized a mobile articulating polyethylene liner against a smooth metal surface rather than a metal head against a polyethylene surface. While clinical results were generally good, problems included intraprosthetic failure, linear polyethylene wear, and suboptimal fixation. Other concerns included lack of documentation of the wear rate of the large polyethylene mobile element against metal surface and independent documentation of the range of motion and stability of dual mobility components.

In recent years the dual mobility hip has been introduced in the American market. The improvements include the incorporation of crosslinked polyethylene and the use of 28mm head with elimination of a skirt which should largely dispel the issue of intraprosthetic dislocation. A number of clinical studies indicate that this may well improve stability and lower the dislocation rate in challenging primary cases as well as many revision cases which are prone to dislocation.

The issue of the indications for the dual mobility hip remains controversial. According to the information for use (IFU) published by the manufactures, the dual mobility hips are potentially indicated for virtually any patient who would be a candidate for hip replacement. The manufacturer does however list absence of an abductor mechanism or poor bone stock or skin coverage around the hip as contraindications for the procedure. They also list a warning and a precaution regarding the use of the dual mobility polyethylene component with femoral heads from another manufacturer or articulation of the dual mobility polyethylene against metal surfaces from another manufacturer. Many revision total hips would be in one of these categories if a stem or acetabular component from a different manufacturer was retained, which is often the case.

There is strong laboratory support for improved stability due to the increased jump distance with the dual mobil-

ity hip. The major remaining question is the wear rate of the large polyethylene articulating mobile element against a metal surface. The general consensus that the best indication currently for dual mobility hips is in patients who are at increased risk for instability in the primary or revision setting. In a primary hip this would include elderly patients, potentially hip fracture patients, and patients with other known risk factors for instability such as neuromuscular disorders and cognitive dysfunction. Potential indications are more widely accepted in the revision scenario in which dislocation rates in double digits are often reported. Dual mobility is a more attractive option at the outset than a constrained liner particularly if there is a functional abductor mechanism since dual mobility imparts increased range of motion and less impingement and thus presumably less wear than a constrained component. It also allows for bone attachment to the acetabular shell without a tensile force which could displace the metal shell from the pelvis before bone growth can occur. The final advantage of a modular dual mobility (MDM) is that it allows use with a versatile titanium highly porous shell with screw fixation and the full array of liner options from large head to dual mobility to constrained. This allows for surgeon flexibility at the time of initial surgery as well as for future revision options.

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O18B3

Low Early Complication Rate with a Modern Dual Mobility Hip Prosthesis in the USA

Primary Author: Manoshi Bhowmik-Stoker

Institution: Stryker Orthopaedics

Coauthors: Kristin L. Robinson (Stryker Orthopaedics), Jim Nevelos (Stryker Orthopaedics), Kipling P. Sharpe (Active Orthopedic), Geoffrey H. Westrich (Hospital for Special Surgery)

INTRODUCTION: Dual mobility bearings have been used in Europe for several decades, particularly in cases at risk of dislocation. The combination of highly cross linked polyethylene and a dual mobility bearing may therefore provide a bearing with low wear and high stability. We analyzed the three dimensional jump height of a modern dual mobility bearing in a computer model and also report on early complications of a series of 167 of these bearings in a clinical study. The anatomic dual mobility (ADM) cup used in both studies was the Restoration ADM with X3 polyethylene (Stryker, Mahwah, NJ).

METHODS: We used a previously published computer model of three dimensional jump height or posterior horizontal dislocation distance, PHDD. The PHDD was measured in a horizontal direction in the coronal plane (Figure 1) as the distance from the acetabular component ID center to the dislocated head center (tangential to the edge of the

cup). The pelvis was oriented with 26° of pelvic tilt which represents a low chair rise situation and therefore may be more clinically relevant as a high risk position for dislocation. Different cup orientations were tested for four different bearings: (1) 28mm and (2) 36mm convention bearings, (3) a resurfacing shell with a 3mm offset bore, and (4) an ADM cup with a 54mm outside diameter with a 48mm mobile polyethylene insert with a 28mm captured head. A prospective, consecutive series, multicenter (7 centers, 8 surgeons) study was conducted to collect adverse events (AEs), radiographs and patient reported outcome measures (PROMs) longitudinally. One hundred sixty-seven ADM acetabular components were implanted in 82 male and 78 female patients with mean age of 61.7 (range 27 - 75) and mean BMI of 29.7 (range 19.4 - 39.4). AEs were recorded intra and post operatively, while Harris Hip Score, Lower Extremity Activity Scale, Short Form-12 was collected at pre-op, 6 weeks and 1 year post-operatively.

RESULTS: The computer model showed that the 54mm ADM cup had the highest PHDD in all orientations with approximately double the PHDD compared to a 36mm head with the cup oriented at 45 degrees of inclination and 10 degrees of anteversion (Figure 1). PROMs indicated improvement in all functional and general health scores over time (Figure 2). Patients indicated reduction in pain and return to function at one year. This study had 2 AEs resulting in revision or reoperation that were unrelated to the acetabular component and the ADM shell was retained in both cases. Two months after surgery, 1 patient had the stem, head and acetabular liner revised due to sub-trochanteric fracture causing the femoral component to subside. In another case, 2 weeks after surgery, 1 patient presented with a peri-prosthetic calcar fracture after rising from a low chair. The patient was treated with an open reduction internal fixation and retained all original device components. There were no dislocations.

DISCUSSION: Early clinical data would appear to confirm that this dual mobility bearing has a very low early complication rate without dislocations in this series.

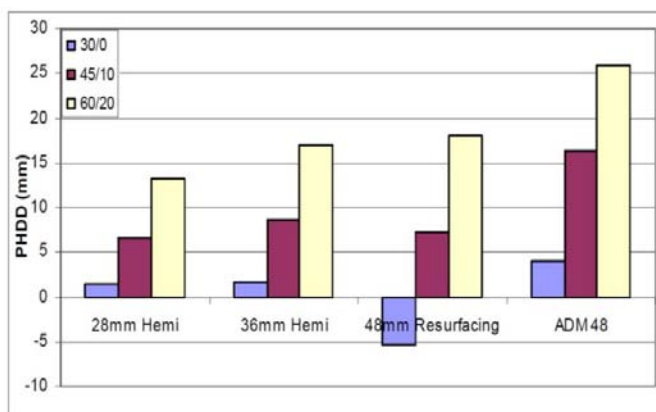


Figure 1. PHDD for four different bearings and three cup positions

	Pre-op (n=167)	6 Wk (n=154)	1 Yr (n=79)
HHS	54.64 (13.95)	81.59 (12.26)	94.76 (7.87)
LEAS	9.13 (2.95)	9.05 (2.49)	10.91 (2.66)
SF-12 PCS	31.82 (9.04)	39.6 (8.22)	47.61 (10.01)
SF-12 MCS	52.93 (10.66)	55.47 (9.68)	54.84 (7.94)

Figure 2. Mean and standard deviations showing improvement in PROMs over the first year of recovery.

O18B4

Early Failure of a Dual Modularity Femoral Component

Primary Author: Russell G. Cohen

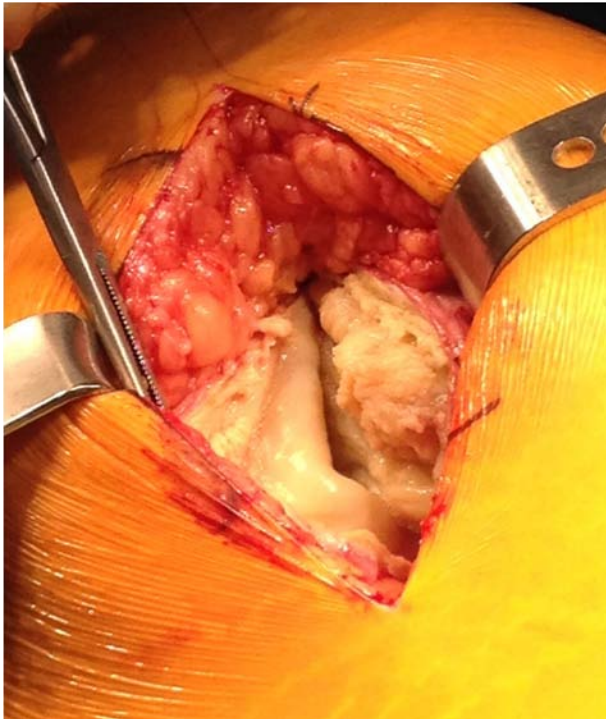
Institution: Tucson Orthopaedic Institute

Coauthors: Nebojsa V. Skrepnik (Tucson Orthopaedic Institute)

A retrospective review of one hundred and ninety one total hip arthroplasties using a femoral component with a modular head and neck was carried out. One hundred and seventy four of 191 hips (91%) were available for review. Initial symptomatic patients presented with pain, swelling, decreased range of motion and limp. Work-up included serum ion levels, and magnetic resonance imaging and aspiration. 60 patients (31.4%) required revision and findings at surgery revealed evidence of corrosion at the modular neck-stem junction with varying degrees of adverse local soft tissue reactions including tense effusions, pseudocapsule (Fig.1) and tissue necrosis. We concluded that patients with modular femoral implants who develop pain and related symptoms within two years of surgery may be experiencing early failure of the femoral component due to corrosion at the modular neck-stem junction (Fig. 2). However, not all patients present with symptoms but do require

screening if this implant is present. Once the diagnosis is made, timely revision is recommended. Based upon this experience, we no longer use modular femoral components and we feel that surgeons should carefully weigh the potential advantages of a modular femoral component versus the potential catastrophic complications before implanting such a component.

KEYWORDS: Modular Rejuvenate Femoral Implant, Early failure, Corrosion, Adverse Local Tissue Reaction



O18B5

Hip Separation: Does Surgical Technique Make a Difference?

Primary Author: Michael T. LaCour

Institution: University of Tennessee Knoxville, TN, USA

Coauthors: Richard D. Komistek, Adrija Sharma, William P. Barrett, Steven J. MacDonald, David F. Dalury

INTRODUCTION: Femoral head separation (sliding) and dislocation within the acetabular cup are common complications in total hip arthroplasty (THA). Although the factors responsible for these phenomena are not well understood, the disruption of soft tissues may play a role in the atypical kinematics. It has been hypothesized that different THA surgical techniques, by resecting different soft tissues, may affect the frequency and extent of separation. The objective of this study was to compare in vivo kinematics and separation after THA with three different surgical approaches: Direct Anterior (DA), Anterior Lateral (AL), and Posterior Lateral (PL).

METHODS: Kinematic data were collected from 30 post-THA subjects, 10 each implanted with one of three different surgical techniques. The study included three surgeons, one for each technique. Fluoroscopy data was collected as each subject performed level gait on a treadmill at a walking speed of 1.0 mile per hour. Sound sensors were placed on the patient's greater trochanter and iliac crest during data collection to determine the in vivo sounds occurring during gait. Three-dimensional kinematics were computed from the fluoroscopic recordings using a validated 3D-to-2D registration method. Hip separation was determined by calculating the distance from the apex of the acetabular cup to the nearest point on the femoral head throughout the duration of the activity. A distance greater than 1.0 mm was considered, with high confidence, to signify "separation" between the femoral head and the acetabular cup. Parameters of interest for this study included the maximum amount of hip separation during swing phase and during stance phase, as well as a correlation of sound to hip separation kinematics. Statistical significance was considered at a 95% confidence level.

RESULTS: Instances of separation were observed for all three groups and did not appear to be dependent on a particular surgical method. During swing phase, on average, two groups experienced less than 1.0 mm of hip separa-

tion. The DA approach had an average maximum amount of separation of 0.9 ± 0.43 mm, the AL approach had an average maximum amount of separation of 0.8 ± 0.38 mm, and the PL approach had an average maximum amount of separation of 1.1 ± 0.52 mm. During stance phase, the DA approach had an average maximum separation of 1.0 ± 0.27 mm, the AL approach had an average maximum separation of 1.0 ± 0.73 mm, and the PL approach had an average maximum separation of 1.2 ± 0.20 mm. Statistically, these mean values were found to be similar. The maximum amount of hip separation for the DA approach group was 1.6 mm during swing phase and 1.4 mm during stance phase. The maximum amount of hip separation for the AL approach group was 1.4 mm during swing phase and 2.3 mm during stance phase. The maximum amount of hip separation for the PL approach group was 1.6 mm during swing phase and 1.5 mm during stance phase. For all surgical methods, hip separation generally occurred near the end of the particular gait phase (swing or stance), with larger magnitudes of separation occurring during stance phase. The sound data collected during this study clearly shows a correlation with hip separation.

CONCLUSIONS: It appears that the differing soft-tissue disruptions between surgical methods do not have an effect on the amount of hip separation experienced by the patient. It is instead believed that accurate component alignment is vital for minimizing hip separation. Furthermore, it appears that greater magnitudes of hip separation occur during the end of stance phase versus during swing phase.



**ICJR Pan Pacific North Asia/
Australia Clinical Research Award
Winner**

O18B6 **Characterization of Progression of Pelvic Osteolysis After Cementless Total Hip Arthroplasty: Computed Tomographic Study**

Primary Author: Won Yong Shon

Institution: Orthopedic Department, Guro Hospital, Korea University

Coauthors: Dong Hoon Suh (Korea University), Seung Beom Han (Korea University), Ho Hyun Yun (Veterans Health Service Medical Center), Suh DH, Han SB, Yun HH, Shon WY. Department of Orthopaedic Surgery, Col-

lege of Medicine, Korea University, Seoul, Korea)

A retrospective analysis of 63 primary total hip arthroplasty cases was done using repeated computed tomography scans to evaluate the pelvic osteolytic lesions in early stage. The progression rate of osteolysis of hips with small osteolytic volume less than 766.97 mm(3) in initial CT was 85.82 mm(3)/year, and that of hips with osteolysis more than 766.97 mm(3) was 456.3 mm(3)/year ($P < 0.001$). Younger patients less than 52 years old with good Harris Hip Scores (more than 80) frequently showed much faster progression in volume of osteolytic lesions. The rate of osteolysis was accelerated when the amount of osteolysis reached a certain threshold volume in active young patients in a cascade manner even in early stage.

O18B7 **High Incidence of Ceramic Head and Liner Fracture in Third-Generation Ceramic-on- Ceramic Total Hip Arthroplasty**

Primary Author: Kyung-Soon Park

Institution: Chonnam National University, Orthopedic Department

Coauthors: Taek-Rim Yoon (Chonnam National University, Orthopedic Department)

PURPOSE: The study evaluated the clinical and radiological results of third-generation ceramic-on-ceramic articulation for total hip arthroplasty (THA) performed at our institute.

PATIENTS AND METHODS: Five hundred twenty seven patients (577 hips) who underwent primary THA using third-generation ceramic-on-ceramic articulation were retrospectively reviewed. They were followed up for an average of 5.9 years and the mean age at the time of surgery was 47.9 years. The sockets used were the SecurFit cup (Howmedica Osteonics Stryker, Limerick, Ireland) and third-generation ceramic head and liner (BioloX Forte®; Osteo AG, Selzach, Switzerland). Seven different stems were used. The causes of THA were osteonecrosis of femoral head in 365 hips, OA in 99 hips, fracture in 69 hips, AS in 19 hips, septic sequelae in 14 hips, rheumatoid arthritis in six hips, and tuberculosis infection in five hips. Modified minimally invasive two-incision method was used in 443 hips, minimally invasive one-incision method

(posterolateral approach) in 83 hips, and the conventional method (posterolateral approach) in 51 hips. Clinical results were evaluated using the Harris hip score (HHS) and radiological evaluation was performed using the method of DeLee and Charnley for the acetabular osteolysis and method of Gruen et al. for the femoral osteolysis. Complications were also evaluated.

RESULTS: The mean HHS improved from 65.3 preoperatively to 93.8 at the final follow-up. There were no changes in cup position, and no osteolytic lesions around the femoral and acetabular components in the last follow-up radiographs. Seven hips experienced ceramic liner fracture and 14 hips experienced ceramic head fracture (Accolade stem was used in one case, M/L Taper in one case, and Conical stems in 12 cases). Squeaking occurred in eight hips. Dislocation occurred in three hips, bone ingrowth failure on the stem and subsidence was observed in three hips, and postoperative infection occurred in five hips.

CONCLUSION: THA with third-generation ceramic-on-ceramic articulation was associated with a higher rate of fracture. The incidence of ceramic fracture was 3.6% and that of squeaking was 1.4%.

KEYWORDS: ceramic-on-ceramic, cementless, ceramic fracture

The Asian Knee

O19A1

How to Address Tibia Vara Often Seen in Asian Knees

Guest Faculty: Masao Akagi, MD, PhD

Institution: Department of Orthopaedic Surgery, Kinki University Faculty of Medicine, Osaka-Sayama City, Osaka, Japan

Coauthors: Shigeshi Mori, MD; Shigeki Asada, MD

In the classic alignment method of TKA, the proximal tibia is resected perpendicular to the tibial shaft axis (TSA). Because the tibial mechanical axis (TMA) accords with the

TSA in the normal tibia, the tibial component is set along both axes, which is good for load distribution to the tibia and knee kinematics. However, in tibia vara often seen in Asian knees the TSA does not accord with the TMA, which has made it difficult to achieve proper frontal alignment and component positioning. Lateralization of the component is required along the TSA, which in turn requires component downsizing to avoid lateral overhang. As a result, medial underhang occurs. The uncovered tibial medial edge is resected off, which may provide a beneficial effect to attenuate the tight medial gap. This technique, however, may result in an AP underhang of the component. We investigated (1) how much the tibias in Japanese patients actually medially bow, (2) whether the tibia vara influences the aspect ratio of the tibial resected surface in aligning the tibial component with the TSA, (3) whether currently available tibial components fit the resected proximal tibias in terms of aspect ratio, (4) whether the medial reduction osteotomy is effective for ligament balancing. We measured the tibia vara angle (TVA), proximal varus angle (PVA), and the mediolateral and middle AP dimensions of the resected surface using 3-D preoperative planning software in 90 knees of 74 female patients with varus knee OA. We determined the correlations of the aspect ratio with TVA or PVA and compared the aspect ratios to those of five prosthesis designs. Further, we intraoperatively measured soft tissue balance using a ligament tensor in 96 knees of 84 patients with varus knee OA. The mean TVA and PVA were 0.6° and 2.0°, respectively. The aspect ratio negatively correlated with both TVA and PVA. The mean aspect ratio of the resected surface was 1.48 but gradually decreased with increasing AP dimension, whereas four of the five prostheses had a constant aspect ratio. The medial reduction osteotomy seemed effective to avoid extensive medial release. The aspect ratio of resected tibial surface was inversely correlated to the degree of tibia vara, and currently available prosthesis designs do not fit well to the resected surface. The design of a tibial component with a smaller aspect ratio could be developed to obtain better bone coverage in Asian patients.

O19A2

Management Of Severe Valgus Deformity Without Constrained Implants

Guest Faculty: Arun Mullaji, FRCS Ed, MChOrth (UK), MS Orth, DNB Orth, D Orth

Institution: The Arthritis Clinic, Mumbai, India

Valgus deformities of the knee are less common than varus deformities, often more recalcitrant in terms of correctability and due to relative paucity of experience in dealing with the severe varieties offer greater challenges in restoring alignment in conjunction with ligament balance. There are additional differences in that the lateral collateral ligament does not attach distally to the tibia but to the fibular head; the peroneal nerve is in proximity to the fibular neck and is vulnerable to stretching when long-standing valgus contractures are released and alignment is restored. One method of treating the more rigid deformity is to release the lateral collateral ligament, the popliteal tendon and the capsule at the posterolateral corner and use a constrained device. This may suffice for the elderly and low-demand patient but may not be the ideal solution for a younger, more active individual. This presentation will discuss the 6 different sub-types of valgus deformities and propose an algorithmic approach to valgus deformity correction. The overarching aim remains to restore alignment with stability, using the patient's own soft-tissues rather than additional constraint in the form of a varus-valgus constrained or hinged device. The steps of soft tissue release will be illustrated and the use of navigation will be highlighted. For rigid deformities, a sliding lateral epicondylar osteotomy is useful and will be described in order to facilitate restoration of alignment and balance in conjunction with posterior-stabilised implants in the majority of cases.

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O19A3

The Flexion Contracture After Total Knee Arthroplasty Correlates with Posterior Offset Ratio

Primary Author: Tomohiro Onodera

Institution: Hokkaido University

Coauthors: Yasuhiko Kasahara (Hokkaido University), Naoki Seito (Hokkaido University), Yusuke Nishio (Hokkaido University), Eiji Kondo (Hokkaido University), Norimasa Iwasaki (Hokkaido University), Tokifumi Majima (International University)

INTRODUCTION: The effect of the implant posterior condylar offset has recently generated much enthusiasm among researchers. Some reports were concerned about the relationship between the posterior condylar offset and an extension gap. However, the posterior condylar offset was measured in a flexed knee position or in reference to femoral anatomy alone. We have previously reported that posterior femoral condylar offset relative to the posterior wall of the tibia (posterior offset ratio; POR) is possibly the risk of knee flexion contracture after TKA. (Onodera T, J Arthroplasty. 2013) However, there are no reports concerning the relationship between POR and flexion contracture in vivo. The aim of this study is to evaluate the relationship between the measurement of POR and flexion contracture in vivo.

METHODS: Twenty-seven patients who underwent a primary posterior stabilized total knee arthroplasty (PFC Sigma RP-F; Depuy) were participated. The lateral femoro-tibial angle (lateral FTA) was measured using lateral radiographs. Two procedures are applied to obtain lateral radiographs of the lower extremities. (1) Full-length lateral radiographs on standing, (2) True lateral radiographs in the prone position (Fig. 1A). 'Posterior offset ratio' was defined as follows (Fig. 1B). The maximal protrusion of the posterior condyle, posteriorly to the extension line parallel to the tibial shaft from the edge of the posterior tibial plateau was measured on true lateral radiographs (a). Antero-posterior diameter of the tibia was also measured orthogonally to the tibial shaft (b). 'Posterior offset ratio' was obtained by dividing 'a' by 'b'. Posterior offset ratio was evaluated on standing lateral radiographs.

RESULTS: The mean value of the POR on standing was $14.94 \pm 7.53\%$. The mean value of flexion contracture of

the knee on standing was 11.67 ± 9.21 degree and that in the prone position was 4.22 ± 6.17 degree ($P = 0.001$). The POR was negatively correlated with flexion contracture of the knee in all procedures with statistical significance (standing: $r = 0.62$, $P = 0.0039$; prone: $r = 0.66$, $P = 0.0001$) (Fig. 2).

DISCUSSION: The mean value of flexion contracture on standing was 11.67 ± 9.21 degree, whereas that in the prone position was 4.22 ± 6.17 degree. We surmised that this discrepancy occurred due to the flexor muscle tension on standing. Regarding the evaluation of POR, muscle relaxation can be achieved in prone rather than standing.

POR is strongly correlated with flexion contracture evaluated by both measurement procedures. The value of POR of this implant in vitro was about 25% in previous study, whereas the mean value of POR in vivo was 14.94 %, suggesting that POR in the flexion contracture knee relatively reduced because posterior soft tissue pushed femoral component anteriorly. Our result clearly showed that if posterior clearance is insufficient, flexion contracture occur due to posterior soft tissue tightness.

In conclusion, POR after TKA in vivo negatively correlate with flexion contracture presumably because posterior soft tissue pushed femoral component anteriorly. POR is a useful indicator of the posterior soft tissue tightness after TKA.

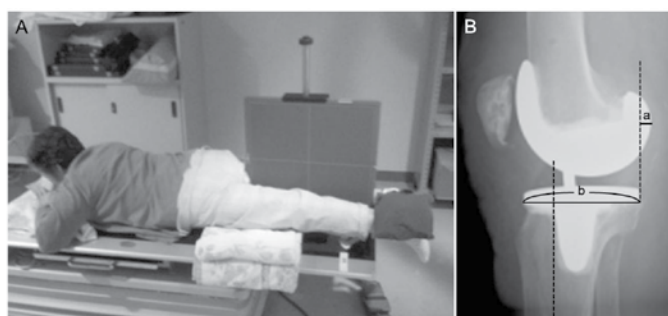


Figure 1. A. The radiographic procedure of true lateral radiographs in the prone position. The X-ray cassette was placed in the patient's inner thighs. B. The measurement of posterior offset ratio. The maximal protrusion of the posterior condyle, posteriorly to the extension line parallel to the tibial shaft from the edge of the posterior tibial plateau was measured on true lateral radiographs (a). Antero-posterior diameter of the tibia was also measured orthogonally to the tibial shaft (b). 'Posterior offset ratio' was obtained by dividing 'a' by 'b'.

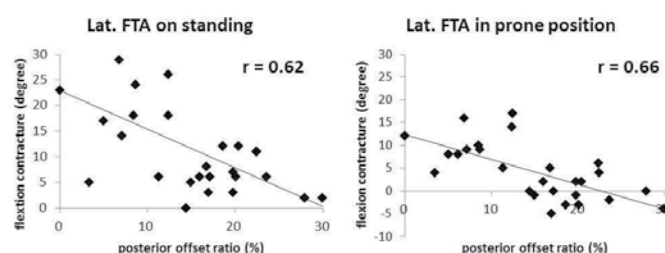


Figure 2. A. Correlation between posterior offset ratio and flexion contracture on standing. B. Correlation between posterior offset ratio and flexion contracture in prone position. Dot plot represents an individual value. FTA, femoro-tibial angle.

O19A4 Navigation-Based Tibial Rotation at 90° Flexion Predicts Better Range of Motion in Navigated

Primary Author: Yuji Hiroshima

Institution: Kobe University

Coauthors: Kazunari Ishida (Kaisei Hospital)

BACKGROUND: Data on varus-valgus and rotational profiles can be obtained during navigated total knee arthroplasty (TKA). Such intraoperative kinematic data might provide instructive clinical information for refinement of surgical techniques, as well as information on the anticipated postoperative clinical outcomes. However, few studies have compared intraoperative kinematics and pre- and postoperative clinical outcomes; therefore, the clinical implications of intraoperative kinematics remain unclear. In clinical practice, subjects with better femorotibial rotation in the flexed position often achieve favorable postoperative range of motion (ROM); however, no objective data have been reported to prove this clinical impression. Hence, the present study aimed to investigate the correlation between intraoperative rotation and pre- and postoperative flexion angles.

MATERIALS AND METHODS: Twenty-six patients with varus osteoarthritis undergoing navigated posterior-stabilized TKA (Triathlon, Stryker, Mahwah, NJ) were enrolled in this study. An image-free navigation system (Stryker 4.0 image-free computer navigation system; Stryker) was used for the operation. Registration was performed after minimum soft tissue release and osteophyte removal. Then, maximum internal and external rotational stress was manually applied on the knee with maximum extension and 90° flexion by the same surgeon, and the ro-

tational angles were recorded using the navigation system. After knee implantation, the same rotational stress was applied and the rotational angles were recorded again. In addition, ROM was measured before surgery and at 1 month after surgery. The correlation between the amount of pre- and postoperative tibial rotation and ROM was statistically evaluated.

RESULTS: The amount of tibial rotation at registration was positively correlated with that after surgery (p Conclusion: It is well known that preoperative ROM affects postoperative ROM. Our results showed that better tibial rotation at 90° flexion predicts favorable postoperative ROM, suggesting that flexibility of the surrounding soft tissues as well as the quadriceps muscles is an important factor for obtaining better ROM. Further evaluation of navigation-based kinematics during TKA surgery may provide useful information on ROM.

O19A5 Can We Improve the Alignment by Modification of Classical Method

Primary Author: Beom Koo Lee
Institution: Gachon University Gil Hospital

Coauthors: Yong Lee (Bundang Seoul National University)

PURPOSE: Use of the guide angle method using intramedullary guide angle for distal femoral cutting in total knee arthroplasty may cause error when rotation of the femur occurs or the insertion point of the intramedullary guide is incorrectly positioned in preoperative radiography. On the other hand, use of the measured cutting method, in which resection of distal femoral condyles is performed according to predicted measured thickness in a preoperative radiograph can allow for correction of these errors intraoperatively. Therefore, we compared these two distal femoral bone cutting methods for restoration of accurate coronal alignment.

METHODS: Between 2010 and 2012, 47 patients (70 knees) underwent total knee arthroplasty for treatment of osteoarthritis with varus deformity and flexion contracture less than 10 degrees. Bone resection depending on distal femur resection thickness measured before the operation was performed in 38 cases (Group I). Distal femoral cutting using the guide angle was performed in 32 cases

(Group II). Radiographic evaluation, including mean value of lower leg mechanical axis angle and the frequency of errors of more than 3 degrees, was performed for comparison between the two groups.

RESULTS: In Group I, mechanical axis was corrected from 8.4 ± 4.9 degrees (-7.2 to 16.9) on average before the operation to 0.1 ± 2.4 degrees (-5.87 to 2.98) after the operation, and, in Group II, from 6.7 ± 3.6 degrees (0.4 to 14.7) on average before the operation to 0.5 ± 2.8 degrees (-5.4 to 6.9) after the operation. No statistically significant difference in mechanical axis ($p = 0.554$) was observed between the two groups after the operation, and no difference in errors of more than 3 degrees was observed between the two groups, with four of 38 cases (11 %) in Group I and six of 32 cases (19%) in Group II ($p = 0.495$).

CONCLUSIONS: No significantly different results were observed between the measured resection technique and the existing guide angle technique. Therefore, predictive measurement of distal femoral cutting thickness is another useful method for restoration of accurate coronal alignment.

KEYWORDS: Knee, Total knee arthroplasty, Mechanical axis, Resected condyle thickness, Guide angle

O19A6 Design Rationale and Postoperative Functional Assessment of Total Knee Arthroplasty Reproducing Anatomic Geometry

Primary Author: Toru Suguro
Institution: Japan Research Institute of Artificial joint

Coauthors: Keitaro Yamamoto (Toho University), Hideyuki Aoki (Toho University), Yoshiyasu Miyazaki (Toho University), Takashi Nakamura (Toho University), Scott A. Banks (Florida University)

AIMS: Recently, total knee arthroplasty (TKA) has been generalized as an operation that achieves excellent clinical results. However, younger and more demanding patients require even greater longevity with a high level of functional performance, especially deep knee flexion to sit on the floor in Asian. We hypothesized a novel posterior cruciate-retaining TKA design that restores the anatomical jointline in both sagittal and coronal planes, main-

tains the femoral posterior condylar offset, and provides low contact stress would provide enhanced patient function with the potential for greater implant longevity. We hypothesized a novel TKA design, refer to as the FINE® Total Knee System (FINE Knee; NAKASHIMA Medical Co., Ltd., Okayama, JAPAN) was constructed. The tibial insert was made of ultra-high molecular weight polyethylene (UHMWPE) that was blended with an anti-oxidant, vitamin E



O19A7 Highly Crosslinked Versus Conventional Polyethylene in Posterior-Stabilized Total Knee Arthroplasty at a Minimum 5-Year Followup

Primary Author: Ajit Mishra, PhD

Coauthors: Phillip Ireland, MD, David Edelstein, MD, Michael Meneghini, MD, Manoshi Stoker, PhD

INTRODUCTION: The posterior-stabilized total knee arthroplasty (TKA) design is commonly used in the Asian population to achieve excellent range of motion and pain reduction [1]. UHMWPE wear continues to be the primary reason for long-term failure of TKA [2, 3]. TKA implants are more susceptible to risk of fatigue failure, pitting and delamination, compared to THA implants, because TKA articulation includes rolling, sliding and rotation. Cross-linking has shown significant promise in improving the wear resistance of UHMWPE. TKA simulator studies have shown wear reductions of 43% to 94% when cross-linked polyethylene is used [4, 5]. Second generation crosslinked polyethylenes have been introduced to address some of the deficiencies of first generation crosslinked polyethylenes.

Although highly crosslinked polyethylene is now commonly used in TKA, its long-term clinical performance remains unknown and concerns exist regarding fatigue resistance and oxidation [5], particularly in PS designs. The purpose of this study is to compare highly crosslinked and conventional polyethylene in a PS TKA design at a minimum of 5 years.

METHODS: Three hundred and seven patients received a primary PS TKA as part of a prospective, multicenter study in the United States. Patients had a mean age of 64.7 years and a mean BMI of 31.2. Ethnicity was recorded as 92.53% Caucasian, 5.55% African American, 1.25% Asian, and 0.34% Native American. Conventional polyethylene inserts were used in 168 knees and second-generation highly cross-linked polyethylene inserts were implanted in 139 TKAs. Health Related Quality of Life (HRQoL), Short-Form 36 (SF36), Knee Society Scores (KSS), WOMAC and Lower Extremity Activity Score (LEAS) and radiographic assessment were collected on all cases for a minimum of 5 years. Student t-test was used to compare group outcomes and $p < 0.05$ was considered statistically significant.

RESULTS: There was no difference in demographics or preoperative outcome measures between groups ($p > 0.05$). There was no radiographic osteolysis or mechanical failures related to the tibial polyethylene in either group at any post-operative time points. At 5 years, the highly cross-linked group had greater KSS function scores (85.5), LEAS (11.5), and SF36 PCS (48.3) in comparison to the conventional group (KSS func- 80, LEAS- 10.6, SF36 PCS- 45). HRQoL showed an index score improvement of 0.12 and 0.16 in the conventional and highly cross-linked groups respectively ($p < 0.05$).

CONCLUSION: Concerns regarding early fatigue failure and mechanical complications related to the PS post-cam articulation of highly-cross-linked polyethylene in TKR were not substantiated at a minimum of 5 years clinical follow-up in this prospective, multicenter study. Highly cross-linked polyethylene demonstrated clinical equivalency compared to conventional polyethylene. While the results support comparative safety, longer-term follow-up is warranted to determine if wear resistance and mechanical properties of highly cross-linked polyethylene are maintained. This study was conducted in the United States and supports the need for clinical wear analysis in international populations who receive PS TKA devices.

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plications related to anticoagulation prophylaxis.

This protocol utilized an inexpensive set of laboratory tests and pre-operative duplex scanning (\$240) to evaluate patients' thrombophilic/hemophilic status. The battery of tests included:

Factor VIII
Factor V Leyden
Factor C (APCR)
Fibrinogen
D-Dimer
Prothrombin Gene Mutation
ESR
CRP
Duplex scan of both lower extremities

It was found that this pre-operative protocol coupled with a multi-modal intra- and post-operative prophylaxis protocol afforded not only a more objective methodology of DVT/PE prophylaxis but also avoided re-admission and wound complications due to over-treatment of patients found to have an elevated risk of potential adverse outcome due to anticoagulation prophylaxis. The overall combined symptomatic and asymptomatic incidence of DVT employing this strategy and assessed by post-operative duplex scanning was 6%.

THA: Concerns that Remain

O19B2

Reducing DVT/PE and Post-op Wound Complications: Balancing the Risks of Clots and Bleeds

Primary Author: Joseph F. Fetto

Institution: NYU Hospital for Joint Diseases

A prospective non-randomized study of 300 patients demonstrated that pre-operative objective risk assessment was not only cost effective but also 100% predictive of post-operative complications related to DVT/PE and wound com-

O19B3

Can the Sound of Hammering Objectively Predict Micro-Fracture in Bones? A Study on Animal Bone

Primary Author: Ali Abdulkarim

Institution: Midland Regional Hospital Tullamore

Coauthors: Anase Elsibaei (Kerry General Hospital), B Jackson (Institute of Technology Ireland), D Riordan (Institute of Technology Ireland), John Rice (Kerry General Hospital)

INTRODUCTION: Many surgeons are familiar with the audible change in the sound pitch while hammering a rasp in a long bone during surgeries like Hip Arthroplasty. We have developed a hypothesis indicating that there is a relationship between that sound change and the development of micro-fracture and subsequently full fracture.

METHODS: An experiment using porcine femur bone

performed by attaching a bone conduction microphone to the distal part of the bone while hammering a rasp of different sizes through the medullary canal till the point where a fracture developed. The transduce sound resonances created in the bone during rasping are converted to an analogue electrical signals that were sent to a Zoom H4n handheld recording device which recorded the signal to a disk. The recorded signals subsequently were analysed using Matlab software and a spectrum analyzer using Fast Fourier Transforms (FFT).

RESULTS: Our analysis of the sound frequency response (SFR) during hammering of a rasp in the medullary canal of a porcine bone proved that the (SFR) changes are influenced by the structural integrity of the Rasp-femur interface. The pitch of the resonance increases as the rasp approaches optimal tension and grip in cortical bone. The SFR graph shifted to the right between successive hammer blows as the fixation stiffness increased and that was reflected by increasing resonance frequencies, Once bone fracture developed this structure was compromised leading to a change in the pitch and duration of the resonance. When the tension decreased due to the fracture The SFR graph shifted to the left as the structure no longer has the capacity to resonate to the same extent. SFR analysis can detect accurately the rasping end point where the risk of fracture increases if hammering continued beyond it.

CONCLUSION: There is a relationship between hammering sound frequency response during rasping and internal stress in the bone which could be used as an objective method to predict and prevent the development of intraoperative micro-fracture through the identification of insertion end point.

O19B4

Jumbo Cup Causes Hip Center Elevation in Revision THA

Primary Author: Nick Dong

Institution: Stryker

Coauthors: Christopher Heffernan (Stryker), Jim Nevelos (Stryker), Michael Ries (Dept of Orthopaedics, University of California San Francisco, CA, United States)

INTRODUCTION: Acetabular revision Jumbo cups are used in revision hip surgeries to allow for large bone to

implant contact and stability. However, jumbo cups may also result in hip center elevation and instability. They may also protrude through anterior wall leading to ilopsoas tendinitis.

METHODS: The study was conducted using two methods: . Computer simulation study 265 pelvic CT scans consisting of 158 males and 107 females were converted to virtual 3-dimensional bones. The average native acetabular diameter was 52.0mm, SD=4.0mm (males in 52.4mm, SD=2.8mm and 46.4mm, SD=2.6mm in females). Images were analyzed by custom CT analytical software (SOMATM V.3.2) and over-sized reaming was simulated. Four distinct points, located in and around the acetabular margins, were used to determine the reamer sphere. Points 1, 2, 3 were located at the inferior and inferior-medial acetabular margins, and Point 4 was located superiorly and posteriorly in the acetabulum to simulate a bony defect in this location, Point 4 was placed at 10%, 20%, 30%, 40%, 50% and 60% of the distance from the superior - posterior margin of the acetabular rim to the sciatic notch to simulate bony defects of increasing size. (Figure 1) Radiographical study Retrospective chart review of patient records for all cementless acetabular revisions utilizing jumbo cups between January 1, 1998 and March 30, 2012 at UCFS (98 patients with 57 men, 41 women). Jumbo cups: ≥ 66 mm in males; < 62 mm in females. Reaming was directed inferiorly to the level of the obturator foramen to place the inferior edge of the jumbo cup at the inferior acetabulum. To determine the vertical position of the hip center, a circle was first made around both the jumbo and the contralateral acetabular surfaces using Phillips iSite PACS software. The center of this circle was assumed to correspond to the "hip center". The height of the hip center was estimated by measuring the height of a perpendicular line arising from the interteardrop line (TL) and ending at the hip center.

RESULTS: The computer simulation and radiographic analysis demonstrated similar results. The computer simulation predicted that the hip center shifted superiorly and anteriorly as the reamer size increased. The hip center shifted 0.27mm superiorly and 0.02mm anteriorly for every millimeter in diameter increased for the reaming. (Figure 1) Anterior column bone removal was increased 0.86mm for every 1mm of reamer size increase. The results of radiographical study showed average superior placement of 1.64mm. (Table 1)

DISCUSSION: Use of a jumbo cup in revision THA re-

sults in elevation of the hip center. Therefore a longer femoral head may be needed to compensate for hip center elevation when a jumbo cup is used. Reaming for a jumbo cup can also result in loss of anterior bone stock and protrusion of the cup anteriorly which may cause iliopsoas tendonitis.

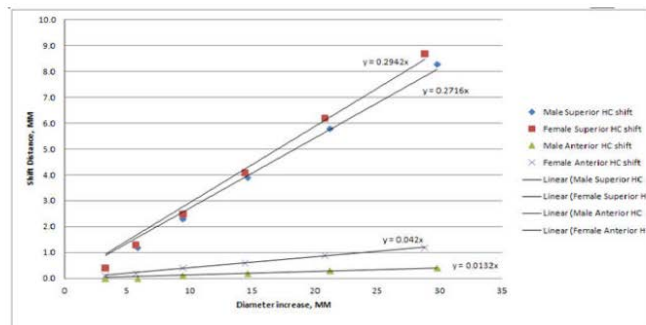


Figure 1. Average jumbo cup center shifts as a function of diameter increase (N male=158, N female=107)

Table 1. Results of radiographical study (UCSF)

	Cup Size (mm)	Hip Center Difference (A, mm)	Superior Placement (d, mm)
AGGREGATE DATA (N=116)	67.3	8.77	1.64
Male(N=69)	69.1	9.71	3.11
Female(N=47)	64.9	7.45	-0.4
P-value	0	.209	0.03

O19B5

Effects of Surgical Positions on the Incidence of DVT After Anterolateral MIS-THA

Primary Author: Arihiko Kanaji

Institution: Department of Orthopaedic Surgery, Keio University, School of Medicine

Coauthors: Toru Nishiwaki (Department of Orthopaedic Surgery, Keio University, School of Medicine), Yoshinari Fujita (Department of Orthopaedic Surgery, Keio University, School of Medicine), Atsushi Funayama (Department of Orthopaedic Surgery, Keio University, School of Medicine)

BACKGROUND AND PURPOSE: Deep venous thrombosis (DVT) in patients who underwent total hip arthroplasty (THA) is one of the most devastating complications, which often results in severe morbidity and mortality. Previous studies suggested that the choice of surgical approach and surgical position of THA could affect the femoral venous flow velocity and thereby the incidence of DVT and pulmonary embolism (PE). However, this hypothesis remained to be elucidated. The purpose of the present study was to clarify the potential involvement of surgical positions in the occurrence of DVT and PE after THA.

MATERIAL AND METHOD: 452 cases who underwent minimally invasive surgery (MIS)-THA with anterolateral approach were included in the present study. The patients were allocated into two groups; those underwent anterolateral MIS-THA in supine-position (AL-S group, 127 cases) and those underwent anterolateral MIS-THA in lateral-position (AL-L group, 225 cases). There were no significant differences in the baseline characteristics, mean age, body mass index, and preoperative D-dimer levels between the two groups. The mean intraoperative blood loss and surgical time were also comparable between the two groups. Routine DVT prophylaxes, including intracutaneous administration of anticoagulants, were performed for all the patients in the present study. Diagnosis of DVT and PE were made by multi-detector row CT scans. Serum D-dimer levels were measured at 3 and 7 days after the surgery. The chi-square test was used to compare the incidence of DVT and PE and the unpaired t-test was used to compare the serum D-dimer levels in the two groups. A significance level of $p < 0.05$ was used for all comparisons.

RESULTS: DVT was detected in 7 cases (6.3%) in the AL-S group and 35 cases (14.1%) in the AL-L group. There was no case with PE in the AL-S group but one in the AL-L group. The incidence of DVT in the AL-S group was significantly lower than that in the AL-L group ($p = 0.041$). On the other hand, there was no statistically significant difference in the incidence of PE or in the serum D-dimer levels between the two groups.

DISCUSSION: To our knowledge, this is the first study to evaluate the effects of surgical positions on the incidence of DVT and PE after MIS-THA. The results of the present study showed that patients who underwent MIS-THA in supine-position exhibits lower incidence of DVT than those did in lateral-position. On the other hand, due to a lower incidence rate, we could not find a significant difference in the occurrence of PE between the two groups. Nevertheless, the present study suggests that supine-position is preferable over lateral-position in avoiding thrombosis-related complications after MIS-THA.

O19B6

Short Stems for Total Hip Arthroplasty: Initial Experience with the Microplasty Stem

Primary Author: Kazuhiro Oinuma

Institution: Funabashi Orthopedic Hospital

Coauthors: Tatsuya Tamaki (Funabashi Orthopedic Hospital), Yoko Miura (Funabashi Orthopedic Hospital), Hideaki Shiratsuchi (Funabashi Orthopedic Hospital)

INTRODUCTION: Short stems have become increasingly utilized with advent of less invasive surgery and rapid-recovery protocols. Several studies have demonstrated good long-term survivorship and decreased perioperative complications of short stems. Others however have shown an increased risk for periprosthetic fracture when short implants are used, particularly when used in poor quality bone. The objective of this study is to report an initial experience with 565 new short stems used for total hip arthroplasty (THA).

METHOD: We reviewed 565 THAs in which a short stem (TaperLoc® Microplasty™ stem, Biomet) was used in 457 patients. 107 patients underwent one-stage bilateral THA. The preoperative diagnosis was 433 in developmental dysplasia of the hip (DDH), 70 hips in primary osteoarthritis, 29 hips in avascular necrosis, 13 in traumatic osteoarthritis, 10 hips in femoral neck fracture or failed femoral neck fracture fixation, 7 hips in rheumatoid arthritis, and 4 in others. In 433 hips in DDH, 339 hips were in Crowe type 1, 38 hips were in Crowe type 2, 16 hips were in Crowe type 3, 9 hips in Crowe type 4, and 31 hips had previous surgery. The mean age of patients at surgery was 63.7 years. 457 hips were in female patients and 108 hips in male patients. All operations were performed through a direct anterior approach in a supine position on a standard surgical table.

RESULTS: The mean operative time was 47 minutes. The mean operative blood loss was 326g. Two stems subsided greater than 2 mm within the first 3 weeks after surgery, but they were asymptomatic and stabilized after then. These subsided stems were in patients who had had a previous surgery. Three femoral fractures occurred in patients with Crowe type 2, 3, and failed femoral neck fracture fixation within 1 week postoperatively. These two patients with Crowe type 2 and 3 required re-surgery with circular cables. The patient with failed femoral neck fracture fixation had revision surgery. There was one intraoperative non-displaced fracture which was treated with a circular cable. There were no other complications such as dislocation, infection, symptomatic deep venous thrombosis, and motor nerve palsy.

CONCLUSION: The use of a short stem is considered to be a viable option for patients with primary OA, mild dysplasia, rheumatoid arthritis, avascular necrosis, traumatic arthritis. However, in patients with severe dysplasia and failed femoral neck fracture fixation, it could take a great risk of postoperative femoral fracture.

O19B7

The Effectiveness of Arthroscopic Intervention on Femoroacetabular Impingement

Primary Author: Harun Yasin

Institution: GMMF

Femoroacetabular impingement (FAI) syndrome is one of the significant reasons for hip pain, loss of ROM at hip joint and developing early osteoarthritis at young active adults. FAI is not a new term and it is treated successfully with open surgical techniques. Some disadvantages of open surgical techniques has lead orthopedists to develop arthroscopic techniques. At this study, we aimed to assess the effectiveness of arthroscopy at the treatment of FAI. We included 25 patients (19 male, 6 female) and evaluated retrospectively which has gone under arthroscopic surgery for the treatment of FAI at Gulhane Military Medicine Academy, Department of Orthopedics and Traumatology and Ankara Koru Hospital, Department of Orthopedics and Traumatology between January 2009 and May 2012. We have evaluated modified Harris Hip Score and Visual Analogue Score (VAS) preoperatively and postoperatively at all of our patients. Also we have evaluated, hip internal rotation and flexion range of motions clinically. Mean preoperative Harris Hip Score was 68,52 (range 55–76), mean postoperative score was 88,84 (range 72–98). Mean preoperative flexion ROM was 87, 6 (range 80–95) and 108,2 (range 90–120) postoperatively. Also 4,4 (range 0–5) degrees of mean preoperative internal rotation ROM increased to 19,80 range (10–30) degrees postoperatively. Mean preoperative alpha angle was 76,76 (range 60–90) and it was decreased to 41,76 (range 34–48) postoperatively. Mean preoperative visual analog score were decreased from 8,63 to 2,8 postoperatively. We had to perform a second look arthroscopy to a patient because of inadequate resection. Also femoral neck stress fracture occurred at a patient probably due to early weight bearing. Transient sciatic nerve neuropraxia occurred at 3 patients and, transient ankle pain (approximately 6 weeks) had occurred at 2 patients due to traction. Loss of sensation has occurred at

a patient due to lateral femoral cutaneous nerve injury during portal placement. With these results, we assessed that arthroscopic treatment of the FAI syndrome is successful with minor complications comparable to open procedures.

Is there Opportunity for Improvement?

O20A2

Bicruciate Retaining TKA: Is it possible? Is it Necessary?

Guest Faculty: Alfred J. Tria Jr., MD

Institution: St. Peter's University, Somerset, NJ, USA

Bicruciate TKA is not a new concept and was initially explored in the 1980s. The Geometric TKA was not a successful design but was followed by designs from Townley and Cloutier who reported quite acceptable midterm results. Pritchett and Romagnoli have implanted combinations of partial knee replacements that save both cruciates and have shown desirable results.

The posterior stabilized and cruciate retaining TKAs have controlled the market place for the past 25 years but there is a persistent 15% incidence of unexplained knee pain that may be related to the status of the cruciate ligaments. New cruciate sparing TKA designs are now returning to the market and offer more normal kinematics and proprioception. The question is whether the knee designs will be user friendly to the operating surgeon and whether they can stand the test of time as the PS and CR TKAs already have.

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O20A3

Condylar Differential in Planned Tibial Cuts in Total Knee Replacement: an Alternative to Computer Navigation

Primary Author: Kodali Siva Rama Prasad

Institution: Prince Charles Hospital

Coauthors: Emil Schemitsch (2St Michael Hospital, University of Toronto, Toronto, Canada), Peter Lewis (Prince Charles Hospital, Merthyr Tydfil, united kingdom)

INTRODUCTION: Mechanics and kinematics of the knee following total knee replacement are related to the mechanics and kinematics of the normal knee. Restoration of neutral alignment is an important factor affecting the long-term results of total knee rereplacement. Tibial cut is a vital and crucial step in ensuring adequate and appropriate proximal tibial resection, which is essential for mechanical orientation and axis in total knee replacement. Tibial cut must be individually reliable, reproducible, consistent and an accurate predictor of individual anatomical measurements. Conventional tibial cuts of tibia with fixed measurements can not account for individual variations. While computer navigated total knee replacement serves

as a medium to achieve this objective, the technology is not universally applicable for differing reasons. Therefore we evolved the concept and technique of Condylar Differential for planned tibial cuts in conventional total knee replacement, which accounts for individual variations and reflects the individual mechanical orientation and alignment.

METHODS: We used the Condylar Differential in 37 consecutive total knee replacements since August 2009. We also applied the technique in valgus knees and severe advanced osteoarthritis. First a vertical line is drawn on the digital weight bearing anteroposterior radiograph for mechanical axis of tibia. Then a horizontal line is drawn across and perpendicular to the mechanical axis of tibia. The distances between the horizontal line and the lowest reproducible points of the articular surfaces of the medial and lateral tibial condyles respectively are measured. The difference between the two measurements obviously represents the Condylar Differential. Condylar Differential, adjusted to the nearest millimetre, is maintained in executing the tibial cuts, if necessary successive cuts.

RESULTS: Condylar Differential measurement showed a very wide variation, ranging from 8-6 (2 mm) to 10-0 (10 mm). We found that prior measurement of Condylar Differential is a simple, consistent and effective estimate and individualises the tibial cut for optimal templating of tibia in total knee replacement. We encountered no problems, adopting this technique, in our consecutive series of total knee replacements.

CONCLUSIONS: Condylar Differential contributes to optimal individualised tibial cut in conventional total knee replacement and is a useful alternative to computer navigated option with comparable accuracy in this respect. While we used the technique of Condylar Differential in digitised radiographs, this technique can also be applied to plain films, allowing for the magnification.

CLINICAL RELEVANCE: Condylar Differential could prove to be a useful alternative to computer navigated option in conventional total knee replacement. In addition, this technique can be adapted to unicondylar knee replacement.



O20A4 Compromises in the Femoral Anterior-Posterior Size Leads to Increased Laxity in Mid-flexion

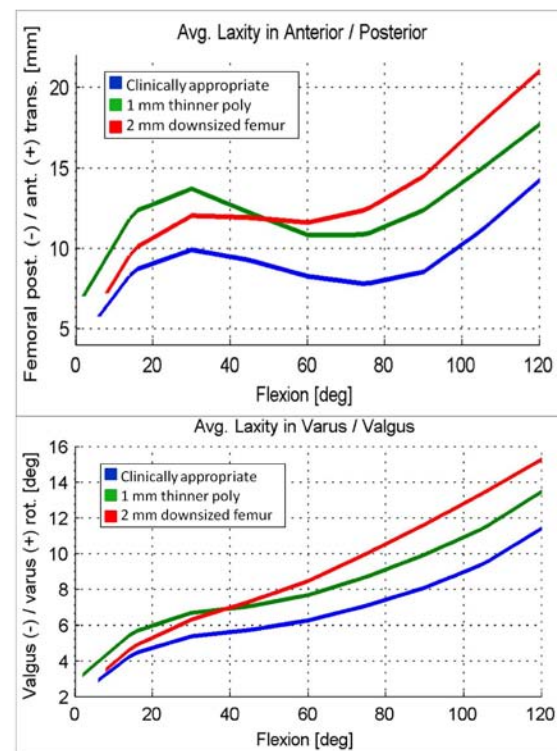
Primary Author: Fred Wentorf

Institution: Zimmer, Inc.

Coauthors: Charlie Parduhn (Zimmer, Inc.), Richard Moore (ADA Orthopaedic Clinic), John Kyle Mueller (Zimmer, Inc.)

The goal of total knee surgery is to allow patients to return to their desired activity level without pain. This goal is only attained if the outcome of the surgery is a stable joint. Stability in mid-flexion, from 30 to 60 degrees of knee flexion, is critical to the patient as most activities occur in this flexion range. One step in creating a stable joint

is proper balancing of the soft tissues in the knee. It is fairly intuitive that the change in polyethylene insert thickness can affect knee laxity, but the effect of anterior/ posterior (AP) femoral implant size on knee laxity is less intuitive. The goal of this study is to evaluate the effect of changing the femoral AP size on knee laxity specifically in mid-flexion. Six cadaveric specimens were evaluated using a six degree of freedom (DOF) robot arm (Kuka Robotics, Augsburg, Germany) incorporated with a 6 DOF load cell (AMTI, Watertown, MA). Translational laxities were performed in the medial, lateral, anterior, and posterior directions with a 100 N maximum load applied. The rotational laxities were evaluated in varus and valgus with 12 Nm applied, and internal and external with 6 Nm applied. All laxities were performed with a compressive load of 44 N. Laxities were evaluated at zero, 15, 30, 45, 60, 75, 90, 105, and 120 degrees of flexion. The first laxity evaluation was performed after a total knee orthopaedic surgeon implanted a cruciate retaining implant, which was considered the clinically appropriate size. The next evaluation was performed with a 1 mm smaller polyethylene insert thickness. The final evaluation was performed after the original femur was removed and a femur with a 2mm smaller ap dimension was put it in its place and the original poly insert was used. The effect of decreasing the femoral AP length by 2mm was shown to have effects on knee joint laxity in mid-flexion. The increase in AP laxity was 2.1 mm at 30 degrees, 2.7 mm at 45 degrees, and 3.3 mm at 60 degrees of knee flexion (Figure 1). The increase in varus/valgus (VV) laxity was 0.9 degree at 30 degrees, 1.5 degrees at 45 degrees, and 2.2 degrees at 60 degrees of knee flexion (Figure 2). The smaller insert thickness increased laxity with a similar magnitude throughout all the flexion angles measured in this evaluation. However, decreasing the femoral AP size had a smaller effect in early flexion on joint laxity, but that effect increased as the flexion angle increased (Figure 1 & 2). These two compromises had similar effects at 40 degrees for VV laxity and 50 degrees for anterior/posterior laxity. Decreasing the femoral AP size by 2mm was found to have a similar effect in laxity in mid-flexion as decreasing the poly insert thickness by 1 mm.



O20A5

Revision Total Knee Arthroplasty Using a Second Generation Constrained Condylar Knee Prosthesis

Primary Author: Naoki Nakano

Institution: Department of Orthopaedic Surgery, Kobe University Graduate School of Medicine

Coauthors: Tomoyuki Matsumoto (Department of Orthopaedic Surgery, Kobe University Graduate School of Medicine), Hirotugu Muratsu (Department of Orthopaedic Surgery, Steel Memorial Hirohata Hospital), Nao Shibamura (Department of Orthopaedic Surgery, Kobe Kaisei Hospital), Takehiko M

INTRODUCTION: Since 2006, for revision total knee arthroplasty (TKA), we have used a second-generation constrained condylar knee prosthesis with a redesigned patellofemoral articulation, right and left femoral components, modular stem extensions for both the femoral and tibial components, and a new locking mechanism for the constrained tibial polyethylene liner. A feature of this prosthesis is that it allows 2° of internal-external rotation and 1.25° of varus-valgus angulation. Theoretically, this design helps the soft tissues around the prosthetic interfaces to ab-

sorb force. The purpose of the present study was to evaluate the clinical and radiographic outcomes of revision TKA using this modern constrained condylar knee prosthesis.

METHODS: 41 revision TKAs in 41 patients using the Legacy Constrained Condylar Knee prosthesis (LCCK; Zimmer, Warsaw, IN, USA) constituted the study group. The cases comprised 7 men and 34 women with a mean age of 73.2 years at the time of the revision surgery. The original diagnosis was predominantly osteoarthritis (85.4%). The most common reason for revision surgery was aseptic loosening of a metal component (75.6%). The mean interval between the primary and revision surgeries was 66.4 months. The mean follow-up period after revision surgery was 37.4 months. We used this prosthesis for revision surgery when a posterior-stabilized (PS) prosthesis was thought to be insufficient because of severe bony defects or severe joint instability. The results were evaluated on the basis of the range of motion (ROM), Knee Society knee score (KSKS), Knee Society function score (KSFS), and the radiological femorotibial angle (FTA).

RESULTS: The mean KSKS improved after revision surgery from 43.8 to 82.9

CONCLUSION: This study showed that the use of the second-generation constrained condylar knee prosthesis in revision TKA provided relatively good clinical and radiographic results. Comparative study with other types of constrained condylar knee prosthesis should be performed to make a final decision whether this relatively new joint prosthesis is advantageous for patients who undergo revision TKA.

O20A6

A Medially Conforming Ball-and-Socket Tibiofemoral Articulation Arthroplasty (MRKTM) Versus a Fixed Bearing Posterior Stabilised Arthroplasty (PFC®) at 5-Year Follow up: A Randomized Controlled Trial

Primary Author: Mazin S. Ibrahim

Institution: University College London Hospital

Coauthors: Haider Twaij (University College London Hospital), Fares S. Haddad (University College London Hospital)

INTRODUCTION: The ball-and-socket articulation of the medial compartment with its femoral rollback profile represented by the Medial Rotation Knee™ (MRK-TM) has shown better high-end function as reflected by the Total Knee Function Questionnaire (TKFQ) compared to a conventional fixed bearing knee design, specifically, the Press Fit Condylar® Sigma Posterior Stabilised Knee System (PFC®) at one- and two-year follow-up. This has not been investigated or analysed at five-year follow-up. We aimed to investigate whether the MRKTM design differences would be associated with (1) improved range of movement (ROM) at five years; and (2) improved functional scores: American Knee Society Score (AKSS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Oxford Knee score, SF-36, and TKFQ scores compared to (PFC®) at five years.

METHOD: We reviewed 80 matched patients in a single-centre, single-blinded, randomized, controlled trial comparing the MRKTM design to the PFC® prosthesis at a minimum five-year follow-up. Our primary end point was ROM at five years. Our secondary end points were AKSS, WOMAC, Oxford Knee, SF-36, TKFQ scores and radiological parameters at five years. SPSS version 17.0 software was used for data analysis. The two-sample Student's t test for parametric data or the Mann-Whitney U test for nonparametric data were undertaken to compare the two cohorts with respect to clinical and radiographic variables. An independent research person who was not involved in the original operation and was blinded to the choice of prosthesis reviewed all patients in an outpatient setting.

RESULTS: The mean ROM was 104.2° and 114.3° in the PFC® and MRKTM groups, respectively ($p=0.001$). The mean physical component scores of SF-36 were better in the MRKTM group compared to the PFC® group (49.3 versus 29, $p=0.002$). There were no differences in AKSS, TKFQ, WOMAC, Oxford Knee scores, mental component of SF36 and satisfaction at five-year follow-up. Only one patient required revision surgery in the MRKTM group due to infection, and only two revisions in the PFC® group; one as a consequence to infection and another to persistent pain. This leads to 97.3% survivorship for the MRKTM and 94.9% for the PFC® if revision is considered as the end point. Three patients died in each arm for reasons not related to their knee operation, and there were no signs of loosening up until their death. No radiological loosening was identified at five years in either of the implant cohorts.

CONCLUSION: Both implant designs relieve pain and improve function with comparable efficacy, including comparable high-end function at five years, but with significantly better ROM with the MRKTM design compared to PFC® design over this time period. Less revision cases were observed in the MRKTM design at five-year follow-up.

O20A7

Evaluation of Tibial Component Coverage in Total Knee Arthroplasty

Primary Author: Emam ElHak Abdel Fatah

Institution: The University of Tennessee

Coauthors: Mohamed Mahfouz (The University of Tennessee), Giles Scuderi (Lenox Hill Hospital), Lyndsay Bowers (The University of Tennessee)

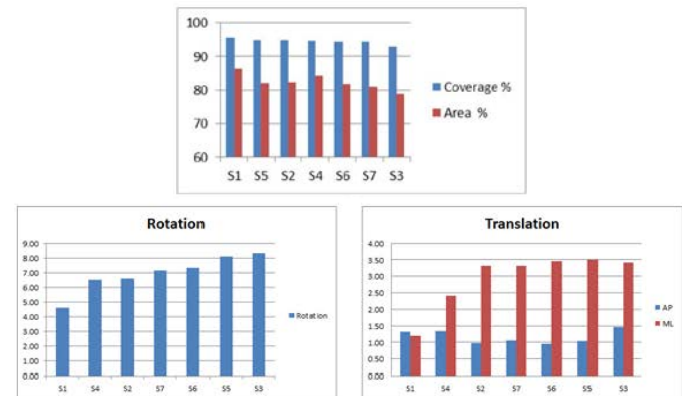
SUMMARY SENTENCE: This study evaluated the coverage and placement of the tibial component of seven contemporary knee systems using the same placement and sizing across multiple gender and ethnic groups.

INTRODUCTION: The objective of this study was to evaluate the coverage and placement of tibial components of contemporary knee systems across Caucasian and African American populations. Bones were added to a statistical atlas and tibial components were then sized and placed. Percentage area coverage and placement were evaluated for each tibial component design across both populations.

METHODS: The dataset consisted of 470 individuals (303 Caucasian males, 118 Caucasian females, 44 African American males, and five African American females). Bones were added to the statistical atlas and automatic landmarking was performed to calculate relevant surgical reference axes. Each bone was sized by selecting the component with the closest medial-lateral width. Components were then placed with 7° posterior slope and rotationally positioned along the AP axis of the tibia. Placement was optimized to match both the anterior and lateral aspects of implant to tibial anatomy. Sizing was then reevaluated to ensure no overhang of more than 0.5 mm. Coverage percentage between the implant and bone surface, as well as difference in surface area, was then calculated.

RESULTS: Results from the tibial coverage analysis are

shown in Figure 1. System 1 outperformed the remaining systems by achieving an overall coverage of 96%, followed by System 5 (95%). Figure 2 displays the amount of rotation and translation for each system. Systems 1 and 4 (asymmetric designs) achieved a less ambiguous placement by minimizing the amount of angular rotation, 4.6° and 6.49°, as well as AP and ML translation.



THA Fixation

O20B1

Cemented or Cementless Fixation – What’s Best?

Guest Faculty: Jasmeet Singh Saren, MsOrtho

Institution: HSC Medical Center, Kuala Lumpur, Malaysia

As we all know, cement is toxic not only to the patient but also to the surgeon. The cement monomer can penetrate the gloves and reach our blood stream in less than one minute. Ultrasound of the heart after cementing also shows a massive amount of fat emboli etc. that no doubt can actually be fateful.

Surgeons usually get good results regardless the method of fixation and if we look at the large registries with hundred of thousand of patients, they usually come out favoring uncemented fixation and the trend is on the rise.

I mainly use uncemented fixation and it is quick and easy. Also it is easy for me to upsize or downsize if needed with ease. Tapered and fully coated stems are easy to use and

uncemented cups are easy to reposition if I'm not happy with its position.

O20B3

The Effect of Femoral Stem Geometry on Fixation Stability: a Finite Element Analysis

Primary Author: Robert D. Russell

Institution: University of Texas Southwestern Medical Center

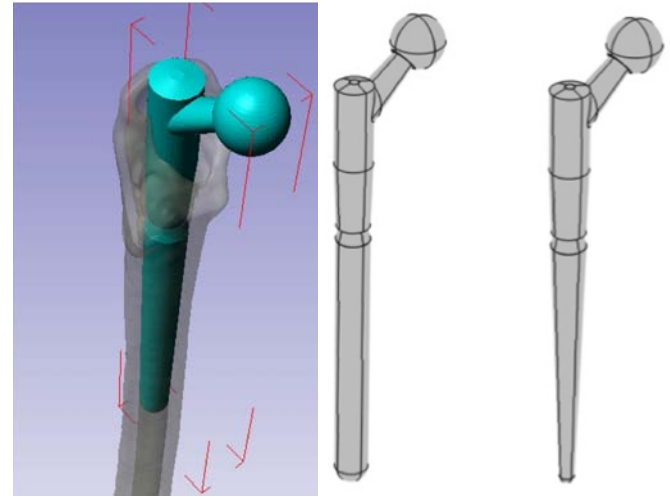
Coauthors: Michael H. Huo (University of Texas Southwestern Medical Center), Victor Kosmopoulos (University of North Texas)

INTRODUCTION: Obtaining stable femoral fixation in revision total hip arthroplasty (THA) is challenging. Femoral defects may eliminate the option of proximal metaphyseal fixation requiring the use of an implant that obtains diaphyseal fixation. Recently, tapered stem geometry has been increasingly used in complex revision THAs. Surgeons have reported obtaining clinically stable fixation using tapered stem geometry in the setting of severe bone defects, however, radiographic subsidence is common. The purpose of this study was to develop a finite element analysis to compare the fixation stability of cylindrical and tapered stem geometry.

METHODS: Three-dimensional (3D) computed tomography (CT) reconstruction images of an anatomic femur model were used to create a digital femur. Two femoral stems were also developed: 1) a cylindrical geometry with an 18 mm diameter, and 2) a 2-degree taper geometry with a maximum diameter of 18 mm. Each stem was virtually implanted into the femur model that was prepared to have 0.05 mm of press-fit. The implant was loaded twice, and the first load (868 N) was half the magnitude of the second load (1736 N). Outcomes recorded included displacement of the stem and contact pressure at the stem-implant interface.

RESULTS: The cylindrical stem had less displacement than the tapered stem (176 μ m vs. 227 μ m) under the same loading conditions. The average contact pressure of the cylindrical stem was 13.2 MPa vs. 3.36 MPa for the tapered stem. The calculated stiffness of the cylindrical stem was 11,239 N/mm compared to 7,417 N/mm for the tapered stem.

CONCLUSION: Although tapered stem geometry has been increasingly used in revision THA, subsidence of greater than 5 mm has been reported in up to 20% of patients. This finite element analysis demonstrates that tapered stem geometry results in lower contact pressure and higher displacement (subsidence) under the same loading conditions as cylindrical stem geometry.



O20B4

Distal Canal Filling Ratio of Cementless Stem with the Proximal Fixation Types and the Influence to the Periprosthetic Femur

Primary Author: Masashi Kawasaki

Institution: Konan Kosei Hospital

Distal canal filling ratio of cementless stem with the proximal fixation types and the influence to the periprosthetic femur.

PURPOSE: The purpose of this study was to calculate distal canal filling ratio for cementless stem with the different two proximal fixation types dividing into three proximal femoral morphologies, and to investigate clinical results and the influence to the periprosthetic femur for proximal femoral morphology between two groups.

MATERIALS AND METHODS: The subjects were total 133 joints of total hip arthroplasty (THA) 61 joints (FF group) was performed using supersecurfit HA of fit and fill stem and THA 72 joints (TW group) was performed using Accolade of tapered wedge stem. Average age was 63 years old. Male was 12 cases and female was 107 cases. Average follow-up was 3.5 years (2-5). Proximal femoral morphol-

ogy was classified as three groups, Stovepipe; canal flare index(CFI) less than 3.0, Normal; CFI3.0~4.7, Champagne flute; CFI more than 4.7. FF group of stovepipe was 12 joints, TW group was 11. Normal was 45, 52 respectively and Champagne flute was 4, 9. We investigated Harris Hip Score, thigh pain, canal filling ratio of smooth distal portion of the stem (the middle-third and distal-third of the stem), spot welds, clear zone, stress shielding, cortical hypertrophy, subsidence and stem stability on radiographs for different two stems was evaluated dividing into three femoral morphology.

RESULTS: In all femoral morphology, canal filling ratio of the distal-third of the stem in FF group was statistically significant greater than that in TW group. With respect to canal filling ratio of the middle-third of stem, champagne flute of FF group was statistically significant greater than that of TW group. The number of clear zone in non-coating area was found FF group was statistically significant greater than TW group. Stress shielding of FF group was statistically significant higher than that of TW group. Harris Hip Score, thigh pain, cortical hypertrophy, subsidence were not statistically significant between FF group and TW group.

DISCUSSION: There was good for clinical results of different two stems of proximal femoral fixation types. Distal canal filling ratio in FF group was great for the reason that non-coating area of stem was long and cylindrical type, as a result it was thought that the occurrence ratio of stress shielding in FF group was higher than that in TW group.

CONCLUSION: Tapered wedge stem indicated lower influence of periprosthetic femur than fit and fill type stem.

O20B5

Intramedullary Aspiration of Ilium During Cementing of the Socket in Total Hip Arthroplasty Improved Radiographic Appearance

Primary Author: Seneki Kobayashi

Institution: Department of Orthopaedic Surgery, Suwa Red Cross Hospital

Coauthors: Toshimitsu Momose (Department of Orthopaedic Surgery, Suwa Red Cross Hospital), Hiroyuki Nakagawa (Department of Orthopaedic Surgery, Suwa Red

Cross Hospital), Satsuki Furukawa (Department of Orthopaedic Surgery, Suwa Red Cross Hospital), Shunsuke Miyaoka (Department of Orthopaedic Surgery, Suwa Red Cross Hospital)

BACKGROUND: The method of intramedullary aspiration of the ilium during cementing of the THA socket was developed to minimize bleeding on the acetabular bony bed. Improved cement-bone interface around the socket has been shown on radiographs made just after THA.

PURPOSE: We have been performing THA employing the method. We examined the acetabular bone-cement interface on radiographs made 1 year or more after THA.

METHODS: A series of 286 primary THAs (in 215 patients) that were followed up for 1 year or more were studied. The average patient age at THA was 70 years and 79% were in female patients. Hip disease etiology was primary osteoarthritis in 55%, developmental dysplasia of the hip 37%, and others 8%. Through the lateral approach, a socket and a stem were cemented. The acetabulum was reamed transversely at a lower anatomical level, preserving the subchondral bone or eburnated bone of the roof. Multiple 6 mm cement anchorage holes were made. Before cementing of the socket, an Exeter iliac-wing aspirator was introduced into the ilium proximal to the acetabulum and connected with suction that was maintained until the cement had hardened.

RESULTS: At 1 year, 93% of the sockets were classified as Hodgkinson type 0 (no demarcation) and 7% as type 1 (demarcation in outer 1/3). At the latest follow-up (3.2 years on average), 89% as type 0 and 11% as type 1. One-year radiogram was reported to be useful in predicting long-term results of cemented sockets. In our previous study of 405 sockets that were cemented without an iliac aspirator, Hodgkinson types at 1 year were type 0 in 75%, type 1 in 17%, type 2 in 7%, and type 3 in 1%. The results were significantly better in the present series in which the iliac aspirator was used.

CONCLUSION: The radiographic results in the present series which employed the intramedullary aspiration of the ilium during cementing of the socket were significantly better than those in a previous series of THAs that were performed without the method. The 1-year radiographic appearance of the cemented socket was reported to predict its long-term durability. The aspiration of the ilium during

cementing is expected to improve long-term durability of the socket.

O20B6

Revision Total Hip Arthroplasty Using an Acetabular Reinforcement Ring with a Hook

Primary Author: Kyung-Soon Park

Institution: Chonnam National University, Orthopedic Department

Coauthors: Taek-Rim Yoon (Chonnam National University, Orthopedic Department)

Revision Total hip Arthroplasty Using an Acetabular Reinforcement Ring with a Hook A Precise Follow-up, at Average 11.4 Years, of a Previous Report We previously reported the result of acetabular revision total hip arthroplasties (THAs) performed using an acetabular reinforcement ring with a hook (ARRH) in severe acetabular bony defects. Presently, we report the average 11.4 year follow-up results with 48 hips. Mean Harris hip scores improved from 52.6 points preoperatively to 82.0 points at the last follow-up. Acetabular revision was performed in nine cases, infection was occurred in five cases, isolated stem revision was done in one case and recurrent dislocation was occurred in only one case. The 11.4-year survival of revision THA with ARRH was 71% as the end point for acetabular revision surgery for any reason. This study shows that ARRH combined with bone graft is a useful treatment that produces relatively satisfactory clinical results.

KEYWORDS: Acetabular bone deficiency, Acetabular revision, Acetabular roof reinforcement ring with hook, Bone graft

O20B7

The Midterm Result of Cementless Total Hip Arthroplasty in the Fused Hip Using Ceramic on Ceramic Articulation

Primary Author: Taek-Rim Yoon

Institution: Chonnam National University, Orthopedic Department

Coauthors: Kyung-Soon Park (Chonnam National University, Orthopedic Department)

This study was undertaken to assess the midterm result of cementless total hip arthroplasty (THA) using ceramic on ceramic articulation performed for fused hips. Twenty-three patients (25 hips) with fused hip underwent THA conversion surgery and the mean follow-up period was 5.4 years. The types of approach were conventional posterolateral approach in 15 hips and modified two incision techniques in 7 hips and direct lateral approach with greater trochanter osteotomy in 3 hips. Postoperatively, range of motion exercises were encouraged after 2 to 3 days of bed rest and subsequent weight bearing crutch ambulation. Mean Harris hip score improved from 42.4 to 84.2 and mean leg lengthening of 36.6 mm was achieved. In the midterm follow-up there was no case with osteolysis around acetabular cup and femoral stem. In this study, there was no case of ceramic fracture and there was one case of squeaking. This study suggests that cementless THA performed for fused hips with ceramic on ceramic bearing articulation can provide good clinical results at midterm follow-up.

KEYWORDS: Fused hip, total hip arthroplasty, cementless, ceramic on ceramic Knee Kinematics II

Knee Kinematics II

O21A1

In Vivo TKA Kinematics for Subjects Walking Down a Ramp

Guest Faculty: Harold E. Cates, MD

Institution: Center for Musculoskeletal Research, University of Tennessee, Knoxville, TN, USA

Coauthors: Trevor F. Grieco, BS (Center for Musculoskeletal Research, University of Tennessee, Knoxville, TN); William H. Hamel, PhD (Center for Musculoskeletal Research, University of Tennessee, Knoxville, TN); Adrija Sharma, PhD (Center for Musculoskeletal Research, University of Tennessee, Knoxville, TN); Richard D Komistek, PhD (Center for Musculoskeletal Research, University of Tennessee, Knoxville, TN)

INTRODUCTION: Previous in vivo kinematic studies have been conducted on subjects performing activities that

can be recorded with a stationary fluoroscopy unit, which is limited by speed and constraints. More recently, a mobile fluoroscopy unit was developed that can be utilized to capture and analyze more challenging activities. The objective of this study was to determine the in vivo kinematics for subjects having a TKA while walking down a ramp, which has been described in previous studies as one of the most difficult activities for a patient having a TKA.

METHODS: Thirty cruciate retaining (CR) knee implants were assessed in this study. Fifteen subjects had a CR total knee arthroplasty (TKA) with a single sagittal radius, and 15 were implanted with a multi radii CR TKA. Fluoroscopic videos were captured for the patients while they performed a gait cycle down a ramp with a -10° incline using a custom developed mobile fluoroscopy unit (Figure 1). Each video was digitized, corrected for distortion, and then analyzed to determine kinematics using a 2D to 3D image registration technique. Statistical analysis was conducted at 95% confidence level to detect differences between the two groups.

RESULTS: Subjects having a single radius CR TKA experienced less motion of both condyles, including axial rotation, during the ramp down maneuver. On average, subjects having a single radius CR TKA experienced -0.4 (-6.7 to 3.7) and 0.0 (-4.8 to 3.2) mm of motion of their lateral and medial condyles, respectively. Subjects with a multi radii CR TKA, on average, experienced -2.4 (-8.8 to 3.6) and -1.0 (-7.3 to 5.3) mm of lateral and medial condyle motion, respectively. The difference in lateral condyle motion was found to be statistically significant ($p=0.042$). The amount of axial rotation was also different as the subjects having a single radius CR TKA experienced, on average, 2.7 (-6.4 to 6.5) degrees of rotation, while subjects having a multi radii CR TKA experienced 4.6 (-7.9 to 11.7) degrees. Subjects having a multi radii TKA also experienced a greater range and variability in the amount of motion that each subject achieved during this activity (Figure 2).

CONCLUSION: This is the first study to utilize mobile fluoroscopy to analyze the motion patterns for subjects walking down a ramp. Numerous articles have stated that patients having knee implants have difficulty performing this activity as it makes them uncomfortable. Subjects having a single radius CR TKA seemed to experience a more stable motion throughout this activity.

O21A2 Fluoroscopic Analysis of “Off the Shelf” vs. Patient Specific Knee Implants

Guest Faculty: Kurtz, WB; Zeller, IM;

Institution: Center for Musculoskeletal Research, University of Tennessee, Knoxville, TN, 37996, USA

Coauthors: Hamel, WH; Young, MA; Anderle MR; Komistek, RD

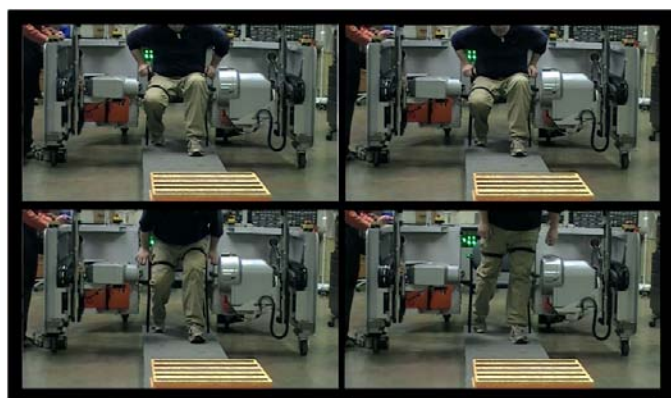
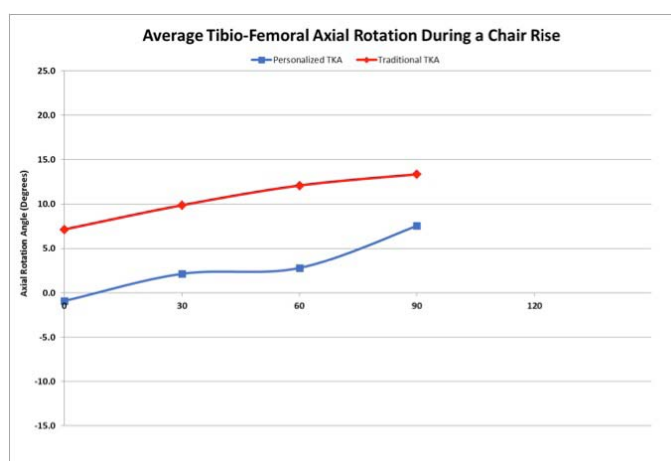
INTRODUCTION: Until recently, knee implants were designed using average patient demographics. More recently, patient specific posterior cruciate retaining (PCR) total knee arthroplasty (TKA) have been individually made based on the patient's anatomy using a CT scan pre-operatively. The objective of this study was to use a state-of-the-art mobile fluoroscopy unit to determine the in vivo kinematics for subjects having either a traditional, off-the-shelf (OTS) knee implant vs. subjects having a customized, individually made (CIM) knee implant that replicates their own femoral and tibial geometries.

METHODS: In vivo kinematics for 20 subjects, 11 of which having the CIM PCR TKA and 9 having a more traditional, OTS PCR TKA were assessed. A mobile fluoroscopic system was used while subjects performed a weight-bearing deep knee bend, rising from a chair (Figure 1) and normal gait under fluoroscopic observation. All the subjects were implanted by a single surgeon and each patient was deemed clinically successful (HSS Score >90) without any laxity or pain.

RESULTS: Differences in overall motion and pattern were evident between the two groups. During a deep knee bend, subjects having a CIM PCR implant experienced more posterior femoral rollback of their lateral condyle (2.1 vs. 0.1 mm) and greater axial rotation (4.2 vs. 2.9 degrees) than subjects having a traditional PCR TKA type. Also, 44.4% of the subjects having a traditional PCR experienced an anterior slide of their lateral condyle and a reverse axial rotation pattern, compared to only 9.0% of the subjects having a personalized PCR TKA. During the chair-rise activity, subjects having a traditional PCR TKA experience a posterior slide of their lateral condyle opposite the normal knee, while subjects having a custom PCR TKA experienced a roll forward motion typical in pattern for a normal knee, but less in magnitude. During a chair-rise, subjects having a traditional PCR TKA experienced 0.9 de-

degrees of axial rotation, while subjects having a personalized TKA experienced 5.3 degrees. Interestingly, subjects having a traditional PCR TKA experienced high magnitudes of femoral external rotation throughout the activity (opposite the normal knee), whereas the CIM subjects experienced a changed from external to internal rotation of the femur throughout the activity (similar to a normal knee in pattern) (Figure 2). On average, subjects having a custom PCR TKA experienced 112 degrees of weight-bearing flexion, compared to only 102 degrees for subjects with a traditional PCR TKA.

DISCUSSION: This is the first study to utilize mobile fluoroscopy to assess chair-rise and gait for subjects having two distinctly different TKA types. Subjects having a custom PCR TKA seemed to experience more normal-like kinematics patterns, more closely approaching that of the normal knee although less in magnitude. Subjects having a traditional PCR TKA seemed to experience greater variability in their kinematic patterns, differing from the normal knee.



021A3

In-vivo Kinematic Analyses of Three Different Designs of Polyethylene Inserts During Total Knee Arthroplasty (TKA)

Primary Author: Katsumasa Tei

Institution: Chibune General Hospital

Coauthors: Tomio Shimizu (Chibune General Hospital), Tomoyki Matsumoto (Kobe Graduate school of Medicine), Masahiro Kurosaka (Kobe Graduate school of Medicine), Ryosuke Kuroda (Kobe Graduate school of Medicine)

INTRODUCTION: Recently, tibial insert design of cruciate-substituting (CS) polyethylene insert is employed. However, in vivo kinematics of using CS polyethylene insert is still unclear. In this study, it is hypothesized that CS polyethylene insert leads to stability of femoro-tibial joint as well as posterior-stabilized (PS) polyethylene insert, even if PCL is sacrificed after TKA. The purpose of this study is an investigation of in vivo kinematics of three different tibial insert designs using computer assisted navigation system intra-operatively in TKA.

MATERIALS AND METHODS: Sixty-four consecutive patients who had knees of osteoarthritis with varus deformity were investigated in this study. All TKAs (Triathlon, Stryker) were performed using computer assisted navigation system. During surgery, three different designs of polyethylene tibial trial inserts (PS, CS, and cruciate-retaining (CR) polyethylene insert) were inserted respectively after implantation of femoral and tibial components. The kinematic parameters of the soft-tissue balance were obtained by interpreting kinematics curve, which display bicompartamental gaps throughout the ROM after implantation of each trial insert. During record of kinematics, the surgeon gently lifted the experimental thigh three times, flexing the hip and knee. Deviation of these three values in each ROM (30, 45, 60, 75, 90, 105, 120 degrees) was calculated in each tibial insert in each patient for descriptive analysis. The data were analyzed with a ANOVA test, and mean values were compared by the multiple comparison test (Turkey HSD test) (p

RESULTS: Regarding to values of compartmental gaps, there are no significance between three inserts in both medial and lateral compartments (Figure 1). On medial compartmental gaps, the values of deviations were significantly higher in CR insert than both of PS and CS insert in

ROM of over 45 degrees in extension (Fig 2a). In addition, concerning lateral compartmental gaps, the values of deviations were significantly higher in CS insert than both PS and CS insert in all ROM (Fig 2b). Furthermore, there was no significance between PS and CS insert in overall range of motion in both medial and lateral compartmental gaps (Fig 2a, b).

DISCUSSION: These results demonstrated that CS polyethylene insert has a stability of femoro-tibial joint nearly as well as PS polyethylene insert. The main design feature of Triathlon CS insert is single radius and rotary arc, in addition, the posterior lip is same as that of Triathlon CR, which can be the factor to avoid paradoxical anterior movement and to permit internal and external rotation between femoral and tibial component. Due to the design features and benefits, there is a high possibility that CS insert can lead same ROM as PS insert, although PS design can produce more ROM than the other type of insert type. Based on these backgrounds, it is suggested that CS insert may have an additional choice in TKA with some advantages especially in concerning of high activity patients like middle aged patients.

Figure 1

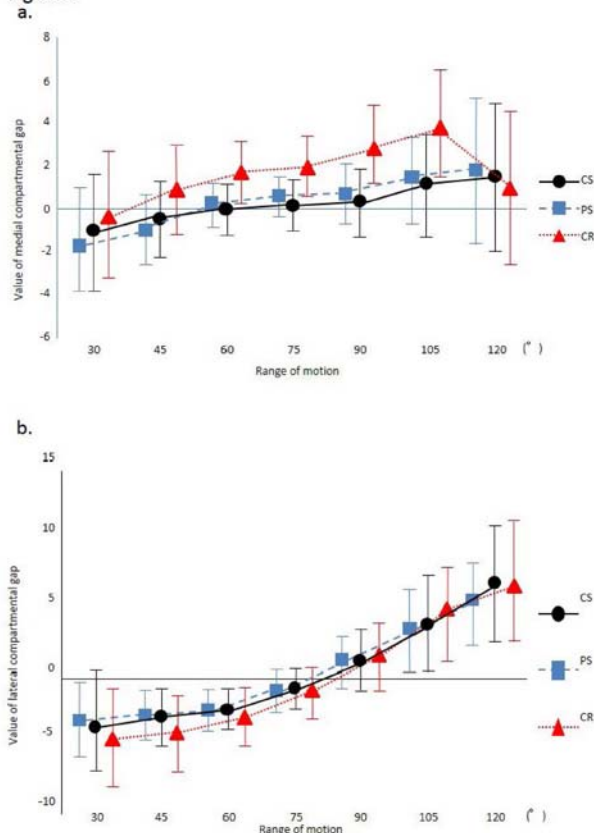
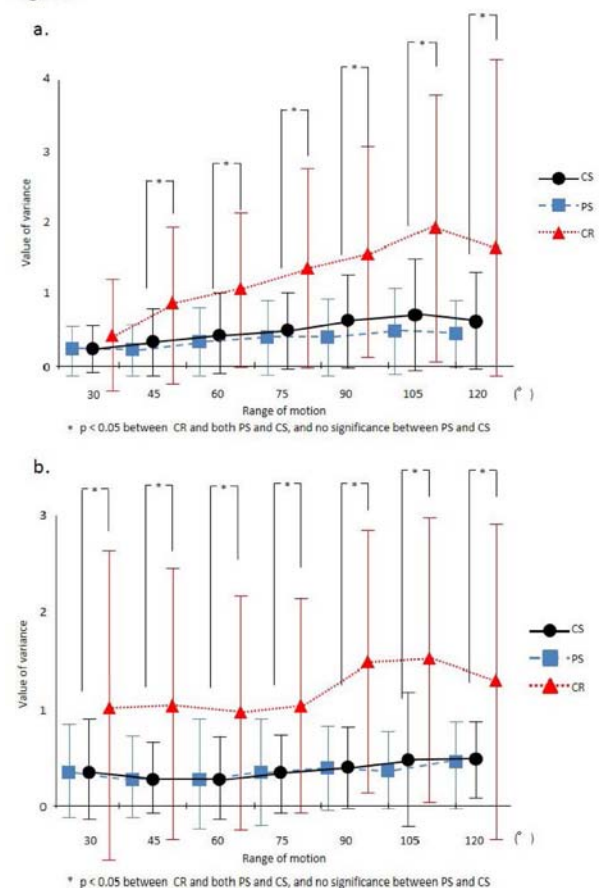


Figure 2



O21A4

Finer TKA Sizing Increments Allow for a Better Compromise: Experimental and Numerical Kinematic Results

Primary Author: John Kyle P. Mueller
Institution: Zimmer, Inc.

Coauthors: Marc Bandi (Zimmer, Inc.), Eik Siggelkow (Zimmer, Inc.), Iris Sauerberg (Zimmer, Inc.)

Surgeons strive to recreate a natural feeling knee using TKA systems with uniform shapes and finite sizing increments. When anatomy is in between the desired femoral component anterior/posterior (AP) length or tibial insert thickness, the surgeon must compromise. Few studies have shown the biomechanical effect of this compromise or the benefit of reducing the increments between component sizes. This study evaluates the effect of smaller compromises on the knee laxity envelope. This study uses both experimental and numerical methods. A six degree of freedom (DOF) robot arm (Kuka Robotics, Augsburg, Germany)

incorporated with a 6 DOF load cell (AMTI, Watertown, MA) was used to test 6 cadaver specimens. The laxity envelopes under low (44 N) and high (500 N) compressive loads were measured by applying 100 N in AP directions, and moments in the varus/valgus (VV) and internal/external (IE) directions (12 Nm and 6 Nm, respectively) at 0, 30, 60, 90 and 120 degrees flexion. Imaging of the specimens was used to determine the anatomical coordinate frame before implantation with a contemporary posterior stabilized TKA. The tests were performed on the initial TKA and after changing the insert thickness with finer increments, -1mm, +1mm and conventional increments, -2mm, +2mm. Specimen specific numerical models of the robot test were developed by testing a different group of 6 cadaveric specimens. Geometry was determined using imaging, and soft tissue structures were calibrated using robotic testing. The same robot test described above was repeated in numerical simulations using two ligament models. The results of the numerical and robotic tests were compared. Additionally, the effect of downsizing and upsizing the femur by changing the AP length in a system with fine increments, 2mm, and conventional increments, 4mm, was evaluated in the numerical model with low compression. Changes of 1mm simulate cases where anatomy is half way between the fine increment system and 2mm simulates between a conventional system. The insert robot and numerical experiments were in agreement (Figure 1). Increasing insert thickness by 1mm decreased laxity in VV, IE and AP directions while decreasing thickness increased the laxity. Changing the thickness by 2 mm doubled the effects in low compression testing. High compression tests exhibited smaller changes, especially in the AP direction. The femoral increment changes had the biggest effect at 90 degrees flexion in IE but affected all tested DOF (Figure 2). Like the insert tests, the change in laxity was doubled when the size increment doubled. There was no effect on femoral sizing in full extension but changes were evident through mid-flexion. Increasing the size options by decreasing TKA component increments to 1mm insert thickness and 2mm femoral AP length has a measureable effect on the laxity envelope. The change in laxity after upsizing or downsizing was reduced by half with a finer sizing scheme. The clinical consequences requires more investigation, however the current results suggest that smaller increments may reduce the effect of compromises surgeons face when a patient's anatomy is between sizes.

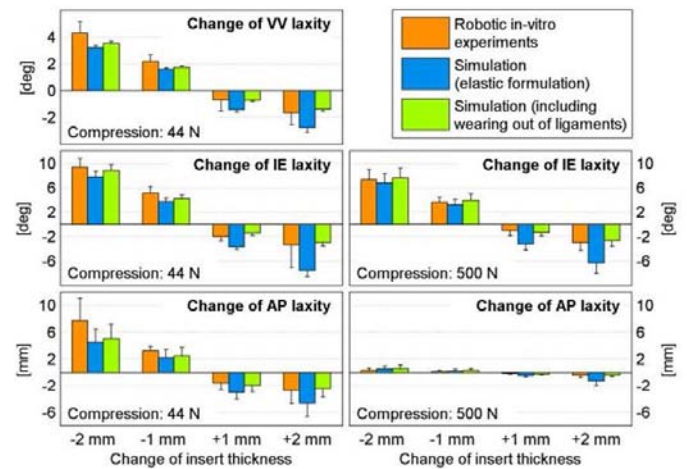


Figure 1: Laxity changes averaged over the whole arc of flexion resulting from varying the tibial inlay thickness (mean, s.d. for N=6 specimens).

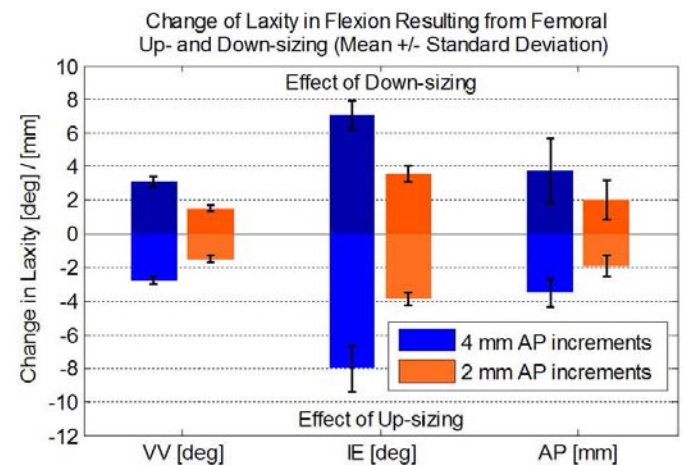


Figure 2: Change in laxity at 90 degrees flexion compared to initial implantation for downsized and upsized femurs with fine 2 mm increments and conventional 4 mm increments in AP length.

O21A5 In Vivo Comparison of 3D Patellofemoral Mechanics of Anatomic, Dome Shaped and the Normal Patella

Primary Author: Trevor F. Grieco
Institution: University of Tennessee

Coauthors: Adrija Sharma (University of Tennessee), Sumesh M. Zingde (University of Tennessee), Douglas A. Dennis (Colorado Joint Replacement), Richard D. Komistek (University of Tennessee)

BACKGROUND: Patellofemoral interactions can lead to complications and have become a major cause of revision surgery in total knee arthroplasty (TKA). High magnitude forces at the patellofemoral joint, coupled with small contact areas pose significant design challenges. There are

mainly two different types of designs for a TKA patella— anatomical and dome shaped, which stem from different design rationale. In this study, the 3D in vivo patellofemoral kinematics and contact behavior of the dome shaped and anatomic shaped patella were compared to the kinematics and contact behavior of the native patella in order to analyze if one design exhibits a distinct advantage over the other.

METHODS: Ten normal non-pathologic knees, ten implanted with the LCS-PS TKA (anatomic patella) and ten implanted with the PFC Sigma RP-PS TKA (dome patella) were analyzed under fluoroscopic surveillance while performing a weight bearing deep knee bend activity from full extension to maximum knee flexion. Relevant bone geometries of the normal patient set were segmented out from CT scans, and CAD models of implanted components were obtained from the manufacturer. 3D patellofemoral kinematics were obtained using 2D to 3D registration, and contact areas between the anterior surface of the femur and the posterior surface of the patella were calculated. For analysis, the contact areas were split into medial and lateral sections based on the longitudinal midline of the patella. Using the contact areas, separate medial and lateral contact points were calculated and tracked on the patella. The center point of the patella was also defined and tracked with respect to the femur in order to observe the path of the patella through the trochlea and femoral articulating region.

RESULTS: While both designs had patellar kinematics similar to those of a native patella, the anatomical design behaved more similarly to the native patella. The dome shaped patella exhibited greater variability in patellar tilt. Both patella designs tracked their respective trochlea and femoral articulating region consistently as did the normal patella. No incidence of patellofemoral separation was observed and the patella always remained in contact with the femur in all three groups at all flexion angles. The contact areas in the TKA groups increased from full extension to mid-flexion and then decreased with increasing flexion and were significantly smaller than that observed for the normal patella. The domed patella experienced higher contact areas compared to the anatomic patella. However, both were able to maintain sufficient contact areas so as to successfully withstand the high amount of forces generally observed in the patellofemoral joint. Contact points on the TKAs stayed closer to the midline of the patella compared to the normal patella.

CONCLUSIONS: Both the dome shaped and anatomical design perform well with respect to the native knee in-vivo as long as the implantation is done correctly and the surgery is successful.

O21A6

Comparison of Axial Rotation in Symmetrical Versus Asymmetrical PCR TKA

Primary Author: Adrija Sharma

Institution: University of Tennessee, Knoxville, USA

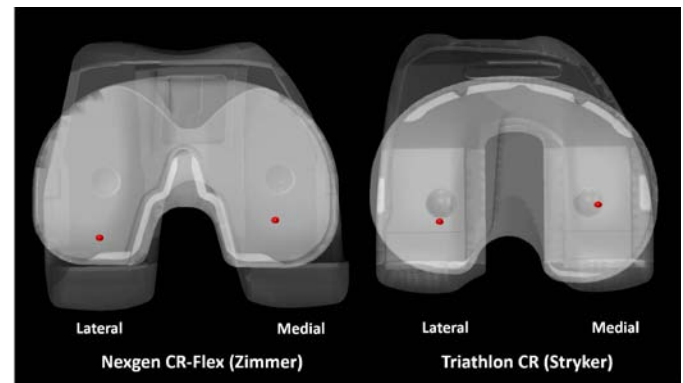
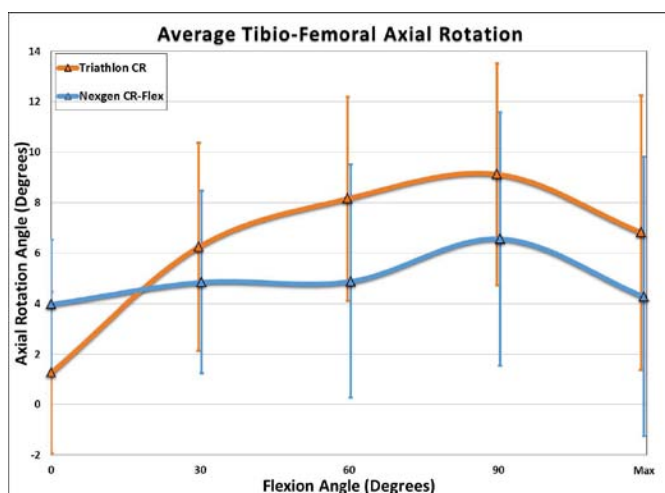
Coauthors: Trevor F. Grieco (University of Tennessee, Knoxville, USA), Harold E Cates (Tennessee Orthopaedic Foundation for Education and Research, Knoxville, TN)

BACKGROUND: Flexion of the normal knee is accompanied by external rotation of the femur with respect to the tibia due to the posterior motion of the smaller lateral femoral condyles and slight anterior movement of the larger medial femoral condyle. Posterior cruciate retaining (PCR) total knee arthroplasty (TKA) exhibits paradoxical anterior slide of their condyles and much less magnitudes of axial rotation (AR). Since the normal knee condyles are asymmetrical, asymmetrical PCR TKAs have been developed to improve AR. The study explores if asymmetrical designs truly offer a rotational advantage over symmetrical designs.

METHODS: The analysis was conducted in 12 patients with Nexgen-CR-Flex (Zimmer Inc., Warsaw, IN) and 13 patients with Triathlon-CR (Stryker, Orthopaedics, Mahwah, NJ) TKAs. While the Nexgen-CR-Flex incorporates J-shaped femoral condylar geometry, the Triathlon-CR is a single radius design. To facilitate AR the Nexgen-CR-Flex incorporates a larger lateral condyle than the medial condyle (asymmetric), while the Triathlon-CR has equal condyles (symmetric) but incorporates a polyethylene insert with a machined rotary arc. Finally, the Nexgen-CR-Flex TKA is implanted with a larger posterior tibial slope than the Triathlon-CR TKA. Fluoroscopic data was captured for the patients while they performed a weight bearing deep knee bend activity (DKB) from full extension (FE) to maximum knee flexion (MKF) using a custom developed mobile fluoroscopy system and analysed for kinematics using a 2D to 3D image registration technique at FE (0°), 30°, 60°, 90° and MKF.

RESULTS: Patients with Nexgen-CR-Flex TKA exhibited an external orientation of $4.0^{\circ} \pm 2.6^{\circ}$ of the femur with respect to the tibia at FE (Figure 1). AR increased slightly with increasing flexion and reached $6.6^{\circ} \pm 5.0^{\circ}$ at 90° knee flexion. Patients with the Triathlon-CR TKA exhibited a more neutral orientation of $1.3^{\circ} \pm 3.2^{\circ}$ of the femur at FE. The average amount of AR increased monotonically with increasing flexion and was found to be significantly higher at 90° of knee flexion ($9.1^{\circ} \pm 4.4^{\circ}$). Seven out of twelve patients with the Nexgen-CR-Flex TKA and none of the patients with the Triathlon-CR TKA exhibited reverse AR patterns from FE to MKF. While AR in the Nexgen-CR-Flex was mainly achieved by more posterior location of the lateral condyle compared to the medial condyle, the Triathlon-CR TKA achieved AR by posterior location of the lateral condyle and anterior movement of the medial condyle. On average the medial condyle of the Triathlon-CR TKA moved 5.3 ± 2.7 mm anteriorly from FE to 90° knee flexion.

DISCUSSION: Several patient, surgical, and design related factors play a role in determining postoperative knee kinematics. In the present study it was found that asymmetrical condylar design in PCR TKAs do not necessarily result in higher magnitudes of normal AR compared to symmetrical designs. One such cause may be the higher posterior slope in the Nexgen-CR-Flex design that might have caused the medial condyle to move more posterior than required, thereby reducing AR (Figure 2). The key is to correctly balance out the movement of the medial and the lateral condyles as happens in the normal knee.



THA & Innovative Concepts

O21B1

Cementation of Acetabular Liners into Secure Cementless Shells: An Example of Translational Research

Guest Faculty: John J. Callaghan, MD

Institution: University of Iowa, Iowa City, IA, VA Medical Center, Iowa City, IA, USA

Coauthors: Lawrence & Marilyn Dorr Chair (University of Iowa, Iowa City, IA, VA Medical Center, Iowa City, IA)

INTRODUCTION: Fixation of cementless acetabular components have demonstrated excellent long term durability with loosening rates of less than 2% at 15 years. However, polyethylene liner wear has been a major long term problem. A commonly encountered clinical scenario is one in which there is significant polyethylene wear in a secure cementless shell. The authors have previously performed a basic biomechanical experimental study to determine the optimal liner and shell preparation for construct durability. The authors employed this technique in a clinical study of patients with acetabular component wear and followed for an average of 5.1 years. The authors hypothesized excellent construct durability based on their mechanical study.

METHODS: The study prospectively evaluated a consec-

utive series of total hip arthroplasties where a worn acetabular liner was revised by cementing a new liner into the same shell. All cases were performed by a single surgeon. 31 consecutive hips in 30 patients with well fixed cementless acetabular shells and worn polyethylene liners were revised by cementing a new constrained liner into the existing acetabular shell. The backs of all acetabular liners were scored in a spider web pattern to a depth of 1 to 2 mm as was determined optimal in the previously performed basic study. Most patients were immobilized in a brace or cast for 6 weeks. Patients were evaluated at 2 to 10 years radiographically for progressive radiolucencies, migration and osteolysis and clinically for need for re-revision, Harris Hip Score, WOMAC Score and SF-36 Score.

RESULTS: The average age of the patients at the time of index surgery was 52 years (range, 33 to 78). The average BMI was 30.8 (range, 19 to 48). The shells had been in place an average 10.8 years (range, 5 to 21). 27 hips (87%) had minimum 2 year radiographic follow-up with an average length of follow-up of 5.1 years (range, 2.4 to 9.9). 2 hips (6%) demonstrated minimally progressive acetabular radiolucencies post-revision. There were no cases of acetabular component migration or progressive osteolysis. No hip required re-revision or dissociated since the time of the initial cemented liner revision. 2 hips (6%) have experienced single dislocations, both treated non-operatively. There were no cases of liner spin-out. All acetabular shells were radiographically stable at final follow-up.

DISCUSSION: Cementation of a liner into a well fixed cementless shell provided excellent fixation and no failures at average 5.2 year follow-up. No cases demonstrated progressive osteolysis and the vast majority of cases demonstrated complete or partial graft incorporation. Post-op dislocation was a minimal problem; however, most patients were immobilized in a brace or cast. This study demonstrates the benefit of defining a clinical problem, performing basic experimental work to find the optimal clinical solution and performing a clinical study to see if the results of the experimental study translate into optimal clinical results.

O21B2

Direct Anterior Approach for Complex Primary and Revision THA: My Experience Pushing the Envelope

Guest Faculty: Cass K. Nakasone MD, MSME

Institution: Straub Clinic & Hospital, Honolulu, HI, USA

Experience with the direct anterior approach continues to grow in the United States. Due to relatively limited experience (as compared to the posterolateral approach) utilizing this approach, the indications and contraindications of its use continues to evolve. Most surgeons who have recently adopted this approach continue to limit its use to relatively straight forward cases of primary hip arthritis. As surgeons gain more experience and comfort with this approach, the use of a direct anterior approach for more complicated cases related to primary or revision hip arthroplasty will likely increase.

I believe the direct anterior approach is a safe and useful approach for a wide variety of primary hip replacement and revision hip arthroplasty situations. At our institution, we use the direct anterior approach as the primary approach for most hip arthroplasty situations. We have used a single incision direct anterior approach for cases of hip deformity, previous childhood trauma resulting in deformity, removal of hardware and conversion to THA, as well as in cases with significant acetabular bone loss. We have used this approach for simple and complex acetabular revisions, simple and complex femoral stem revisions, two stage revisions for cases of infection and for periprosthetic fractures which required ORIF and femoral stem revisions.

This presentation is intended simply to share my experience with applying the direct anterior approach to more complicated cases related to primary hip arthritis and revision hip arthroplasty. Further study will be required before formal conclusions can be suggested. Our experience thus far have been very promising.

O21B3

The use of Sound Analysis to Guide Femoral Reaming in Uncemented Total Hip Arthroplasty: A New Concept

Primary Author: Ali Abdulkarim

Institution: Midland Regional Hospital Tullamore

Jackson (Institute of Technology Ireland), D Riordan (Institute of Technology Ireland), John Rice (Kerry General Hospital)

INTRODUCTION: Proper femoral reaming is a key factor for a successful outcome in cementless hip arthroplasty. Good quality reaming minimizes risks of intra-operative femoral fracture during reaming and prevents poor fitting of the implant which can lead to subsidence of the stem postoperatively. Determining the quality of reaming is largely a subjective skill and dependant on the surgeon's experience with no documented intraoperative method to assess it objectively.

METHOD: We recorded and analysed the frequencies of sound signals recorded via a bone conduction microphone during reaming of the femoral canal in a series of 27 consecutive patients undergoing uncemented total hip replacement performed by same surgeon. Hammering sound frequencies and intensity were analysed by mean of computer software. The relationship between the patterns of the recorded reaming sound frequencies compared with surgeon judgment of the reaming quality intraoperatively and post operative x rays. All patients were followed up clinically and radiologically for 24 months after surgery to determine the integrity of the fix and to evaluate the stability of the prosthesis.

RESULTS: There was a consistent pattern of frequency changes detected in all cases regardless of gender, age, bone density size of reamer etc. Our results showed that the resonances in the femur can be accurately recorded during canal reaming and proved that there is a definite increase in the amplitude of sound frequencies between 600 and 1000Hz when the tension of the reamer moves from loose to tight during hammering. Adding all of the dB values between 600 to 1000 Hz for the loose tension sound and comparing this to the total for the tight tension sound showed an average of 449.6 % increase. Our Analysis of the sound signals changes was comparable to the adequacy of the reaming postoperatively

CONCLUSION: There are identifiable audio frequency patterns changes associated with satisfactory reaming of the femoral canal. Our findings may pave the way for the development of a real-time intraoperative reaming audio analyser which can guide the surgeon to the optimal reaming tension.

O21B4 **Preoperative Templating Prediction Model for Hip Arthroplasty Cases**

Primary Author: Amir Pourmoghaddam

Institution: Memorial Bone and Joint Research Foundation

Coauthors: Stefan W. Kreuzer (University of Texas Health Science Center Houston), Adam M. Freedhand (University of Texas Health Science Center Houston)

INTRODUCTION: In the recent years the utilization of digital radiography has gained more popularity in clinical settings even those with limited resources. This technology has reduced the overall cost of radiography compared to analogue approach. In addition, the cost of storing and recycling has been minimized by utilizing this technology[1]. The application of advanced computer software has also reduced the amount of time to analyze and prepare the digital images and has provided the opportunity to increase the quality of imaging and accuracy of measurements[2]. One of the essential preoperative procedures is the application of preoperative planning to prepare the surgical team. Previous studies indicated that the application of this planning results in significantly lower surgical time and rate of intraoperative complications [3]. The goal of this study was to develop a predictive model to further improve the accuracy of preoperative templating in which anthropometric characteristics of the patients were used in addition to preoperative digital radiograph measurements. We hypothesized that preoperative measurements, age, gender, weight, height, and body mass index (BMI) would be significant factors in accurately predicating the actual implant size in patients with total hip arthroplasty (THA).

METHOD: In this study we retrospectively reviewed preoperative digital radiographs obtained from 468 patients (1 to 1 male/female ratio) who were treated by THA from August 2012 to December 2013 at a single institution by one of the co-authors (SKW). The average age was 59.96 \pm 12.50 years 436 diagnosed with osteoarthritis, 53 with avascular necrosis, 13 with failed THA, 2 with infection, 4 post trauma, and 13 with failed hemi arthroplasty. For THA templating, the anteroposterior view of the pelvis was used by centering the template over the pubic symphysis, with the hips in 10° to 15° of internal rotation when possible, and a lateral frog-leg view of the affected hip. A multiple regression model that include preoperative acetabular size,

preoperative femoral size, body mass index (BMI), age, gender, height, and weight were used to derive the predictive model. A stepwise algorithm was used to define the significant factors with level of significance $\leq .05$.

RESULTS: We have concluded the following equations for predicting the acetabular size and femoral component size.

$$\begin{aligned} \text{(Act)}_{\text{Estimated}} &= 11.746 + 0.638 \times (\text{Act})_{\text{Temp}} + 0.176 \times (\text{Fem})_{\text{Temp}} + 0.02 \times \text{Weight} + 0.038 \times \text{Height} \\ (\text{Fem})_{\text{Estimated}} &= -1.892 + 0.77 \times (\text{Fem})_{\text{Temp}} + 0.019 \times \text{Age} + 0.011 \times \text{Height} \end{aligned}$$

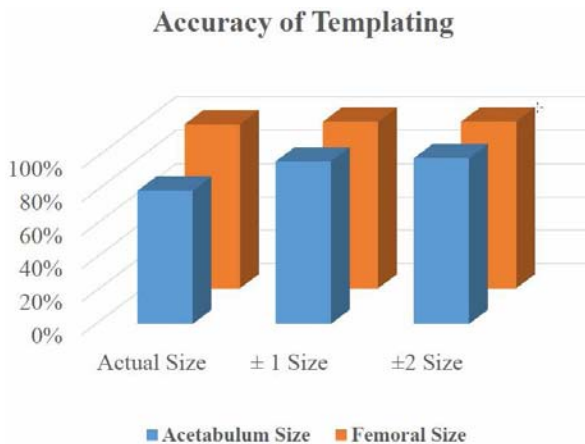


Figure 1- The accuracy of the model to retrospectively predict the implant sizes in the current study.

DISCUSSION: In this study we explored the potential of utilizing a predictive model to predict the actual implant size during THA. This model successfully predicted the implant size within ± 1 size. In addition, the findings of this study may help with reducing the expensive inventory costs.

O21B5 EOS Imaging is Accurate for Preoperative Total Hip Arthroplasty Templating

Primary Author: Alexander S. McLawhorn
Institution: Hospital for Special Surgery

Coauthors: Joseph D. Maratt (Hospital for Special Surgery), Kaitlin M. Carroll (Hospital for Special Surgery), David J. Mayman (Hospital for Special Surgery)

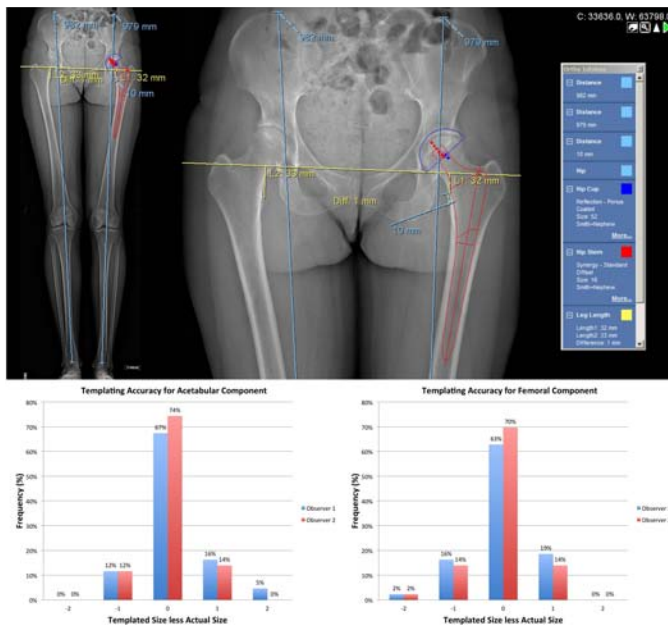
BACKGROUND: Templating is a critical part of preoperative planning for total hip arthroplasty (THA). It anticipates appropriate component sizes and thereby assists avoiding postoperative leg length discrepancy, failure to restore offset, femoral fracture, and instability. While tem-

plating on conventional and digital radiographs is reliable and accurate, the accuracy of templating on digital images acquired with EOS, a novel slot scanner, is unknown. EOS captures calibrated, full-limb-length images with an eighth of the radiation exposure of conventional radiographs, without their magnification errors. The purpose of this study was to examine the accuracy of digital templating for THA using EOS imaging.

METHODS: After IRB approval, we retrospectively templated forty-three primary unilateral THA that had preoperative 2D EOS imaging (EOS Imaging Inc, Cambridge, MA, USA) available for review. All patients had received THA with the same THA system (R3 Acetabular System and Synergy Cementless Stem, Smith & Nephew, Inc., Memphis, TN, USA). Two blinded observers templated each case for acetabular size, femoral component size, and stem offset. Templating was performed with standard software (Ortho Toolbox, Sectra AB, Linköping, Sweden) [Fig. 1]. Interpretation of interobserver agreement was performed by kappa analysis for the acetabular and femoral components. The accuracy of templating was reported as the average percent agreement between the implanted size and the templated size for each component. Templated sizes were compared to the actual sizes of components implanted with two-tailed Wilcoxon signed-rank tests. P

RESULTS: Mean age was 60.6 \pm 7.6 years. 22 patients (51.2%) were female. Mean body mass index was 29.2 \pm 6.41 kg/m². 26 THA (60.5%) were right-sided. EOS templating accurately predicted acetabular size in 70.9% of cases, and to within 1 size in 97.7% of cases [Fig. 2]. It predicted stem size accurately in 66.3% of cases, and to within 1 size in 97.7% of cases. Offset choice was accurately predicted in 82.6% of cases. Interobserver agreement was excellent for acetabular components (kappa = 0.85) and femoral components (kappa = 0.86). We observed no statistical differences between the actual and templated sizes for the acetabular component (p = 0.22) and femoral component (p = 0.66).

CONCLUSIONS: This study demonstrates that preoperative digital templating for THA using EOS imaging is accurate, with excellent interobserver agreement. EOS exposes patients to less radiation than traditional radiographs, which are acquired with a fixed cone beam. Improved magnification error may partially explain the accuracy of our templating method. Templating Accuracy for Acetabular Component



O21B6

Bio-inspired Technologies with PMPC-Grafting and Vitamin E-Blending Make Life-long Durability of Orthopedic Bearings

Primary Author: Masayuki Kyomoto
Institution: The University of Tokyo

Coauthors: Toru Moro (The University of Tokyo), Shihori Yamane (KYOCERA Medical Corporation), Kenichi Watanabe (KYOCERA Medical Corporation), Yoshio Takatori (The University of Tokyo), Sakae Tanaka (The University of Tokyo), Kazuhiko Ishiha

Periprosthetic osteolysis is considered the main problem limiting the longevity and clinical success of artificial hip joints. Aiming at the reduction of the wear particles and the elimination of periprosthetic osteolysis, we have developed an articular cartilage-inspired technology (Aquala technology) for nanometer-scaled surface modification with poly(2-methacryloyloxyethyl phosphorylcholine) (PMPC) grafting for a crosslinked polyethylene (CLPE) acetabular liner in an artificial hip joint. Our previous study on the tribological and biological effects of PMPC revealed that the grafting decreased the production of wear particles and the bone resorptive responses. On the other hand, as well as wear-resistance, oxidative stability is an important indicator of the clinical performance of acetabular liners. The incorporation of the antioxidant vitamin E (VE) has been proposed recently as an alternative to post

melting treatment after gamma-ray irradiation to avoid oxidation. The purpose of this study is to demonstrate a nanometer-scaled surface modification with PMPC on the VE-blended CLPE; further, to investigate the effects of surface modification layer and substrate on the wear-resistance and oxidative stability of the acetabular liner. VE-blended CLPE was prepared with a high dose of gamma-rays (100–150 kGy) and annealed for cross-linking (HD-CLPE(VE)). PMPC grafting onto the HD-CLPE(VE) liner was performed by a photoinduced polymerization. Untreated and PMPC-grafted CLPE liners with 50 kGy gamma-ray irradiation were used as controls. All liners were sterilized by gamma-ray with a dose of 25 kGy. Surface properties and oxidative properties of the three distinct liners were examined by several methods. The wear resistance of liners against Co-Cr alloy femoral head was evaluated using a 12-station hip joint simulator. The oxidative stability (oxidation-induction time) of liners was evaluated by differential scanning calorimetry. The oxidative degradation of accelerative aged liners was evaluated by Fourier transform-infrared spectroscopy (FT-IR). After PMPC grafting, the peaks ascribed to the MPC unit were clearly observed in both FT-IR and X-ray photoelectron spectroscopy spectra. PMPC layers with 100-nm thick were clearly observed on the CLPE and HD-CLPE(VE) surfaces. Furthermore, PMPC-grafted CLPE and HD-CLPE(VE) surfaces exhibited highly hydrophilicity and low friction. After 5.0 million cycles of the simulator test, PMPC-grafted CLPE and HD-CLPE(VE) were found to show extremely low and stable wear [Fig. 1]. Oxidation-induction time of PMPC-grafted HD-CLPE(VE) was significantly longer compared to CLPE without VE-blending [Fig. 2]. Oxidation degradation in the PMPC-grafted HD-CLPE(VE) was not observed even after accelerative aging. In this study, we confirmed that the PMPC-grafted layer was successfully fabricated on the HD-CLPE(VE) surface, and the PMPC-grafted HD-CLPE(VE) brought high wear- and oxidation-resistances. When the surface is modified by PMPC grafting, the PMPC-grafted layer leads to a significant reduction in the sliding friction between the surfaces which are grafted because thin film of the hydrated PMPC layer and water can act as extremely efficient lubricants. Furthermore, and in spite of gamma-ray and UV irradiations for cross-linking and PMPC grafting, the substrate modified by VE-blending maintains high-oxidative stability. Indeed VE is an extremely efficient antioxidant. In conclusion, the PMPC-grafted HD-CLPE(VE) provides not only high wear resistance but also high-oxidative stability, i.e., life-long durability.

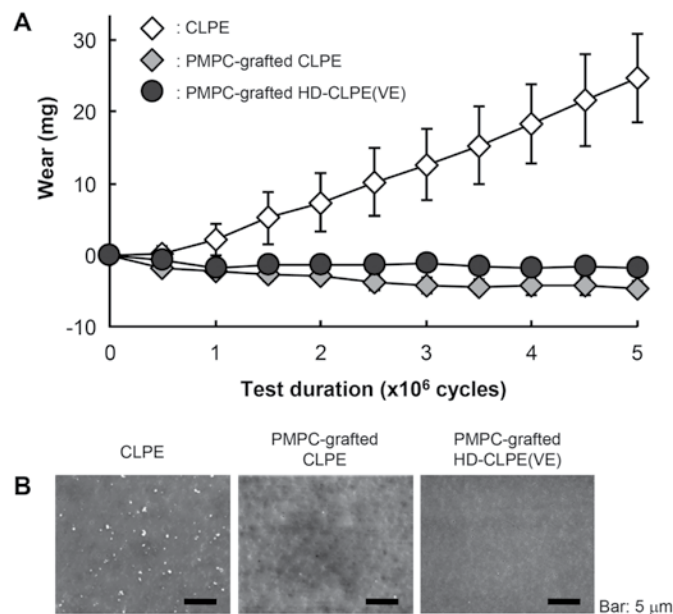


Fig. 1. Wear resistances of several types of CLPE liners in the hip joint simulation test. (A) Gravimetric wear, bar, SDs, (B) 3D coordinate measurements of liners, and (C) SEM images of wear particles isolated from lubricants.

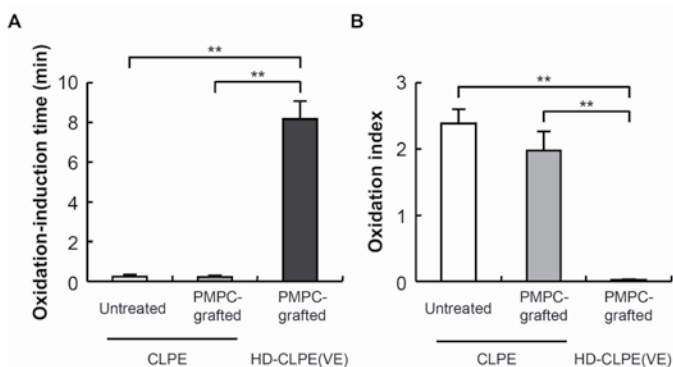


Fig. 2. (A) Oxidation-induction times and (B) oxidation indices of untreated and PMPC-grafted CLPE with/without vitamin E. Bar, SDs, ** $p < 0.01$.

O21B7 A Novel Composite Bone Grafting Technique for Total Hip Arthroplasty

Primary Author: Gurdip S. Chahal
Institution: Solihull Hospital UK

Coauthors: Mazin Ibrahim (Solihull Hospital, UK), Krishnaiah Katam (Solihull Hospital, UK), Lawrence Trevor (Solihull Hospital UK)

BACKGROUND: Over 8000 revision hip arthroplasties were reported in the UK in 2011. This will continue to rise and result in increased acetabular bone deficient cases requiring reconstruction. Impaction bone grafting was de-

scribed as an answer for this growing challenge which can affect reconstruction options to restore hip centre and biomechanics. The senior author developed a technique where a composite graft can be used to tackle this problem. This is a description of the technique, which can be used in both primary and revision procedures as well as in all types of acetabular defects including pelvic discontinuity.

TECHNIQUE: We prepare the acetabulum using a reamer, gouge and 4.5mm drill to expose any available cancellous bone. One or two low dose irradiated fresh frozen femoral heads (NHSBT Tissue Services, Liverpool, UK) are defrosted and held in a motorhead jig. A saw is used to remove all sclerotic and cortical bone from the allograft and the remaining cancellous bone is cut into longitudinal sections at approximately 4mm widths. The latter are then further cut into 4mm cubes using bone nibblers and washed to remove all fat. 160mg of gentamicin is then added for each femoral head. A layer of simplex cement (Howmedica, Limerick, Ireland), one half to one third of a mix, is then laid over the top surface of the graft. Once the acetabulum is prepared with hydrogen peroxide soaked gauze and thorough lavage to remove as much blood as possible, the composite graft is then laid over the acetabulum with the graft against the acetabulum and the cement on top (Diagram I). Immediate impaction of the composite graft is then carried out using large diameter impactors gradually reducing down to smaller diameter impactors to increase pressure at the point of impaction. This impaction is only carried out over the areas not affected by any defects and is directed into the acetabulum radiating peripherally. The composite layer is then allowed to set completely. This layer then acts as a base to cement a polyethylene cup onto it as per standard cup cementing technique with a further cement mantle. Augmentation using trabecular metal (Zimmer, Warsaw, IN, USA) is used to address any segmental defects or pelvic discontinuity using screw fixation prior to the application of this graft.

DISCUSSION: This novel technique can be used in bone deficient acetabulum in both cemented primary and revision hip arthroplasties. The well-known slooff's technique 3 utilises cortico-cancellous bone grafting, in our technique cancellous bone is only used. Furthermore, Slooffs laid the bone chips first then impacted them to be followed by the cement layer, The described technique uses cancellous bone and cement as a composite graft without individual impaction. This technique is different from the IBG technique in use for uncemented acetabular cups 4 where

a reverse reaming following impaction is utilised. We recommend using this technique, which was successful in a cohort of 140 patients with five-year follow-up in hip arthroplasty with all types of defects including pelvic discontinuity.

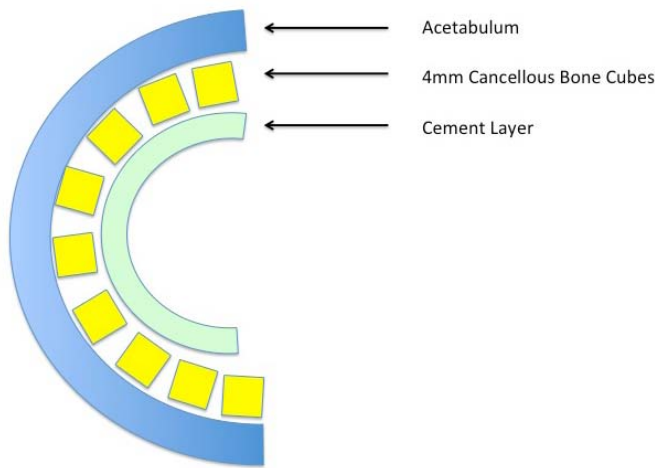


Diagram 1

Computer Navigation: Is There a Benefit Over Traditional Techniques?

O22A1 TKR Navigation, How Beneficial?

Guest Faculty: Dae K. Bae, MD, PhD

Institution: Kyung Hee University, Seoul, South Korea

Coauthors: Sang J. Song(Kyung Hee University), Dong C. Nam(Kyung Hee University)

INTRODUCTION: In patients with excessive diaphyseal bowing, fracture malunion, retained fixatives for fracture stabilization, it might be difficult or inaccurate to use intramedullary rod with conventional technique compared to navigation technique. The purpose of this study is to evaluate the results of CAS-TKA in patients for whom it would be difficult to use the conventional technique.

METHODS: One hundred fifty consecutive CAS-TKAs were performed in 132 patients. Among them, 34 CAS-TKAs were performed because it would be difficult to use the conventional technique for patients whose femoral or tibial diaphysis are extra-articularly deformed or implanted with internal devices. These patients were reviewed retrospectively. Indications for CAS-TKA included extra-articular deformity due to excessive diaphyseal bowing (19 knees), fracture malunion (7 knees), multiple epiphyseal dysplasia (2 knees), and infection sequelae (1knee). Other indication included retained internal devices in cases of previous hip arthroplasty (2 knees), high tibial osteotomy (2 knees), and fracture stabilization with fixatives (1knee). The average age at the time of TKA was 65.5 years (range, 35–79 years). The average follow-up period was 3.0 years (1–7.1 years).

RESULTS: The average preoperative knee score was 48.3 ± 6.1 and increased significantly to 89.9 ± 4.3 at the last follow-up examination ($p < 0.001$). The average preoperative function score was 52.6 ± 6.1 and increased significantly to 92.2 ± 4.4 at the last follow-up examination ($p < 0.001$). The average ROM increased from $104.3 \pm 29.3^\circ$ preoperatively to $119.4 \pm 15.9^\circ$ at the last follow-up examination ($p = < 0.001$). The MA was $17.9 \pm 12.7^\circ$ varus preoperatively and $1.5 \pm 2.3^\circ$ varus postoperatively ($p < 0.001$). Twenty-nine of 34 knees (85.3%) had a mechanical axis within $\pm 3^\circ$ from neutral.

CONCLUSION: The clinical and radiographic results of CAS-TKA were satisfactory without major complications in patients for whom it would be difficult to use the conventional technique due to the extra-articular deformity or internal devices. It was useful and safe without help of intramedullary or extra-medullary guide system to use the navigation system in these patients.

O22A2 Dreams or Facts? The Value of Daily Work in TKR

Guest Faculty: Nicolaas C. Budhiparama Jr., MD

Institution: Nicolaas Institute for Constructive Orthopaedic Research & Education Foundation Jakarta, Indonesia

Computer navigation has been introduced as an adjunct to Total Knee Arthroplasty (TKA) to assure precision positioning, accurate bone resection and optimal component

alignment. Using Computer Assisted Navigation in TKA was a hotly debated issue in United States and elsewhere. Although Computer Navigation has progressed from the 1st generation to the current 3rd generation system, there are still no clearly tangible, apparent long term clinical benefits.

There is some evidence that using Computer Assisted Surgery may lower the incidence of malalignment of mechanical limb axis compared to conventional component placement methods, but it is unclear whether this marginal benefit will translate to concrete positive long term outcomes. AAHKS survey results indicated that the majority of Orthopedic Surgeons were not using computer navigated surgical techniques. The implementation of CAS met with so many hurdles and obstacles because its approach consumes more time and a long learning curve, which translates to added cost and complexity. It is also labor and equipment intensive but only increases accuracy in the “right” hands. Lack of popularity for CAS has induced the innovation of Patient Specific Jigs which has been proven to be extremely accurate, efficient with respect to time and allows surgeons to navigate the operation prior to the procedure.

Since CAS remains unpopular in the US, it would be even less popular in Asia for the obvious reasons of high cost, lack of experts to handle technical difficulties, lack of publicity, and the paucity of beneficial expert testimonies. The “Better, Cheaper, Faster” culture is fully ingrained in the minds of most Asian Arthroplasty surgeons and CAS would seem to only fulfill the “Better”, but not the “Cheaper and Faster” expectations in most hands.

O22A3 **Comparison of Costs Using Custom Cutting Blocks, Computerized Navigation and Conventional Instrumentation in TKA**

Primary Author: Aaron A. Glynn
Institution: Rothman Institute

Coauthors: Pouya Alijanpour (Rothman Institute), Carlos Higuera (Rothman Institute), Camilo Restrepo (Rothman Institute), William J. Hozack (Rothman Institute)

BACKGROUND: Custom cutting blocks (CCB) were developed to provide the accuracy of computer assisted navigation

(CAN) in total knee arthroplasty (TKA) but without the increased cost.

Questions/Purpose: To evaluate cost differences between CCB, CAN and conventional intramedullary instrumentation (CII) in an academic center.

METHODS: 23 patients had TKA performed using CCB, 26 had TKA using CAN, and 24 had TKA using CI. The three groups were comparable in terms of age, gender, body mass index, and surgeon experience. Operative parameters such as tourniquet time, procedure time and total OR time, and instrumentation usage and cost were evaluated.

RESULTS: Shorter average operating times were recorded with CCB versus CII and CAN for both the experienced (81 vs. 86 and 92 minutes, respectively) and junior surgeons (86 vs. 98 and 99 minutes, respectively). The differences were not significant. Fewer instrument trays were needed for TKA with CCB than for CAN or CII (average 2.4 vs. 6.8 and 7.2 trays, respectively). Comparison of costs showed that for a high volume surgeon, use of CCB was only \$73 more expensive than CII, but \$508 cheaper than CAN.

CONCLUSION: Use of CCB resulted in shorter surgical times and used less instrument trays. The reduction in costs helped offset the cost of cutting block production. While not cost saving, CCB do not appear to add expense either.

O22A4 **A Novel Navigation Protocol for Revision of Unicompartamental Knee Replacement to Total Knee Replacement**

Primary Author: Kodali Siva Rama Prasad
Institution: Prince Charles Hospital

Coauthors: Salim Punjabi (Prince Charles Hospital, Merthyr Tydfil, United kingdom), Rakesh Kumar (Prince Charles Hospital, Merthyr Tydfil, United kingdom)

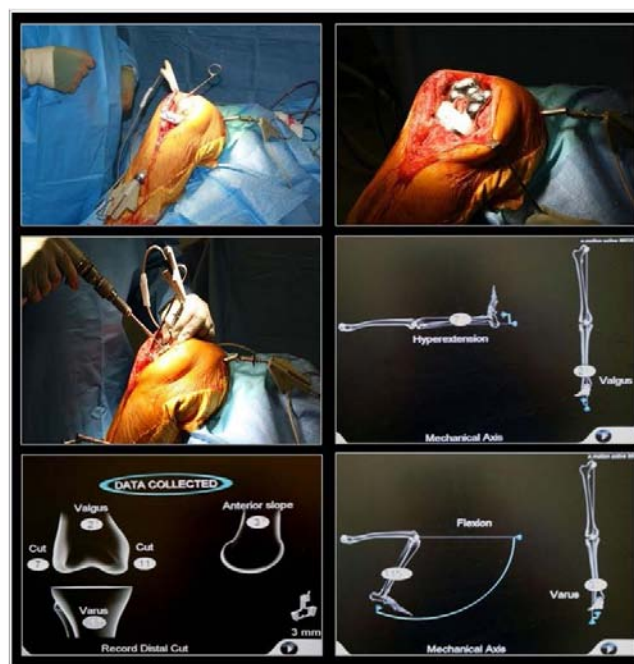
BACKGROUND: As limited literature is available about the use of computer Navigation to revise unicompartamental knee arthroplasty to total knee arthroplasty, we would like to present our modification of the Standard Primary Navigation System to revise unicompartamental knee re-

placement to total knee replacement, avoiding the complex Revision Navigation System, revision instrumentation and hence larger exposure and potential subsequent blood loss. We present our modification of Standard Primary Navigation System to revise unicompartmental knee replacement to total knee replacement, avoiding complex Revision Navigation System and revision instrumentation.

METHODS: We applied our modified protocol for conversion of medial unicompartmental knee replacement to total knee replacement in a 55-year old man. We used Primary Navigation protocol (E-Motion Active with Tibia First and Gap Management) for initial referencing with the implants in situ. We proceeded to recalibrate the reference points after sequential removal of implants. We then added the thickness of implants to the values before making the necessary Tibial and Femoral cuts. We added 8mm for Uni-thickness for calculation of femoral cut and 5mm for Uni-thickness for calculation of tibial cut. Tibial cut was made using extramedullary computer navigated alignment. Flexion/Extension gap balancing was assessed using navigation protocol. Femoral cut was made using posterior referencing extramedullary alignment. Components inserted after Trial and establishing soft tissue balancing, checking alignment and range of movement on computer.

RESULTS: We found that our modified protocol ensured that joint line was preserved, flexion/extension gap was easily balanced and patellar tracking was normal.

CONCLUSION: This application of our modified protocol showed that we can make use of simpler Standard Navigation Protocol with modification in Revision of Unicompartmental Knee Replacement to Total Knee Replacement. A larger cohort of patients will be required to establish our Protocol as standard technique for such revisions.



O22A5 Computer Assisted Surgery Technology: A Teacher in Your Hands

Primary Author: Fabio Conteduca

Institution: Rome University "Sapienza" S. Andrea Hospital

Coauthors: Andrea Ferretti (Rome University), Raffaele Iorio (Rome University), Daniele Mazza (Rome University), Ludovico Caperna (Rome University), Gabriele Bolle (Rome University)

From the first experience with computer assisted total knee replacement we observed more accurate alignment of the leg. We compared the last traditional surgery with the first Cas. We observed that with Cas all less acceptable alignment were avoided. On the basis of these results we started comparing during live surgery manual alignment with computer-assisted alignment to better understand where manual alignment fails. Many data contribute to change alignment of the resection. First of all the human mistake, but also hardware positioning, pin insertion cutting jig movement, blade size and wear, soft and strong bone surface contribute all together do determine errors in bone resection. The most important aid of Cas is in femoral alignment because it is possible to determine exactly the center of the femoral head avoiding pitfalls in rod insertion. All

femoral and tibial resection mixed together change during surgery the target of the reconstruction. Ligament balancing, equal space in flexion extension, medial and lateral spaces, and sizing of the component are also important to determine. It is not so easy to control these topics also with CAS, but it is possible to better investigate during surgery ligament release to improve precise surgery. After a long period of CAS experience with rotating uncemented prosthesis we performed a statistical analysis comparing a pre CAS experience (group A) a CAS group (group B) and a post CAS traditionally operated knees (group C). The alignment difference is statistically significant comparing group A and Group B (P). On the basis of the personal experience and statistical data the reported experience suggests that CAS surgery has an educational role to improve the positioning of the prosthetic components and skills of the surgeon in total knee replacement. CAS surgery should be routinely adopted for fellows in TKA. Future improvements by accelerometer technology instrumentation will be an easier way to improve resection alignment in TKA.

O22A6

Extension Gap Sometimes Decreases by Gap Technique in Total Knee Arthroplasty. “Sore Spot of Measurement of Center Gap”

Primary Author: Tadashi Fujii

Institution: Nara Kashiba Center for Arthroplasty and Spine Surgery

Coauthors: Munehito Seko (Nara Kashiba Center for Arthroplasty and Spine Surgery), Marehoshi Noboru (Nara Kashiba Center for Arthroplasty and Spine Surgery), Yushi Ando (Saiseikai Tondabayashi Hospital), Shuji Kitano (Saiseikai Tondabayashi Hospital), Hiroaki Ku

The goal of gap technique in total knee arthroplasty (TKA) is basically to gain complete rectangular and same size of both flexion and extension gap. Some recent papers, however, overlook the lateral opening gap for the clinical result and anatomical feature. Various kinds of tensors have been provided and most of them are based on the measurement of center gap by tilting board. We experienced extension gap narrowing compared with flexion gap in spite of careful decision of gap size by these tensors. The query that center gap can be really recognized as the essential gap size, was investigated during surgery. Thirty five medial osteoarthritic knees of 33 patients were enrolled in this

study after permission of our ethical committee. Distal end of the femur and the proximal plateau of the tibia were resected to make the extension gap. Varus-valgus angle and center gap size were measured by VT tensor™ (Biomet co. ltd. Warsaw, IN) under 75N, 100N, and 125N of extension forces by the heel put on multiple polyethylene layers (under the shank free). Center gap size, then, measured under the same forces at varus-valgus 0 degree (shank was fixed). Under 75N, 100N, and 125N extension forces, 1.9 ± 2.0

O22A7

Identification of the Landmark Registration Safe Zones During Total Knee Arthroplasty Using an Imageless Navigation System

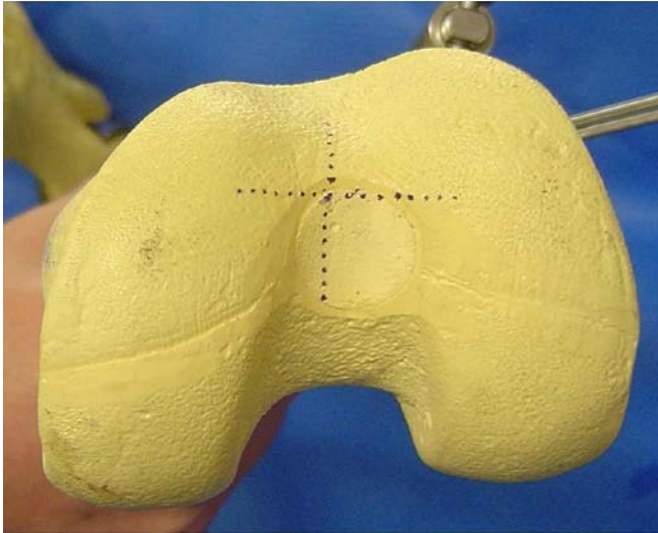
Primary Author: Derek Amanatullah

Institution: Mayo Clinic

Coauthors: Paul Di Cesare (NYH - Queens), Patrick Meere (NYU - HJD - Ortho), Gavin Pereira (UCDMC - Ortho)

Incorrect registration during computer assisted total knee arthroplasty (CA-TKA) leads to malposition of implants. Our aim was to evaluate the tolerable error in anatomic landmark registration. We incorrectly registered the femoral epicondyles, femoral and tibial centers, as well as the malleoli and documented the change in angulation or rotation (Figure 1). We found that the distal femoral epicondyles were the most sensitive anatomic landmarks to register (Figure 2 - C: medial and D: lateral). The other bony landmarks (e.g., medial (A) and lateral (B) malleoli as well as femoral (E) and tibial (F) centers) were significantly more forgiving tolerating at least 6 mm of incorrect registration in any given direction (Figure 2). This observation has clinical implications in obese patients where identification of the medial and lateral malleoli can be compromised. Several studies document considerable inter- and intra-observer variability in identifying the distal femoral epicondyles. This affects the data input during registration and may negate the advantage of improved accuracy during CA-TKA. The statistically significant inter- and intra-observer variability during the identification of the distal femoral epicondyles and our observation that there is less than 2 mm of safe zone in the anterior or posterior direction during registration of the medial and lateral epicondyles may explain the inability of CA-TKA to improve upon the outcomes of conventional TKA, since CA-TKA has not improved the accuracy of femoral component rota-

tion (Figure 2C and 2D).



How Successful is THA?

O22B1

Long Term Success of a Ceraver* Titanium Alloy Cemented Stem

Primary Author: Laurent Sedel

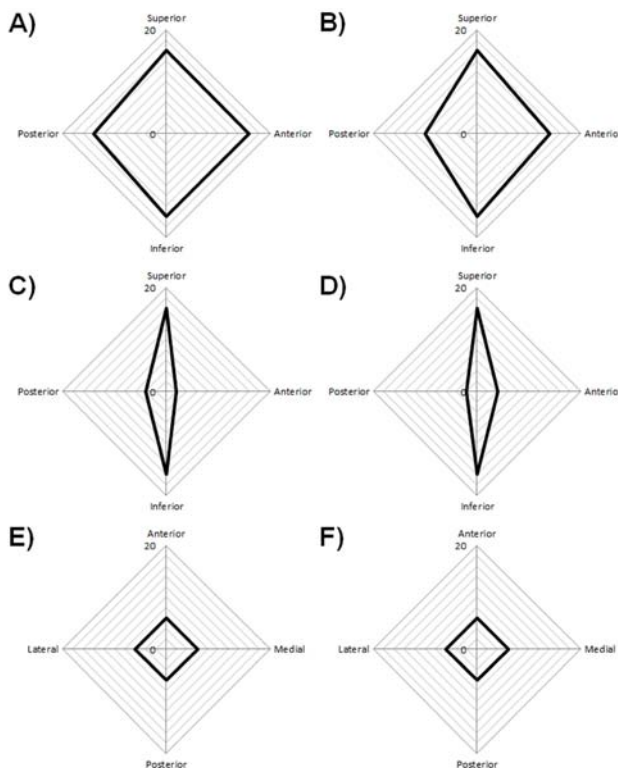
Institution: APHP Paris

INTRODUCTION: Titanium Cemented stems are still implanted with success in Europe, they are still not approved by the FDA in the United States. Why? This paper try to address this issue.

MATERIAL AND METHODS: In 1977 a new cemented stem made of titanium alloy (with vanadium) was designed with rectangular section, smooth surface covered with thin layer of titanium oxide, filling the medullary cavity, with a collar, with 8 different size available. As a consequence the cement mantle was thin. Initial cementing technique used dough cement, vent tube and finger packing; during a second period we added a cement retractor and low viscosity cement. Since ten years we moved back to initial technique with cement retractor made of polyethylene and a vent tube.

RESULTS: Long term results were published in different papers by different teams (Hernigou et al , Sedel et al, Hamadouche et al). Long term follow up results depicting about 98 to 100 percent survivors at 10 years and 95 to 98% at 20 years. Radiological results depicted some radiolucent lines that appeared at the very long term. But the majority of XRays depicted absolutely no change over very long period reaching at the moment more than 30 years in some case. The majority of these stems were implanted with an all alumina bearing system. In many occasion, when revision had to be performed, the stem was left in place (108 cases over 132 revisions published recently by Hannouche et al).

DISCUSSION AND CONCLUSION: To understand why these stems which are not available in the US did so well, we must refer to Robin Ling paper published in 2003 and called “the French paradox”. Robin Ling proved that if a cemented prosthesis is smooth and fills the medullary



cavity, long term excellent results could be expected whatever the metal and the shape. It was described identically with stainless steel Kerboul shape, the Exeter design and the Ceraver design. In case of Ceraver Osteal stem, the coverage of the titanium alloy by a titanium oxide, which is very hard and very smooth could explain the quality of our results, compared to bad results with rough titanium stem surfaces experienced in the US. Rough titanium surface rubbing against the cement could explain the production of titanium debris that might oxidised and then play a very adverse biological role.



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O22B2

Multicenter Outcomes of Endoscopic Pubic Symphysectomy for Osteitis Pubis Associated with Femoroacetabular Impingement

Primary Author: Dean K. Matsuda

Institution: Kaiser West Los Angeles Medical Center

Coauthors: Manel Ribas (Instituto Universitario Dexeus Barcelona), Nicole A. Matsuda (Westchester High School), Benjamin Domb (Hinsdale Orthopaedics)

INTRODUCTION: Athletic osteitis pubis (OP) is associated with femoroacetabular impingement (FAI). Surgical options include open curettage and, more recently, endoscopic pubic symphysectomy. The purpose of this study is to determine outcomes from endoscopic pubic symphysectomy performed in the setting of FAI surgery.

METHODS: A multicenter retrospective case series was performed of 7 consecutive adult patients (4 male) of mean age 33 years with symptomatic FAI and OP that underwent arthroscopic surgery for the former and endoscopic pubic symphysectomy for the latter with mean follow-up of 2.8 years (1.8-5.0 years). Visual analogue scale (VAS), non-arthritic hip scores (NAHS), and patient satisfaction were measured. Complications and revision surgeries were recorded and pre- and post-operative radiographs were assessed.

RESULTS: Mean pre-operative VAS of 6.7 (8-4) improved to a mean post-operative VAS of 2.0 (7-0). Mean pre-operative NAHS of 50.2 (21-78) improved to a mean post-operative NAHS of 85.5 (41-99). Mean patient satisfaction was 8.3 (3-10). 2 male patients had post-opera-

References:

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tive scrotal edema which resolved spontaneously. There were no other complications. Pre- and post-operative radiographs demonstrated no anterior or posterior pelvic ring instability. 1 patient underwent pubic symphyseal arthrodesis because of continued pain.

CONCLUSION: Endoscopic pubic symphysectomy offers a minimally invasive treatment with encouraging early outcomes that may be performed concurrently with surgery for FAI in co-afflicted patients. The only complication was transient scrotal swelling.

O22B3

Use of a Porous Tantalum Monoblock Acetabular Cup in Primary THA: 10- to 15-Year Follow-up

Primary Author: Ivan De Martino

Institution: Catholic University of the Sacred Heart

Coauthors: Rocco D'apolito (Catholic University of the Sacred Heart, Rome, Italy), Vincenzo De Santis (Catholic University of the Sacred Heart), Giorgio Gasparini (Magna Graecia University, Catanzaro, Italy)

Use of cementless acetabular component in primary total hip arthroplasty (THA) has shown excellent results at up to 10-year follow-up, however asepting loosening is still the most frequently reported reason for revision, limiting the survival of uncemented THA. Porous Tantalum Monoblock cup (Trabecular Metal Monoblock Acetabular Component; Zimmer Inc, Warsaw, Ind) (Fig.1) has been proposed in orthopaedic surgery to minimize osteolysis and improve the durability and stability of arthroplasties. The purpose of this study was to review the long-term clinical and radiographic results of the use of Tantalum Monoblock cups for primary THA. A total of 196 consecutive primary THAs were performed using a porous tantalum acetabular cup in 190 patients between June 1998 and June 2003. Four patients died from reasons unrelated to their arthroplasty prior to 10 years, three patients were lost to follow-up and one patient was excluded, leaving 182 patients (188 hips) for our study group. Seventy-one men and 111 women with a mean age of 63 years (range, 33–81 years) were included. Mean follow-up was 12 years (range, 10–15 years). Clinical evaluation was carried out using preoperative and post-operative Harris Hip Score (HHS). We also evaluated implant survivorship, reoperation rates, compli-

cation rates and radiographic outcomes. The stability of the acetabular cup was determined by modified Engh's criteria. Osteolytic lesions, radiolucent lines or zones of increased bone density were also recorded and classified according to the system of DeLee and Charnley. The average preoperative total HHS score was 48 preoperatively and increased at one-year follow-up to 95, remaining constant through the 10- 15-year follow-up at 96. The 10-year survival rate of the cup, with revision for any reason as the end point, was 99.5%. The subjective outcome was widely satisfying, with the majority of patients experimenting good functional recovery and return to daily activities. Osseointegration of the acetabular component was present in all X-rays controls at one year after surgery. There was no evidence of progressive radiolucent lines, no evidence of osteolysis, and no revision for loosening. There were two postoperative complications all unrelated to the acetabular component. We revised one cup for infection. The porous tantalum monoblock acetabular components in primary THA has shown excellent clinical and radiographic outcomes at 10- 15 year follow-up. High biocompatibility of porous tantalum and its initial stability in conjunction with an elastic modulus and a porosity very close to that of cancellous bone influence positively earlier and wider osseointegration of the implant.



O22B4

Revision Hip Arthroplasty with the ZMR Modular Cementless Stem: Intermediate-Term Follow Up

Primary Author: Sureshan Sivananthan

Institution: Department of Orthopaedic Surgery, Stanford University

Coauthors: James Huddleston (Department of Orthopae-

dic Surgery, Stanford University School of Medicine), Stuart Goodman (Department of Orthopaedic Surgery, Stanford University School of Medicine)

INTRODUCTION: Modular, cementless, extensively porous coated femoral components facilitate intra-operative customization of fit and fill during revision total hip arthroplasty. However, long-term data regarding the performance of these implants is lacking.

METHODS: 67 hips in 61 patients underwent revision surgery with a modular femoral component (ZMR: Zimmer, Warsaw, Indiana). All hip replacements had a minimum 6 years and a maximum of 12 years follow-up. All patients were evaluated clinically using the Harris Hip Score and WOMAC Score, and all radiographs were reviewed independently at final follow up. Kaplan Meier Analysis was used to calculate survivorship of the implants. Average follow up was 9 years.

RESULTS: The Harris Hip Score improved from an average of 38.09 to 80.06 ($P < 0.01$), with significant improvements in the WOMAC pain/stiffness/function scores. Four hips required reoperation, due to either infection, loosening or late fracture. No other implant related complications were encountered and at the most recent follow up 97% were in-situ. No complications regarding the modular junction were encountered.

DISCUSSION AND CONCLUSION: Modular, cementless, extensively porous coated femoral components have demonstrated intermediate term clinical and radiographic success. Initial distal intramedullary fixation ensures stability and proximal modularity further maximizes fit and fill while optimizing hip offset and length. The ability to adjust anteversion independent of the distal stem is also an advantage in these modular stems.

O22B5

Five Year Survivorship of a Three Dimensional Porous Titanium Shell in Revision Total Hip Replacement

Primary Author: Kristin L. Robinson

Institution: Stryker Orthopaedics

Coauthors: Michael A. Masini (St Joseph Mercy Hospital), Ivan M. Tomek (Dartmouth-Hitchcock Medical Cen-

ter), Geoffrey H. Westrich (Hospital for Special Surgery), Arthur L. Malkani (Jewish Physician Group), Robert M. Molloy (Cleveland Clinical Foundation)

INTRODUCTION: Acetabular revision surgery remains a technically demanding procedure in orthopaedics, with higher failure rates than those in primary total hip arthroplasty (THA). An acetabular component with three dimensional porous titanium and anatomic screw holes was developed for revision THA in order to provide more reliable fixation that allows the cup to be positioned anatomically.

METHODS: A prospective multicenter study of 226 cases (222 patients) was conducted to assess the midterm clinical outcomes of the revision titanium acetabular shell. Potential predisposing factors for failure - including gender; alcohol use; femoral head diameter; BMI; age; preoperative Harris Hip Score (HHS); self-reported physical and mental function (Short Form 36, SF-36); concurrent medical conditions; surgical approach; augment use; bone graft use; reason for revision; and Paprosky bone defect classification - were all recorded. Clinical and radiographic follow-up was at 6 weeks, 3 months, and annually thereafter. Patients with minimum 2 year follow-up were included in this analysis (136 of 222 patients, 72 men and 64 women). The mean duration of follow-up was 3.75 years (range 2 to 5). At time of surgery, mean patient age was 63.7 years, mean BMI was 28.5, 42% were current or previous smokers and 94% had one or more co-morbid medical conditions. A posterior approach was used in 83% of patients. In all, 67 hips (48.5%) had Paprosky Type 2 defects and 36 hips (26.1%) had Paprosky 3A defects. Screws were used in 96% of patients and augmentation was used in 42% of cases.

RESULTS: Mean HHS improved from 56.0 preoperatively to 85.4 at 2 years and 85.6 at 5 years. Excellent or good results were seen in 76% of patients at 2 years and 73% at 5 years. Mean SF-36 Physical Component Summary (PCS) score improved from 33.86 preoperatively to 43.15 at 5 years; mean Bodily Pain Score (BPS) improved from 35.95 to 49.25 at 5 years; and mean Mental Component Summary score (MCS) remained relatively stable throughout follow-up (Figure 1). The mean Lower Extremity Activity Scale (LEAS) score was 8.36 preoperatively, 10.37 at 2 years and 10.22 at 5 years. There were 8 acetabular shell re-revisions reported in the overall study population, 5 of which were for confirmed or suspected infection, 2 for aseptic loosening and 1 for recurrent dislocation. Ka-

plan-Meier survivorship curves for the overall study population at 5 years showed 94.10% CI=(87.65% -- 97.23%) survivorship with all-cause revision as the endpoint and 97.54% CI=(93.52% -- 99.07%) when aseptic loosening was used as the endpoint (Figure 2). In the Paprosky 3A group the survivorship at 5 years to all cause revision was 93.69% CI=(81.47% -- 97.95%) and 95.50% CI=(82.91% -- 98.87%) when aseptic loosening was used as the endpoint.

CONCLUSION: Next generation acetabular components with three dimensional porous titanium and anatomic screw holes provide for predictable midterm biologic fixation and improved clinical function compared to many historic outcomes. Further follow-up of this cohort will determine if this form of fixation is durable over time.



Figure 1. Mean Physical Component, Mental Component and Bodily Pain scores over time

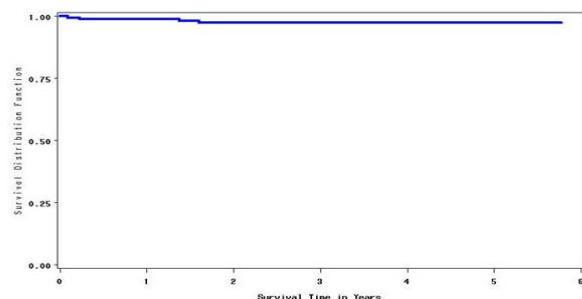


Figure 2. Kaplan-Meier survival risk analysis of acetabular shell revision due to aseptic loosening

O22B6 Short- and Medium Term Results with a Cementless Metaphyseal Anchored Short Stem Hip Implant (MiniHip)

Primary Author: Christian P. Kothny

Institution: MunichOrthoCenter

Coauthors: Joerg Jerosch (Joh.-Etienne-Krankenhaus, Neuss, Germany), Christian Graselli (Tett nang, Germany)

AIM: The purpose of the study was to analyse short- and medium-term results of a modern cementless short stem design hip joint endoprosthesis together with different parameters (offset, CCD, leg length), radiological findings and scores.

MATERIAL AND METHODS: 186 cases using a metaphyseal fixed short stem prosthesis (MiniHip, Corin) at two hospitals were included for clinical follow-up. 180 patients were available for clinical follow-up with standardized scores: Oxford-Hip Score (OHS), Hip Dysfunction an Osteoarthritis Outcome Score (HOOS) and EQ-5D – Score. The scores were caught preoperatively and postoperatively every year. Further on we could do a prospective radiological study of 250 consecutive hips with degenerative hip osteoarthritis were included (246 patients). These patients were operated by five different surgeons at 4 different hospitals. Standardized X-rays were performed with the same technique pre- and postoperatively in all patients. Different anatomical parameters of the hip were documented by using the pre- and postoperative x-rays (Offset, CCD angle, length of leg). The 250 patients included 129 female and 117 male. The average age of the patients was 59,7 years (range: 27 - 82 years). The whole follow-up and all measurements were performed by an independent examiner.

RESULTS: The Oxford Hip Score increased from a preoperative average of 17.63 to a postoperative average of 44.22 within the first year (180 hips). The postoperative average was 45.74 within the second (94 hips), and 46.20 within the third year (15 hips). The HOOS rose from a preoperative average of 29.91 to 96.20 (180 hips) within the first year. After two years the HOOS had an average of 94.30 (94 hips) and 95.72 (15 hips) after three years. The EQ-5D showed a postoperative average of 77.66 points for the 180 patients. At the time of the last follow-up two stems had aseptic loosening. The Offset only changed +0.29cm (SD: 0.45cm) after surgery. We could document only a small decrease of -0.51° (SD: 4.10°) of the CCD angle. The length of leg increased on average of +0.09cm (SD: 0.34cm). We found no difference between the measurements of female and male patients.

CONCLUSION: Our results show, that we could reconstruct the individual geometry of the hip quite well by using the metaphysial short stem prosthesis. The tendency of an increasing CCD angle and a decrease of the offset seems not to be existent with the design of this kind of short stem prosthesis.

KEYWORDS: primary hip arthroplasty, short stem endoprosthesis, offset, CCD angle, leg-length, clinical results.

O22B7

Femoral Revision Hip Arthroplasty with the Use of Impacted Cancellous Allograft and Cement

Primary Author: Suc-hyun Kweon

Institution: Wonkwang University Hospital

Coauthors: Tae-gyun Kim (Wonkwang University Hospital), Jeong-woo Kim (Wonkwang University Hospital), Young-an Jeong (Wonkwang University Hospital)

PURPOSE: To evaluate the radiographic mid-to long-term result of femoral revision hip arthroplasty using impacted cancellous allograft combined with cemented, collarless, polished and tapered stem.

MATERIALS AND METHODS: Among 27 patients with impacted cancellous allograft with a cemented stem, 28 hips from 26 consecutive patients were analyzed retrospectively. The average patient age was 59 years. The follow-up period ranged 36 months to 10 years, 3 months (mean, 76.6 months). Radiographic parameters analyzed in this study included subsidence of the stem in the cement, subsidence of the cement mantle in the femur, bone remodeling of the femur, radiolucent line, and osteolysis.

RESULTS: Radiographic analysis showed very stable stem initially. 27 stems showed minimal subsidence (less than 5 mm) and 1 stem showed moderate subsidence (about 8 mm) in the cement. But there was no mechanical failure and subsidence at the composit-femur interface. Evidence of cortical and trabecular remodeling were observed in all cases. No radiolucent line or osteolysis were found in the follow-up period. There were 4 proximal femoral cracks and 1 distal femoral splitting during operation.

CONCLUSION: The result of cemented stem revision with the use of impacted cancellous allograft was good mid-to long-term. and femoral bone stock deficiency may be reconstructed successfully.

KEYWORDS: Revision total hip arthroplasty, Impacted cancellous allograft TKA: Pre-Operative to Revision

TKA: Pre-Operative to Revision

O23A1

Mobile Bearing Posterior Stabilized vs. Cruciate Retaining TKA: Patients Preference

Guest Faculty: Jasmeet Singh Saren, MsOrtho

Institution: HSC Medical Center, Kuala Lumpur, Malaysia

The debate about the role of the Posterior Cruciate Ligament has been going on for about 3 decades now. We know that the PCL is important in the “roll-back” mechanism of the knee. We also know that it’s easier to balance PS knee compared to the CR knee in severely deformed knees. Many studies have shown there is little difference between the two in terms of patient derived outcomes such as knee scores and range of motion. Both designs clearly have their pros and cons.

The Mobile-bearing knee (mobility with congruency) was developed 30 years ago to increased longevity of the implant by decreasing polyethylene wear. So far, the long-term results (>15 years) do not show any difference between the mobile over the fixed bearing knee.

What happens when we combine these 4 different types of designs into a group of patients?

O23A2

Severe Varus Knee Deformity is a Risk Factor for Abnormal Knee Kinematics after Fixed Bearing TKA

Guest Faculty: Tokifumi Majima, MD, PhD

Institution: International University of Health and Welfare, asushiobara City, Japan

INTRODUCTION: Total knee arthroplasty (TKA) is a well-established procedure associated with excellent clinical results. We have previously reported that intraoperative knee kinematics correlate with clinical outcome in mobile bearing TKA. In addition, intraoperative knee kinematics pattern does not correlate with the degree of preoperative knee deformity in mobile bearing TKA. However it is unknown the relationship among preoperative knee deformi-

ty, intraoperative kinematics, and clinical outcome in fixed bearing TKA. The purpose of this study is to compare the relationship among preoperative knee deformity, knee kinematics after fixed bearing TKA and clinical outcome including the subjective outcomes evaluated by new knee society score (KSS).

MATERIAL AND METHOD: A cross-sectional survey of thirty-five consecutive medial osteoarthritis patients who had a primary TKA using a CT-based navigation system was conducted. All knees had a Kellgren-Lawrence grade of 4 in the medial compartment and underwent a primary posterior stabilized total knee arthroplasty (Genesis II, Smith&Nephew) between May 2010 and October 2012. In all cases, a computed tomography-guided navigation system (Brain LAB, Heimstetten, Germany) was used. All surgery were performed by subvastus approach and modified gap technique. Intraoperative knee kinematics was measured using the navigation system after implantation and closure of the retinaculum and soft tissues except of the skin. Subjects were divided into two groups based on intraoperative kinematic patterns: a medial pivot group (M group, n=19) and a non-medial pivot group (N group, n=16). Subjective outcomes with the new KSS and clinical outcomes were evaluated. Statistical analysis to compare two groups was made using unpaired Student t test. The significance level was set at $p = 0.05$.

RESULT: Regarding postoperative clinical result (knee flexion angle, knee extension angle, mechanical FTA, % mechanical axis), there were no significant differences between two groups. Although there were also no significant differences in KSS evaluation between two groups, there were tendency that M group is superior to N group in current knee symptom (M group: 17.3 ± 5.6 , N group: 12.9 ± 8.2 , $p = 0.07$) and functional activities (M group: 55.1 ± 21.5 , N group: 42.7 ± 22.6 , $p = 0.10$).

Regarding preoperative examination, varus knee deformity (mechanical FTA and % mechanical axis) in N group was significantly severer than that of M group ($p=0.04$, $p=0.04$, respectively).

DISCUSSION: Over half of patients (54%) could achieve medial pivot kinematics in fixed bearing TKA with the tendency to improve subjective clinical result. Although we previously could not detect any relationship between preoperative varus knee deformity and intraoperative kinematics in mobile bearing TKA, preoperative varus knee

deformity in non-medial pivot group was significantly severer than that of medial pivot group in fixed type TKA. Our results suggest that fixed type TKA is susceptible to the effect of preoperative severe varus knee deformity. In conclusion, we need great attention to perform fixed type TKA for severe varus knee deformity because severe varus knee tend to result in non-medial pivot pattern.

O23A3

Prospective Comparison of Early and Late Readmissions Between Cruciate-retaining and Posterior-Stabilizing TKA

Primary Author: Mark A. Kester

Institution: Stryker Orthopaedics

Coauthors: Michael A. Mont (Sinai Hospital), Kimona Issa (Sinai Hospital), Jeffrey Cherian (Sinai Hospital), Kristin L. Robinson (Stryker Orthopaedics), Manoshi Bhowmik-Stoker (Stryker Orthopaedics)

INTRODUCTION: Total knee arthroplasty (TKA) is a cost-effective procedure to treat endstage knee arthritis. However, patients considering TKA may present with a range of comorbid medical conditions affecting the likelihood of having an unplanned hospital readmission. The readmission rates of different knees prosthesis designs have not been widely evaluated, though they have implications for patient care and the potential burden on the healthcare system. The purpose of this study was to compare the readmission rates between cruciate-retaining (CR) and posterior-stabilizing (PS) TKA designs and evaluate the potential contributing factors.

METHODS: Prospectively collected data on 763 patients who had undergone 845 TKAs at 22 institutions (24 surgeons) between 2005 and 2008 was reviewed. This included 441 TKAs implanted with a CR design in 170 men and 242 women with mean age of 66 years and a mean body mass index (BMI) of 30.3 kg/m². There were 404 TKAs implanted with a PS design in 200 women and 151 men with mean age of 65 years and a mean BMI of 30.9 kg/m². Outcomes evaluated included incidence of readmission at 30, 60, and 90 days, the underlying medical or surgical cause of the readmissions, and the potential contributing risk factors such as patients' age, BMI, and comorbidities to these unplanned readmissions.

RESULTS: There were no significant differences in readmission rates between the two cohorts at 30, 60, and 90 days after discharge. There were 15 readmissions (3.4%) in 6 men and 9 women who received the CR prosthesis and 19 readmissions (4.7%) in 10 women and 7 men who received the PS prosthesis. This included a readmission rate of 2% (n=9) at 30-days and 3.2% (n=14) at 60-days after discharge for the CR group and 2.2% (n=9) at 30-days and 3.7% (n=15) at 60-days after discharge for the PS group. Of the readmission events, 9 (2%) and 10 (2.4%) were due to general medical related causes in the CR and PS groups respectively. In addition, there were 6 (1.4%) CR and 9 (2.2%) PS operative site or surgery-related readmissions. There were no significant differences in demographics ($p>0.54$) between the readmitted and non-readmitted cases in the CR group. However, these readmitted patients had a 29.8% higher incidence of cardiovascular disorders. In the PS groups, the readmitted patients had a significantly higher BMI ($p=0.03$) and 26% higher incidence of diabetes, 7.4% higher incidence of musculoskeletal, and 3.9% higher incidence of cardiovascular disorders. Medical causes were the etiology of early readmissions (within 0 to 30 days) in 66.5% and 44.5% and of late readmission (within 60 to 90 days) in 0% and 66.5% of patients who had received CR and PS prostheses, respectively.

DISCUSSION: The readmission rates of this CR and PS prosthesis in the setting of primary total knee arthroplasty are encouraging since these rates are lower than previously reported outcomes in the literature (4 to 8 %). Unplanned hospital readmissions are expensive and an undesired outcome for the patient, physician, and healthcare system and should be further investigated.

O23A4

Periprosthetic Infection in the Tumor Patient

Primary Author: Daniel C. Allison

Institution: Cedars-Sinai Medical Center + University of Southern California

Coauthors: Eddie Huang (University of Southern California), Ahlmann R. Elke (University of Southern California), Scott Carney (University of Southern California), Lingjun Wang (University of Southern California), Lawrence R. Menendez (University of Southern California)

INTRODUCTION: Infection complicates traditional joint reconstruction prostheses in at least 1 – 2.2% of cases. Oncologic prostheses become infected at a higher rate, and such infections are more difficult to remit. We aim to review our experience with prosthetic infection in our oncologic patients in order to help determine the incidence of the condition, associated factors, and potential prognostic variables.

METHODS: We retrospective case reviewed 329 consecutive oncologic patients treated with hip or knee tumor resection and endoprosthetic joint reconstruction. We then evaluated these patients for the development of deep periprosthetic infection, and further analyzed these infected patients with regard to comorbidities, adjuvant therapies, and infection treatments.

RESULTS: Of all of the lower extremity oncologic joint reconstruction cases, a total of 13.1% developed periprosthetic infection (20.5% about the knee and 6.1% about the hip). The most common organism cultured was *Staphylococcus aureus*. Debridement with implant retention procedures achieved a 42% infection remission success rate, as opposed to 62% with the two-staged procedure and 100% with amputation. Adjuvant radiation and chemotherapy alone were associated with statistically increased infection rates, with 3.85 and 1.5 relative risk increase, respectively. Infection cases were correlated with a statistical increase in revision surgery rates.

DISCUSSION AND CONCLUSION: Infection complicates lower extremity prosthetic joint reconstructions in oncologic patients in approximately 13% of cases. The most common organism remains *Staphylococcus* species, and eradication rates are lower than those for periprosthetic infections in non-oncologic patients. Infection is associated with radiation and chemotherapy administration, as well as an overall increase in revision surgery rates. Such information should be kept in mind when counseling such patients before reconstruction as well as while managing these patients during the initial peri-operative process.



O23A5

Survival of Knee Modern Tumor Endoprostheses: Complications, Functional Results, and a Comparative Statistical Analysis

Primary Author: Pietro Ruggieri

Institution: University of Bologna, Istituto Rizzoli

Coauthors: Elisa Pala (University of Bologna, Istituto Rizzoli), Giulia Trovarelli (University of Bologna, Istituto Rizzoli), Andrea Angelini (University of Bologna, Istituto Rizzoli), Ilaria Piraino (University of Bologna, Istituto Rizzoli), Marco Maraldi (University of Bologna, Istituto Rizzoli)

OBJECTIVE: to retrospectively analyze results of a modular reconstructive tumor prosthesis after resection of bone tumor around the knee.

MATERIALS AND METHODS: between 2003 and 2010, 259 GMRS knee prostheses were implanted: 148 male, 111 female, mean age 33 years (range 9-81 yrs). Sites included 199 distal femur, 60 proximal tibia. Histologic diagnoses: 152 osteosarcomas, 15 Ewing sarcomas, 11 chondrosarcomas, 17 spindle cell sarcoma, 11 other sarcomas, 6 metastases, 353 giant cell tumors. In 12 cases the prostheses was used for failed implants for non oncologic reasons. Causes of endoprosthesis failure were classified according to Enderson et al. classification in 5 types. Reconstruction of the extensor mechanism and wound coverage was performed with gastrocnemius muscle flap in 55 cases, with gastrocnemius muscle flap and augmentation in 5 cases (2 LARS® artificial ligament and 3 equine pericar-

dium xenograft) Functional results (MSTS system) were analyzed and Kaplan-Meier curves of implant survival defined comparing primaries and revisions.

RESULTS: At a mean oncologic follow up of 4 years (range, 2 to 8 years), 176 patients are continuously NED, 36 NED after treatment of relapse, 8 AWD, 27 DWD. The overall failure rate in our series was 28.9% (75/259) at a median of 1.7 years (range, 1 month to 7 years). Type 1 failure occurred in 21 cases, type 2 in 15, Type 4 in 25 and type 5 in 14. Breakage of prosthetic components (type 3 failure) did never occur. The overall survival of all series to all types of complications is 70% at 4 yrs and 58% at 8 yrs. In proximal tibia reconstructions the overall complication rate is 37% (22/60): 8 type 1, 4 type 2, 7 type 4, 3 type 5. In distal femur reconstruction the overall complication rate is 37% (53/199): 13 type 1, 11 type 2, 18 type 4, 11 type 5. Functional scores were obtained in 199 of 259 patients. The average overall score was 83% (25 range, 8-30). In proximal tibia reconstruction the mean MSTS score was 25.6 (85%).

CONCLUSION: Middle term results with GMRS are good, with excellent functional results and low incidence of complications. Proximal tibia reconstruction with modular megaprosthesis showed good function; the medial gastrocnemius flap was the gold standard for both reconstruction of extensor mechanism and coverage of the prostheses.

O23A6

Patellofemoral Degenerative Changes and Congruence in Unicompartmental Knee Arthroplasty

Primary Author: Saker Khamaisy

Institution: Hospital for Special Surgery

Coauthors: Ran Thein (Hospital for Special Surgery), Hendrik A. Zuiderbaan (Hospital for Special Surgery), Andrew D. Pearle (Hospital for Special Surgery)

BACKGROUND: Pre-existing patellofemoral joint (PF) degeneration and pain are classic exclusion criteria for unicompartmental knee arthroplasty (UKA). However, considering pathologic findings in PFJ radiographs as contraindication is a constant subject of debate. The purpose of this study is to evaluate the PFJ degeneration and congruence alterations following UKA. Furthermore, we evalu-

ate if there is any correlation between these values and the clinical outcomes in a cohort of patients who underwent minimally-invasive medial fixed bearing UKA using a robotic assisted surgery technique.

METHODS: Retrospectively, we evaluated pre- and post-operative radiographs of 113 knees (110 patients) for radiographic PFJ degenerative alterations including; congruence (i.e. congruence angle, lateral patellar angle, lateral patellar displacement), degenerative changes (modified Altman) and mechanical lower limb alignment. None of the patients had PFJ symptoms prior to the surgery. Secondly; we prospectively collected the Western Ontario and McMaster Universities Osteoarthritis Index scores of all patients who underwent medial UKA pre- and postoperatively.

RESULTS: The mean follow-up was two years (1 to 4.2). Pre-operative 101 (75.5%) of the PFJ radiographs have showed mild degenerative changes (modified Altman score=1) and 31 (23.5%) showed moderate to severe degenerative changes (modified Altman score=3 or 4). Pre-operatively the absolute patellar congruence angle was 14.23 ± 11.22 which decreased significantly to 10.05 ± 10.28 post-operatively, ($P=0.0038$). Pearson product moment correlation test showed no correlation between WOMAC scores, patellar congruence angle, lateral patellar displacement, lateral patellar angle or limb alignment. GEE Regression analysis showed no correlation with the severity of PFJ degeneration and WOMAC scores. GEE Regression analysis showed correlation (between lateral patellar displacement and WOMAC functional and pain scores ($p=0.0212$, $p=0.001$ respectively)). However these changes were too minimal to consider as clinically significant.

CONCLUSIONS: Our data show that pre-operative PFJ congruence and degenerative changes do not affect UKA clinical outcomes. These findings suggest that UKA may secondarily delay patella-femoral joint OA by improving patellar alignment.

O23A7 Second Generation Robotic in Vivo Fluoroscopic Imaging of Normal Patient Movements

Primary Author: W. R. Hamel, R. D.

Institution: Center for Musculoskeletal Research, Univer-

sity of Tennessee, Knoxville, Tennessee 37996, USA

Coauthors: Komistek, D. Dennis (Center for Musculoskeletal Research, University of Tennessee, Knoxville, Tennessee 37996, USA), Matthew Young (Center for Musculoskeletal Research, University of Tennessee, Knoxville, Tennessee 37996, USA), and William Anderson (Center for Musculoskeletal Research, University of Tennessee, Knoxville, Tennessee 37996, USA)

A Tracking Fluoroscope System (TFS), the first of its kind, has been developed and the design of this new technology has been previously presented. The TFS is a unique mobile robot that can acquire real-time x-ray records of hip, knee, or ankle joint motion while a subject walks/maneuvers naturally within a laboratory floor area. By virtue of its mechanizations, test protocols can involve many types maneuvers such as chair rises, stair climbing/descending, ramp crossing, walking, etc. Because the subjects are performing such actions naturally, the resulting fluoroscope images reflect the full functionality of their musculoskeletal anatomy. To date, the TFS has been used in numerous TKR clinical studies with effective results. These studies also help identify key areas where the machine could be improved, particularly with regard to tracking through fast and complex maneuvers.

The second generation of the original TFS, TFS-II, has been designed and implemented. TFS-II includes major mechanical and control modifications that have significantly enhanced its dynamic response and joint imaging capabilities, which means that it is able to track faster joint motions and to maintain tracking during leg crossovers. In this paper, the second-generation modifications will be summarized and the human-subject experiments verifying the performance enhancements will be presented. A new joint tracking algorithm based on the integration of the subject gait kinematics is shown.



Figure 1, Tracking Fluoroscope System, Front View

Hip Anatomy & Component Positioning

O23B1

Surgical Pearls of Hip Anatomy

Guest Faculty: Harold E. Cates, MD

Institution: Center for Musculoskeletal Research, University of Tennessee, Knoxville, TN, USA

Visualization in contemporary total hip arthroplasty is often limited with the advent of smaller incisions and surgical perspective can be altered when different or newer surgical approaches are utilized. This presentation reviews traditional hip anatomy relative to specific approaches with emphasis on mini- posterolateral and direct anterior approaches. Specific topics discussed are femoral and acetabular anteversion, hip abductors and external rotators, approach specific bleeding points and anatomic danger zones. Special attention to three-dimensional anatomy is also discussed in relation to component positioning. In addition, gender, disease specific and ethnic anatomic variations are discussed. A better knowledge of anatomic relationships and component positioning leads to improved surgical technique and ultimately improved surgical outcomes.

O23B2

Component Positioning in TKR: Traditional Instrumentation and Anatomic Landmarks

Guest Faculty: John J. Callaghan, MD

Institution: University of Iowa, Iowa City, IA; VA Medical Center, Iowa City, IA, USA

Coauthors: Lawrence & Marilyn Dorr Chair (University of Iowa, Iowa City, IA; VA Medical Center, Iowa City, IA)

TKR alignment includes coronal, sagittal, and rotational plane considerations.

- I. Coronal plane alignment
 - A. Anatomic alignment: femoral tibial angle of 5-9 degrees valgus²
 - B. Mechanical axis: line through the center of the

hip, center of the knee, and center of the ankle²

- II. Sagittal alignment
 - A. For PS knee, avoid flexion of the femoral component and posterior slope of the tibia (to avoid cam post impingement).
 - B. For posterior cruciate retaining TKR, tibial posterior slope is required to assure flexion
- III. Rotational alignment
 - A. Posterior referencing:
 1. 3 degrees external rotation to the posterior femoral condyles
 2. Epicondyles secondary reference
 3. Also, Whiteside's line
 - B. Anterior referencing
 1. A resection block parallel to the cut tibial surface.
 2. Epicondyles and Whiteside's line secondary reference
- IV. Traditional Instruments for TKR
 - A. Instrument options
 1. Intramedullary
 2. Extramedullary
 - B. Intramedullary femoral and extramedullary tibial coronal plane resection instruments most common:
 1. Extramedullary femur instruments (difficult to identify femoral head)
 2. Intramedullary tibial instruments tendency to varus cut if bowing in Tibia
 - C. Tips to traditional instrumentation
 1. Avoid varus of proximal tibial resection. Goal perpendicular to shaft
 - a. Align tibial guide to center of talus rather than between malleoli (in valgus knee, err in extra degree of varus – due to tibial deformity)
 2. 5-7 degree valgus resection of femur in varus knee. 5 or less in valgus knee. Goal is joint line parallel to ground.
 3. In sagittal plane, avoid distal femoral resection causing flexion of the femoral component. Avoid excessive tibial slope. Different for PS and CR designs. [4]

TKA performed with traditional alignment jigs create few outliers and minimal loosening long term. [1,3]

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O23B3

Proper Positioning of THA Components

Guest Faculty: Mohamed R. Mahfouz, PhD

Institution: University Of Tennessee, Knoxville TN, USA

It is well known that malalignment of the acetabular cup is a leading cause of early implant failure and dislocation. Malalignment is said to occur when a component is placed outside of Lewinnek's safe zone (5–25° anteversion and 30–50° abduction). Bosker calculated the likely percentage of placing the component within 5° of desired orientation at 21.5%. To improve cup positioning, smart systems such as computer navigation, robotics or patient specific instruments have been developed. While literature suggests these methods reduce placement variability and improve likelihood of placement within the safe zone, they are not without shortcomings. Computer navigation is expensive and highly sensitive to landmark selection and correct registration in the operating room. Optical systems can also suffer from line of sight obstructions. Robotic surgical systems provide excellent accuracy and reproducibility, but cost can be prohibitive. Patient specific instrumentation for THA is gaining momentum, but requires prohibitive preprocessing to generate a patient-matched component – and the footprint of the component must fit into the limited available incision space, often degrading stability and accuracy.

Existing system and implant design philosophies rely on the concept of the 'safe zone' as defined relative to the an-

terior pelvic plane (APP). The failure to identify the correct anatomical landmarks for the APP will lead to error in final cup alignment. Wolf found an error of 4 mm in measuring the anterior superior iliac spine and the pubic tubercles would result in a 2° abduction error and 7° error in anteversion angle. Using APP relies on static reference frame, however, the inclination of the pelvis relative to the coronal plane of the body varies significantly between individuals and between the supine, sitting and standing positions. Such variations have effect on the functional orientation of the acetabular component. In conclusion proper positioning of the acetabular component is a challenging problem, which has to be addressed with new methods that offer accuracy, reliability and less limitations in the operating environment and accounting for the patient-specific dynamic behavior of the pelvis in the sagittal plane.

O23B4

Combined Safe-Zone (cSafe-Zone) for Correct Cup/Stem-Positioning in MIS-THA : Basics and Surgical Application

Primary Author: Karl-Heinz Widmer

Institution: University of Basel, Switzerland, Orthopedic Department Kantonsspital Schaffhausen

INTRODUCTION: Optimizing the intended range of movement (iROM) by reducing the risk for prosthetic impingement highly contributes to the prevention of mechanical complications in total hip arthroplasty (THA) like subluxation, dislocation, edge loading, increased debris, surface damage or squeaking in ceramic-on-ceramic hips. Component positioning is one of the major parameters that affect these factors which can be easily controlled by the surgeon. Unfortunately component positioning is more difficult in MIS-surgery. It should be follow the recommendations given by the new combined safe-zone which is bordered polygonally and varies in size. This study shows how this optimal combined orientation of both components can be determined for a specific total hip prosthetic system and how the result can be transferred to surgery and realized intraoperatively using minimal-invasive stem-first technique.

MATERIAL AND METHODS: A total of 829 minimal-invasive total hip arthroplasties (MIS-THA) have been performed from 2007 to 2013 in our institution via a minimal-invasive direct anterior approach (DAA). All patients were

positioned supine on a proprietary orthopedic table providing foothold. In 168 of these cases a systemspecific navigation trial head was used intraoperatively in order to control the combined version and inclination according to the cSafe-Zone. This is called “stem-first technique” meaning that the prosthetic stem dictates the orientation of the socket while it has nothing to do with the sequence of implantation. This simple navigational tool redirects the socket appropriately according to the stem’s type. It equally applies to standard, anatomic (Fig. 1) or short stems (Fig. 2). Hence, the socket orientation is primarily referred to the neck of the stem and not to bony landmarks but nevertheless sufficient containment within the acetabular bone has to be considered. All other patients were operated on using our standard minimal-invasive DAA-procedure. The majority of the patients suffered from osteoarthritis, their mean age was 68 years.

RESULTS: Optimal combined component orientation is derived from the 3D-model for each prosthesis system by simulating physiologic hip joint motion. The size of the cSafe-Zone is maximized when the socket is radiographically anteverted between 20° and 25°. Combining it with a straight 130°-CCD-stem this stem should be in 20° \pm 4-degree of antetorsion while an anatomic 127°-CCD-stem should be in 8° \pm 4-degree antetorsion. Cup anteversion and stem antetorsion show a linear but inverse correlation. In the stem-first group cup orientation was in the new cSafe-Zone in 92% of the cases and no squeaking or prosthetic impingement did occur in any of these patients. Leg length did not differ more than \pm 5mm. 83% of all patients received a ceramic-on-ceramic articulation, one early dislocation did occur and was treated by closed reduction.

CONCLUSION: Stem-first technique using a navigation trial head is ideally suited for the minimal-invasive direct anterior approach in total hip arthroplasty to control the combined orientation of the prosthetic components. It assists the surgeon in aligning the cup and the stem according to the cSafe-Zone in order to get the optimal iROM which is especially important in young patients.

O23B5

A Comparison Between Imageless Navigation and a 2D-3D Reconstruction Technique in Determining Acetabular Cup Orientation

Primary Author: Guoyan Zheng

Institution: Institute for Surgical Technology and Biomechanics, University of Bern

Coauthors: Benjamin S. Craiovan (Regensburg University Medical Center, Germany), Tobias Renkawitz (Regensburg University Medical Center, Germany), Joachim Grfika (Regensburg University Medical Center, Germany), Lutz-P. Nolte (University of Bern)

BACKGROUND: Optimal acetabular cup orientation has been shown to be an important factor in determining the success of total hip arthroplasty (THA). In order to improve the intra-operative cup placement precision, navigation systems have been developed. Despite the fact that the registration method in imageless navigation, i.e., percutaneously touching bony landmarks may decrease the accuracy, especially in obese cases or in patient with acetabular dysplasia, such systems remain to be the most-often used in clinical routine.

MATERIALS AND METHODS: To study the related accuracy, two additional techniques were developed to measure the post-operative cup orientation of 20 patients (9 men and 11 women) who received a primary THA. Each patient had a CT study and a standard anteroposterior (AP) radiograph after surgery. Post-operative cup orientations were measured with a post-operative CT based technique and a single conventional X-ray image-based 2D-3D reconstruction technique. This technique is a validated method for measuring acetabular cup orientation. Underlying this method is a statistical shape model-based 2D-3D deformable registration algorithm that can reconstruct a patient-specific 3D-model from a single standard AP pelvis radiograph (Fig-1). Based on a statistical shape model of the pelvis, our 2D-3D reconstruction method uses a sophisticated, three-stage sequential optimization procedure to estimate not only the affine transformation between the statistical shape model and the input image but also the weights for the principal shape modes by matching the silhouettes detected from the statistical shape model to contours extracted from the input radiograph. Required input includes a digital radiograph, the pixel size, and the film-to-source distance. No specific calibration of the X-ray radiograph or a CT scan of the patient is required. After reconstruction, cup orientation (inclination and anteversion) is then calculated with respect to the APP extracted from the reconstructed 3D model.

RESULTS: In this study, the post-operative CT based

measurements were regarded as the ground truth. In comparison to the ground truth, the measurements with the intra-operative imageless navigation technique showed a mean deviation of -2.3 ± 3.3 degrees (range $-7.8 - 2.3$ degrees) for inclination and a mean deviation of 1.1 ± 6.5 degrees (range $-11.9 - 11.7$ degrees) for anteversion while the measurements with the single x-ray image based 2D-3D reconstruction technique demonstrated a mean deviation of 1.4 ± 1.9 degree (range $-2.7 - 3.7$ degrees) for inclination and a mean deviation of 0.6 ± 2.2 (range $-3.1 - 5.5$ degrees) for anteversion. The measurements from the 2D-3D reconstruction technique were strongly correlated with the ground truth for both inclination ($R^2=0.69$) and anteversion ($R^2=0.89$) while the measurements from the imageless navigation technique were not ($R^2=0.12$ for inclination and $R^2=0.04$ for anteversion, respectively).

CONCLUSIONS: This study raises a question about the measurement accuracy of imageless navigation technique for THR. It also demonstrates that the single X-ray image based 2D-3D reconstruction technique is an accurate method for determining post-operative cup orientation without the need of a post-operative CT scan.



O23B6 Clinical Experiences with ROBODOC in Total Hip Arthroplasty

Primary Author: Boerner Martin

Institution: Chairman of the board Dr. Erler Clinics Nuremberg, Germany.

Coauthor: Erbe Klaus (CTC Fremont)

During my active phase in a Trauma Hospital in Frankfurt/Germany (now I am retired): we started 1994 with computer-assisted surgery (Robodoc). Robot-assisted THR can be performed without unforeseeable risks for the patient. The use of ORTHODOC in pre-operative planning is the real benefit of the system. The robot guarantees the precise execution of the pre-op planning. Femoral fractures can be

avoided. The OR-time is longer but acceptable. More than 5000 patients had been operated on using the Robodoc system. We also used a special designed implant (short stem) with a reduction of OR-time while at the same time soft tissue and bone is saved. Overview of the advantages of ROBOT-assisted surgery after 5000 cases: - optimal preoperative planning and execution by the robot - greatly increased bone/implant contact - pinless procedure (no additional surgery) - high primary stability - successful osseointegration - no fractures or fissures intraoperatively - no increased rate of infection, muscular deficiencies, nerve- or vessel lesion - exposure not greater than in conventional method - OR-time increased by about 20 minutes. In all the years a disadvantage was however that the cup must be done conventional. But now there is a progress. There will be a short report about the cup implantation assisted by Robodoc. The report shows the own experiences (advantages/drawbacks) with the ROBODOC system.

O23B7 Measuring Pelvic Tilt and Rotation Using 2D 3D Matching

Primary Author: Guoyan Zheng

Institution: Institute for Surgical Technology and Biomechanics, University of Bern

Coauthors: Simon D. Steppacher (University of Bern), Moritz Tannast (University of Bern), Lutz-P. Nolte (University of Bern)

INTRODUCTION: Previously, we introduced a program called "HipMatch" for accurate determination of cup orientation by performing a 2D-3D registration between a CT scan of the patient and a post-operative x-ray radiograph. The transformation that is obtained from the 2D-3D matching also allows one to transform the anterior pelvic plane from the CT data coordinate system to the x-ray image coordinate system for a computation of the pelvic tilt and rotation with respect to the x-ray imaging table/plate. In this paper, we present a cadaver study to validate the accuracy of measuring pelvic tilt and rotation using this previously introduced 2D-3D matching program.

METHODS: 13 cadaver pelvises were used in our validation study. A custom-made holding device with radiolucent brackets was used to clamp each pelvis between the acetabula thereby allowing tilting around the interacetabular

lar axis and rotation around the longitudinal axis in graded (1 degree). Each pelvis initially was placed in a neutral orientation. Starting from this neutral position, we then obtained serial digital Anterior-Posterior radiographs for different pelvic orientations. The pelvis was tilted around two axes in graded increments of 3 degree at a time. The maximum tilt amplitude was chosen to be ± 12 degree and the maximum rotation amplitude was chosen to be ± 9 degree. At each position, we acquire one radiograph in a standardized manner. To validate the accuracy of measuring pelvic tilt and rotation using 2D-3D matching, we also obtained a CT scan for each pelvis. Each time one of the x-ray radiographs of a pelvis was used together with its associated CT data as the input to our program for a computation of the pelvic tilt and rotation (Figure-1). To measure the incremental tilt and rotation changes of the pelvis using the 2D-3D matching, we subtract the pelvic tilt and rotation measured using the x-ray radiograph acquired at the neutral position from those measured using the x-ray radiographs acquired at other positions. We then compared the incremental tilt and rotation changes as measured by the 2D-3D matching technique to the associated readouts from the custom-made holding devices, which we regarded as the ground truths.

RESULTS: The differences between the incremental pelvic tilt and rotation changes as measured by the 2D-3D matching technique and the associated ground truths of all thirteen pelvises were obtained. An average difference of -0.2 ± 0.7 degree (range: from -2.5 to 1.6 degrees) was found for the pelvic tilt measurement and an average difference of -0.01 ± 0.7 degree (range: from -2.1 to 3.5 degrees) was found for the pelvic rotation measurement.

DISCUSSION: In this paper, we present a cadaver study to validate the accuracy of measuring pelvic tilt and rotation using 2D-3D matching technique. Our experimental results demonstrate that the pelvic tilt and rotation can be accurately measured by performing a 2D-3D registration between a CT scan of the patient and an x-ray radiograph. One of our future directions is to apply this technique to more clinical applications such as investigating the pelvic tilt change before and after surgery.



The Future of Knees?

O24A2

The Ergonomics of Efficient Surgical Technique in TKR

Primary Author: SM Michnick

Coauthors: PC Noble, GS Sharma, HE Adams, SK Ismaily, RE Booth, VL Brown and KB Mathis

INTRODUCTION: With the growing emphasis on the cost of medical care, there is renewed interest in the productivity and efficiency of surgical procedures. We have developed a method to systematically examine the efficiency of the surgical team during primary total knee replacement (TKR). In this report, we present data derived from a series of procedures performed by different joint surgeons. This data demonstrates a variation between the duration and efficiency of each step in this procedure and its relationship to the experience and coordination of the surgeon working with the scrub team.

METHODS: After consent was achieved, videotaped recordings were prepared of ten primary TKR procedures performed by five highly experienced joint surgeons. For quantitative analysis, each procedure was divided into 7 principal tasks from initial incision to wound closure. In order to quantify efficiency, we recorded the occurrence of events leading to delays in each step of the procedure (Table 1). Starting with a total score of 100 points, deductions were made, based on the number of delaying events and

its impact on the efficiency of the procedure. A final score for the surgery was then determined using the individual scores from each principal task. The experience of each member of the surgical team in participating in TKR, and in working with the surgeon, were recorded and correlated with the total efficiency score for the entire procedure.

RESULTS: The average duration of the 10 procedures examined was 55 minutes (range: 38 to 81 mins). The longest steps during the procedure were closing the incision (13 mins; 24%) and performing the osteotomies of the distal femur (12 mins; 22%). A total of 570 delaying events were recorded from 10 surgeries, an average of 57 per surgery; least frequently the surgeon was handed the wrong instrument (0.4 /case), and most commonly, the surgeon diverting his attention from the surgical field, (35.2 times/case). Using our scoring system, the mean efficiency of the surgeries was 81.2%. The least efficient step was performing osteotomies of the distal femur (71.5%), whereas the opening incision is the most efficient step (96%). The median experience of the surgical assistant working with each operating surgeon was 5 years. Surgical team experience correlated positively with efficiency. The mean score of surgeries of teams with 5 years experience was 81.2%, vs. only 71.9% when the surgical tech had never operated with the surgeon previously.

CONCLUSIONS: The results of this study suggest that team experience has an important impact on operating efficiency, which has a direct impact on operation times. This suggests that a training exercise, which promotes operation knowledge and teamwork, will have a beneficial effect on efficiency.

Events Leading to Reduced Surgical Efficiency		
Delaying Event	Total Events (n=10)	Average events per surgery
Surgeon makes verbal request for item	79	7.9
Surgeon waits 5-7 seconds for item	37	3.7
Surgeon handed the wrong item	6	0.6
Surgeon's attention diverted from surgical field	360	36
Surgeon repositions grip on item	36	3.6
Surgeon assembles instrument	285	2.9
Retractor adjustments required for better visualization	13	1.3

Table 1: Information about the number of individual events impacting surgical efficiency

O24A3 Joint Line Reconstruction in Revision TKA

Primary Author: Bruno Violante

Institution: Istituti Clinici Zucchi, Monza, Cava de Tirreni (sa) Italy

The presentation focus on the different aspects of Revision TKA, treat the bone defects and recreate the Patello femoral Joint Line and the Femur Tibia Joint Line. Analysis is made on the bone landmarks and the classic scenario presented during a Revision TKA.

How to manage a flexion GAP greater then the extension GAP recreating the correct posterior condilar offset and the joint line.

How to manage the distal joint line and obtain a re building of distal femur with a respect of the P/F Joint Kinematic.

How to balance gaps in Revision TKA.

Analysis made on the use of methaphisis sleeve and cones and use of short cemented stem.

O24A4 Reconstructing Knee Anatomy and Surgical Axes From X-ray Radiography Using Statistical Shape Models

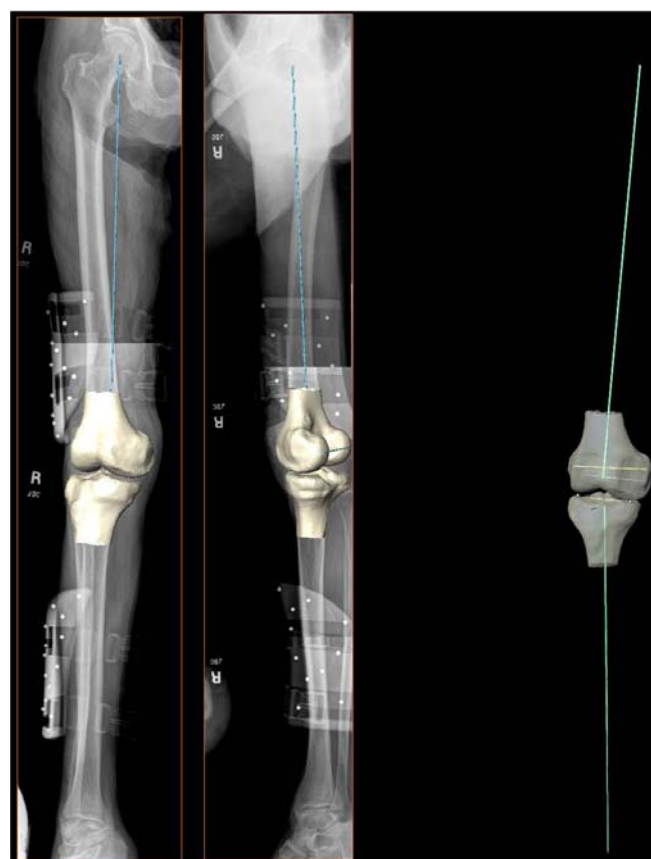
Primary Author: Hatem El Dakhakhni

Institution: Techmah, LLC

Coauthors: Mohamed Mahfouz (University of Tennessee), Michael Johnson (Techmah, LLC)

The availability of a three-dimensional (3-D) bone model for Total Knee Arthroplasty (TKA) allows for accurate patient-specific surgical planning. Unfortunately, such models are not always available due to the high cost of 3-D imaging solutions. In this work, we provide an accurate and cost effective alternative by using current radiographic imaging protocols (Anterior-Posterior (AP) and Lateral views) to reconstruct the patient-specific 3D models. Furthermore, in order to eliminate the need for expensive biplanar imaging modalities, two calibration targets were attached to the patient's thigh and calf using patient-friendly braces to track the poses to the femur and tibia between

images. The reconstruction process overcomes the lack of sufficient 3-D bone shape information, by utilizing gender specific 3-D statistical bone models. The statistical models were generated from a large ($n=314$) database of dry and cadaveric CT bone scans. The mean of the statistical is used as an initial template, which is registered to the image space based on a combination of image landmarks and relative transformation constraints, as extracted from the calibration target. The registered template bones are then utilized in a sophisticated bone deformation platform that iteratively fits the bone 3-D shape to manually extracted radiographic image contour features. This process is done to produce patient-specific bone models for both the distal femur and proximal tibia. A cartilage thickness model created from a database of segmented MRI datasets ($n=80$) is then used to automatically add cartilage to the generated bone models by deforming the thickness models in order to fit the knee gap constraints. Surgical landmarks were then automatically extracted from the generated models (with cartilage) using our statistical atlas landmarking information. In order to extract the mechanical axes extreme points, a circle into the femoral head, and the center of the tibial inferior articular surface were selected on all image views. From the extracted 2-D points, 3-D points were generated using epipolar geometrical constraints obtained from the calibration target poses. The accuracy of our method was assessed on eight cadaveric legs, and one live patient study was performed. Results for reconstruction surface RMS surface error and surgical axes angular difference was compared to corresponding manually segmented MRI datasets. Surface RMS error obtained was 1.19 ± 0.75 mm for the femur and 1.06 ± 0.66 mm for the tibia. Femur mechanical axis error was 1.5 ± 0.03 degrees. Tibia mechanical axis error was 2.4 ± 0.1 degrees. Femur Transepicondylar axis error was 1.87 ± 0.93 . Femur Posterior condylar axis error was 1.82 ± 0.78 . The results show the adequacy of the proposed method for surgical planning. It provides a much faster method for obtaining 3-D models, with a total processing time of less than 30 minutes, compared to more than 3 hours for MRI. It also provides a more accurate solution than current 2-D templating methods.



O24A5 TKA Patients Balanced with Intraoperative Sensing Demonstrate Significantly Higher Outcomes Scores at One Year

Primary Author: Martin W. Roche

Institution: Holy Cross Hospital, Orthopedic Institute

Coauthors: Kenneth Gustke (Florida Orthopaedic Institute), Gregory Golladay (VCU), Gerald Jerry (Bone and Joint Institute)

BACKGROUND: Obtaining proper soft-tissue balance is a critical intraoperative factor which strongly influences clinical outcomes following TKA. Traditionally, assessing balance of the soft-tissue envelope has been dictated by the subjective judgment of each surgeon. However, intraoperative sensors have recently been developed to provide dynamic feedback and guidance for the nuances of soft-tissue release.

OBJECTIVES: The purpose of this 3-year, multicentric study is to evaluate 500 patients (who have had primary

TKA with the use of intraoperative sensors) in order to correlate quantified ligament balance to clinical outcomes.

METHODS: 8 centers have contributed 135 patients who have undergone primary TKA with the use of intraoperative sensors. All patients have subsequently been seen in clinic at the 1-year follow-up interval. Standard demographic/surgical data was collected. At the one-year interval, KSS, WOMAC, and satisfaction evaluations were administered, and activity levels were assessed. Intraoperatively, medial-lateral compartmental loads were recorded, pre- and post-release, as shown by the graphic user interface of the sensor system. “Optimal” soft-tissue balance is defined as a medial-lateral load difference of ≤ 15 lbs., based on previously reported literature. Figure 1 shows pre-release imbalance in the left panel (with a medial-lateral loading difference of 54 lbs.), and the post-release correction and subsequent balance in the right panel (with a medial-lateral loading difference of 1 lb.).

RESULTS: The average age of this cohort was 70 years: 63% are female and 37% are male, with a mean BMI of 30.6. In this cohort, 13% of patients remained unbalanced, due to surgeon discretion, and were thus able to be statistically compared to the remaining balanced patients, at all follow-up intervals. There was no statistically significant difference between the balanced and unbalanced groups’ outcomes scores, or activity levels, pre-operatively. However, at 1-year, balanced patients demonstrated significantly better scores in total KSS, KSS pain, KSS function, activity level, and satisfaction ($p < 0.001$, $p < 0.001$, $p = 0.022$, $p = 0.015$, $p = 0.043$) (Figure 2). WOMAC scores, while not statistically different ($p = 0.085$), indicate that balanced patients are performing, on average, 7.5 points better than unbalanced patients. Of the balanced patients, 96.7% reported “satisfied-very satisfied”, while only 78% of the unbalanced patients reported “satisfied-very satisfied”.

CONCLUSIONS: Optimized ligament balance using intraoperative sensors led to a significant disparity between the scores of balanced versus unbalanced patients. Notable was the 23.2-point difference between the two groups, in Total KSS at one year, and the 96.7% satisfaction of the balanced group. These results may indicate more favorable kinematics in the balanced group of patients, which would contribute to the increase in function and decrease in pain, when compared with unbalanced patients. These results are promising. Thus further follow-up will prove important in affirming the observation that sensor-quantified soft-tis-

sue balancing improves patient outcomes in TKA.



	Balanced Average Score	Unbalanced Average Score	P
KSS Total	179.3	156.1	$p < 0.001$
KSS Pain	96.4	87.8	$p < 0.001$
KSS Function	82.4	68.3	$p = 0.022$
WOMAC	10.4	17.9	$p = 0.085$
Activity Level	Light Labor	Semi-Sedentary	$p = 0.015$
Satisfaction	32.5	29.6	$p = 0.043$

O24A6

High Satisfaction and Early Adaptation of Limb Length Change in Simultaneous Bilateral Open Wedge HTO

Primary Author: DongBeom Heo

Institution: Yonsei Sarang Hospital

Coauthors: YongGon Koh (Yonsei Sarang Hospital), OhRyong Kwon (Yonsei Sarang Hospital), SeungBae Jo (Yonsei Sarang Hospital), DongSuk Suh (Yonsei Sarang Hospital), YunJin Choi (Yonsei Sarang Hospital)

BACKGROUND: We compared the clinical, radiologic results and limb length change after the staged- and simultaneous-bilateral open-wedge high tibial osteotomies using TomoFix (Shyntes Inc., Bettlach, Switzerland) fixation device.

MATERIALS AND METHODS: From July 2010 to January 2013, 130 open-wedge high tibial osteotomies were performed in 65 patients with an average age of 54.5 years (40~79) at the time of operation. Among them, simultaneous bilateral procedures were performed in 70 knees of 35 patient, staged (more than 6 months) bilateral procedures were performed in 60 knees of 30 patients. The mean follow-up period was 13.4 months. For clinical assessment, the Knee Society knee and function score, WOMAC score, and range of motion were evaluated. Furthermore, we evaluated discomfort frequency according to the limb length change in both two groups. For radiological assessment, the femorotibial angle and Limb length of the lower

extremity was measured. Clinical and radiological results were compared between two groups.

RESULTS: The average knee and function score improved from 58.1, 63.4 preoperatively to 86.1, 79.1 at the last follow-up in the simultaneous group. In the staged group, this score changed from 59.8, 63.2 to 85.8, 78.3. The WOMAC score improved from 31.7 preoperatively to 14.7 at the last follow up in the both group. The average ROM was 135.2° before high tibial osteotomy, which changed to 135.8° at the last follow-up. The femorotibial angle was 1.0° varus before high tibial osteotomy, which improved to 8.9° valgus at the last follow-up in the simultaneous group, 0.8° valgus to 7.9° valgus in the staged group. There was no statistical significance in these clinical and radiologic results. In the simultaneous group, limb length difference was average 3.37±2.3mm on both lower extremities at the last follow up. But, in the staged group, differences and increasing amount of the limb length was average 6.64±9.4mm after first operation(p=0.022). Furthermore, discomfort frequency of the limb length change after first stage procedure in staged group was 36.7%, but 14.3% in simultaneous group(p=0.036). And, after second procedure, this frequency decreased to 20.0%. There was no correction loss, implant failure, collapse of the artificial bone wedge, or screw breakage.

CONCLUSIONS: The clinical and radiological results in simultaneous and staged group were similar at the last follow up. But, when the same rehabilitation schedule were performed in both group, there were less discomfort according to limb length differences of patients in the simultaneous group. The early adaptation of limb length change were possible in the simultaneous bilateral HTO group compared to the staged group. Furthermore, simultaneous bilateral open wedge HTO have potential advantages of low cost, short hospitalization and rehabilitation period compared to the staged operation.

O24A7

Unicompartmental Knee Arthroplasty Versus Total Knee Arthroplasty. Are We Able to Create the Forgotten Joint?

Primary Author: Andrew Pearle

Institution: Hospital for Special Surgery

INTRODUCTION: The Forgotten Joint Score (FJS) was

developed to assess the patient's ability to forget their artificial joint during everyday life. The purpose of this study was to compare the Forgotten Joint Score (FJS), WOMAC and EQ-5D between patients who underwent medial UKA and TKA 12 months post-operatively. We hypothesized that more physiologic kinematics of UKA will result in a higher the likelihood that the joint will be 'forgotten'.

METHODS: Patients who qualified for medial UKA had (i) antero-medial OA, (ii) an intact Anterior Cruciate Ligament (ACL), (iii) an intact lateral compartment, (iii) correctable varus alignment of the lower extremity and (iv) a flexion deformity < 15°. Patients who did not fulfill these criteria, were candidates for TKA. Pre-operative demographics and clinical data were recorded including age, Body Mass Index (BMI), gender, comorbidities and diagnosis. For placement of the UKA, a robot-arm assisted technique was used for the preparation of the femoral as well as the tibial surfaces (MAKO Surgical Corp, Ft. Lauderdale, FL). At the 12 months post-operative visit all patients were asked to complete the FJS, the WOMAC and EQ-5D.

RESULTS: Sixty-three patients underwent medial UKA and 45 underwent TKA. No significant differences were observed in age, gender and follow-up between the two cohorts (Table 1). The average BMI of the TKA cohort (34.4 ± 6.7) was significantly higher than the UKA cohort (28.3 ± 3.5; p<0.001). At a minimum of 12 months postoperative the average FJS in the UKA cohort (FJS 73.6 ± 22.8) was significantly higher than the TKA group (FJS 63.7 ± 26.65, p=0.04). No statistical differences were observed in all the domains of the WOMAC and EQ-5D scores (Table 2).

CONCLUSION: Our results show that 1 year post-operatively patients who underwent UKA are better capable of forgetting their artificial joint in activities of daily living, than patients who underwent TKA. This data supports the concept that patient satisfaction may be better with UKR as compared to TKR.

	Medial UKA	TKA	P-Value
	N=63	N=44	
Female sex	26 (41.3%)	25 (56.8%)	0.1131
Age	66.7 ± 10.5	68.1 ± 9.3	0.4702
BMI	28.3 ± 3.5	34.4 ± 6.7	<0.0001
Time of follow-up (ys.)	1.5 ± 0.7	1.6 ± 0.6	0.6419

Table 1. Patient baseline characteristics

EQ-5D			
	Medial UKA	TKA	
Mobility	N (%)	N (%)	P-value
Level I	46 (79.3%)	33 (76.7%)	0.7574
Level II	12 (20.7%)	10 (23.3%)	
Level III	0	0	
Self-Care			
Level I	56 (96.6%)	40 (93.0%)	0.6482
Level II	2 (3.4%)	3 (7.0%)	
Level III	0	0	
Usual Activities			
Level I	47 (81.0%)	37 (86.0%)	0.5056
Level II	11 (19.0%)	6 (14.0%)	
Level III	0	0	
Pain/Discomfort			
Level I	33 (56.9%)	27 (62.8%)	0.6083
Level II	24 (41.4%)	16 (37.2%)	
Level III	1 (1.7%)	0	
Anxiety/Depression			
Level I	50 (86.2%)	40 (93.0%)	0.3457
Level II	8 (13.8%)	3 (7.0%)	
Level III	0	0	

Table 2. Comparison (%) of the UKA and TKA responses for each of the five EuroQol (EQ-5D) domains (Level 1, no problems; Level 2, moderate problems; Level 3, severe problems)

Complicated Hip Procedures

O24B1

THA for Salvage of the Failed Hip Fracture

Guest Faculty: Daniel J. Berry, M.D.

Institution: Mayo Clinic, Rochester, MN, USA

I. The Failed Femoral Neck Fracture:

A. Young patient:

Attempt to preserve patient's own femoral head. Clinical results reasonably good even if there are patches of avascular necrosis. Preferred methods of salvage: valgus-producing intertrochanteric femoral osteotomy: puts the nonunion under compression. Other treatment option: Meyer's vascularized pedicle graft.

B. Older patient:

Most reliable treatment is prosthetic replacement. Decision to use hemiarthroplasty (such as bipolar) or THA based on quality of articular cartilage, perceived risk of instability problem. In most patients THA provides higher likelihood of excellent pain relief. Specific technical issues: (1) hardware removal: usually remove after hip has first been dislocated (to reduce risk of femur fracture); (2) Hip stability: consider anterolateral approach in older

patients at risk. (3) Acetabular bone quality: poor because it is not sclerotic from previous arthritis; caution when impacting a pressfit cup; low threshold to augment fixation with screws; don't overdo reaming; just expose the bleeding subchondral bone. A reasonable alternative is a cemented cup.

II. The Failed Intertrochanteric Hip Fracture:

A. Young patient:

Attempt to salvage hip joint with nonunion take-down, autogenous bone grafting and internal fixation. Blade plate usually the favored internal fixation device.

B. Older patient:

Decision to preserve patient's own hip with internal fixation versus salvage with hip arthroplasty should be individualized based on patient circumstances, fracture pattern, bone quality. THA is an effective salvage procedure for this problem in older patients. If prosthetic replacement is chosen special considerations include:

1. THA vs. hemiarthroplasty: hemiarthroplasty better stability; THA more reliable pain relief.
2. Removal of hardware: be prepared to remove broken screws in intramedullary canal.
3. Management of bone loss: bone loss to level of lesser trochanter common. Often requires a calcar replacement implant. Proximal calcar build-up size dictated by bone loss.
4. Length of stem: desirable to bypass screw holes from previous fixation if possible.
5. Stem fixation: cemented or uncemented fixation depending on surgeon preference, bone quality. If uncemented, consider extensively coated (damaged proximal bone).
6. Greater trochanter: often a separate piece, be prepared to fix with wires or cable grip. Residual trochanteric healing, hardware problems not rare after THA.
7. Bone deformity/heterotopic bone: manage in individual basis.

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O24B2

Presentation Title: “Role of Modular Designs for Complex THA”

Guest Faculty: Robert L. Barrack, MD

Institution: Washington University School of Medicine, St. Louis, MO, USA

As with primary cementless THA, the dominant cementless revision stem design concept was an extensively coated, cylindrical, cobalt-chrome stem with a collar. The same basic surgical technique involved obtaining a scratch fit for 4-6 cm into the diaphysis. It became apparent that with stem length greater than 7 inches, a bowed stem was frequently desirable to conform with the bow of the native femur and lower the risk of perioperative fracture. This approach proved to be relatively successful and dominated the American market. After a number of years as the volume and severity of revision procedures continued to increase, a number of issues were identified and revision stem design evolved to address the issues. Among the clinical problems that were identified were: the relatively high incidence of perioperative fracture, thigh pain and stress shielding associated with large, stiff, Co-Cr stems, difficulty consistently obtaining mechanical stability with higher degrees of bone loss, instability and limb length issues partially attributable to the limitations of adjusting length and offset with a solid one piece stem with fixed angle of neck version relative to the shaft. Many of these issues have been addressed with the introduction of conical, titanium, modular revision stems. These stems were initially utilized in complex revision cases in which a solid fully coated stem presented challenges. The clinical results and surgical technique proved to be so desirable, however, that this stem design has become the dominant approach to femoral revision at many centers.

The goals of revision total hip arthroplasty are no different to primary total hip arthroplasty: restore biomechanics and reduce or eliminate pain with a durable construct which should last the life of the patient. With this in mind the first step should be to establish where fixation is going to be achieved. This of course depends on the degree of bone

loss after removal of the primary implant which is not always fully known or appreciated from pre-operative imaging. Similarly bone quality may not be found to be as good as it may have seemed from the pre-op imaging. Therefore the right revision femoral component may not be identifiable prior to the operation. This has led to the dominance of modular systems in modern revision hip arthroplasty. These systems typically offer several stem and body types which allow for fixation in different parts of the femur and these can be chosen during the operation. Once fixation is achieved then attention must be turned to the biomechanics. The ability to adjust leg length, offset and anteversion independently allow the surgeon the ability to optimize the reconstruction. Care must be paid to the anteversion (which is not commonly discussed) as adjusting the anteversion effectively translates the femur anteriorly or posteriorly within the soft tissue envelope of the femur and thus can have a marked effect on the forces being conducted by the reconstruction to the bone. Exact reconstruction of leg length, offset and anteversion will result in a more natural feeling joint and lower forces being transmitted to the bone interfaces and to the bearing. The final consideration, in terms of design, is the ‘just in case’ factor. The surgeon may be unhappy with result at final trial reduction and spontaneous bony fractures such as trochanteric escape are always a potential risk. Therefore the ideal system is easy to use with plates, grips and cables and can also be disassembled in situ without having to remove a well fixed distal stem. Finally, the ease of use of the instruments and the track record of the implant itself must also be considered at these can considerably reduce stress within the OR team which in itself can lead to a shorter, more successful operation. Following this thought process should allow the surgeon to select the right implant for the patient, himself and the OR team.

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O24B3 Total Hip Arthroplasty after Periacetabular Osteotomy

Primary Author: Derek F. Amanatullah
Institution: Mayo Clinic

Coauthors: Derek F. Amanatullah (Mayo Clinic), Louis Stryker (Mayo Clinic), Perry Schoenecker (Mayo Clinic), Michael J. Taunton (Mayo Clinic), John C. Clohisey (Washington University), Robert T. Trousdale (Mayo Clinic), Rafael J.

BACKGROUND: Conversion of a periacetabular osteotomy (PAO) to a total hip arthroplasty (THA) may be required for continued pain or progression of hip arthritis. The objective of this study was to review and compare the outcomes of THA after prior PAO to a matched group of patients who underwent THA for developmental dysplasia of the hip (DDH) without a history of PAO.

METHODS: A multi-center retrospective review of 562 patients undergoing 645 PAOs was performed. Thirty hips in 29 patients required a THA after the PAO (4.7%). The THA after PAO group was matched with 51 hip in 52 patients with developmental dysplasia of the hip undergoing

THA without a history of PAO. The rates of intra-operative and post-operative complications as well as functional outcomes were compared.

RESULTS: The average time to THA after PAO was 5.4 ± 2.8 years. Clinical follow-up after THA averaged 10.7 ± 3.9 years after PAO and 3.8 ± 3.6 years without PAO. There was no statistically significant difference ($p > 0.05$) in complication or revision rates between the two groups. Adjusting for confounding variables (i.e., abductor sparing approach), the HHS for THA after PAO was 93.1 ± 7.1 , ranging from 73.4 to 100 and the HHS for THA without PAO 95.9 ± 9.3 , ranging 54.1 to 100. There was no statistically significant difference in HHS at final THA follow-up after adjusting for confounding variables ($p = 0.401$).

DISCUSSION: There was a marked functional improvement after THA for a failed PAO. However, functional outcome was worse when compared to patients with DDH undergoing THA without a history of PAO. This difference is related to violation of the abductor attachment at the time of PAO.

LEVEL OF EVIDENCE: Therapeutic Level III. See Instructions to Authors for a complete description of levels of evidence.

O24B4 Cemented Versus Uncemented Hemiarthroplasty for Intracapsular Hip Fractures

Primary Author: Rohit Rambani
Institution: Leeds Teaching Hospital NHS Trust

Coauthors: Lutz Koch (Dewsbury district hospital)

We undertook a study involving 538 patients with a displaced intracapsular fracture of the hip to determine whether there was any difference in outcome between treatment with a cemented hemiarthroplasty and an uncemented prosthesis and also between the unipolar vs bipolar prosthesis. In hospital mortality, complications were noted. The surviving patients were followed up using telephonic consultation with patients, GP by a doctor blinded to the type of prosthesis used. The mean age of the patients was 84 years (39 to 103) and 381 (79.3%) were women. The degree of residual pain was less in those treated with a ce-

mented prosthesis (p The use of a cemented hemiarthroplasty (unipolar and bipolar) resulted in less pain and less deterioration in mobility than an uncemented prosthesis with no increase in complications.

O24B5

Middle-term Results of Paprosky Type III Bone Defect Acetabular Revision Using Anti-Protusio Cage in Chinese Patients

Primary Author: Qiang Huang

Institution: department of West China Hospital, Sichuan University

Coauthors: Jing Yang (department of West China Hospital, Sichuan University), Bin Shen (department of West China Hospital, Sichuan University), Zongke Zhou (department of West China Hospital, Sichuan University), Pengde Kang (department of West China Hospital, Sichuan University)

OBJECT: To investigate the middle-term results of anti-protusio cage combining with allograft bone graft for revising acetabular with Paprosky type III bone defect.

METHOD: The complete clinical data of patients with acetabular defect of Paprosky type III revised by using anti-protusio cage from January 2002 to December 2009 were retrospectively analyzed. Nineteen patients (20 hips) completed the follow up. There were 11 males and 8 females, aged from 42 to 76 years (average, 57.4 ± 6.4 years). Seven hips (35%) were Paprosky type IIIA, while 13 hips (65%) were Paprosky type IIIB. The average follow-up time was (5.8 ± 2.4) years. Hip function of patients pre- and post-operation, the radiological results of acetabular prostheses, and the results of the bone grafts were assessed. The five-year cage failure-free survivorship was analysed by Kaplan-Meier survivorship analysis.

RESULT: Harris Hip Scores improved from preoperative 14.6 ± 4.3 to 83.5 ± 7.9 and final follow-up. Lower limb discrepancy improved from preoperative (26.3 ± 9.1) mm to (1.2 ± 3.4) mm. The hip rotation center was reconstructed from preoperative (23.6 ± 7.4) mm up-toward and (4.4 ± 14.7) mm lateral-toward dislocation to inside Renawat triangle. All the allograft bone was incorporated with host bone. None of cage displacement, screw fracture, progressive radiolucency and cement fracture was observed. Mild allograft bone resorption was observed in 3

hips (15%). There was no moderate or severe bone resorption observed at final follow-up. The five-year cage failure-free survivor rate was 100% (95% CI, 0.95-1.00).

CONCLUSION: Using anti-protusio cage combined with allograft bone graft could revision acetabular with Paprosky type III bone defect and result in satisfied middle-term clinical and radiological results.

O24B6

Handling the Salvaged Femur

Guest Faculty: Adolph V. Lombardi Jr., MD, FACS

Institution: Joint Implant Surgeons, Inc; The Ohio State University Wexner Medical Center; Mount Carmel Health System; New Albany, Ohio USA

Complicated revision total hip arthroplasty (THA) and total knee arthroplasty (TKA), septic prosthetic failure, and periprosthetic femoral fractures seem to be increasing. With expanding applications for arthroplasty in younger patients and higher longevity, numerous revision situations are seen more frequently. With the increasing elderly population and increasing numbers of THAs and TKAs done in elderly patients, prostheses are being used in more osteoporotic bone and the incidence of periprosthetic fractures is increasing. When a patient elects to have THA or TKA, he or she trades arthritic disease for prosthetic disease. Prosthetic disease encompasses the life of the patient with his or her prosthesis, and represents all of the possible failure modes of that prosthesis. With each subsequent revision, there is accompanying bone loss, especially in cases of failed periprosthetic fracture fixation, and in cases of prosthetic infection treated with radical debridement. Once numerous and frequently massive reconstructive efforts have failed secondary to any or a combination of etiologies, sufficient bone stock may not remain to provide meaningful fixation of femoral components for THAs and TKAs. Furthermore, it is not uncommon to have a patient with multiply failed THAs or TKAs with severely compromised femoral bone stock and have concomitant ipsilateral hip or knee arthritis. In cases such as these, treatment strategies lie beyond published algorithms. Total femoral arthroplasty (TFA) has been described as a viable salvage option in these difficult cases. The complications and outcomes in patients who had total femoral arthroplasty for salvage of a severely compromised femur were studied. The clinical scenarios included numerous revision total hip

or knee arthroplasties, failed periprosthetic fractures, or recurrent infection treated with multiple radical debridement surgeries. Fifty-nine patients (average age, 73.7 years) were identified. At an average 4.8 years followup, adequate pain relief was achieved with Harris hip pain scores averaging 33.8 of 44 points, and knee pain scores averaging 42.8 of 50 points. Good function was achieved with 98% of patients able to ambulate and 43% using no assistive device or a cane only. There were 18 complications or subsequent surgeries. Infection and dislocation occurred in eight patients and seven patients, respectively. This type of procedure, although used increasingly rarely is required. Instead, this selected series of patients was identified from thousands of patients who had hip revision surgeries performed at a hip referral center during 13 years. Total femoral arthroplasty seems to provide good functional outcomes, acceptable complication rates, and good pain relief in patients with end-stage prosthetic disease.

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Kinematic and Kinetic Evaluation of the Knee

O25A1

Computational Evaluation of Tendo-Femoral Contact in PS TKA

Guest Faculty: Paul J. Rullkoetter, PhD

Institution: Center for Orthopaedic Biomechanics, University of Denver, Denver, CO, USA

Coauthors: Raymond H. Kim, MD (Center for Orthopaedic Biomechanics, University of Denver, Denver, CO; Colorado Joint Replacement, Denver, CO), Douglas A. Dennis, MD (Center for Orthopaedic Biomechanics, University of Denver, Denver, CO; Colorado Joint Replacement, Denver, CO), Clare K. Fitzpatrick, PhD (Center for Orthopaedic Biomechanics, University of Denver, Denver, CO)

INTRODUCTION: Clinical evidence suggests that excessive contact between the femoral component of a posterior-stabilized (PS) total knee arthroplasty (TKA) and the quadriceps tendon in the suprapatellar region causes fibrosynovial hyperplasia. The tissue contacts and/or becomes entrapped within the intercondylar box of the femoral component and during knee extension following active deep flexion, creates patellar crepitus or clunk syndrome. A recent case-controlled clinical study identified an increased incidence of crepitation in patients with decreased patellar ligament length, decreased patellar component size, decreased patellar composite thickness and increased posterior femoral condylar offset. The objective of the present study was to use a computational model to evaluate the findings of the clinical study and attempt to elucidate primary causal mechanisms.

METHODS: Crepitus-control patient pairs matched by age, gender, and BMI were modeled to assess quadriceps tendon contact while wrapping on the PS femoral component throughout flexion. In the crepitus patient models, surgical interventions were suggested to improve the deleterious contact between the femoral component and tendon. Parameters identified as affecting crepitation (patellar tendon length, component size, composite thickness) were perturbed in the model and results were compared to the clinical findings. Perturbations in joint line and femoral

component flexion were performed in order to evaluate potential surgical interventions in the crepitus patient models. The joint line was lowered by 2 mm and 4 mm. Separately, the femoral component was flexed by 2° and 4°. For each alignment evaluated, the cumulative region of tendon articulation over the femoral component, cumulative contact area within 2 mm of the intercondylar notch, and the minimum distance between the anterior border of the intercondylar notch and the suprapatellar tendon were calculated during knee flexion (Figure 1). Analyses were performed with two current PS designs.

RESULTS: Decreased patellar component size and decreased patellar tendon length were shown to have an increased tendo-femoral contact area near the intercondylar notch, an increased total contact area, and a decreased minimum notch-to-tendon distance (Figure 2). The patient-specific models showed substantially more cumulative tendon contact near the intercondylar notch in the crepitus patients, compared to their matched controls. Both lowering the joint line and increasing femoral component flexion showed decreased tendofemoral contact near the intercondylar notch, and increased minimum notch-to-tendon distance. Simultaneously increasing femoral component flexion alignment and decreasing the joint line resulted in the best tendo-femoral contact conditions. A modern PS component with extended trochlear groove was shown to have improved tendo-femoral contact characteristics.

CONCLUSION: Perturbations of key parameters were in agreement with results from the clinical study; decreased patellar tendon length and decreased patellar component size were shown to create tendon contact closer to the superior and lateral edges of the intercondylar box and to decrease the minimum notch-to-tendon distance, increasing the likelihood of crepitation.

Scaled models based on patient-specific radiographic data demonstrated clear differences in tendo-femoral contact surrounding the intercondylar box of the femoral TKA component in crepitus patients when compared to matched controls. PS design with modified patellofemoral geometry will likely avoid tendo-femoral contact issues.



Figure 1. The contact patch (in red) between the quadriceps tendon and femoral component during deep flexion.

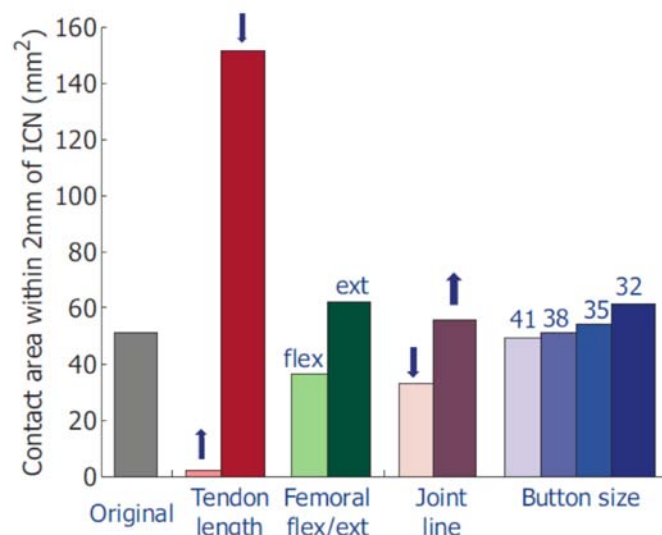


Figure 2. Composite contact area within 2 mm of intercondylar notch (up to 1208) with original alignment and changes due to variation in patellar tendon length (alta and baja), flexion–extension alignment of the femoral component, joint line, and patellar button size.

O25A2 Computer Simulation in Total Knee Arthroplasty – Effect of Ligament Balance and Alignment on Lift-off Motion

Guest Faculty: Shuichi Matsuda, MD, PhD
Institution: Kyoto University, Kyoto, Japan

INTRODUCTION: Appropriate alignment and soft tissue balance are important factors to acquire good knee function and component durability after total knee arthroplasty (TKA). Fluoroscopic analyses has shown a femoral condylar lift-off phenomenon, which is an excessive the joint space opening, can occur after TKA. The incidence of the lift-off would induce various complications such as excessive polyethylene wear. Proper ligament balancing and coronal knee alignment are the crucial tips to avoid postoperative lift-off motion, but these effects have not been fully evaluated. The purpose of this study was to evaluate the influence of the collateral ligament laxity and coronal alignment on lift-off motion during gait after posterior cruciate substitute-TKA using a musculoskeletal computer model.

METHODS: The computer model used in this study is a dynamic, musculoskeletal modeling program of the knee. The modeled systems were subjected to two gait cycles up to 60° knee flexion. We determined that the lift-off was positive when the intercomponent distance between the femoral and tibial components was measured more than

2mm. The femoral coronal alignments were changed from neutral to 5° varus in 1° increments. Simultaneously, the LCL lengths were also elongated from 0 mm (free length) to 5 mm in 1 mm increments as pathological slack without changing the femoral and tibial attachments.

RESULTS: Incidence of condylar lift-off and peak amount of lift-off motion were changed by the lateral collateral ligament tension and femoral varus alignment. Within 1° of the femoral varus alignment, the femoral condylar lift-off did not occur even if the LCL was elongated by up to 5mm. With 2° of the femoral varus alignment, however, the lift-off occurred with 2mm slack of the LCL in the late stance phase of gait. With 5° of the femoral varus alignment, the lift-off occurred without slack of the LCL. The combination of 5° of the femoral varus alignment and 3mm slack of the LCL caused a maximum lift-off distance of 7.7mm from the early stance phase to the late stance phase. When the ligament imbalance was deteriorated further, the simulation software was not able to evaluate these conditions.

DISCUSSION AND CONCLUSION: A previous study reported that the lateral soft tissue structure was looser with greater preoperative varus deformity and the contracture of the medial soft tissue structure did not exist even in severe varus knees. If the neutral alignment is aimed for such severe varus knees, it is hard to achieve appropriate ligament balance. In this study, we found that no lift-off occurred in neutral coronal alignment regardless of collateral ligament laxity. These findings suggest that we should avoid varus alignment to decrease lift off motion after TKA.

O25A3

Impact Finite Element Analysis During impact Loading Propagations Through TKR Joint

Primary Author: Kohei Murase

Institution: Department of Mechanical Science and Engineering, Graduate School of Engineering, Nagoya University

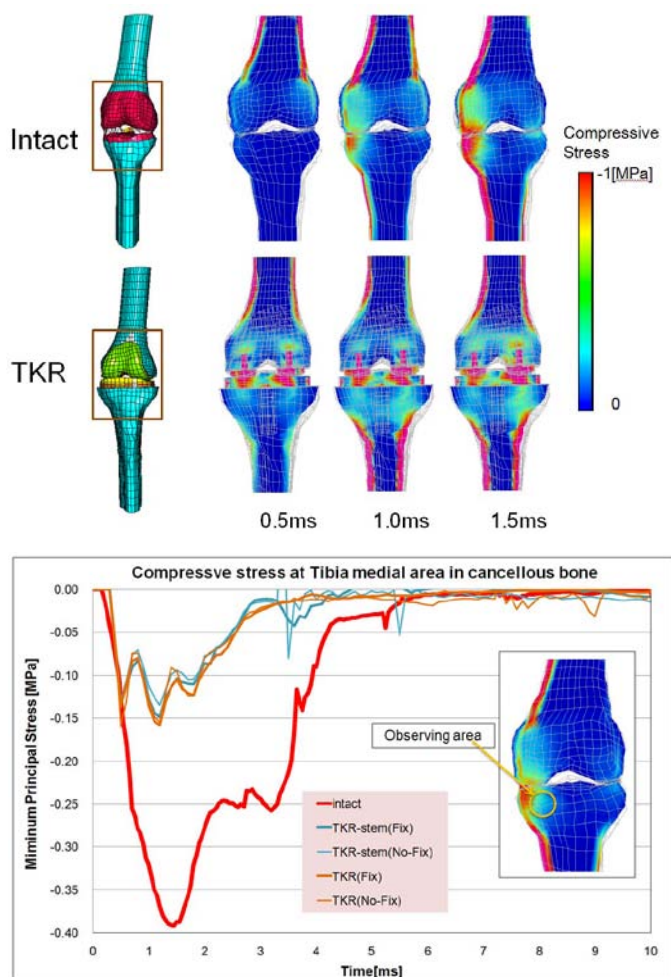
The contact condition in the human knee joint must play important roles in dynamic loading, especially in impact situations where the loads transfer in the knee. In this study, the impact load propagations through the inside of the knee joint were simulated using the three-dimensional finite element analysis. The differences in the stress distribution between the intact knee and the total knee replace-

ment (TKR) condition were investigated.

The three-dimensional shape of the intact and the TKR model were modeled to finite element meshes with high fidelity. All tissue and the components were meshed to the hexahedral elements for the precise simulations during the impaction phase. The intact model (3952 elements) included the cortical bone, cancellous bone, articular cartilage, bone marrow, and meniscus. The TKR model (5547 elements), which consists of the artificial femoral and tibial components was also prepared to compare the impact propagations with the intact model. The each cartilages, meniscus and the artificial components had the contact and the sliding definitions at the interfaces with the other tissues. Impact loadings were applied to the proximal femur of the models under the same conditions as those of the weight-drop experiments with the knee joint specimens.

The FEA results showed that the impact stress propagated to the tibia through the knee joint during several milliseconds. The progress of the compressive strain on the cortical surface had good agreement with the experimental results. And the simulation revealed that the impact stress propagated not only to the cortical area but also the cancellous region which has soft properties. The mass density of the cancellous bone has similar to that of the cortical bone, and thus the role of the load bearing in the cancellous area must be much increasing under the impact condition. The compressive stress mainly propagated at the medial side, with 1.0MPa at 1.2 milliseconds.

On the other hand, the impact stress distributions in TKR model has quite difference aspects compared with the intact situation. Impact compressive stress was observed with 2.8MPa at the tibial region, while not under the normal intact conditions. Since the total replacement model was formed of different materials and the impact transmission was inhibited by the interface conditions, such as the difference of material property or the change of the sliding. It is considered that the contact condition between such materials have a great effect on the stress propagation.



O25A4

The Effect of Malrotation of Tibial Component of Total Knee Arthroplasty on Tibial Polyethylene Insert Using a Finite Element Analysis

Primary Author: Kei Osano

Institution: Sugioka Memorial Hospital, Fukuoka, Japan

Coauthors: Ryuji Nagamine (Sugioka Memorial Hospital, Fukuoka, Japan), Mitsugu Todo (Research Institute for Applied Mechanics, Kyushu University, Fukuoka, Japan)

INTRODUCTION: Total knee arthroplasty (TKA) prostheses design and surgical procedure are important for knee kinematics and long term survivorship. One of the most common procedure errors is malrotation of tibial component. The object of this study is to analyze the effect of malrotation for stress of tibial polyethylene insert during squatting using a finite element analysis(FEA).

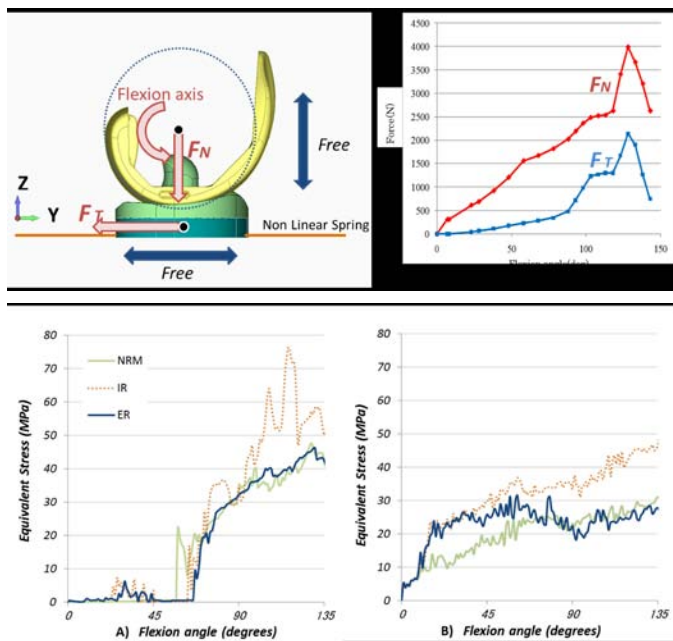
MATERIALS AND METHODS: Posterior-stabilized total knee prosthesis, Scorpio NRG(Stryker Co.), was used for analysis. The feature of tibial insert design is symmetrical and flat, which enables flexible axial rotation. Three dimensional FEA models, consisting of femoral component, tibial insert and tibial component, were constructed from the CAD data. Tetrahedral mesh was generated on these models by FEMAP ver.10.1(Siemens PLM Software). The numbers of nodes and elements were 28,254 and 121,536. Tibial insert made from ultra-high molecular weight polyethylene was assumed to be elastic-plastic material. Femoral and tibial components were assumed rigid. A coefficient of friction of articular surface was set to be 0.04. Four nonlinear springs were attached to tibial component in order to represent soft tissues around the knee. Its nonlinear force-displacement relation was given by, $F = 0.18667d^2 + 1.3313d$ (F: force, d: displacement) Boundary conditions were shown in Fig.1. Femoral component was free along Z-direction and fixed along X- and Y-direction. Tibial component was free along Y-direction and fixed along X- and Z-direction. Vertical load was applied for femoral component which rotated for 135 degrees while horizontal load along the Y-direction was applied for tibial component which internally rotated for 15 degrees during knee flexion. Three different initial conditions of tibial components, normal(NRM), internally rotated for 15 degrees(IR) and externally rotated for 15 degrees(ER), were analyzed. For FEA, an explicit finite element code LS-DYNA ver.971 and LS-PREPOST ver.4.0(Livermore Software Technology Co.) were utilized as a solver and a post-processor.

RESULTS: Maximum Mises equivalent stress of tibial insert was shown in Fig. 2. Although ER malposition had almost the same as NRM position, IR malposition caused significant increase in stress on post surface during high flexion of knee. The level of maximum stress in IR at 120 degrees of flexion was twice as high as that in NRM. Stress on condyle surface was also high in IR malposition throughout knee flexion.

DISCUSSION: Rotational alignment of femoral and tibial components affects the stress distribution on contact surface. Few studies, to our knowledge, have analyzed the effect of malrotation of tibial component. As the tibial insert of NRG is symmetrical and flat, the prosthesis has a certain amount of flexibility for axial malrotation. However, the results of this study revealed that excessive internal rotation malrotation increased stress on tibial insert signifi-

cantly. Therefore, internal rotation malrotation should be avoided to use this prosthesis.

CONCLUSION: According to this finite element analysis study, internal rotation malrotation of tibial component of NRG caused significant increase on tibial polyethylene insert.



O25A5 The Relationship Between Gap Size and Force Applied During Total Knee Arthroplasty: An In Vivo Study

Primary Author: Douglas G. Nuelle
Institution: Union General Hospital

Coauthor: Justin Creel (PH.D.)

BACKGROUND: In spite of advances in the development of implants and guides to assist the surgeon in performing Total Knee Arthroplasty, soft tissue balancing remains a subjective evaluation of tracking and “tightness” by the surgeon’s visual and proprioceptive senses.

METHODS: This is a study to determine the quantitative dynamics of the soft tissue envelope during Total Knee Arthroplasty. Fifty consecutive patients undergoing primary TKA were studied using a simple tensioning device that correlated the flexion and extension gap distances with the amount of force applied.

FINDINGS: We found that the mechanical properties of the soft tissue envelope in flexion and extension dramatically changes when more than 60 lbs. of force is applied.

INTERPRETATION: Choosing a tibial spacer that applies 40-60 lbs. of force to the soft tissue envelope in flexion and extension will achieve a stable and physiologically normal knee.

O25A6 Validation and Future Uses for a Forward Solution Model of TKA as a Theoretical Knee Simulator

Primary Author: Bradley A. Meccia
Institution: University of Tennessee Knoxville

Coauthors: A Sharma (University of Tennessee Knoxville), R D. Komistek (University of Tennessee Knoxville), D D’Lima (Scripps Clinic)

Currently, the most effective method of evaluating the performance of a total knee arthroplasty (TKA) implant is to perform a ten year follow-up study. While these studies provide valuable information, they are inherently inefficient. They require the investment of extensive capital and do not provide essential feedback in a timely manner. The costs can be great to both patients and companies in health and financial terms. Other methods for evaluating potential knee implants include cadaveric rigs and wear testing. While these are less time and capital intensive, they still require the implants to be fabricated which is a moderately extensive practice.

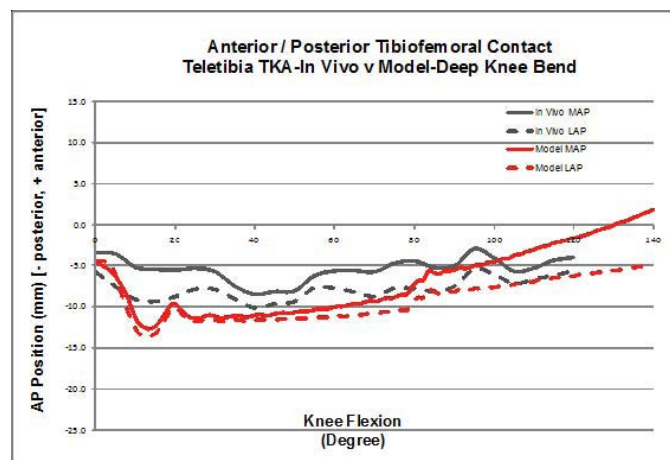
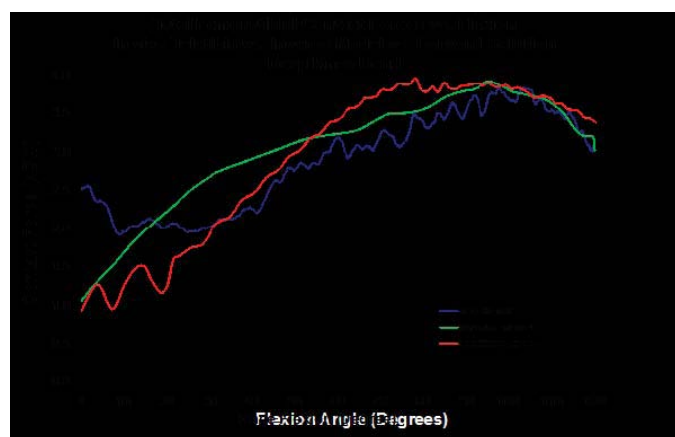
An ideal method of evaluating potential TKA designs would be through theoretical simulations that are accurate, through validation, and provide the designer instant, predictive feedback. To this end, a theoretical knee simulator has been developed using a forward solution model (FSM) of a deep knee bend activity. This simulator allows for three-dimensional (3D) computer aided design (CAD) models to be analyzed. By inputting both the 3D CAD model and 3D patient specific data, accurate kinematic and kinetic results can be generated efficiently. This allows both minor and major revisions to the 3D CAD model for future simulations without additional fabrication time.

To validate the theoretical knee simulator, fluoroscopic re-

cordings were taken of a patient with a telemetric knee implant while simultaneously recording synchronized force data. The recorded kinematics and kinetics were compared to the predicted mechanics from the FSM model with the telemetric knee geometry and patient geometry used as inputs. This model predicted a maximum knee force of 3.96 times body weight while the telemetric data had a maximum measured force of 3.84 times body weight (Figure 1). This results in an error of 3.1%. The model also accurately predicted the amount of posterior femoral rollback (Figure 2).

With this validated model, the FSM has been used to analyze the effect of both prostheses design and surgical technique. For the design, the effect of the radius of the J curve geometry was analyzed as well as trochlear groove location and its effect on patellar tracking. The effect of surgical technique has also been analyzed. This was done by varying ligament tension to simulate the effects of different amount of soft tissue release. Additionally, mechanical alignment implantation, anatomical alignment implantation, or malrotated implantation were simulated. Ideally, an implant should perform well even if not aligned perfectly.

In the future, this theoretical model could play an important role as a pre-surgery analysis tool. In much the same way that radiographic imaging can provide substantial data useful to surgeons, this FSM could do the same. It could calculate the expected mechanical results for multiple size implants if the patient is between sizes. Additionally, it could predict the mechanics for different soft tissue balances.



O25A7 Proximal Tibia Perforation to Enhance Shear Strength at the Bone-Cement Interface

Primary Author: Spencer H. Amundsen

Institution: Dartmouth

Coauthors: Doug Van Citters (Dartmouth), Stephen Kantor (Dartmouth), James Yang (Dartmouth)

Aseptic loosening of the tibial component is a major cause of knee arthroplasty failure and likely related to shear forces. Failure occurs in part at the bone-cement interface. Good fixation is challenging in sclerotic bone, where lack of porosity leads to poor bone-cement fit. A previous study showed that drilling holes in the cut tibia prior to implant cementation decreased failure at the bone-cement interface. We hypothesized that increasing bone-cement interdigitation through use of an optimized perforating tool prior to cementation would lead to an increased ultimate shear strength failure at this interface.

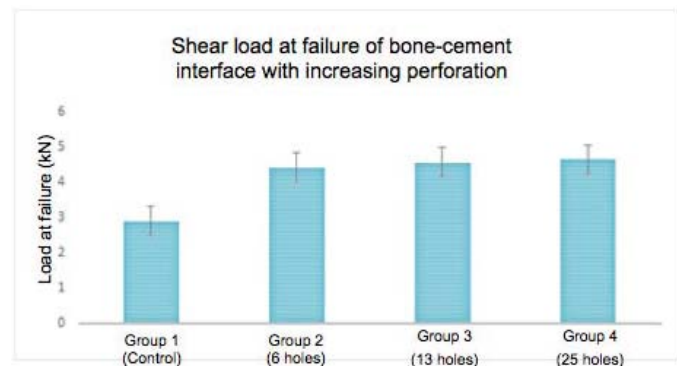
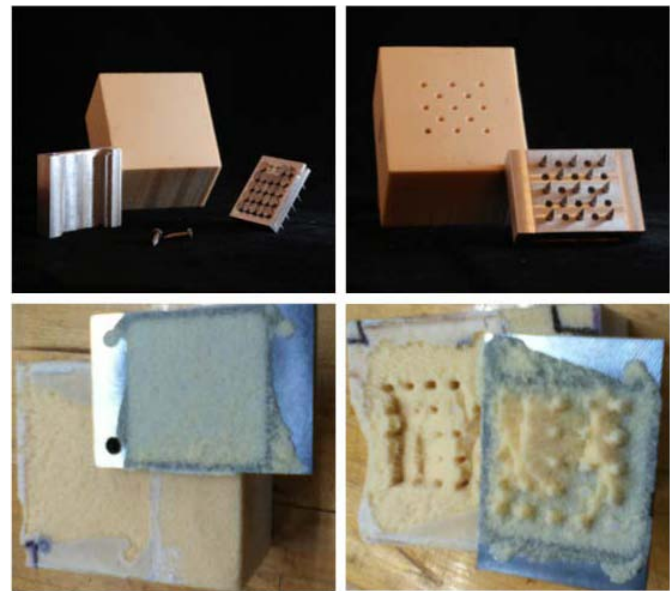
In vitro tests were performed using a custom-built bone-cement shear testing device. Housing was machined to accept blocks of Sawbones rigid polyurethane foam. Ti-6Al-4V plates were machined to include a 1mm-deep rectangular recess (33x33mm). Titanium surfaces were grit blasted to achieve a surface roughness of $R_a=0.9 \mu\text{m}$, mimicking a titanium tibial implant tray. A modular punch device was machined to allow for insertion of a collection of sharpened pins into a matrix of holes in different punch patterns and numbers [Fig. 1]. For the present test, three hole patterns (2 mm dia. x 5 mm depth) were tested by impaction of the device into Sawbones material representing sclerotic bone (15 pcf) followed by cementation with

medium viscosity cement. Finger packing was performed in the holes, and a cement mantle was established through spreading cement in the recess of the titanium plate and on the surface of the bone substitute. A uniform, 1 mm cement mantle was achieved through clamping the titanium plate during the cure. Tested designs include: Group 1=control (no holes, n=8), group 2=6 holes (n=7), group 3=13 holes (n=10), group 4=25 holes (n=8). The constructs were rigidly fixed, and loaded in shear with a servohydraulic load frame. Load at failure for the bone-cement interface was measured.

No failure occurred at the cement-implant interface. Failure rates include: Group 1=2.9 kN (SD=0.3), Group 2=4.4 kN (SD=0.6), Group 3=4.6 kN (SD=0.8), Group 4=4.6 kN (SD=0.8) [Fig. 2]. The control group showed failure with significantly less force than the other groups ($p<0.004$). The 6-hole, 13-hole, and 25-hole samples were not statistically different from each other.

Our study shows that perforating a Sawbones model prior to cementation increases the ultimate load required for shear failure at the bone-cement interface. This stands to reason given that bone cement acts as a grout, rather than an adhesive. As such, increased mechanical interaction between the cement and the Sawbones improves fixation. We expected a dose relationship where more perforation strengthens the constructs against shear. Nonparametric correlation however, showed no statistical difference between texturized groups. One interpretation of this is that increased mechanical interaction between the bone and cement is offset by decreased mechanical integrity from increasing porosity of the Sawbones. Typical aseptic loosening occurs from repetitive stresses and further studies will include cyclic loading, cadaveric testing, and cross-sectional analysis.

We conclude that perforating sclerotic bone significantly increases shear forces needed to cause failure, and is likely of clinical benefit for improving bone-cement interface strength.



So Many Choices, but Still Concerns

O25B1

Influence of Parameters on the Wear at the Taper-Trunnion Interface of the Modular Hip Prosthesis

Primary Author: Obinna K. Ihesiulor

Institution: UNSW Canberra

Coauthors: Krishna Shankar (), Smith Paul (), Alan Fein ()

Total hip replacement (THR) is one of the most popularly performed operations in orthopaedics as evident in clinical

outcomes. Potentially, an approximate of 400,000 hip joint replacement procedures are performed each year in the U.S. However, studies have identified that majority of hip implants are prone to wear at the taper-trunnion junction.

The taper-trunnion (head-stem) is essentially the interface between the ball of the hip joint which articulates with the pelvis and the hip stem which is constrained rigidly to the femur bone. The head and stem components connect at a taper on the hip head and a trunnion on the hip stem. This junction is of peculiar and remarkable interest because it is associated with excessive fretting wear due to the taper sliding relatively against the trunnion.

Excessive fretting wear at the taper-trunnion junction (trunnionosis) apparently contributes to the high failure rates of hip implants. Implant wear and corrosion lead to the release of metal particulate debris and subsequent release of metal ions at the taper-trunnion surface. This results in a type of metal poisoning referred to as metallosis. The consequences of metal poisoning include; osteolysis (bone loss), osteoarthritis (pain), aseptic loosening of the prosthesis and revision surgery. Follow up after revision surgery, metal debris particles are commonly found in numerous locations.

In order to quantify the amount of volume loss, a parameterized finite element (FE) method is adopted to assess the wear, its pattern and stress distribution at the taper-trunnion junction. Reduction of wear at the taper trunnion interface will increase the durability of the prosthetic implant as well as reduce the detrimental effects of metallosis in patients. The fretting wear at the taper-trunnion junction is a function of many parameters including the material properties, surface condition, friction coefficient, interference or clearance between the two components and the distribution of stresses at the interface, which depends on the applied loads and the geometric design of the components. This research proposes to conduct a detailed analysis of the influence of these parameters on the wear at the taper-trunnion interface of the modular hip prosthesis through numerical simulation, working towards the ultimate goal of minimizing the wear and thus prolonging the life of the implant through judicious choice of design parameters.

O25B2

Total Hip Arthroplasty in Ankylosing Spondylitis

Primary Author: Zenat Ahmed. Khired

Institution: Ministry of Health

Ankylosing spondylitis is an inflammatory disease of unknown etiology that affects an estimated 350,000 persons in the United States and 600,000. AS typically affects young adults, most commonly males (M:F = 3:1) in their second through fourth decades -Fifteen percent to 20% of patients with AS have a positive family history AS is linked to HLA-B27 -laboratory evaluation : ESR,CRP, HLA-B27 -Radiological evaluation: The sacroiliac joints usually are the first joints affected in patients with AS. a Ferguson view of the pelvis. Hip involvement presents as ossification of the ligamentous origins and insertions about the trochanters, iliac crests, and ischial tuberosities. Late findings include loss of joint space, sclerosis, and fusion with loss of sclerosis at the hips. Both computed tomography (CT) and MRI Non-Surgical management -Correction of hip flexion contracture with THA can restore sagittal balance in patients with AS. Tang and Chiu²⁷ noted that, because of the presence of relative hyperextension of the hips after THA, AS patients are more prone to anterior dislocation when acetabular components are placed in their normal position relative to the pelvis. When positioning the acetabular component in a patient with AS, one must account for the relationship of the pelvis to the lumbar spine in the sagittal plane in order to avoid an excessively hyperextended hip once the patient resumes an upright position. In patients with severe spinal deformity corrective spinal osteotomies should be performed before THA to prevent future acetabular component malposition. However, many surgeons still concur with Lee, who as early as 1963 stated that THA should be performed before considering spinal osteotomy because improvement in hip ROM and pain relief may obviate the need for spinal osteotomy in patients with severe hip flexion deformity Several studies indicate that THA is beneficial in AS patients. Fifteen-year survival (ie, time to THA failure) ranged from 66% to 81.4%. Average age at time of surgery was 38 years. Thirty patients had Brooker³³ class 3 or 4 HO. Eighty-six revision THAs were performed -Sweeney et al reviewed charts and questionnaires of 340 patients with AS who were treated with THA. Survival rates of primary THA were 90%, 78%, and 64% at 10, 15, and 20 years, respectively. Survival rates of revisions were 73%, 55%, and 55% at 10, 15, and 20

years, respectively. Higher rates of HO after THA have been reported in AS patients who have undergone repeat operations, who have experienced postoperative infection, who were treated with a trans-trochanteric approach, and/or who had an active disease (reflected by elevated ESR or CRP level). --Post op: A long period of rehabilitation is typically required to achieve maximal functional capacity. Postoperative complications: trochanteric osteotomy, nonunion, infection, and dislocations. Kim et al¹³ reported many complications in their series. Intraoperative complications included one case of pelvic discontinuity, one greater trochanteric fracture, one femoral perforation, and two cases of calcar fracture.

O25B3

A New Zonal System for Radiographic Assessment of Hip Resurfacings

*Primary Author: Catherine Van Der Straeten
Institution: Ghent University Hospital, Belgium*

Coauthors: Koen De Smet (Anca Medical Center, Deurle, Belgium)

INTRODUCTION: Systemic levels of metal ions are surrogate markers of in-vivo wear of metal-on-metal hip resurfacings (MoMHRA). The severity of the wear is associated with component size and positioning but also with design specific features such as coverage angle, clearance and metallurgy. A randomized controlled trial (RCT) comparing 9 different hip resurfacing designs was conducted at hip resurfacing specialist centre to evaluate the possible difference in ion release, clinical and radiographic outcome, complications and revision rate between different HRA designs.

METHODS: Patients scheduled for a unilateral MoMHRA were randomized to receive one of 9 different HRA designs (20 per group). Only patients who had no other metal implants and a normal renal function were included. Surgical, clinical (Harris Hip Score and UCLA activity scale) and radiographic data and Chromium (Cr) and Cobalt (Co) levels in whole blood, serum and urine were compared at preoperative, 3, 6, 12, 24 and 60 months intervals. In the Titanium-Niobium-coated prosthesis group, Titanium (Ti) ions were also measured. Complications, re-interventions and revisions were noted.

RESULTS: 129 patients were included as 3 designs were discontinued: ASR after market withdrawal, DUROM and MITCH for cup fixation problems. The other groups were ACCIS, ADEPT, BHR, Conserve Plus, Conserve Plus Aclass, and RECAP. In all groups except ACCIS, Cr and Co ion concentrations increased from preoperative till 1-year (running-in) and subsequently levelled off (steady-state). There was a significant correlation between whole blood, serum and 24 hour urine levels ($p < 0.01$). Overall mean ion concentrations (Cr $1.5 \mu\text{g/l}$ and Co $2.0 \mu\text{g/l}$) were low at all intervals. Outliers occurred more often in the RECAP and ASR groups. ACCIS at 1 year ($p < 0.01$) and DUROM at 2 years ($p < 0.05$) had the lowest levels. For the ACCIS design, Cr and Co levels were untraceable till 1 year but increased at 2 years whilst Ti levels were elevated with a peak at 6 months. Cr and Co levels were higher in females ($p < 0.001$) and with smaller head sizes. Seven HRA were revised at a mean of 25.6 months follow-up (11-48 months): 2 RECAP (high wear/loosening), 1 ASR (high wear), 1 ADEPT (metal allergy), 1 Conserve plus (metal allergy), 1 BHR (infection), 1 ACCIS (loosening).

DISCUSSION: In general, metal ion levels were low in all MoMHRA designs. Outliers and increasing ion levels occurred more often with designs with smaller coverage angle and in smaller sizes, associated with edge loading causing higher wear. Differences in ion levels between resurfacing designs may also reflect differences in clearance and metallurgy. The lower ion levels with the DUROM design are probably related to its highest coverage angle and its metallurgy. The TiNb surface coating of the ACCIS prevents Cr and Co release in the running-in phase whilst peak Ti concentrations at 6 months illustrate the wearing-off of the TiNb coating with formation of a wear patch at the contact area of the articulation. Once the TiNb coating is worn off at the contact area, Co and Cr release starts and systemic Co and Cr levels increase

O25B4

Outcomes Following Extended Trochanteric Osteotomy in Revision Total Hip Replacement

*Primary Author: Peter Cnudde
Institution: Prince Philip Hospital, Llanelli, Wales*

Coauthors: Konrad S. Wronka (Prince Philip Hospital, Llanelli, Wales)

INTRODUCTION: Extended Trochanteric Osteotomy is useful technique when performing revision total hip replacement. It allows surgeon to retrieve cement, stem, to debride femoral canal more accurately, to correct deformities of proximal femur and helps to expose acetabulum. Objectives: Aim of this study was to evaluate the outcome following Extended Trochanteric Osteotomy in series of single surgeon, with emphasis on complications and union of osteotomy.

METHODS: Retrospective Case Series of all patients who had revision Total Hip Replacement surgery performed by senior author between 2003 and 2012, with clinical and radiological follow up between 1 and 10 years. Clinical notes and radiographs were reviewed by independent observer.

RESULTS: 168 Revision Total Hip Replacement procedures were undertaken in 165 patients. 3 had bilateral operations on separate occasions. All procedures were performed by posterior approach. In 108 cases Extended Trochanteric Osteotomy was performed. Osteotomy was performed using 2.5mm drill and oscillating saw reaching 12 to 14 cm from tip of greater trochanter. Osteotomy was reconstructed using Dall-Miles (Stryker) cables (2 or 3) in 91 cases, using Spider Clamp in 10 cases or trochanteric plate in 7 cases, autologous bone graft obtained from acetabular reaming was inserted into osteotomy site in all cases. Spider clamp or trochanteric plates were used if fracture of osteotomised fragment occurred intra-operatively (15 cases) or the fragment was found to be very thin and fragile (2 cases). In 101 cases solid bony union was achieved confirmed on follow up radiographs. In 7 cases the bony union was not seen, but there was no displacement of osteotomy and position of cables used for fixation was not changed. Those patients did not have symptoms related to osteotomy. In those cases fibrous union was achieved. In 10 cases greater trochanter fracture was noted postoperatively and greater trochanter migrated proximally between 5 to 10mm. In one case exploration was required to re-attach greater trochanter, in remaining 9 cases this healed spontaneously. Of all operated patients, 10 reported symptoms of trochanteric pain during follow up. No failure of fixation occurred and no reaction to cables was seen in any of cases. All cases repaired using Spider clamp of trochanteric plate lead to uneventful complete union of the osteotomy.

CONCLUSIONS: Extended Trochanteric Osteotomy is safe and very useful technique that can be utilized in revision hip surgery.

When performed carefully and repaired promptly using cables and supported by autologous bone graft, it results in reliable union with relatively rare complications. If intra-operative fracture of osteotomy occurs, this should be repaired with either Spider clamp of Trochanteric plate and cables. Revision hip surgeons should be familiar with this technique and use it conscientiously when necessary.

O25B5

Efficiency of the Magic Tower® Device in Total Hip Arthroplasty Using the Direct Anterior Approach

Primary Author: Koichi Kanekasu

Institution: Saiseikai Takaoka Hospital

Coauthors: Hiroshi Hisakado (Saiseikai Takaoka Hospital)

INTRODUCTION: Total hip arthroplasty (THA) using the direct anterior approach (DAA) in a supine position is a minimally invasive surgery that reduces postoperative dislocation. Excellent exposure of both the acetabulum and proximal femoral part is important to reduce intraoperative complications. Generally, two surgical assistants need to hold four retractors to maintain excellent exposure of the acetabulum. We examined intra- and postoperative complications as indicators of the efficiency of using the "Magic Tower®" (MT) device compared with a non-MT group.

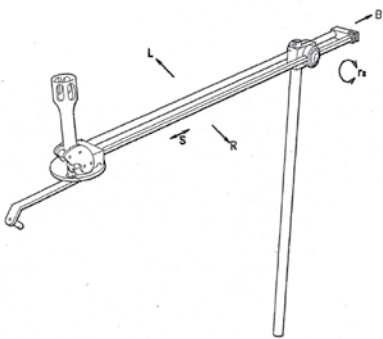
MATERIAL AND METHOD: Twenty consecutive DAA THAs using MT were analyzed, and 20 DAA THAs not using MT were also analyzed. MT is a retractor-holding device, and has an arm structure that can be moved in a wide variety of directions. This device holds a retractor stably, and each movement of the arm can be locked by one click (Fig.1). Operating time, blood loss, length of skin incision, intraoperative complications, and number of assistants were recorded. Postoperative radiographs were obtained to evaluate implant position.

RESULTS: Mean operating time was 105 min in the MT group and 118 min in the non-MT group. Mean blood loss was 232 g in the MT group and 233 g in the non-MT group. Mean length of skin incision was 80 mm in the MT group and 85 mm in the non-MT group. Mean cup inclination was 45.8° in the MT group and 47.3° in the non-MT group.

group. Postoperative implant position was also excellent in both groups. In all comparisons, no significant differences were seen between groups. No intraoperative complications were encountered. Two assistants were required in the non-MT group, and one in the MT group.

DISCUSSION: A majority of the complications reported with THA can be attributed to access issues, i.e., difficulties in exposure and accurate component implantation. To achieve excellent exposure at the acetabulum, four retractors (anterior, posterior, cranial, and caudal) are desirable. In such procedures, two surgical assistants are needed to hold retractors. One of these assistants needs to hold the anterior retractor and cranial/caudal retractor from the opposite side of the surgery beyond the abdomen of the patient. However, the assistant on the opposite side cannot achieve good exposure, as strong retraction of the anterior part of the acetabulum may cause complications of femoral nerve palsy. The MT is able to hold a retractor firmly by applying pressure toward the acetabulum instead of traction, and also reduces the number of surgical assistants required (Fig. 2). While preparing the femur, exposure of the femoral canal was also better than in the non-MT group.

CONCLUSION: In primary DAA THA, no significant differences between groups were identified. However, the MT is clearly a useful device that allows maintenance of excellent exposure, reducing the number of surgical assistants required.



O25B6

Laser Assisted Arthroscopic Surgery in Special Indications

Primary Author: Michael Kunz

Institution: Marienhausklinikum Saarlouis, Germany

Arthroscopic surgery in hip is nowadays a common procedure for different disorders. We perform this treatment in the wellknown indications like Cam and Pincer Impingement, chondral lesions, labral pathologies, degenerative joint disease and extraarticular disorders. Synovitis or Bursitis is in nearly all of these diseases an accompanying pathology. For the treatment of the synovitis we use a Holmium-YAG Laser. The Holmium-YAG Laser with a wavelength of 2100 nm has the ability to cut, resect, ablate and coagulate the tissue. This kind of laser does not cause a thermal necrosis like radiofrequency and works very precisely, rapidly and exactly. Due to the immediate coagulation effect no bleeding occurs during the procedure. The small handpieces enable the surgeon to reach the narrow and hidden areas of the hip joint. Especially in cases of severe stiffness the arthrolysis of the scarred tissue with the laser is superior to a mechanical treatment. Laser arthroscopy is also performed in cases with cartilage defects to remove the chondral flaps. Also the release of the capsular contracture or the stiff labrum is a possible alternative method in comparison with mechanical tools. Extraarticular disorders like trochanteric bursitis or the snapping hip Syndrome are further indications for the use of the laser device. We have performed more than 500 hip arthroscopic surgeries with the help of the Holmium-YAG laser. The results of the procedures are astonishing and significantly better than with the use of mechanical tools or the RF. Postoperative pain, movement and swelling perform superior in laser surgery. This will be pointed out together with the demonstration of special cases.

Let's Not Forget the Patient

O26A1

Comparison of Pain Scores and Postoperative Outcomes in Total Knee Arthroplasty Using Three Different Local Anesthesia Techniques

Primary Author: Sureshan Sivananthan

Institution: Stanford University

Coauthors: Matthew Miller (Department of Orthopaedic Surgery, Stanford University School of Medicine)

INTRODUCTION: There has been considerable interest of late in Enhanced Recovery Protocols and early return to function following Total Knee Arthroplasty (TKA). This is due to a number of factors including increased patient expectation, demand from payors and the need to save costs by decreasing the duration of hospital stay. We prospectively compared three groups of patients who underwent Total Knee Arthroplasty using different local pain control techniques.

METHODS: 90 consecutive patients undergoing Total Knee Arthroplasty were split into 3 groups of 30. Group A received infiltration of our local anesthesia “cocktail” in the knee and surrounding tissues plus insertion of an intra-articular catheter for second dose of Ropivacaine on POD#1. Group B received infiltration of our local anesthesia “cocktail” in the knee and surrounding tissues plus an adductor canal block prior to surgery and Group C received an intra-operative infiltration of Exparel™ (liposomal injectable suspension of bupivacaine) in the knee and surrounding tissues. All patients were given light general anesthesia and the rest of their treatment protocol was standardized. Our local anesthetic “cocktail” consisted of 60ml of 0.2% ropivacaine + 0.5 ml 1:1000 epinephrine + ketorolac 30mg/1ml solution mixed with normal saline to make up 150ml of injectable solution.

RESULTS: We hypothesized that group C would have better early pain control than groups A or B and have a shorter length of stay and use less narcotics than groups A or B. The average daily pain score in Group C was significantly less than in Groups A and B. The average length

of stay in Group C (1.81 days) was significantly less than in Groups A (2.20 days) and B (2.24 days). There was no significant difference in the worst pain score between the groups. There was no significant difference in the average narcotic use between the groups. All patients did well post operatively and there were no complications with the surgery. One patient was readmitted after a fall one week after surgery and a local wound dehiscence, which required a washout in the OR. One patient was readmitted after swallowing a foreign body, which required a partial small bowel resection.

CONCLUSION: Liposomal bupivacaine (Exparel™) is superior or equivalent to ropivacaine cocktail in the post-operative rehabilitation following Total Knee Arthroplasty.

O26A2

Financial Analysis of Revision Knee Surgery Based on the NHS Tariff and Actual Costs: Does It Pay to Provide a Revision Service?

Primary Author: Rami F. Kallala

Institution: University College Hospital London

Coauthor: Fares S. Haddad (UCLH)

Revision surgery for total knee replacement is a complex procedure, carrying a greater risk for patients and cost for hospitals. As well as the increased cost of peri-operative investigations, blood transfusions, surgical instrumentation, implants and theatre time, there is a well-documented increased length of stay (LOS), accounting for the majority of actual costs associated with surgery.

We compared revision surgery for infection vs. other causes (pain, instability, aseptic loosening, dislocation, fracture). Complete clinical, demographic and economic data were obtained for 168 consecutive revision total knee replacements from a database of 384 cases performed at a tertiary referral centre between 2005 and 2012.

Revision surgery for infection was associated with a more than double mean LOS compared to aseptic cases (21.5 vs 9.5 days, $p < 0.0001$), and hospital costs for infection were more than triple those in aseptic cases ($p < 0.0001$). Current NHS tariffs do not fully reimburse the increased costs associated with providing a revision knee surgery service, with even greater cost incurred by the treating hospital for

infected cases. These losses may negatively influence the provision of revision surgery in the NHS.

O26A3

Saucerization Repair with Fibrin Clot Insertion for Discoid Lateral Meniscus in Matured Age - A Case Report

Primary Author: Shozaburo Terai

Institution: Osaka City University Graduate School of Medicine Dept. of Orthopaedic Surgery

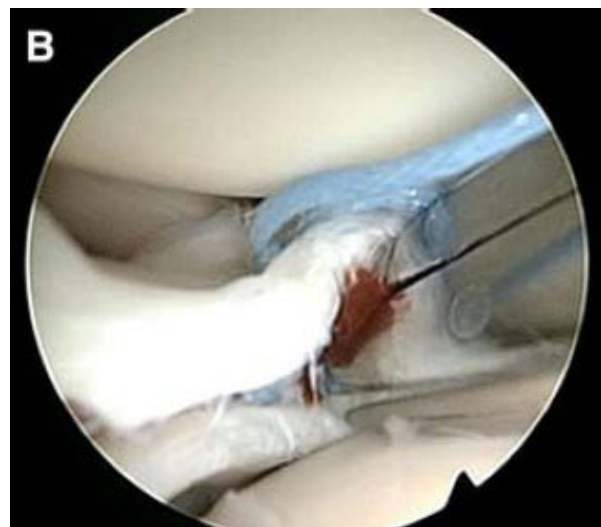
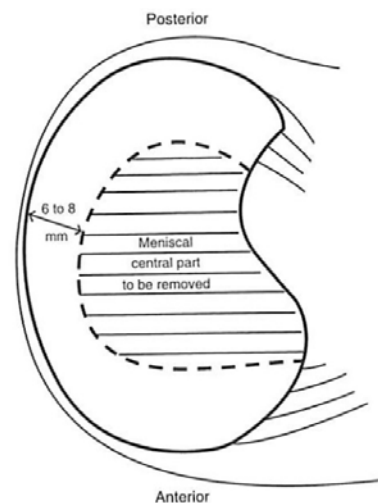
Coauthors: Yusuke Hashimoto (Osaka City University Graduate School of Medicine Dept. of Orthopaedic Surgery), Shinya Yamasaki (Osaka City University Graduate School of Medicine Dept. of Orthopaedic Surgery), Junsei Takigami (Osaka City University Graduate School of Medicine Dept. of Orthopaedic Surgery)

INTRODUCTION: Symptomatic torn discoid lateral meniscus is still often forced to perform total meniscectomy for surgical treatment. We present a case which performed meniscal saucerization and repair with fibrin clot insertion in matured age for severely damaged discoid lateral meniscus.

CASE REPORT: The patient was a 38-year-old man who had right knee pain and swelling. He had a medical history of locking in right knee 20 years ago. He visited our clinic with a chief complaint of click sensation in his right knee and was diagnosed as symptomatic torn discoid lateral meniscus. Physical examination of the knee showed a full range of motion, tenderness at lateral joint space and positive ballottement sign. The McMurray sign was also positive. Radiographs of the knee were normal. A magnetic resonance imaging (MRI) scan of the right knee showed a discoid lateral meniscus with internal high intensity change. He was operated on for his right knee, and the lateral meniscus had an unstable peripheral tear extending from the anterior horn to the posterior horn. After saucerization of the discoid lateral meniscus, there was a horizontal tear at the mid portion of lateral meniscus. Fibrin clot were inserted into the cleavage and tied with four sutures. The meniscal tear was repaired with twenty-nine inside-out procedure with nonabsorbable polyester braid and one all-inside procedure with FasT-Fix. The knee was immobilized at ten degrees flexion with brace for a week and then started joint mobilization with a continuous passive motion device. Partial weight bearing was started af-

ter two weeks and took six weeks to full weight bearing. Three months postoperatively, the patient complaint knee pain and hydrarthrosis, however, one year postoperatively, the patient has little complaint for daily activity, though he cannot play sports, so far.

DISCUSSION: According to Habata et al. and Okazaki et al., long term follow-up of total meniscectomy of symptomatic discoid lateral meniscus in older age is prone to progress osteoarthritic change than younger age. Recent surgical strategy of symptomatic discoid lateral meniscus is to perform saucerization (left six to eight mm width from peripheral) and add repair if there are meniscal instability at peripheral side. Although clinical outcome of saucerization and repair in younger age is relatively good, we couldn't find the report about that in matured age like our case. On the other hand, Kamimura et al. report fibrin clot insertion is effective and helpful for meniscal repair in horizontal tear due to degeneration.



O26A4

The Clinical Results of Saucerization Alone versus Saucerization and Repair for Discoid Lateral Meniscus in juvenile Patients

Primary Author: Shinya Yamasaki

Institution: Osaka City University Graduate School of Medicine

Coauthors: Yusuke Hashimoto (Osaka City University Graduate School of Medicine), Junsei Takigami (Osaka City University Graduate School of Medicine), Shozaburo Terai (Osaka City University Graduate School of Medicine), Hiroaki Nakamura (Osaka City University Graduate School of Medicine)

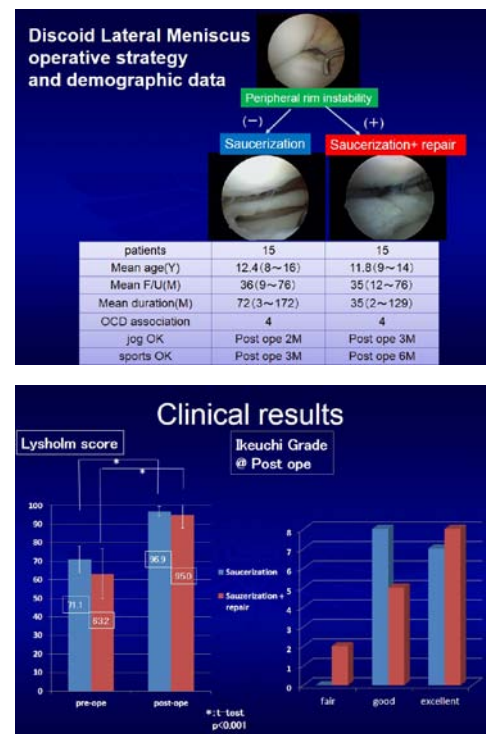
OBJECTIVE: There are few reports comparing the clinical results of saucerization alone with saucerization and repair for discoid lateral meniscus (DLM). The purpose of current research is to retrospectively compare the clinical results of the saucerization alone with saucerization and repair for symptomatic DLM in juvenile patients.

METHODS: From March 2007 to January 2013, we performed arthroscopic saucerization alone for 15 knees without peripheral instability of DLM in 13 patients (8 boys, 5 girls with mean age of 12.4 years) and arthroscopic saucerization and repair for 15 knees with peripheral instability in 15 patients (7 boys, 8 girls with mean age of 11.8 years). Mean follow up period was 36 months (8-76) for saucerization alone, 35 months (12-75) for saucerization and repair. In all cases, at first saucerization was performed in such a way as to resect the central portion of DLM leaving a peripheral rim to 6-8mm width. Then, for the case with peripheral instability, meniscus repair was added through inside-out and all-inside technique. Patients with saucerization alone were allowed to jogging 2 months after surgery and sports 3 months after surgery. Patients with saucerization and repair were allowed to jogging 3 months after surgery and sports 6 months after surgery (Fig.1). We examined the characteristics of patients including symptom, the duration from occurrence of symptom to operation, and tear type of DLM with MRI. Clinical results were evaluated by using Lysholm score and Ikeuchi's grading scale. Statistical analyses were performed by t-test. Differences were considered significant at p

RESULTS: Duration from occurrence of symptom to operation was 76 months in saucerization alone and 26

months in saucerization and repair. Seven patients in saucerization and repair complained snapping in their knees. Four patients were associated with osteochondritis dissecans. Magnetic Resonance Imaging examination of saucerization alone revealed that all 15 knees were no shift type and that of saucerization and repair revealed 7 Anterocentral, 3 Posterocentral, 2 Central, 3 no shift type according to Ahn's classification. Mean Lysholm score in saucerization alone group significantly improved from 71.1 preoperatively to 96.9 postoperatively and that of saucerization and repair group also significantly improved from 63.2 preoperatively to 95.0 postoperatively at final follow-up. And there was not significance between both operative procedures. Ikeuchi's scale of saucerization alone group was excellent in 7, good in 8 and that of saucerization and repair group was excellent in 8, good in 5, fair in 2 (Fig.2). Three patients underwent re-operation including meniscal additional repair and partial resection. However their final Lysholm score of these patients were 95-100 and comparable to other patients.

CONCLUSION: Current clinical results of the saucerization alone and saucerization with repair for symptomatic DLM in juvenile patients were favorable as well as some reports described before. In addition, the clinical results of the saucerization and repair with peripheral instability are almost equivalent to the results of the saucerization alone without peripheral instability.



O26A5**The Efficacy of No Suction Drainage in Simultaneous Bilateral Total Knee Arthroplasty***Primary Author: Hidetaka Higashi**Institution: Funabashi Orthopaedic Hospital**Coauthors: Ryutaku Kaneyama (Funabashi Orthopaedic Hospital), Hideaki Shiratsuchi (Funabashi Orthopaedic Hospital), Kazuhiro Oinuma (Funabashi Orthopaedic Hospital), Yoko Miura (Funabashi Orthopaedic Hospital), Tatsuya Tamaki (Funabashi Orthopaedic Hospital)*

INTRODUCTION: In total knee arthroplasty (TKA), closed drains have been conventionally used to prevent intra-articular hematoma. However, patients who underwent TKA, even unilateral TKA, with closed drains may have experienced excessive hemorrhage in the surgical area within a short time after surgery. Recently reported “no-drain” methods have been demonstrated to be safe and effective, especially for decreasing hemorrhage. However, there has been no report of a major study on a no-drain method in simultaneous bilateral TKA.

OBJECTIVE: Our objective is to evaluate the efficacy and the safety of simultaneous bilateral total knee arthroplasty without suction drainage.

METHODS: We examined 109 patients (218 joints) with preoperative hemoglobin (Hb) level of at least 11.0 g/dl who underwent simultaneous bilateral TKA performed by the same one surgeon in our department between Jan 2009 and Dec 2011. The patients were 14 men and 95 women, of average age 70.4 ± 7.7 years (mean \pm SD) and BMI 26.9 ± 3.9 (mean \pm SD). We excluded patients who had a minor blood type such as Rh (-) and preoperatively donated autologous blood. Three patients who did not receive Xa inhibitor as postoperative anticoagulant therapy were also excluded. Among 109 cases, 43 patients were aged 75 years old and over.

RESULTS: The surgical time per patient was 198.4 ± 23.3 minutes (mean \pm SD). No oral iron preparation or allogeneic transfusion was required for any patient. The Hb levels (mean \pm SD) were 12.8 ± 1.1 g/dl before surgery, 11.0 ± 1.2 g/dl on the day after surgery, and 9.3 ± 1.2 g/dl one week after surgery. The difference in Hb level between the day before surgery and the day after surgery was $2.0 \pm$

0.8 g/dl (mean \pm SD). The difference in Hb level between the day before surgery and one week after surgery was 3.2 ± 0.9 g/dl (mean \pm SD). From these values and body weights, the estimated total hemorrhage volume until the day after surgery was 656.8 ± 252.7 ml (mean \pm SD) and the estimated total hemorrhage volume until 8 days after surgery was 1074.1 ± 303.6 ml (mean \pm SD). No patient experienced hypotension requiring vasopressor or rapid fluid therapy (BW [kg] $^\circ$ —5 ml/h or faster) between the end of surgery and the day after surgery, and no complication caused by a sudden change of hemodynamics was found in any case of bilateral TKA. A gait training/range of motion exercise while bearing full load of the body weight was initiated from the day after surgery, which allowed patients to be discharged from the hospital in an average of 10.9 days. There was no significant difference between the postoperative hospital days of a patient aged 75 and over (10.6 days), and that of a patient aged 74 and below (11.2 days). Complications that occurred within one year after surgery included 2 cases (4 joints) of contracture requiring stereoarthrolysis 4 weeks after surgery. There were no early infection cases.

CONCLUSIONS: The simultaneous bilateral TKA without drain placement can be applied not only to younger patients, but also elderly patients aged 75 years or older.

Shoulder Joint: Imaging Through to Revision

O26B1**Novel 3D Shoulder Imaging System using RF Ultrasound***Guest Faculty: Mohamed R. Mahfouz, PhD**Institution: University Of Tennessee, Knoxville TN, USA**Coauthors: Emam E. Abdel Fatah (University Of Tennessee), J. Michael Johnson (TechMah LLC), Gary To (University of Tennessee)*

INTRODUCTION: Several studies have demonstrated that using 2-D ultrasound for injection guidance greatly

improves the clinical outcome for the joint injections. A recent step has been taken by some ultrasound manufacturers to enhance the guidance technology by providing real-time tracking of the needle (currently only biopsy needles can be used) and projecting the needle on the 2-D ultrasound images. However, these guidance systems still cannot provide the physician with a full or realistic view of the bones and joint space or an accurate reconstruction of the three dimensional patient bones and joint space. In this work, a novel shoulder imaging system using RF ultrasound was developed. The developed system is capable of creating accurate patient-specific 3D models of a joint's bones.

METHODS: The new imaging system uses a commercial diagnostic ultrasound machine that provides the RF data (A-mode signals) for each scan line from the ultrasound transducer. A 14 MHz linear ultrasound probe is used to achieve high axial resolution. The ultrasound probe is tracked while it is being used to scan the joint. The scan lines' RF data provided by the ultrasound machine are then filtered and used along with the probe orientations provided by the tracker are then used to automatically detect the ultrasound echoes generated by the bones and soft tissue interfaces. These detected echoes are then registered together using the orientation data captured by the optical tracker to create a point cloud representing the bone's surface. This point cloud is then used to create the patient specific 3D bone model using atlas based deformable models. Mean models of the humerus, clavicle, and scapula are morphed from the collected point cloud.

RESULTS: The system was tested on a phantom bone geometry (Fig 1) which was created from a manually segmented CT reconstruction. The reconstructed point clouds and 3D models will be compared with the segmented models to measure the reconstruction accuracy using the proposed ultrasound-based method. System has been validated using cadaveric experiments (Fig 2). Mean RMS error for the morphed models were < 2 mm.

DISCUSSION: In this paper we presented an US shoulder imaging system capable of accurately reconstructing patient specific bone and joint space. Output models can be used for 3D guidance during surgery or as clinical tool for shoulder injection.

O26B2

Reverse Shoulder Arthroplasty for Trauma. Thirteen Cases with a Mean Follow-up of Fifteen Years: What Happened?

Primary Author: Jean-François Cazeneuve

Institution: Centre Hospitalier

The aim of this retrospective and mono centric study is to explore the outcome of the reverse concept for trauma in the very long term.

We reviewed thirteen patients operated consecutively by the same surgeon at a mean of 15.4 years (13 to 20). The mean age at the implantation was 66 years (48 to 82). The mean age at the last revision was 81 years. There were one man and twelve women with eight complex four-part fractures and five fracture-dislocations. The trauma involved eight times the dominant side. An anterior approach was used in each case. There were twelve 36-mm spheres and one 42. All stems were cemented.

From the postoperative time to one-year follow-up, we observed, one deep *Acinetobacter* infection at 3-week follow-up solved by debridement and drainage without further problems, one complex sympathetic dystrophy at 1-month follow-up treated by medication. The mean Constant's score was 66 points (20 to 84) which represented a pondered score of 92%. When the dominant side was involved (8 patients), 50% (4 patients) dropped into a state of dependency because of poor rotations avoiding nourishment with utensils, dressing and personal hygiene. 69% of the patients were satisfied or very satisfied. Four of the five spurs and all the notches (n=8) were appeared. There were no critical images associated.

From one-year to 13-year follow-up, we noticed one aseptic loosening of the base-plate with a broken screw and no wear at 12-year follow-up leading to implant a classic base-plate because of a fair bone stock and efficient primary grip after impaction. The mean Constant's score dropped to 52 points (pondered score of 75%). Critical images appeared: one 2-mm radiolucent line between the glenoid and the base-plate at 8-year follow-up in a man with a 42-mm glenospheres and notches kept growing. Three of them (n=8) were associated with one proximal and medial humeral bone loss and two radiolucent lines between the cement and the medial humeral shaft appeared respectively at eight, nine and ten years.

From 13-year follow-up to the last revision, the mean Constant's score kept dropping to 45 points (pondered score of 65%). Inferior spurs, isolated notches with sclerotic borders and the radiolucent line between the glenoid and the base-plate stayed stable. Notches with critical images kept growing as well the humeral bone loss and humeral radiolucent lines. In these cases, there was a negative effect on the Constant's score with only 36 points. There was not any base-plate or humeral loosening or complications or revision surgery.

The very long term follow-up shows that there are two peaks of problems: one before 1-year follow-up with post-operative complications, a loss of autonomy for 50 % of the patients when their dominant side is involved and the apparition of the majority of the radiological images and another peak between 8 and 12 years with diminution of the Constant's score and apparition of critical images. These tendencies keep growing without evidence of radiological loosening or time of revision surgery.

O26B3

Voltage-Controlled Electrical Stimulation of Titanium Implants for Infection Prevention and Eradication

*Primary Author: Mark T. Ehrensberger
Institution: University at Buffalo*

Coauthors: Scott Nodzo (University at Buffalo), Menachem Tobias (University at Buffalo), Ross Cole (University at Buffalo), Lisa Hufnagel (University at Buffalo), Nicole Luke-Marshall (University at Buffalo), Anthony Campagnari (University at Buffalo)

INTRODUCTION: Infection rates of primary joint arthroplasty have been reduced to 0.3-2% with modern aseptic techniques, but this rate may reach 20% in some revision procedures. Currently, the gold standard for treating delayed periprosthetic joint infections (PJI) remains a two-staged revision arthroplasty due to bacterial biofilm formation on the retained components. Unfortunately, this treatment method involves multiple surgical procedures and removal of implants that may be well fixed. Due to the limitations of a two-staged revision arthroplasty, alternative methods for treating PJI must be investigated.

OBJECTIVE: To evaluate the in-vitro and in-vivo effec-

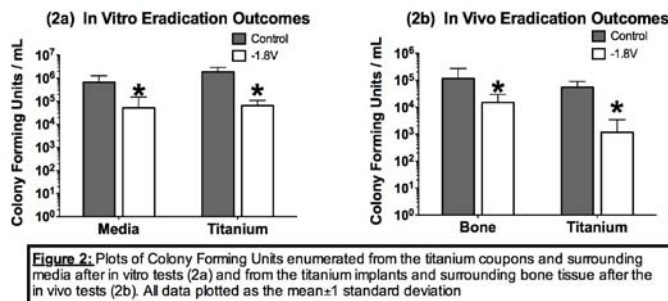
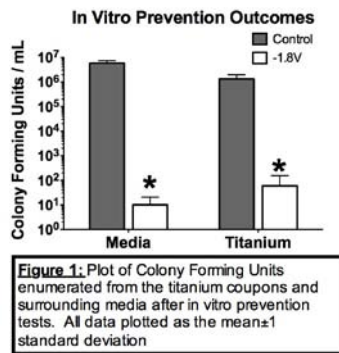
tiveness of applying voltage-controlled electrical stimulation directly to titanium implants for prevention and/or eradication of device-related biofilm infections.

METHODS: In-vitro studies utilized a three-electrode configuration, within a custom chamber simulating soft tissue coverage of an orthopedic implant, to apply constant voltage-controlled stimulation to titanium (Ti) coupons. In prevention tests, Ti coupons were placed in bacterial cultures while receiving stimulation of -1.8V for 4 hrs. In eradication tests, bacterial biofilms were preformed on the Ti and subsequently received stimulation of -1.8V for 1 hr. In both types of tests, after stimulation the Ti and surrounding media was harvested and dilution plated to enumerate colony-forming units (CFUs). A clinical isolate (NRS70 strain) of methicillin resistant *Staphylococcal aureus* (MRSA) was utilized for both types of in-vitro tests. In-vivo infection eradication studies utilized an IACUC approved rat prosthetic infection model. Briefly, a Ti rod was implanted through the humeral head of Long-Evans rats and inoculated with MRSA (NRS70) to establish a local infection. On post-op day 6 an implantable three-electrode configuration was utilized to deliver stimulation of -1.8V to the Ti for 1 hr. Subsequently the Ti, synovial fluid, and bone tissue were collected for enumeration of CFUs. The bone tissue was also examined histologically. Control experiments (no stimulation) were performed for all in-vitro and in-vivo tests. Six samples were conducted for each in-vitro test group and eight samples were conducted for each in-vivo test group. Student t-tests compared the stimulation and control groups (significant if $p < 0.05$).

RESULTS: Electrical stimulation resulted in significantly lower CFUs as compared to the controls in every in-vitro and in-vivo test. Figure 1 shows that the preventative stimulation reduced the CFUs attached on the Ti and in the media by roughly 5-logs (99.999% reduction) as compared to the no stimulation control samples. Figure 2 shows that the electrical stimulation for eradication had similar effects both in vitro (2a) and in vivo (2b). Notably, in-vivo electrical stimulation reduced NRS70 CFUs on the implant by roughly 2-logs (99%). Histology showed stimulation had no deleterious effects on the bone tissue.

CONCLUSIONS: Voltage-control electrical stimulation of -1.8V applied to titanium is an effective antimicrobial strategy both for infection prevention and eradication. As such, this approach may represent a paradigm shift in the treatment of device-related biofilm infections. Ongo-

ing studies are currently evaluating the use of this electrical stimulation in combination with traditional antibiotics.



O26B4

Guidelines for the Selection of Optimal Glenoid Augment Size for Moderate to Severe Glenohumeral Osteoarthritis

Primary Author: Jeffrey Freyder

Institution: Orthopedic Surgery Western Michigan University School of Medicine

Coauthors: Vani J. Sabesan (Department of Orthopaedic Surgery, Western Michigan University School of Medicine), Mark Callanan (Harvard Combined Orthopaedic Surgery Residency Program), Vinay K. Sharma (Department of Orthopaedic Surgery, Western Michigan University School of Medicine)

INTRODUCTION: Total shoulder arthroplasty is technically demanding in regards to implantation of the glenoid component, especially in the setting of increased glenoid deformity and posterior glenoid wear. Augmented glenoid implants are an important and innovative option; however, there is little evidence accessible to surgeons to guide in the selection of the appropriate size augmented glenoid.

METHODS: Solid computer models of a commercially

available augmented glenoid components (+3,+5,+7) contained within the software allowed for placement of the best fit glenoid component within the 3D reconstruct of each patient's scapula. Peg perforation, amount of bone reamed and amount of medialization were recorded for each augment size.

RESULTS: There was strong correlation between the medialization of the joint line and the glenoid retroversion for each augmented component at neutral correction and correction to 6° of retroversion. At neutral, the range of retroversion that restored anatomic joint line using the +3 augmented glenoid was -3° to -17°, -5° to -24° using the +5 augmented glenoid, and -9° to -31° for a +7 augmented glenoid. At 6° of retroversion, the range of retroversion that restored the anatomic joint line using the +3 augmented glenoid was -4° to -21°, -7° to -27° using the +5 augmented glenoid, and -9° to -34° using the +7 augmented glenoid.

CONCLUSIONS: There was a strong correlation between glenoid retroversion and medialization for all augment sizes supporting the recommendation for glenoid retroversion as the primary guide in selecting the amount of augmentation.

O26B5

What to Wear Against the Wear? Ceramics in Shoulder Arthroplasty: a Comparative Study

Primary Author: Mateusz Maria Juszczuk

Institution: CeramTec GmbH

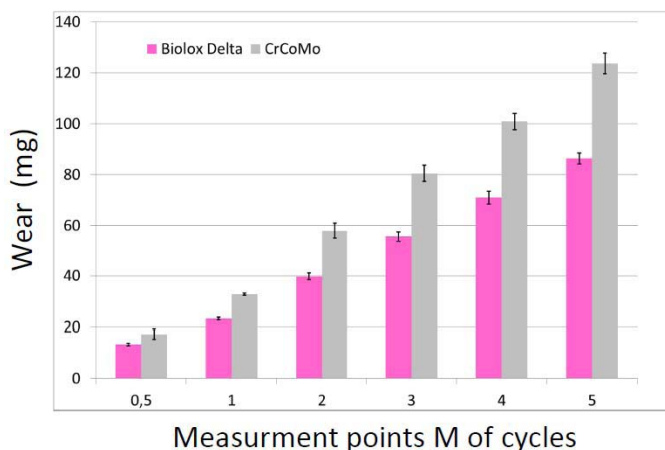
Coauthors: Martin Hintner (Endolab), Christian Kaddick (Endolab), Alfons Kelnberger (Ceramtec GmbH), Wecker Heinrich (Ceramtec GmbH)

INTRODUCTION: Failure of the polyethylene glenoid component is the most common complication of Reversed Total Shoulder Arthroplasty (TSA) and accounts for a majority of the unsatisfactory results after this procedure. Most of nowadays shoulder prostheses are metal on polyethylene bearings. Repetitive contact (sliding) between the metal ball and the polyethylene socket produces progressive abrasion of articulating surfaces. Usually polyethylene part being less wear resistant, releases debris that may then lead to an active osteolysis and implant loosening. Failure of the glenoid component is often manifested

clinically by pain, loss of function, and the presence of a clunking noise and leads to revision surgery. The use of ceramic balls aims at reducing the amount of polyethylene debris. In many studies regarding knee and hip replacement it has been shown that the use of ceramic on polyethylene is more beneficial in terms of polyethylene wear and failure, when compared to metal on polyethylene. In this study we have compared performance of standard a CoCr-Mo against Biolox Delta glenosphere vs. PE liner. This is, to our knowledge, the first study to address in direct comparison wear behavior in RTSA.

MATERIALS AND METHODS: A Biolox Delta based glenospheres were produced based on a popular Co-Cr-Mo 40mm diameter design. Three articulating couples for each material were tested for total of 5 million cycles against a standard PE humeral liner. Standard midterm gravimetric measurements were conducted at each 1 million cycles. Since up today, there is no test standard for wear testing for RTSA a customized joint simulator was used to create worst-case motion scenario. The orientation of the glenoid component and humeral component and applied kinematics was based on a study of G. Kohut (2012) and ISO 14242-1 (2012) standard, with loading varying from 250N to 1000N.

RESULTS: After 5M cycles the UHMWPE liner components articulating with the Biolox Delta showed a mean wear rate of 18.02 mg per million cycles (StdDev. 0.64 mg/million cycles) and the UHMWPE articulating with CoCr-Mo showed a mean wear rate of 26.51 mg per million cycles (StdDev. 1.08 mg/million cycles), see fig.1. That is 30% lower wear rate for Biolox Delta – PE pairing compared to CoCrMo – PE. Measured wear rates are comparable to previous studies (Kohut et al 2012).



Poster Session

Abstracts

– Hip –

H500

Restoration of Full Anatomy From Partial Bones

Primary Author: Emam E. Abdel Fatah

Institution: University Of Tennessee

Coauthors: Mohamed R. Mahfouz (University Of Tennessee)

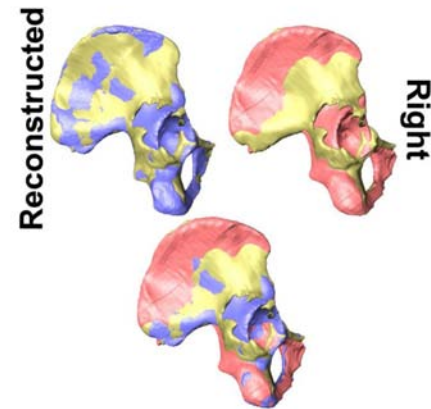
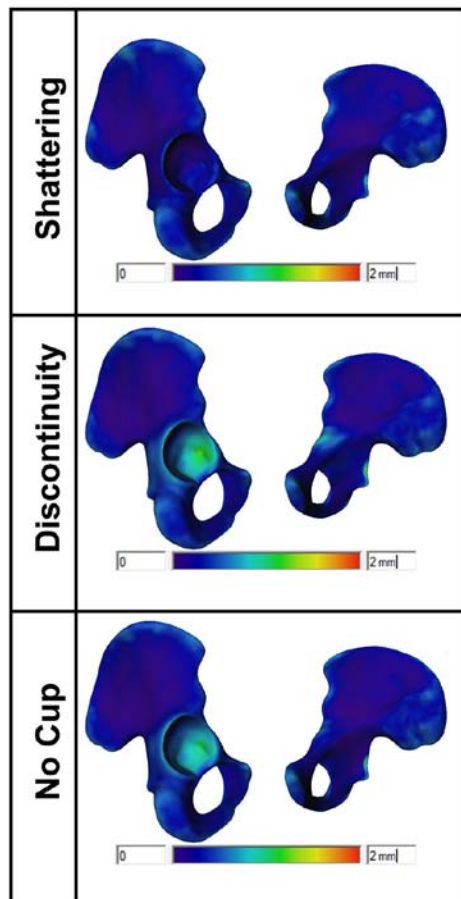
INTRODUCTION: Medicine bone reconstruction is an essential task in cases where bone loss is present, due to tumors, abnormalities or trauma, especially in mandibular defects. Bone reconstruction is also crucial in cases of pelvis defects, especially in case of pelvic discontinuity, a distinct case of bone loss associated with total hip arthroplasty (THA), where the superior aspect of the pelvis is separated from the inferior aspect. In this study we propose a new method for restoration of full anatomy from partial bones.

METHODS: The sample for this analysis is a subset of documented innominate from people with 20th century birth years from the William M. Bass Donated Skeletal Collection at the University of Tennessee's Department of Anthropology (n=94, 33 females and 61 males). Segmented innominate were then added to the statistical atlas to generate point correspondence and principal components were then computed to reconstruct a statistical shape model. In order to accurately assess the ability of SSM to reconstruct missing anatomy from partial information, the SSM was constructed using the leave-one-out method. For each innominate bone three scenarios were simulated. The Process of the missing data restoration or interpolation starts by first, extracting a data point cloud from the partially reconstructed bone. Then the closest bone in size in the atlas is selected as initial bone. This bone is then aligned to the point cloud using affine registration. A morphing process is used to optimize the shape parameters contained in the atlas (principal components) and to generate a bone

that minimizes the distance error from the atlas to the point cloud from the partially reconstructed bone. The output for this process is a fully reconstructed bone that best represents the partial bone. Output was then compared to original bone and surface error was calculated. Method was also tested on real data from a patient suffering from pelvis discontinuity.

RESULTS: Overall RMS error was less than 0.61 mm with a maximum of 3.29 mm error. Average RMS error map is shown in figure 1 for the 3 experiments. For the real case with pelvis discontinuity RMS error of 1.4 mm was achieved between reconstructed and left innominate bone, whereas average RMS error between left and mirrored right model for the same patient was 3.61 mm. Figure 2 shows results of the reconstruction, and comparison between reconstructed left bone and the right bone.

DISCUSSION: The method proposed in this study has shown great potential in restoration of missing anatomical information in partial innominate bones, with high accuracy. This can enhance the outcome of reconstructive surgeries and creation of patient specific implants.



H501 Bacterial Contamination Of Diathermy Tips Used During Orthopaedic Procedures

Primary Author: Ali Abdulkarim

Institution: Midland Regional Hospital Tullamore, Ireland

Coauthors: Andrew Moriarity (Midland Regional Hospital, Tullamore, Ireland), Peter Coffey (Midland Regional Hospital, Tullamore, Ireland), Eoin Sheehan (Midland Regional Hospital, Tullamore, Ireland)

INTRODUCTION: The role of diathermy in orthopaedic surgical practice has increased since its introduction. It is widely used for underlying tissue dissection, cutting, and haemostasis. Previous studies have compared electro-surgical and scalpel incisions in terms of wound infection, wound-related pain, and blood loss. There are well documented hazards associated with diathermy use including burns injury, electrocution, hypoxic stress, inhalation of diathermy plume, and gene mutation. No single study to date has focused on the potential for diathermy tips to cause wound contamination and infection. We sought to identify whether diathermy tips could be possible sources of infection in orthopaedic procedures.

OBJECTIVES: To determine the prevalence of bacterial contamination of diathermy tips during orthopaedic surgery and to assess any correlation with surgical site infections. **Methods:** From July 2013 to September 2013, the diathermy tips from 86 consecutive orthopaedic procedures using diathermy were cultured using direct and enriched media. None of the diathermy tips were used for the skin incision. All patients underwent an orthopaedic pro-

cedure for a non-infected condition. For each procedure an unused control diathermy tip was placed on the instrument table at the beginning of the procedure and processed similarly. All patients were followed for any postoperative complications.

RESULTS: 108 diathermy tips from 86 orthopaedic procedures were cultured. None of the tips cultured directly on blood agar demonstrated bacterial growth. Following enrichment culture, 6 (5.6%) of the procedure diathermy tips and 1 (0.92%) of the control tips demonstrated bacterial growth. Coagulase-negative staphylococci (83.3%) and propionibacterium (16.7%) were cultured from the tips. 1 of the patients who had bacterial growth from the diathermy tip developed a superficial surgical site infection.

CONCLUSIONS: Surgical site infections contribute substantially to orthopaedic surgical morbidity and mortality each year. The prevention of these infections encompasses careful operative technique, preoperative antibiotics, and a number of important measures to minimize the risk of bacterial contamination posed by operative staff, the operating theatre environment, and the patient's endogenous skin flora. Identifying potential bacterial sources is an important component of surgery. The two bacteria cultured in our study (coagulase-negative staphylococci and propionibacterium) are both well known major culprits in orthopaedic infections, responsible for up to 70% of early and late peri-prosthetic infections. Our study suggests diathermy tips and the tissue coagulated by its use may not be as sterile as previously thought. There may be benefit in changing the diathermy tips during orthopaedic procedures as they may represent a possible source of bacterial contamination.

H502

Cemented versus Uncemented Fixation in Total Hip Replacement: A Systematic Review & Meta-Analysis

Primary Author: Ali Abdulkarim

Institution: Midland Regional Hospital Tullamore

Coauthors: P. Ellanti (Cappagh National Orthopaedic Hospital), N. Motterlini (Royal college of Surgeons in Ireland), T. Fahey (Royal college of Surgeons in Ireland), J.M. O'Byrne (Cappagh National Orthopaedic Hospital)

INTRODUCTION: Controversy exists regarding the optimal method of fixation for primary total hip replacement, particularly fixation with or without the use of cement which has been the subject of much debate.

METHODS: We performed a systematic review and meta-analysis of all randomized controlled trials (RCTs) available in the published literatures that compare cemented versus uncemented fixation in THR.

RESULTS: Our Meta analysis of the included RCTs suggests that there is no significant difference between cemented and cementless hip arthroplasty in term of survival of implant measured by revision rate.

However, better short-term clinical outcomes mainly improved pain score can be obtained with cemented fixation than those without cement. On the other hand the results are still unclear for the long-term clinical and functional outcome.

No difference was evident in mortality or complications rate between the two fixation methods. On the other hand, radiographic differences are variable and do not seem to correlate with clinical findings. Differences in both cemented and cementless surgical technique combined with nature of the prosthesis might be associated with the incidence of osteolysis.

We strongly emphasize the need for more uniform standards in the selection of control groups and better reporting technique in future orthopaedic randomized trials. Further research, improved methods and longer follow up are necessary to better define specific subgroups of patients in which the relative benefits of cemented and uncemented implant fixation can be more clearly demonstrated.

CONCLUSION: Cemented hip arthroplasty is similar if not superior to cementless fixation, and provide better short term clinical outcomes. Our findings summarize the best available evidence and provide important information for future research.

H503**The Effect of Orthopaedic Surgery on the Intrinsic Properties of Surgical Gloves**

Primary Author: Ali Abdulkarim

Institution: Midland Regional Hospital Tullamore, Ireland

Coauthors: Andrew Moriarity (Midland Regional Hospital, Tullamore, Ireland), Eoin Sheehan (Midland Regional Hospital, Tullamore, Ireland)

INTRODUCTION: Surgical gloves function as a mechanical barrier that reduces transmission of body fluids and pathogens from hospital personnel to patients and vice versa. The effectiveness of this barrier is dependent upon the integrity of the glove. Infectious agents have been shown to pass through unnoticed glove microperforations which have been correlated to the duration of wear. Varying factors may influence the integrity of the glove such as the material, duration of use, activities and fit. Studies have recommended changing gloves 90 minutes into a general surgical operation, however there are no known EBM recommendations in orthopaedic surgery.

OBJECTIVES: The aim of our study was to determine whether the intrinsic properties of sterile surgical gloves can be compromised when exposed to common orthopaedic materials in the operating theatre.

METHODS: A total of 20 unused sterile surgical gloves (neoprene and latex) were exposed to blood, bone shavings and cement over 15, 30 and 60 minute intervals. Following each time point, the palmar surface and finger tips of each glove was analyzed under the scanning electron microscope (SEM), and were tested for changes in contact angle and tensile properties.

RESULTS: Exposure to cement caused a significant increase in both the neoprene and latex glove porosities at 15 min but no significant further changes at any later time points. The latex gloves had a greater increase in pore diameter than the neoprene gloves. Exposure to cement for 15 min duration significantly decreased the tensile strength of both latex and neoprene gloves. Exposure to either blood or bone shavings did not cause any significant changes in the latex or neoprene glove properties.

CONCLUSIONS: This study provides evidence that exposure to cement, a common orthopaedic material, can dis-

rupt the intrinsic properties of the surgical gloves worn in the operating theatre. This can lead to micro or macro perforations putting both the patient and operating room personnel at risk of contamination.

H504**Pseudo Arthrosis in Paraplegia: New Approach for Treatment of Hip Stiffness and Infection in Paraplegic Patients**

Primary Author: Abdul Radha kh.jabbar Al kafaji

Institution: Ministry of Health Iraq

Coauthor: Abdul Radha Al Khafaji (Al Sader General Hospital, Baghdad, Iraq)

INTRODUCTION: Bed sores, chronic osteomyelitis and stiffness are common complications in paraplegic patient. Available treatments like skin graft and flap or excision and physiotherapy are of limited success because of the pressure caused by bony prominences.

TOOLS: The procedure was explained in detail to patients and their relatives and a written consent forms were taken. Antro_lateral approach to the hip. Excision of head, neck and trochanteric bone. A gap is left, wound is closed.

RESULTS: Result and discussion from 2001-2009 15 young Iraqi patients aged 20-40 years who underwent this procedure. Other 7 patients and their relatives refused the operation. All the patients recovered, the ulcers were healed within 3 weeks infections were controlled and movement improved.

DISCUSSION: This procedure was not mentioned in any orthopedic references but we used it for saving life and treating indolent ulcers that threaten the life of the patient by making pseudoarthrosis of the hip joint.

Conclusion: It is an effective procedure when other procedures failed.

H505**Non-oncologic Total Femoral Replacement: Retrospective Review***Primary Author: Derek Amanatullah**Institution: Mayo Clinic*

Coauthors: Derek F. Amanatullah (Mayo Clinic), Robert T. Trousdale (Mayo Clinic), Arlen D. Hanssen (Mayo Clinic), David G. Lewallen (Mayo Clinic), Michael J. Taunton (Mayo Clinic)

BACKGROUND: Orthopaedic surgeons are increasingly confronted with excessive bone loss during revision total hip arthroplasty and total knee arthroplasty. Total femoral replacement (TFR) has emerged as an option to hip disarticulation or above knee amputation in the setting of extremely compromised bone stock.

METHODS: We retrospectively reviewed the records of 20 non-oncologic patients treated with a total femoral replacement with a minimum of two years of clinical or radiographic follow-up (Figures 1 and 2). The pre-operative, post-operative, and latest radiographs of all femurs were reviewed for loosening, implant failure, or dislocation. Pre-operative and postoperative Harris hip scores (HHS) were calculated from clinical examinations and patient surveys. Complications were recorded from the clinical and operative record.

RESULTS: There were a total of 20 TFRs performed for non-oncologic indications. The average clinical follow-up was 73 ± 49 months. The incidence of new TFR infection was 10% (2/20), while the overall infection rate was 35% (7/20). The incidence of primary hip instability after TFR was 10% (2/20), while the overall instability rate was 25% (5/20). Six patients (30%) underwent revision for any failure mode. The average pre-operative HHS was 30.2 ± 13.1 , ranging from 9 to 57. The average post-operative HHS was 65.3 ± 16.9 , ranging from 28 to 86.

CONCLUSIONS: TFR is a viable alternative to amputation in non-oncologic patients with massive femoral bone deficiency. Level of Evidence: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.

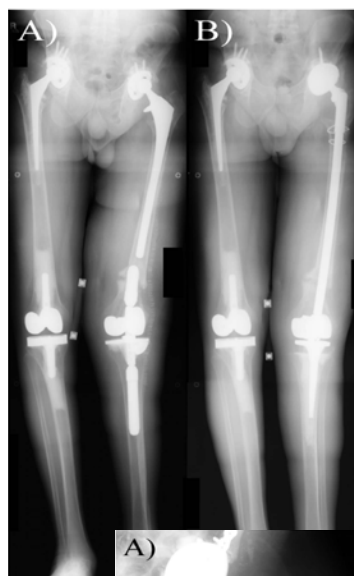


Figure 1: A) Standing full length radiograph of 55 year old male after left distal femur fracture between a long, fully-coated, integrated THA and a cemented revision TKA. B) After extended trochanteric osteotomy, implant removal, and TFR with uncemented acetabular and cemented tibial revision.

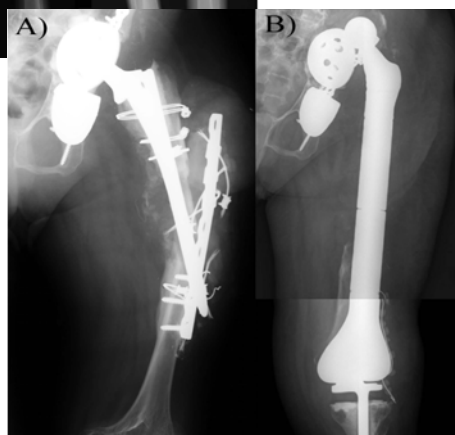


Figure 2: A) Anterior to posterior radiograph of 44 year old female with mucopolidosis type 3 dwarfism and left infected preprosthetic non-union. B) After resection arthroplasty placement of antibiotic cement spacer and intravenous antibiotics and replantation with a TFR complicated by dislocation.

H506**Hip Arthroplasty in Patients with Down Syndrome***Primary Author: Derek F. Amanatullah**Institution: Mayo Clinic*

Coauthors: Derek F. Amanatullah (Mayo Clinic), Sridhar R. Rachala (Mayo Clinic), Robert T. Trousdale (Mayo Clinic), Rafael J. Sierra (Mayo Clinic)

INTRODUCTION: Multiple pathologies predispose the hip to osteoarthritis in patients with Down syndrome. The presence of mental retardation (i.e., lack of compliance with hip precautions), hypotonia, decreased bone density, generalized ligamentous laxity, and anatomic deformity

about the hip increase the risk of failure after THA in patients with Down syndrome.

METHODS: We retrospectively reviewed the records of 22 primary hip arthroplasty with a minimum of two years of follow-up performed in 14 Down syndrome patients at a single center (Figure 1). The pre-operative, post-operative, and latest radiographs of all hips were reviewed for loosening, implant failure, or dislocation. Pre-operative and post-operative Harris hip scores (HHS) were calculated from clinical examinations and patient surveys. Complications were recorded from the clinical and operative records.

RESULTS: Eight patients (57.1%) required bilateral THA while the rest were unilateral. The average clinical follow-up after primary THA was 5.9 ± 4.6 years. There were no major post-operative complications. Five THAs (22.7%) in 3 patients underwent revision THA for aseptic loosening of the femoral component in one case and the acetabular component in 4 cases (Figure 2). The average pre-operative HHS was 37.9 ± 7.8 and increased to 87.0 ± 15.2 at final follow-up.

CONCLUSIONS: THA in Down syndrome patients have a relatively high revision rate as a result of aseptic loosening, but Down syndrome patients gain clinically significant functional benefits and pain relief from THA. Level of Evidence: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.

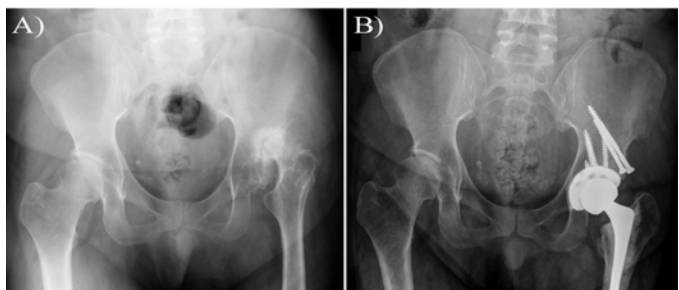


Figure 1: A) Anterior-to-posterior pelvis of a patient with Down syndrome and left hip Crowe IV developmental dysplasia of the hip. B) Anterior-to-posterior pelvis after total hip arthroplasty with a press-fit 54 mm Pinnacle acetabular cup and acetabular autograft as well as a cemented Exeter V40 stem.

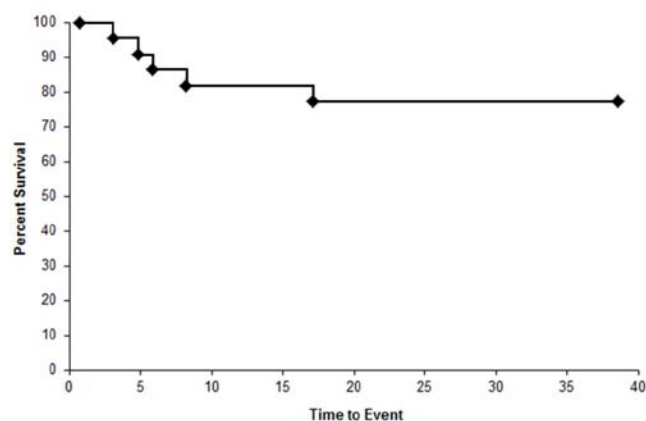


Figure 2: Kaplan-Meier survival curve for revision THA in patients with Down syndrome from any cause.

H507 Total Hip Arthroplasty after Lower Extremity Amputation

Primary Author: Derek F. Amanatullah

Institution: Mayo Clinic

Coauthors: Derek F. Amanatullah (Mayo Clinic), Robert T. Trousdale (Mayo Clinic), Rafael J. Sierra (Mayo Clinic)

BACKGROUND: Amputation predisposes both hips to symptomatic osteoarthritis. The ipsilateral hip has a three times greater risk of degeneration when compared to the contralateral hip in the amputee population. We report the clinical and patient reported outcomes of total hip arthroplasty (THA) in the amputee population.

METHODS: We retrospectively reviewed the records of 35 patients treated with a total hip arthroplasty (THA) after lower extremity amputation with a minimum of two years of clinical or radiographic follow-up. Seventeen (48.6%) THAs were performed on the contralateral side of the amputated limb and 18 (51.4%) THAs were performed on the ipsilateral side of the amputated limb. The average clinical follow-up was 5.3 ± 4.0 years. THA after contralateral lower extremity amputation represents 0.059% of all THAs, while THA after ipsilateral lower extremity amputation represents 0.063% of all THAs. The pre-operative, post-operative, and latest radiographs of all hips were reviewed for loosening, implant failure, or dislocation. Pre-operative and postoperative Harris Hip Scores (HHS) were calculated from clinical examinations and patient surveys. Complications were recorded from the clinical and operative record.

RESULTS: The average time from amputation to THA was 12.2 ± 12.8 years after contralateral lower extremity amputation and 5.4 ± 6.0 years after ipsilateral lower extremity amputation ($p = 0.050$). There was a statistically significant improvement in HHS of 40.9.

CONCLUSIONS: THA after lower extremity amputation is rare. Patient with an ipsilateral lower extremity amputation may progress to THA faster than those with a contralateral lower extremity amputation, regardless of patient experience a significant clinical improvement with THA in the setting of a lower extremity amputation.

LEVEL OF EVIDENCE: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.

H508

Early Failures with a Big Femoral Head (BFH) Metal-on-Metal Total Hip System

Primary Author: Vikram Chatrath

Institution: The Ottawa Hospital, Ottawa, Canada

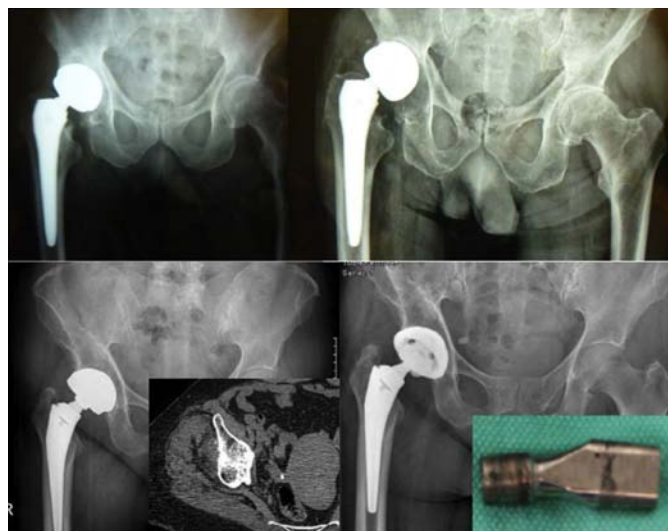
Coauthors: Paul Beaulé (The Ottawa Hospital, Ottawa, Canada), Isabelle Catelas (The Ottawa Hospital, Ottawa, Canada)

Recently, the CONSERVE® Total Hip with BFH™ (Big Femoral Head), a new metal-on-metal (MM) total hip system, has become available. The BFH™ system utilizes a large diameter femoral head (36-54 mm), which may result in decreased rates of dislocation by reducing impingement. The system also employs a differential hardness bearing that has been shown, in hip wear simulators, to wear up to 10 times less than standard MM bearing couples. The purpose of this study is to present the early clinical results of our center's experience with the use of this total hip system.

From October 2005 to May 2010, 89 procedures were performed in 88 patients (53 males, 35 females) by four surgeons. The mean age of patients was 59.7 ± 9.8 years (range: 20 to 79). The mean BMI of patients was 29.5 ± 6.2 (range: 21.2 to 44.8). Post-operative clinical follow-up consisted of a physical examination, standard radiographs, and three patient-reported outcomes: WOMAC, modified Harris Hip Score (HHS), and the UCLA Physical Activity Scale.

At mean follow-up of 30 months (range 24 to 72), all outcomes showed improvement ($p < 0.001$). Mean scores were 83.6 (follow-up) vs. 49.1 (pre-surgery) for WOMAC Pain, 73.2 vs. 44.5 for WOMAC Stiffness, 81.7 vs. 47.4 for WOMAC Function, 81.4 vs. 47.5 for WOMAC Total, 82.4 vs. 54.0 for HHS, and 6.4 vs. 4.7 for UCLA. However, nine cases required revision (mean=31.9 months, range: 11 to 48) due to aseptic cup loosening ($n=6$) Fig 1. or pseudotumor ($n=3$) Fig 2.

A high revision rate of a large head MM total hip replacement was observed due to poor acetabular component fixation as well as adverse tissue reactions. Use of this implant should be restricted to conversion of a failed resurfacing arthroplasty.



H509

Acetabular Cup Revision Using Cementless Cup with Structural Allograft

Primary Author: Yoon Je Cho

Institution: Department of Orthopedic Surgery, School of Medicine, Kyung Hee University

Coauthors: Dong Cheol Nam (Department of Orthopedic Surgery, School of Medicine, Kyung Hee University), Eun seong Sagong (Department of Orthopedic Surgery, School of Medicine, Kyung Hee University), Myung Seo Kim (Department of Orthopedic Surgery, School of Medicine, Kyung Hee University)

PURPOSE: The number of revision total hip arthroplasty

has increased recently. In case of revision surgery acetabular bone defect reconstruction is common problem. Proper manage of acetabular bone loss can reduce the re-revision total hip arthroplasty. In case of severe acetabular osteolysis, revision of acetabular cup is very difficult and challenging. We wanted to verify that the structural allograft with cementless cup can be a good option for revision of acetabular cup with severe bone defect. We also wanted to verify if structural allograft resorption is really does matter in the stability of cementless acetabular cup.

MATERIALS AND METHODS: From May 1992 to July 2011, 25 patients were evaluated. There were 9 males and 16 females with an average age of 50.2 years. The average follow up period was 90.3(16~226) months. All cases were used deep freeze allo-femoral head as a structural allograft bone and acetabular cup was fixed with cementless method. The clinical evaluation was performed using Harris Hip Score(HHS) and UCLA activity score. The radiological evaluation was done by check the degree of graft bone resorption, allograft incorporation with normal bone, osteolysis and cup loosening.

RESULTS: Clinically, the HHS was improved from 54 to 93.4 in last follow up. The UCLA activity score was improved from 4.3 to 6.4 in last follow up. Radiologically, the allograft incorporation was accomplished in 11.4 months and the graft bone resorption was noted in 13 cases but didn't progressed to moderate resorption in long term follow up. The cup loosening was not checked and average survivor rate was 100% in 7.6 years. There was no infection, allograft bone fracture, resorption or cup loosening in any cases.

CONCLUSION: Cementless cup with structural allograft in acetabular cup revision can provide excellent long term clinical and radiological results. Structural allograft can provide enough mechanical support for the bone ingrowth of cementless cup. Cementless cup with structural allograft can be a good option for acetabular cup revision with severe bone defect.

H510 Comparison of Long-term Results of Highly Crosslinked Polyethylene vs Conventional Polyethylene

Primary Author: Yoon Je Cho

Institution: Department of Orthopedic Surgery, School of Medicine, Kyung Hee University

Coauthors: Dong Cheol Nam (Department of Orthopedic Surgery, School of Medicine, Kyung Hee University), Eun seong Sagong (Department of Orthopedic Surgery, School of Medicine, Kyung Hee University), Myung Seo Kim (Department of Orthopedic Surgery, School of Medicine, Kyung Hee University)

PURPOSE: Highly Crosslinked polyethylene is the most commonly used articulation in total hip arthroplasty. Hip stimulator studies, short and midterm studies have suggested that wear rate of highly crosslinked polyethylene is significantly less than conventional polyethylene. The aim of this study is to identify any difference in the wear performance and clinical outcomes between highly cross-linked polyethylene and conventional polyethylene in the long term.

MATERIALS AND METHODS: Seventy eight persons who had undergone primary cementless total hip arthroplasty were enrolled in a retrospective study. There were 43 hips, 37 patients using conventional polyethylene, and 41 hips, 41 patients using highly crosslinked polyethylene. Patients were assessed clinically and radiographically at postoperative 6weeks, 3months, 9months and annually thereafter. Mean follow-up period was 10.7years (96 to 189 months) in conventional PE group, and 10.2years (96 to 166 months) in highly crosslinked polyethylene(HXLPE) group. Clinical assessment was performed using Harris Hip Score. Radiographic analysis included measurement of acetabular component position, polyethylene wear(Dorr Method) and evidence of osteolysis using a validated radiographic technique. Statistical comparison of polyethylene wear was performed with the use of generalized estimating equations

RESULTS: Harris Hip Score did not differ between highly crosslinked(96.7) and conventional polyethylene(95.0) groups. The mean bedding in penetration of highly cross-linked PE (0.027mm) was significantly lower than conventional PE (0.193mm). The subsequent penetration with elimination of the bedding in wear, resulted in a reduction in annual linear wear rate in highly crosslinked PE compared to conventional PE by 86%. Mean linear wear rate according to age was significantly different in bivariate correlation analysis.

CONCLUSIONS: At a mean of 10 years of follow up, annual linear wear rate of HXLPE was 86% lower than conventional PE. There was no concerned complications, osteolysis and crack in the HXLPE group where as five cases of osteolysis in conventional PE. There was no difference in the clinical outcome between two groups.

H511 Outcome and Survivorship Following Modular, Uncemented, Fully Porous Coated Stem in Revision Total Hip Arthroplasty

Primary Author: Peter Cnudde

Institution: Prince Philip Hospital, Llanelli, Wales, UK

Coauthors: Konrad S. Wronka (Prince Philip Hospital, Llanelli, Wales, UK)

INTRODUCTION: Modular, uncemented, fully porous coated stem is commonly used in revision total hip arthroplasty. It is versatile, allows accurate positioning and balancing of the hip, use of various bearing surfaces and leads to satisfactory results.

OBJECTIVES: Aim of this study was to evaluate the outcome and survivorship of implant following uncemented modular fully porous coated femoral stem used in revision hip arthroplasty in series of single surgeon.

METHODS: Retrospective Case Series of all patients who had revision Total Hip Replacement surgery performed by senior author between 2003 and 2012, with clinical and radiological follow up between 1 and 10 years. Clinical notes and radiographs were reviewed by independent observer.

RESULTS: 168 revision Total Hip Replacement procedures were undertaken in 165 patients. 3 had bilateral operations during their life. All procedures were performed by posterior approach. Femoral deficiency varied from type I to type IIIB according to Paprosky classification. In 126 cases uncemented modular fully porous coated femoral stem was used -either MP (Link) Revitan (Zimmer) or Restoration Modular (Stryker). In 104 cases Extended Trochanteric Osteotomy (ETO) was performed. There occurred one intra-operative femoral fracture that required fixation. ETO was not performed in this case. In 12 cases (9.5%) there was subsidence of the stem observed on serial X-Rays. Subsidence varied from 3mm to 20mm (mean –

8mm, mode – 5mm). In one case the stem was revised as a result of subsidence. There were 2 cases of post operative dislocations – one recurrent that required revision of the acetabulum and one single dislocation that was managed conservatively. There was one recurrent infection in patient who had stage revision of THR due to infection. This patient required stem removal and girdlestone procedure as definitive treatment. In all surviving patients with stem in situ, complete osteo-integration occurred and there were no radiological signs to suggest aseptic loosening of the stem. No stem dissociation or breakage occurred. Survivorship of the uncemented modular fully porous coated femoral stem following revision hip arthroplasty in this series with 1 to 10 years follow up is 98.4% with re-operation for any reason as the end-point. Survivorship with end point being aseptic loosening is 99.2%

CONCLUSIONS: Uncemented modular fully porous coated femoral stem is reliable implant in revision surgery with good survivorship and excellent rate of osteo-integration even in presence of significant femoral deficiencies. When implanted with care it lead to excellent clinical results in short and medium term. Subsidence can occur but pre-operative planning as well as intra-operative judgment is important to avoid it.

H512 Outcome and Survivorship of Uncemented Acetabular Component in Revision Total Hip Arthroplasty

Primary Author: Peter Cnudde

Institution: Prince Philip Hospital, Llanelli, Wales

Coauthors: Konrad S. Wronka (Prince Philip Hospital, Llanelli, Wales)

INTRODUCTION: Uncemented acetabular component is commonly used in revision total hip arthroplasty. It is versatile, allows accurate positioning, use of various bearing surfaces and leads to satisfactory long term results.

OBJECTIVES: Aim of this study was to evaluate the outcome and survivorship of implant following uncemented acetabular component placement in revision hip arthroplasty in series of single surgeon.

METHODS: Retrospective Case Series of all patients who

had revision Total Hip Replacement surgery performed by senior author between 2003 and 2012, with clinical and radiological follow up between 1 and 10 years. Clinical notes and radiographs were reviewed by independent observer.

RESULTS: 168 revision Total Hip Replacement procedures were undertaken in 165 patients. 3 had bilateral operations during their life. All procedures were performed by posterior approach. In 142 cases uncemented, hemispherical cup was used. In 24 cases HA porous coated Trident (Stryker) prosthesis was used, in 118 cases Trabecular Metal Trilogy (Zimmer) implant was utilized. Acetabular defects varied from Paprosky type I to IIIB. In all cases multi-hole version of cup was used and secured using 2 to 4 screws. In 6 cases augments had to be used. In 5 cases constrained liner was used, in remaining patients either unconstrained ceramic or 10 degree elevated lip polyethylene liner was used. In all but 2 cases complete osteo-integration of the cup occurred. In one case the cup with unconstrained liner failed and displaced within first 6 months after surgery and required revision procedure. Larger diameter uncemented Trabecular Metal acetabular component was used. In other case, the cup that was fixed with 3 screws displaced immediately after surgery and had to be revised to larger diameter augmented TM cup held by 6 screws. 2 further patients had recurrent post operative dislocations of hip replacement and had cup re-revision to uncemented component with constrained liner. 22 patients died from causes unrelated to surgery. None of them developed complications of the acetabular component before death. In all 120 living patients the acetabular component does not show any sign of failure. There are no radiological signs to suggest aseptic loosening. Survivorship of the uncemented acetabular component following revision hip arthroplasty in this series with 1 to 10 years follow up is 97.1% with re-operation for any reason as the end-point. Survivorship with end point being aseptic loosening is 98.6%

CONCLUSIONS: Uncemented hemispheric acetabular component is reliable implant in revision surgery with excellent survivorship and rate of osteo-integration even in presence of significant acetabular deficiencies. When implanted with care and secured with at least 2 screws, one can expect excellent clinical results in short and medium term.

H513

Revision in Hip Resurfacing: How to Deal with it and How to Change the Results

Primary Author: Koen A. De Smet

Institution: Anca Clinic

Coauthors: Catherine Van Der Straeten (University Hospital Ghent)

INTRODUCTION: Ease of revision was one of the perceived advantages that lead to the increased use of Hip Resurfacing Arthroplasty (HRA). However, studies have shown an increased risk of re-revision following revision of HRA and poor outcome when adverse soft-tissue-reactions are present. The purpose of this study was to identify factors that improve outcome following revision of a failed HRA, including cases with soft-tissue-reactions.

METHODS: 162 HRA revisions performed by a single surgeon (2001-2013), were retrospectively reviewed. The most common cause of revision was cup-malpositioning (n=67) and the most common intra-operative finding was adverse-soft tissue-reaction/bursa (n=64). Harris-Hip-Score (HHS) was obtained pre-operatively and at latest follow-up (3years, 0.5-10). The initial experience of the first 42 cases (Initial Group) and second group 43-113 were previously reported (2008 and 2012). Ion levels were used as a diagnostic tool since 2006. Patients of the second group were noted to have less soft tissue damage and fewer complications. In the last group an increase was seen in revisions because of only high metal ions and general medical symptoms.

RESULTS: For the whole cohort (59% females, 41% males), HHS significantly improved post revision (93, 42-100) ($p < 0.001$). With time the Outcome {HHSpost-op ($p = 0.04$), complication and re-revision rates ($\alpha^2 = 0.005$)} was significantly better in the Later Group compared to the Initial groups. The incidence of complications (n=11)/re-revisions (n=9) significantly reduced since the introduction of routine metal ion level analysis ($\alpha^2 = 0.004$). The metal ion serum levels (n=119) had an average of 23,0 $\mu\text{g/l}$ Chromium, 24,2 $\mu\text{g/l}$ Cobalt, a mean of 8,7 (0,5-146,0) $\mu\text{g/l}$ Chromium, 6,0 (0,5-171,0) $\mu\text{g/l}$ Cobalt. For the whole cohort, the presence of a bursa did not significantly affect the outcome ($\alpha^2 = 0.65$). Since the use of a well-defined algorithm, the understanding of general toxic symptoms the right time for revision and better results are

found. An increase is seen in revisions for high metal ion levels only without clinical symptoms that lead to further investigations with MRI and a Cobalt toxicity questionnaire.

CONCLUSION: This study highlights the importance of surgical experience, use of metal ion levels, understanding of general toxicity and patient education/compliance as factors in improving outcome following HRA revision. Patients with soft tissue reactions can have good outcome if operated prior to extensive soft tissue destruction.

H514 The Improved Biax Hip System™

Primary Author: Ashok Desai

Institution: HOD Orthopedics Poona Hospital & Research Centre

INTRODUCTION: This implant is designed by me and machined by Engineer Mr. Ravindra Vartak in 2004. Later it gradually evolved to present design as 'The Improved Biax Hip System' in 2007. We have used this implant in 382 patients since then. Its patent is pending.

The implant is designed to overcome some pitfalls in conventional Sliding Hip Screw, like poor purchase in the bone, needs tapping, and inefficient compression mechanism. Single screw offers very little resistance to torsional loads. This in turn causes loosening of SHS, migration and cutout.

The present system deals with these issues and has yielded better results in our trials.

THE IMPLANT:

1. Sliding Screw: is conical with expanding profile. It is self-tapping. It has a 9mm cylindrical body. Its distal end has machine threads for compression and locking nuts.
2. Side plate: Has a tunnel for sliding screw and a hole for anti-rotation screw. The tunnel is at various angles from 120- 145 degrees with 5 degree increments. The plate is thickened to 10mm for the tunnels. It comes in 2 designs, one with a flange for lateral cortical support and other type allows medialisation.
3. Anti-rotation screw: is conical and expanding in profile. It is also self-tapping.
4. The Compression device: it consists of 'T' Shaped hexagonal screw driver, which is inserted through 'T' Shaped hollow hexagonal nut spanner.

agonal screw driver, which is inserted through 'T' Shaped hollow hexagonal nut spanner.

5. The Nuts: 9mm hexagonal nut for compression, other is for locking.



ADVANTAGES OF THE IMPROVED BIAx HIP SYSTEM:

- The compression achieved is 3 1/2 times more than the conventional SHS, thereby it gives stable fixation of # on day one.
- The purchase in the bone is far superior due to –
 - o Expanding conical profile of screws.
 - o Self-tapping ability
 - o Compaction of bone and preservation of bone stock
 - o The area of purchase is 3 1/2 time more than conventional SHS
- The resistance to torsional forces – The system resists torsional forces effectively due to fixation in Bi (2) axis with 2 screws inserted through tunneled plate.

It prevents bone destruction cancellous bone, thereby avoiding cutting out of the implant.

- Tip-apex distance – can be adjusted to optimum within 5mm. Our experience: We have included 382 cases of unstable trochanteric #s with 3-15 months follow ups. The mean time of union was 4months. There were no non-unions. We had one screw penetration, one breakage of implant in pathological # due to malignancy, 3 patients had superficial infection subsided with antibiotics.

CONCLUSION: The technique is simple and similar to conventional SHS. Only 2 additional instruments are required- compression device and jig for parallel screw. It gives excellent purchase in femoral head, it achieves stable anatomical fixation with good compression. If situation demands # can be fixed with medialisation plate. 'The Improved Biax Hip System' resists and counters sheer, bending and torsional forces effectively.

H515

Uncemented Bipolar Hip for a Cardiac Patient with Grade IV Trochanteric

Primary Author: Ashok Desai

Institution: Poona Hospital & Research Centre

A seventy year old man presented with history of fall in the bathroom. He had pain in the hip and inability to walk. He was ambulatory and he used to perform ADL independently. He was obese and diabetic on insulin. He also had ischemic heart disease. His activities were restricted due to pain in his left hip.

His X-ray of left hip revealed Grade IV intertrochanteric #. It also showed osteoarthritic changes and multiple loose bodies in the hip region.

After medical assessment, it was decided that since he needs early ambulation, therefore Uncemented Bipolar Arthroplasty was done under epidural anesthesia. Some loose bodies were free floating & some were embedded in the synovium. Loose bodies were removed and synovectomy was performed before implantation of hip. The greater trochanter was fixed with wires.

Five days later coronary angioplasty was performed with two stents. Patient was mobilized 3rd day after angioplasty

and patient was discharged after 10days.

At 3months follow up, he had no pain and was ambulatory with a walking stick.

DISCUSSION: In very old patients, grade IV trochanteric #s are treated with Hip Arthroplasty, for early ambulation. In present case, patient was only 70 years old; however he had osteoarthritis with synovial osteo-chondromatosis. He was obese and diabetic with ischemic heart disease, therefore A Bipolar Hip replacement was done with uncemented stem to avoid cardiac morbidity. Arthroplasty was done prior to angioplasty as post angioplasty patient would have needed anti-coagulants & blood thinner.

H516

Leg Length Discrepancy Following THA: Comparing Three Approaches

Primary Author: Benjamin G. Domb

Institution: Hinsdale Orthopaedics/American Hip Institute

Coauthors: Youssef F. El Bitar (American Hip Institute), Jennifer C. Stone (American Hip Institute), Timothy J. Jackson (American Hip Institute), Dror Lindner (American Hip Institute), Christine E. Stake (American Hip Institute)

BACKGROUND: Total hip arthroplasty (THA) has been proven to be successful in achieving adequate pain relief and favorable outcomes in patients suffering from hip osteoarthritis (OA). However, leg length discrepancy (LLD) is still a significant cause of morbidities such as nerve damage, low back pain and abnormal gait. Despite most of the reported values of LLD in the literature being within the acceptable threshold of.

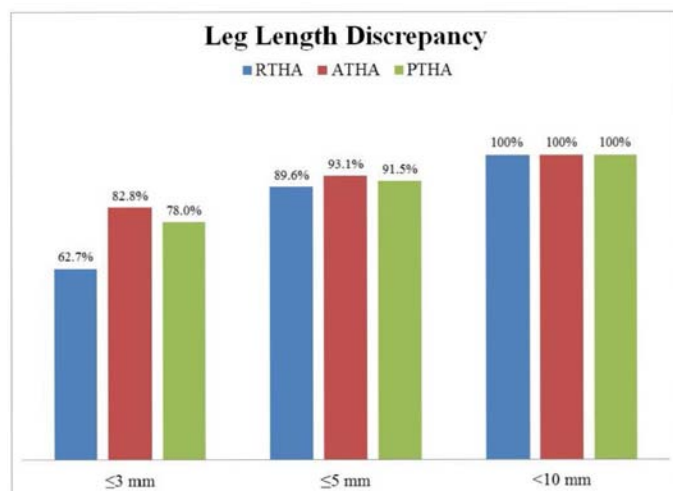
MATERIALS AND METHODS: All cases of RTHA, ATHA and PTHA that were performed by the senior surgeon between Sep 2008 and Dec 2012 were reviewed. Patients included in this study had a primary diagnosis of hip osteoarthritis, with available and proper post-operative antero-posterior pelvis radiographs. All radiographs were calibrated and measurements done twice by two blinded observers.

RESULTS: After exclusions, 67 RTHA cases, 29 ATHA cases and 59 PTHA cases were included in this study. There was a strong inter- and intra-observer correlation for

all LLD measurements ($r > 0.9$, $p < 0.001$ in all). Mean LLD in the RTHA, ATHA and PTHA groups was 2.7 ± 1.8 mm (CI95: 2.3, 3.2), 1.8 ± 1.6 mm (CI95: 1.2, 2.4) and 1.9 ± 1.6 mm (CI95: 1.5, 2.4) respectively ($p = 0.01$). When LLD > 3 mm was set as an outlier, the percentage of patients in the RTHA, ATHA and PTHA groups was 37.3%, 17.2% and 22% respectively (p value range, 0.06 - 0.78). When LLD > 5 mm was set as an outlier, the percentage of patients in the RTHA, ATHA and PTHA groups was 10.4%, 6.9% and 8.5% respectively (p value range, 0.72 - 1.0). None of the patients in all three groups had LLD ≥ 10 mm (Figure 1).

CONCLUSION: There was no difference between the robotic-assisted posterior-approach, the fluoroscopically-assisted anterior-approach and the conventional posterior-approach THA in achieving minimal LLD. All three techniques can be used effectively to achieve accuracy in LLD.

RESULTS: After exclusions, 67 RTHA cases, 29 ATHA cases and 59 PTHA cases were included in this study. There was a strong inter- and intra-observer correlation for all LLD measurements ($r > 0.9$, $p < 0.001$ in all). When LLD > 3 mm was set as an outlier, the percentage of patients in the RTHA, ATHA and PTHA groups was 37.3%, 17.2% and 22% respectively (p value range, 0.06 - 0.78). When LLD > 5 mm was set as an outlier, the percentage of patients in the RTHA, ATHA and PTHA groups was 10.4%, 6.9% and 8.5% respectively (p value range, 0.72 - 1.0). None of the patients in all three groups had LLD.



H517

Liposomal Bupivacaine Injection Versus Bupivacaine Injection Alone After a Total Hip Arthroplasty: A Comparative Cohort Study Using Prospectively Collected Data

Primary Author: Benjamin G. Domb

Institution: Hinsdale Orthopaedics/American Hip Institute

Coauthors: John Redmond (American Hip Institute), Asheesh Gupta (American Hip Institute), Christine E. Stake (American Hip institute), Kinzie G. Sharp (Hinsdale Orthopaedics)

BACKGROUND: Pre-operative and postoperative analgesia in total hip arthroplasty (THA) involves multimodal analgesia using differing classes of drugs and varying introductions of these agents. Postoperative opioid-related events can slow recovery and increase patients' length of stay. Long-acting local anesthetics can reduce early postoperative pain at the surgical site, potentiating a decrease in the amount of opioid intervention needed postoperatively. Decreasing opioid use while maintaining adequate pain control could potentially reduce opioid-related events, increase patient time to first ambulation and decrease length of stay. The study purpose was to compare liposomal bupivacaine to bupivacaine for postoperative analgesia.

METHODS: Between November 2012 and February 2013, 58 consecutive patients that underwent THA and hip resurfacing received either an intraoperative injection of liposomal bupivacaine or bupivacaine alone. All patients received a combination of medications prior to the procedure including celecoxib 400 mg by mouth, pregabalin 75 mg by mouth and 1gm of intravenous acetaminophen. The study group received 20 cc of liposomal bupivacaine, combined with 40 cc 0.25% bupivacaine with epinephrine and 20 cc of normal saline. The control group received 60 ml of 0.25% bupivacaine with epinephrine. Exclusion criteria included patients on chronic narcotics preoperatively. Data was prospectively collected including average visual analog pain scale (VAS), opioid consumption, time to first ambulation, hospital length of stay measured by days, and post-operative opioid-related adverse drug events.

RESULTS: During the study period 58 patients met the inclusion criteria. The study group included 28 consecutive patients who received liposomal bupivacaine and the control group included the previous 30 consecutive patients

who received bupivacaine alone. Both groups had average VAS scores of 2.8 during the first 24 hours after surgery and 3.3 during the time frame of 24 to 48 hours after surgery. The study group average morphine equivalent use during the first 24 hours after surgery was 31.7 mg, and the control group 53.4 mg (p 20 ft on the day of surgery, compared to the control group with four patients).

CONCLUSION: In our cohort study, administration of liposomal bupivacaine demonstrated decreased opioid consumption during the first 24 to 48 hours, while maintaining equivalent pain scores following THA. In addition, length of stay was decreased from 2.5 to 1.9 days with the use of liposomal bupivacaine. Compared to the control group, four times as many patients in the study group were able to ambulate.

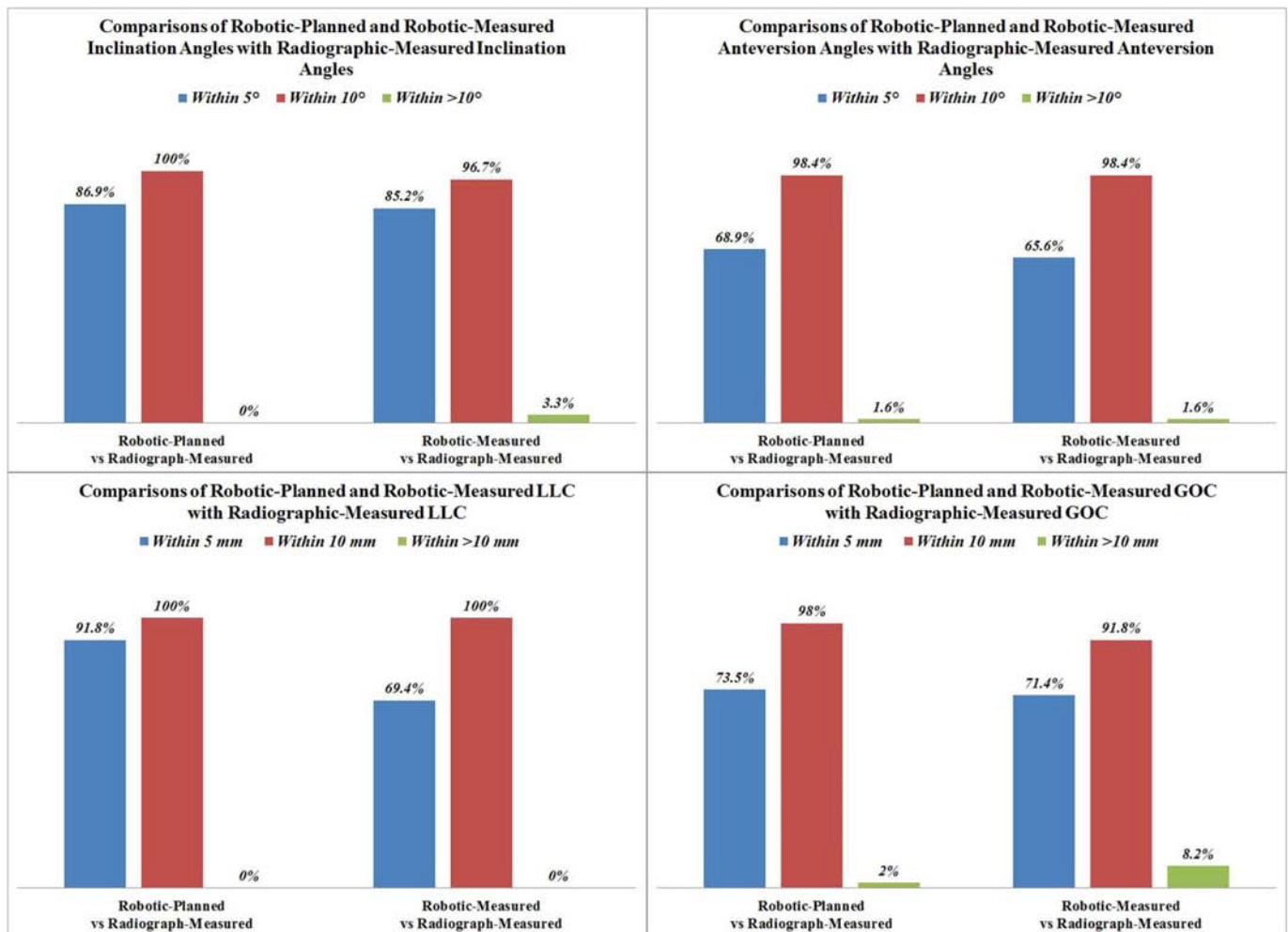
H518 Predictive Value of Robotic-Assisted Total Hip Arthroplasty

Primary Author: Benjamin G. Domb

Institution: Hinsdale Orthopaedics/American Hip Institute

Coauthors: Youssef F. El Bitar (American Hip Institute), Itamar B. Botser (American Hip Institute), Christine E. Stake (American Hip Institute), Dror Lindner (American Hip Institute), Timothy J. Jackson (American Hip Institute)

BACKGROUND: Acetabular cup positioning^{1, 2}, leg length discrepancy³ and global offset⁴ are important parameters associated with outcomes following total hip arthroplasty (THA). Deviation from an accepted range of values for each of these parameters can lead to significant complications including nerve injury, low back pain, abnormal gait, increased dislocation rate, and bearing surface wear. The primary purpose of this study was to assess whether the use of robotic-assisted THA is reliable in predicting post-operative radiographic measurements of cup



inclination, cup anteversion, leg length change, and global offset change in THA.

MATERIALS AND METHODS: All robotic-assisted THAs performed between June 2011 and Dec 2012 were reviewed. A single surgeon performed all cases through a mini-posterior approach. The intra-operative measurements of cup inclination and anteversion angles, leg length change, and global offset change recorded by the robotic system were compared to the post-operative radiographic measurements.

RESULTS: Sixty one cases met the inclusion and exclusion criteria. A strong inter- and intra-observer correlation was found for the radiographic measurements of cup inclination, cup anteversion, leg length discrepancy and global offset ($r > 0.8$ with $p < 0.001$ for all). Comparison between the robotic and the radiographic measurements showed mean differences in inclination of $3.2^\circ \pm 2.7^\circ$ (CI95 = 0.7), mean differences in anteversion of $3.8^\circ \pm 2.6^\circ$ (CI95 = 0.7), mean differences in leg length change of 3.5 ± 2.6 mm (CI95 = 0.7), and mean differences in global offset change of 4.5 ± 3.7 mm (CI95 = 1.0). 85.2% of robotic-measured inclination angles were within 5° of radiographic measurements, and 96.7% within 10° . 65.6% of robotic-measured anteversion angles were within 5° of radiographic measurements, and 98.4% within 10° (Figure 1). 69.4% of robotic-measured leg length change measurements were within 5 mm of radiographic measurements, and 100% within 10 mm. 71.4% of robotic-measured global offset change measurements were within 5 mm of radiographic measurements, and 91.8% within 10 mm (Figure 1).

CONCLUSION: The robotic hip system showed good predictive value for cup inclination and anteversion angles, leg length change and femoral offset change measurements done post-operatively on plain radiographs. Further refinement of the robotic system would be expected to make it more accurate in predicting the post-operative parameters mentioned.

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H519

Comparisons Of Proximal Femoral 3D Morphology Between Chinese and Caucasian Populations

Primary Author: Nick Dong

Institution: Stryker

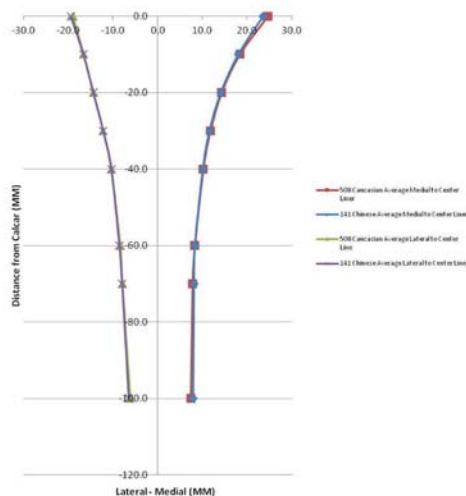
Coauthors: Tracy Rickels (Stryker), Adam Bastian (Stryker), Aiguo Wang (Stryker), Yixin Zhou (Department of Orthopaedics, JST Hospital, Beijing, China), Xianlong Zhang (Department of Orthopaedics, No. 6 People's Hospital, Shanghai, China)

OBJECTIVE: The purpose of this study was to compare the proximal femoral morphology between normal Chinese and Caucasian populations by 3D analysis derived from CT data.

MATERIALS AND METHODS: 141 anonymous Chinese femoral CT scans (71 male and 70 female) with mean age of 60.1years (20/93) and 508 anonymous Caucasian left femoral CT scans (with mean age of 64.8years (20/93). The CT scans were segmented and converted to virtual bones using custom CT analytical software. (SOMATM V.4.0) Femoral Head Offset (FHO) and Femoral Head Position (FHP) were measured from head center to proximal canal central axis and to calcar or 20mm above Lesser Trochanter (LT) respectively. The Femoral neck Anteversion (FA) and Caput-Collum-Diaphyseal (CCD) angles were also measured. The Medial Lateral Widths (MLWn) of femoral canal were measured at 0, -10, LT, -30, -40, -60, -70 and -100mm levels from calcar. Anterior Posterior Widths (APWn) were measured at 0, -60 and -100mm levels. The Flare Index (FI) was derived from the ratio of widths at 0 and -60mm. All measurements were performed in same settings for both populations. The comparison was analyzed by Student T test.

RESULTS: The average FHO and FHP of Chinese were 38.4mm and 25.2mm and were both shorter than 42.1mm and 29.7mm of Caucasian's, $P=2.3E-15$ and $P=1.7E-10$. CCD angle was 130.3° comparing to 127.7° of Caucasian $P=1.5E-05$. Chinese FA angle was 15.6° and Caucasian's was 14.7° , $P=0.31$. The average MLW1-8 were 43.1, 34.6, 28.5, 23.8, 20.6, 17, 16.2 and 14.4mm for Chinese and 43.7, 35.0, 28.7, 24.0, 20.6, 16.7, 15.7 and 13.5mm for Caucasian. $P=9.4E-02$, .32, .47, .50, .93, .20, .02 and $1.7E-05$ respectively. The average APW1-3 were 35.9, 15.5 and 13.7mm for Chinese and 43.7, 15.2 and 12.5mm for Caucasian. $P=4E-62$, 0.11 and $7.4E-10$. The total medial/lateral and medial/center FI were 2.5 and 2.8 for Chinese, 2.6 and 2.9 for Caucasian. $P=.004$ and $4.5E-06$. The total anterior/posterior and anterior/center FI were 2.3 and 2.6 for Chinese, 2.9 and 2.5 for Caucasian. $P=5.3E-61$ and $8.5E-04$.

Figure 2. Average Canal M-L Width As A Function of Distance From Calcar



CONCLUSION: Chinese had significantly lower FHO, FHP, APW-calcar, FI-medial, M-L and FIA-P; significantly higher CCD angle and MLWisthmus, APWisthmus and FI-anterior than that of Caucasian population. There were no significant differences in FA and MLW from 10mm above to 50mm below LT. The average reduction of 3.7mm in FHO and 4.5mm in FHP for Chinese suggests a necessary adjustment of femoral implant neck length designed for Caucasian population.

H520

Gender Differences for Combined Acetabular And Femoral Anteversion Angles

Primary Author: Nick Dong

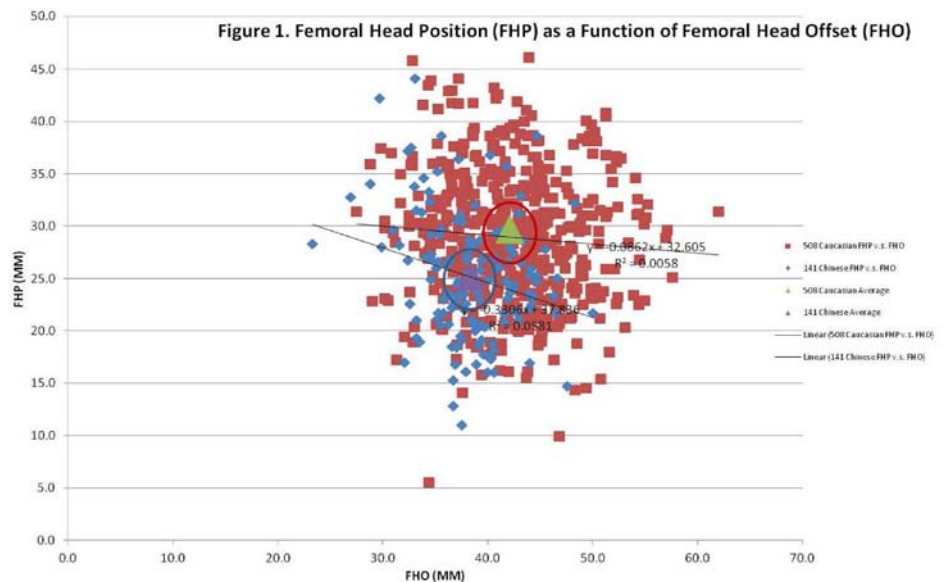
Institution: Stryker

Coauthors: Jim Nevelos (Stryker), Stefen Kreuzer (University of Texas, Medical School)

INTRODUCTION: Combined Anteversion (CA) angle of acetabular component and femoral neck is an important parameter for a successful Total Hip Arthroplasty (THA). The purpose of this study was to electronically measure the version angles of native acetabulum and femur in matured normal Caucasian population from large 3D CT data base. Our question was if there was any significant difference in CA between male and female population.

METHODS: 221 anonymous (134 males and 87 females) CT paired pelvic and femoral scans from normal Caucasian population with age range of 30-93 years old were analyzed. CT data was converted to virtual bones using custom CT analytical software1(SOMATM V.3.2). Acetabular Anatomical Anteversion (AA) angle as defined by Murray2 was selected. The acetabular rim plane was constructed by selecting 3 bony land marks from pubis, ilium and ischium. The AA was measured against pelvic frontal plane. Femoral neck Anteversion (FA) was measured between neck axis plane and the Coronal plane which was defined by posterior condyles. The neck axis plane was defined as being the plane passing through femoral neck axis and being perpendicular to the transverse plane which is defined

Figure 1. Femoral Head Position (FHP) as a Function of Femoral Head Offset (FHO)



by distal femoral condyles. The CA angle in standing position was computed as the summation of AA and FNA angles. All the measurements were performed for total, male and female populations. Student's t tests were performed to compare gender difference with an assumed 95% confidence level. The relationship between AA and FA for each gender was studied by the plot of AA and a function of FA.

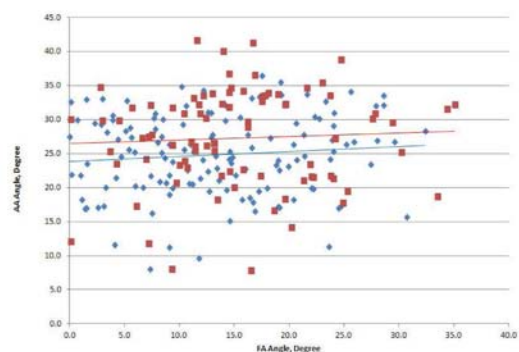


Figure 1. AA as a function of FA (N male=135, N female=86)

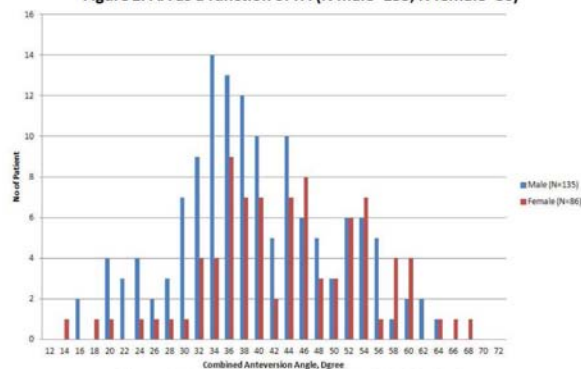


Figure 2. Frequency distribution of CA N=221

RESULTS: The mean AA angle for total population was 25.8° , $SD=6.52^\circ$. (male 24.8° , $SD=5.91^\circ$, female was 27.3° , $SD=7.12^\circ$. $P=0.006$). The mean FA angle for total population was 14.3° , $SD=7.95^\circ$. (male 13.4° , $SD=7.99^\circ$, female 15.6° , $SD=7.76^\circ$. $P=0.051$). The mean CA angle for total population was 40.1° , $SD=10.76^\circ$. (male 38.2° $SD=10.38^\circ$, female 42.9° $SD=10.79^\circ$. $P=.0002$). The plot of AA as a function FA is shown in Figure 1. The frequency distribution of CA angle is plotted for males and females. In Figure 2.

DISCUSSION/CONCLUSION: The results showed both AA and CA angles were significantly smaller in the male than that in female. However there was no significant difference in FA between male and female. The plot of AA as a function of FA showed no correlation ($R^2<.09$) between the two angles for both male ($R^2=.0097$) and female ($R^2=.0029$). The FA angle of a femoral stem implant in THA may be smaller than that of natural femur, therefore a

higher AA or higher posterior build up may be required for the acetabular component to achieve optimal function of a THA. This may be a more significant issue in female population. The limitations of this study was that this population did not have pathological conditions which could lead to THA. However, it should provide reference guidance comparing normal anatomy between male and female.²

H521

Digital Image Correlation Predicts Cadaveric Proximal Femoral Fractures in a Sideways Fall on the Hip Configuration

Primary Author: Dan Dragomir-Daescu

Institution: Mayo Clinic

Coauthors: Vinod Kushvaha (Mayo Clinic), Samad Javid (Mayo Clinic), Tim Rossman (Mayo Clinic), Hugo Giam-bini (Mayo Clinic)

Hip fracture in the elderly resulting from a fall has become one of the most serious health problems among the osteoporotic patient population. Treatment of osteoporotic fractures costs over 20 billion dollars per year in both the United States and the European Union. Existing clinical methods for estimating fracture risk in patients such as dual-energy x-ray absorptiometry are only up to 70% accurate, therefore, it is essential to better understand bone mechanical properties, including fracture strength, to improve our understanding of this difficult healthcare problem. Analytical and numerical methods accounting for three-dimensional geometry and heterogeneous material property distribution, such as quantitative computed tomography-based finite element analysis (QCT/FEA), have become a common approach for researchers trying to better estimate the mechanical response of bone to impact loading. However, for future clinical implementations, the accuracy of QCT/FEA models needs to be validated experimentally.

As a means to validate upcoming computer models we used Digital Image Correlation (DIC) to analyze experimental fractures of proximal femora in a simulated sideways fall on the hip. Thus, the aim of our study was to test the validity of DIC in predicting fracture locations, independently of bone mineral density, from the strain distributions calculated from bone deformation measurements. Seventeen human cadaveric femora (six with normal bone mineral density, six osteopenic, and five osteoporotic)

were fractured in a fall on the hip configuration using an MTS Mini Bionix system. The femora were tested in four positions, resulting from combinations of two internal adduction and two shaft angles, at a speed of 700 mm/s. The fracture experiments were recorded from the anterior and posterior sides using two high-speed video cameras and DIC was used to obtain full field surface strain distributions from the high speed video recordings, including at the fracture locations (Fig.1).

Regions of large von Mises strains correlated very well with locations of damage initiation and fracture patterns for 16 out of 17 femora. DIC predicted an increase in strains leading to fracture even before visual failure could be observed. In addition, DIC allowed us to track strain over time on the femoral surface and to distinguish between areas undergoing large and small dynamic deformations (Fig. 2).

In conclusion, this work is the first to implement the use of DIC to analyze and predict cadaveric femoral fractures in a fall on the hip configuration, with bone mineral density uniformly covering the range from osteoporotic to normal. Fracture locations were correctly predicted by von Mises strains estimated from DIC irrespective of bone mineral density or femoral orientation during testing. The measured local full field strains will help validate QCT/FEA models of femoral strength in patients at risk of osteoporotic fracture, and will provide a greater insight on how bone tissue fractures due to the impact forces occurring during a sideways fall. In addition, these results will add to a better understanding of complex compressive and bending loading leading to femoral fracture which will further improve fracture risk prediction.

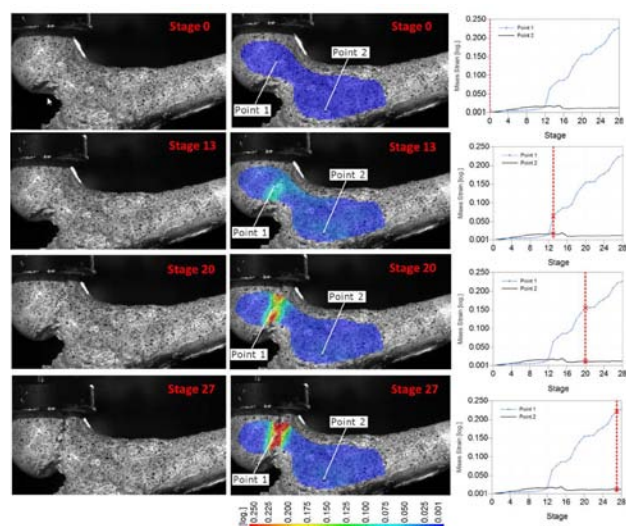


Figure 2. Time sequence of osteoporotic fracture using DIC-estimated von Mises strains

H522

Long-term Patient Outcomes Following Implantation of Modular Neck Hip Prostheses in Primary THA

Primary Author: Aidin Eslam Pour

Institution: University of Michigan

Coauthors: Takayuki Murayama (University of Michigan), Robert Borden (University of Michigan), J. David Blaha (University of Michigan)

INTRODUCTION: Total hip arthroplasty remains one of the most popular and successful orthopaedic procedures to date. Optimizing implant size and dimensions is critical to ensuring long-term success of the operation. To this end, modular femoral neck junctions were used to allow for intra-operative sizing of various implant dimensions during primary and revision THA. While this design feature offers several advantages to the surgeon, the failure of modular necks must be assessed to ensure that their use does not compromise implant longevity. This study investigates the causes of failure in implants featuring one modular neck junction.

MATERIAL AND METHODS: We included 275 patients (124 male and 151 female) with ‘Profemur E’ and ‘Profemur Z’ femoral stems manufactured by Wright Medical. This population included primary, unilateral and bilateral cases, as well as metal-on-metal, metal-on-polyethylene and ceramic-on-ceramic bearing surfaces. Correlation of various implant dimensions with failure rate was analyzed to estimate the survival function for select implant variables. Implant failure was defined as cases requiring revision surgery.

RESULTS: The average follow up time was 49 months (range 0.13-126 months). In 65% of the patients a metal on metal bearing surface was used. Profemur E was the most commonly used stem (62%) followed by Profemur Z (38%). The rate of revision surgery was 19.3%. The most common reason for aseptic revision was femoral stem loosening (5.5%) followed by modular neck fracture (2.5%), acetabular implant loosening (2.5%), metallosis (1.5%) and periprosthetic fracture (1.5%). The rate of revision for any reason was higher among those patients with metal on metal bearing surface (21.8% in MoM, 14.6% in non-MoM) but no significant difference was found ($p=0.149$). The rate of stem loosening was significantly higher among

Profemur E stems (8.8% versus 0%, $p=0.002$) but the rate of modular neck fracture was significantly higher among Profemur Z patients (5.7% versus 0.6% in Profemur E, $p=0.009$). The revision rate for modular neck fracture was significantly higher among the long neck (0% in short neck versus 15% in long neck, $p<0.001$). The revision rate for modular neck fracture was slightly correlated with greater offset and larger head diameter ($\eta=0.31$, 0.22, respectively).

CONCLUSIONS: These data suggest that failure of modular neck junctions may be potentiated by long neck lengths, greater offset and larger head diameters. It is suspected that these factors contribute to modular neck failure by creating a stronger moment arm about the neck's insertion into the stem. These data may help identify a set of patient dimensions that contraindicate the use of modular neck junctions.

H523

Gait Analysis of Pathological Inclination of the Trunk and Pelvis in Patients with Hip Osteoarthritis

Primary Author: Shuichi Eto

Institution: Saga University

Coauthors: Shunsuke Kawano (Saga University), Takayuki Akiyama (Saga University), Masatsugu Tsukamoto (Saga University), Masaya Ueno (Saga University), Masaru Kitajima (Saga University), Motoki Sonohata (Saga University)

INTRODUCTION: Abnormal gait pattern in the frontal plane (i.e. Duchenne gait and Trendelenburg gait) is often seen in patients with hip osteoarthritis and can cause several disorders. The aim of this study was to quantify the compensatory movements of the trunk and pelvis in the frontal and sagittal planes during the gait in patients with hip osteoarthritis, by using a three-dimensional(3D) gait analysis.

METHODS: Twenty patients with severe unilateral hip osteoarthritis scheduled for total hip arthroplasty (THA) were included in this study. Twelve healthy subjects were recruited as the control group. All subjects underwent 3D gait analysis before and 1 year after surgery. The range of motion (ROM) and absolute mean inclination (MI) of the

trunk and pelvis in the frontal and sagittal planes were calculated. The MI of trunk and pelvis in frontal and sagittal plane were compared before and after surgery, and the ROM of the trunk and pelvis were compared to that in healthy subjects.

RESULTS: Before THA, the MI of the trunk and pelvis leaned to the affected side in the frontal plane and the MI of the pelvis was retroverted in the sagittal plane. There was a significant difference compared to the MI of the pelvis in the frontal plane (p In the frontal plane, the ROM of the trunk significantly decreased and the pelvic ROM significantly increased. In the sagittal plane, the ROM of the pelvis decreased significantly. When comparing the post-THA data to that of healthy subjects, no significant differences in the ROM of the trunk and pelvis in the frontal plane were found, although the ROM of the pelvis in the sagittal plane still showed a significant difference.

Table 1 Mean inclination of the trunk and pelvis in the frontal and sagittal planes

	Preoperation mean \pm SD	1 year after operation mean \pm SD	P-value
Trunk	2.9 \pm 3.5°	1.9 \pm 2.3°	0.110
Pelvis (frontal)	1.5 \pm 4.3°	-0.6 \pm 1.7°	0.037
Pelvis (sagittal)	4.1 \pm 8.7°	7.3 \pm 5.3°	0.090

Table 2 Range of motion of the trunk and pelvis in the frontal and sagittal planes

	Preoperation mean \pm SD	1 year after operation mean \pm SD	Cont. mean \pm SD	P-value*
Trunk	6.4 \pm 2.9°	4.0 \pm 2.0°**	3.2 \pm 0.7°	0.143
Pelvis (frontal)	4.7 \pm 2.0°	6.4 \pm 1.8°**	7.9 \pm 2.6°	0.077
Pelvis (sagittal)	9.5 \pm 3.7°	5.6 \pm 1.8°**	3.8 \pm 1.1°	0.004

* P-value vs 1 year after operation and Cont.

** $P<0.05$ vs Preoperation and 1 year after operation

DISCUSSION: The Trendelenburg gait, which is a compensatory movement caused by pain, loss of muscle strength, leg length discrepancy, and restricted ROM, is often seen in patients with hip osteoarthritis. Loss of muscle strength takes a long time to improve, although pain, leg length discrepancy, and restricted ROM improve after THA. At 1 year after THA, the ROM of the trunk and pelvis in the frontal plane is equal to that in healthy subjects, because the pain reduces and the affected hip can take the normal abducent position. However, with respect to loss of strength in the flexor and extensor muscles, the ROM of the pelvis in the sagittal plane is more than that in healthy subjects.

CONCLUSION: The Trendelenburg gait, which is seen in patients with osteoarthritis, can be improved by performing THA, but it does not normalize the gait completely. Long-term observation is needed to improve loss of muscle strength.

H524

The Influence of Surgical Approaches on the Frequency of Venous Thromboembolism After Primary Total Hip Replacements

Primary Author: Yoshinari Fujita

Institution: Dept. of Orthopaedic Surgery, National Tokyo Medical Center

Coauthors: Tetsugen Chou (Dept. of Orthopaedic Surgery, National Tokyo Medical Center), Yasuhiro Endo (Dept. of Orthopaedic Surgery, National Tokyo Medical Center), Kentarou Haraya (Dept. of Orthopaedic Surgery, National Tokyo Medical Center), Takanori Kameda (Dept. of Orthopaedic Surgery, National Tokyo Medical Center)

INTRODUCTION: Venous thromboembolism (VTE) is one of the common complications after total hip replacements (THRs). To reduce the risk of VTE, early rising, active movement of the ankle, the use of a foot pump or graduated compression stockings and prophylactic administration of anticoagulant drugs are important. Further, intraoperative factors should be taken into consideration.

OBJECTIVE: The objective of this study is to assess the influence of surgical approaches, which are a modified Watson-Jones approach and a posterolateral approach, on the frequency of VTE after primary THRs.

MATERIALS AND METHODS: One hundred seventy-five patients underwent 199 primary total hip replacements by a single surgeon using modified Watson-Jones approach between gluteus medius muscle and tensor fascia lata (AL Group). The average age at the operation was 63.4 ± 12.5 years old. The average BMI was 23.6 ± 3.6 . The original diagnosis consisted of 151 cases of osteoarthritis of the hip, 34 cases of avascular necrosis of the femoral head, 7 cases of rheumatoid arthritis and two cases of rapidly destructive coxopathies. Control group was 159 primary total hip replacements by a single surgeon using posterolateral approach (PL Group). The average age at the operation was 63.0 ± 11.3 years old. The average BMI was

22.8 ± 3.6 . The original diagnosis consisted of 130 cases of osteoarthritis of the hip, 17 cases of avascular necrosis of the femoral head, 7 cases of rheumatoid arthritis and four cases of rapidly destructive coxopathies. VTE was detected by either contrast computed tomography or ultrasound, and soluble fibrin monomer complex (SF) was measured on the first day after surgery.

RESULTS: The frequency of VTE was thirty three of 199 cases (16.6%) in the AL Group. On the other hand, the frequency of VTE was sixty three of 159 cases (39.6%) in the PL Group. The average value of SF on the first day after surgery was 16.1 ± 28.1 in the AL Group, 15.4 ± 20.6 in the PL Group, respectively. In each group, the SF values showed a significant difference between VTE detected cases (41.7 ± 55.3 in the AL Group; 24.2 ± 26.4 in the PL Group) and VTE non-detected ones (10.9 ± 13.6 in the AL Group; 9.4 ± 12.4 in the PL Group) by Mann-Whitney U test.

CONCLUSION: The risk of VTE after THRs was reduced in the AL Group, compared with the PL Group. The foot position during THRs by posterolateral approach may obstruct venous perfusion, which may be the risk factor for VTE.

H525

Accuracy of Acetabular Cup Position Using a New Acetabular Reaming Guide in Total Hip Arthroplasty

Primary Author: Atsushi Funayama

Institution: Saiseikai Yokohama-city Tobu Hospital

Coauthors: Shinsuke Fukuda (Saiseikai Yokohama-city Tobu Hospital), Yuuki Takeda (Saiseikai Yokohama-city Tobu Hospital), Kenji Yamaguchi (Saiseikai Utsunomiya Hospital), Kentaro Takeda (Saitama City Hospital), Syunichi Kawasaki (Ashikaga Redcross Hospital)

INTRODUCTION: The goal of total hip arthroplasty (THA) should be to reconstruct the acetabulum by positioning the hip center as close as possible to the anatomical hip center. However, the true position of the anatomic hip center can be difficult to determine during surgery on an individual basis. In 2005, we designed, produced an acetabular reaming guide, and clinically used to enable cup placement in the ideal anatomical position. This study was

examined the accuracy the reaming guide for THA in prospective study.

METHODS: This guide was applied consecutive 230 patients in primary THA. During planning, the distance from the acetabular edge to the reaming center and from the center to the perpendicular of the inter-teardrop line was measured on an anteroposterior (AP) X-ray. The reaming guide was adjusted depend on the reaming center by based planning. Acetabular reaming was performed with the process reamer.

RESULTS: At planning, the position of the hip center was 18.1mm in the vertical offset (VO) and 29.6mm in the horizontal offset (HO). After surgery, the position of the hip center had a VO of 18.1mm and an HO of 29.9mm. The absolute error between planning and post-operation was a VO of 2.7 mm and an HO of 2.9 mm. Overall, 199 cases (86.5%) had an HO error of less than 5 mm and 204 cases (89.6%) had a VO error of less than 5 mm. The vertical height from the teardrop line to the inferior edge of the acetabular cup was 0.5 ± 3.5 mm.

CONCLUSION: The new reaming guide was closely reproduced the preoperative planning position in this prospective study. Our original acetabular reaming guide is a very useful tool for performing reaming during THA and for ensuring accurate cup placement at the anatomical hip center.

H526

Mini-incision Total Hip Arthroplasty by Modified Watson-Jones Approach Using New Double Offset Broach Handle and Partial Femoral Reamer

Primary Author: Atsushi Funayama

Institution: Saiseikei Yokohama-city Tobu Hospital

Coauthors: Shinsuke Fukuda (Saiseikei Yokohama-city Tobu Hospital), Yuuki Takeda (Saiseikei Yokohama-city Tobu Hospital), Kenji Yamaguchi (Saiseikei Utsunomiya Hospital), Kentaro Takeda (Saitama-city Hospital), Syunichi Kawasaki (Ashikaga Redcross Hospital)

INTRODUCTION: Recently total hip arthroplasty (THA) was performed by mini incision technique. Many surgical approaches were reported in the world. We designed and

produced the new double offset broach handle and short partial femoral reamer to reduce the complication during and after surgery at 2nd series in this study.

The purpose of study was to examine the short term results for mini-incision modified Watson-Jones approach.

METHODS: Mini-incision, muscle sparing, anterolateral modified Watson-Jones approach for THA were performed 225 osteoarthritis patients according to the group I and group II by the Crowe classification between April 2006 and March 2011. 33 patients were male and 192 patients were female. Average age at operation was 64 years old and average body mass index was 23.3. About Surgical time, total blood loss, acetabular cup position angle of anteversion and inclination, complication during surgery and after operation were examined at the compared the first 75 patients (1st series) with the last 150 patients (2nd series).

RESULTS: At 1st series, operative time averaged 106 minutes (range 75-155 minutes), blood loss was 693ml, average cup anteversion was 19.8° , and inclination was 44.3° . There were six complications, including one deep infection, three intraoperative proximal femoral fractures, three postoperative greater trochanter fractures. At recent 2nd series, operative time averaged 81 minutes (range 47-150 minutes), blood loss was 535ml, average cup anteversion was 15.9° , and inclination was 41.8° . There were only two complications, including one deep infection and one intraoperative calcar fracture. No patients sustained hip dislocation and pulmonary infarction.

DISCUSSION AND CONCLUSION: Mini-incision modified Watson-Jones approach was widely-spread for minimal invasive total hip arthroplasty. But recently some surgical errors and complications after operation were reported. At our experience five complications except for deep infection were occurred at 1st series because of surgical errors, but at 2nd series, surgical errors were mostly reduced to learn safety and correct surgical skills. At that time, we designed new double offset, high offset broach handle and short partial femoral reamer. These surgical instruments were provided helpfully and safety operation for mini incision modified Watson-Jones approach.

H527**Validation of the Software ACX Dynamics to Evaluate the Acetabular Coverage Using a Pelvic Radiograph**

Primary Author: Hiroki Furuhashi

Institution: Department of Orthopaedic Surgery Hamamatsu University School of Medicine

Coauthors: Hiroshi Koyama (Department of Orthopaedic Surgery Hamamatsu University School of Medicine), Mitsuru Hanada (Department of Orthopaedic Surgery Hamamatsu University School of Medicine), Hironobu Hoshino (Department of Orthopaedic Surgery Hamamatsu University School of Medicine), Yukihiro Matsuyama (Department of Orthopaedic Surgery Hamamatsu University School of Medicine), Seiji Yamamoto (Department of Orthopaedic Surgery Hamamatsu University School of Medicine)

BACKGROUND: In 1990, software named “ACX” was developed by Konishi to perform 3D analysis of hip joint morphology with a 2D anterior-posterior pelvic radiograph using a geometrical calculation. The analysis using ACX is performed by marking the edges of the acetabular edges with the assumption of the femoral head shaped as a sphere. ACX analyses acetabular coverage (AC) as a projection view of the cranio-caudal direction. However, since ACX was software developed approximately 20 years ago it requires a digitizer for the analysis. Therefore we redeveloped the software “ACX dynamics” to enable analysis on PC.

PURPOSE: To validate the accuracy of the AC using newly developed software “ACX dynamics” with the comparison of Computed tomography (CT) images.

MATERIALS AND METHODS: Ninety eight hips consisting of 72 patients (17 men, 55 women, average age 53 years old) who underwent CT imaging for their treatment were included in this study. Hips with severe degenerative change and deformity of femoral head were excluded from this study. Digital reconstruction radiography images (DRR images) of coronal plane in anterior pelvic plane were produced from CT images using total hip arthroplasty preoperative planning software (Zed Hip; LEXI Corp, Ltd, Tokyo, Japan). The DRR images were used in substitute of the AP pelvic radiographs. Then the DRR images were analysed using ACX dynamics to calculate AC (AC-ACX). The AC of the entire acetabulum, anterior 1/2

acetabulum and the posterior 1/2 acetabulum were measured and compared with AC from the 3D-CT(AC-CT).

RESULTS: The average AC-ACX for the entire acetabulum was 76%, 69% for the anterior 1/2 and 84% for posterior 1/2. The average AC-CT was 75% for the entire acetabulum, 73% for the anterior 1/2 and 78% for the posterior 1/2. The comparison between the ACX and CT-AC revealed that AC-ACX was smaller than AC-CT in the anterior 1/2, and was greater than AC-CT in the posterior 1/2 ($p < 0.05$). The correlation between the AC-ACX and AC-CT were $r = 0.91$ ($p < 0.01$) for the entire acetabulum, $r = 0.79$ ($p < 0.01$) for the anterior and $r = 0.91$ ($p < 0.01$) for the posterior 1/2.

CONCLUSION: AC-ACX measured by our newly developed software ACX dynamics showed high correlation with the AC-CT. We conclude that measurement of the acetabular coverage calculated by ACX dynamics is useful for the clinical settings.

H528**Three-Dimensional Metaphyseal Fit Analysis of Anatomic Stems**

Primary Author: Justin Gerges

Institution: Stryker Orthopaedics

Coauthors: Viktor Krebs (Cleveland Clinic), Anthony Hedley (Arizona Institute for Bone & Joint Disorders), Kirby Hitt (Scott & White Memorial Hospital)

INTRODUCTION: For 30 years, uncemented anatomic hip stems have been implanted with documented clinical results[1,2]. Their geometry can be linked back to the geometry of the PCA and ABG stems. Modifications to date include stem length, body geometry, material, and reduction in distal geometry. New tools have been developed allowing anatomical measurements and analysis of three-dimensional digital femora geometry through CT scans[3]. The purpose of this study is to analyze three-dimensional contact of various anatomic hip stem designs using this technique.

METHODS: Six femora (57-87yrs, 72-88kg), were selected from a CT scan database (SOMA™) of 604 Caucasian bones. They were selected based on femoral anteversion (average ± 1.5 times std.dev.) with three

measuring[4] 8-10° and three 31-33° of anteversion. The CT scans were segmented into cancellous/cortical bone and converted into CAD models in PRO/Engineer Wildfire(v.5). A/P views of the bones were scaled to a 120% magnification to allow three surgeons to surgically template and choose the stem size and location (maximizing fill(n=1); restoring the head center(n=2)) with two implant designs (1-Citation TMZF and 2-ABG II Monolithic, Stryker Orthopaedics, Mahwah). Measurements from templating were used to virtually implant CAD models of the implants into the bones (n=36 bone/stem assemblies). The assemblies were imported into Geomagic Qualify 2012 for 3D deviation analysis comparing the coated region of the implant to the cortical-cancellous boundary. The analysis generated color map profiles based on the following categories: Contact(-2.0 to 0.5mm), Conformity(0.5 to 2.0mm), Proximity(2.0 to 5.0mm), and Gap(5.0 to 12mm) and the percent of the surface that was within each of these categories. These results were compared for patterns within and across the anatomic families.

Stem	Category	Restoring Head Center			Maximizing Fill
		Average for Surgeons 1 and 2	Surgeon 1	Surgeon 2	Surgeon 3
Design 2	GAP	56.5	55.2	57.7	45.8
	PROXIMITY	27.4	27.8	26.9	28.6
	CONFORMITY	9.3	9.6	8.9	20.0
	CONTACT	1.2	1.2	1.1	2.7
Design 1	GAP	60.6	58.8	62.4	48.2
	PROXIMITY	23.5	24.6	22.3	40.9
	CONFORMITY	8.2	7.8	4.7	7.7
	CONTACT	0.8	0.7	0.8	1.5

Table 1: Average percentage of distances from the cortical bone boundary in each category by method and surgeon

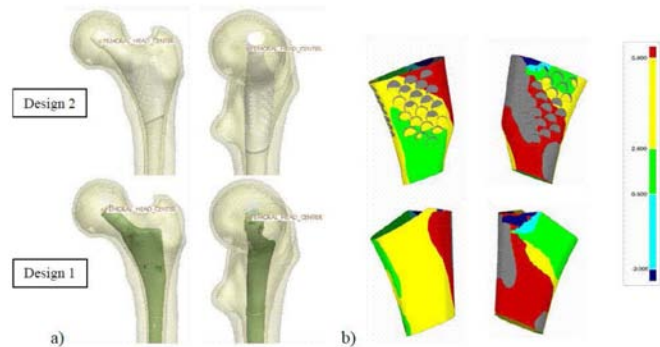


Figure 1: a) Virtual 3D implantations of Design 1 and Design 2 in bone. b) Color map profiles of metaphyseal regions of Design 1 and Design 2 stems, with the color scale.

RESULTS: Similar patterns of fit were observed within and across both families. The same size implants were not always used together across both systems. The strongest commonality was found regarding the percentage of the implant adjacent to more than 5mm of cancellous bone (Gap, shown in red in Figure.1b) and the pattern of contact on the medial curvature of the implants. On average 61% and 56% of the metaphyseal region of Implants 1 and 2,

respectively, is adjacent to 5-12mm of cancellous bone between the implant and cortical bone. Implants 1 and 2 also demonstrated 30% and 37% between 0.5 and 5mm of cancellous bone to the cortical boundary. Contact (< .5mm) was only achieved in areas where bone would have been removed through femoral preparation. When maximizing fill, it was found that the percent Gap was reduced and distributed between conformity and proximity. There was also less variability between both systems when the goal was to maximize fill, however there was no statistical difference given the sample size between both stems regardless of method.

DISCUSSION: Proper load transfer is essential for positive bone remodeling for short/long term fixation. As anatomic stems load femurs circumferentially, it is important to note that common characteristics transfer load to bone potentially contributing to their success. Previously, technology has not permitted circumferential analysis of implant fit on a wide scale, reproducible basis.

H529
Releasing Short External Rotators During Primary THA: The Effect on Remaining Muscles to Maintain Normal Activity

Primary Author: Said Gomaa
Institution: DePuy Synthes Joint Reconstruction

Coauthor: Daniel N. Huff (DePuy Synthes Joint Reconstruction)

INTRODUCTION: The anterior approach to Total Hip Arthroplasty (THA) is one technique by which the acetabular and femoral articulating surfaces are replaced by prostheses, replacing a diseased joint. One advantage of the anterior approach is that it can enable retention of all muscle attachment points, whereas the posterior hip approach requires that certain tendon attachments be released. Specifically, the posterior approach generally requires release of the short external rotators, including the piriformis, triceps coxae (obturator internus, inferior gemellus, superior gemellus), and the obturator externus (stahelin, bottner). While the released tendon attachment can be repaired via sutures, failure of the repair has been reported in many cases [1]. The purpose of this study was to use a lower limb multibody-dynamics musculoskeletal model to investigate the effect of removal of the short external rotators will

have on the remaining muscle groups spanning the hip during gait, chair rise, and golfing activities after THA for a 62 years old subject. The results of this study suggest a redistribution of the muscle forces after releasing the short external rotator muscles. This redistribution may increase the forces in other muscle groups significantly for certain activities of the daily living.

MATERIALS AND METHODS: A lower limb musculoskeletal model was constructed using the AnyBody inverse-dynamics modeling system (AnyBody Technology, Denmark). The model consists of seven segments, the pelvis, the left and right femur, the left and right tibia and the left and right foot. Six joints were used to connect the model segments, two hip joints, two knee joints and two ankle joints. The hip joints were modeled as spherical joints, the knee joints were modeled as revolute joints in the sagittal plane and the ankle joints were modeled as universal joints. A plane fixed in space representing the floor was constructed and a contact conditions were prescribed between back of the feet and this plane. A comprehensive muscle system from the AnyBody repository library was added to the model. Two models were constructed, one with a complete muscle system intact representing the situation after Anterior Approach THA and the other with the external rotators released representing the case for posterior approach.

Motion capture data were obtained for a 62 years healthy subject for the activities of gait walking, chair rise and golfing. The two models were scaled to represent the subject specific data. A two steps analysis were used, first to optimize the position of the motion capture markers attached to the model and the second to perform the inverse dynamics calculations.

RESULTS AND DISCUSSION: The removal of short external rotators as effective contributors to hip motion has a vastly different effect dependent upon the activity and motion being performed. As one example, the force required of the quadratus femoris is increased between 3x and 5x throughout the gait cycle in the absence of the short external rotators. Clinically, this may mean natural gait is unable to be performed unmodified if the quadratus femoris cannot contribute the force required to perform natural gait.

H530 Biomet Uncemented Hip Resurfacing. Minimum 5-year Follow-up

Primary Author: Thomas P. Gross

Institution: Midlands Orthopaedics, P.A.

Coauthor: Fei Liu (Midlands Orthopaedics, P.A.)

INTRODUCTION: Most metal-on-metal hip resurfacing implants currently being used worldwide utilize bone ingrowth fixation on the acetabular side, but cement fixation remains the standard method of fixation on the femoral side. Our hypothesis is that bone ingrowth fixation of a fully porous-coated component is superior to cement fixation of the femoral hip resurfacing component.

METHODS: From March 2007 to Jan 2009, 429 consecutive metal-on-metal hip resurfacing arthroplasties were performed by a single surgeon in 396 patients using both uncemented femoral and acetabular components. All of these are at least 5-years follow-up. Three patients died with causes unrelated to their hip arthroplasty. The three most common primary diagnoses were osteoarthritis in 318 (74%) cases, dysplasia in 66 (15%) hips, and osteonecrosis in 19 (4%) hips. The average size of the femoral component was 50 ± 4 cm. All pre-operative, intra-operative, and post-operative data were prospectively collected and entered into our database for review. All patients are allowed unrestricted activity including impact sports after 6 months.



RESULTS: Metal ion test results were available for 78% of patients. There were 14 (3.2%) failures identified at the time of this study. There were six (1.4%) early femoral failures (4 femoral neck fractures, 2 head collapses prior to 2 years), four loose acetabular components (one failed at 2 months postoperatively; three after 2 years), two (0.5%) adverse wear related failures (AWRF; metal ion levels ≥ 10 ug/L, AIA > 500 , metalosis), one intertrochanteric fracture;

and one failure due to subluxation. There were no cases of failure of femoral ingrowth or late loosening. For the remaining group, the average post-operative HHS score was 97 ± 9 at their latest follow-up; the average UCLA Activity Score was 7 ± 2 . Survivorship was 96.7% at 5 years (all failures). Femoral survivorship was 98.4%. The AWRF rate was 0.5% at 5 years. No femoral failures occurred after one year postop up to 7 years.

CONCLUSIONS: Bone ingrowth fixation with a fully porous femoral component in hip resurfacing remains highly durable beyond 5 years. Femoral ingrowth is more reliable than acetabular ingrowth. No cases of femoral loosening have been encountered up to 7 years post implantation. AWRF is rare (0.5% at 5 years) and is caused by acetabular component malposition.

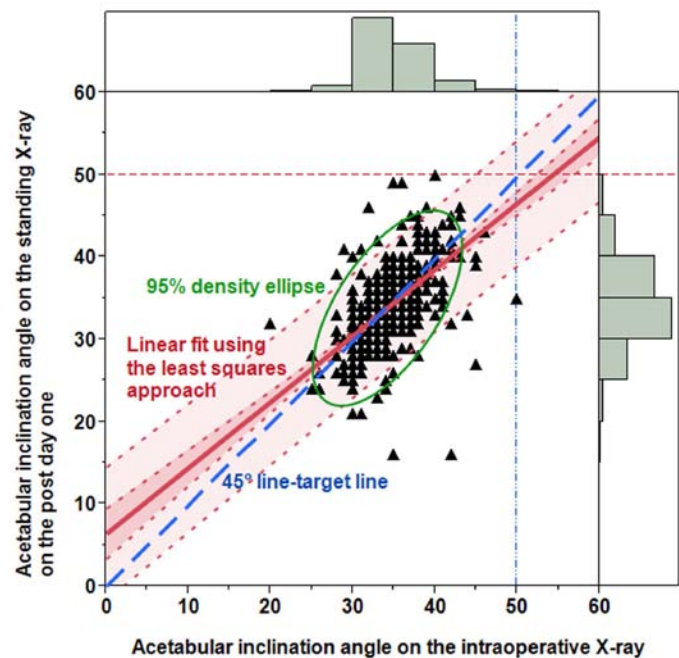
H531 Refined Intraoperative X-ray Technique to Routinely Achieve an Acetabular Inclination Angle

*Primary Author: Thomas P. Gross
Institution: Midlands Orthopaedics, P.A.*

Coauthor: Fei Liu

BACKGROUND: A steep acetabular inclination angle is one of the primary causes of adverse wear related failure with well-designed metal-on-metal bearing hip resurfacing arthroplasties (HRA). One recent study demonstrated that positioning acetabular components of stemmed total hip arthroplasties (THA) within the “Lewinnek safe zone” is difficult; only 62% had AIA within the safe zone. We now report our results using a refined technique, suggested by our previous study, as well as a lower acceptable limit for inclination angle (AIA).

METHODS: We evaluated radiographs of 513 consecutive metal-on-metal HRAs performed by a single surgeon between Oct 2010 and Mar 2012. Intra-operative, recovery room supine pelvis, first postoperative day standing pelvis, and 6-week standing pelvis X-rays were used to determine AIAs on all patients. Our previous study indicated that an intraoperative target inclination limit of 45° was required in order to have a final AIA.



RESULTS: Only one of 513 cases had an AIA outside our “safe range for HRA” on the standing X-ray taken on the first postoperative day (Fig 1). In this case, the intraoperative radiograph showed an AIA of 40° , while it was 50° on the standing postoperative radiograph. The acetabular component was judged not to have shifted. In all of the remaining 512 (99.8%) cases the AIA was within the safe range of $\text{AIA} < 50^\circ$. The average absolute difference between the AIA on the portable intra-operative X-rays and the AIA on the standing X-ray on post day one was $2.6^\circ \pm 2.9^\circ$ (range: 0° to 26°). The variance was $\geq 5^\circ$ in 83 (16.2%) cases and was $\geq 10^\circ$ in 20 (3.9%) cases. One (0.7%) component in the group in which the acetabular component was repositioned during surgery was found to have shifted by the 6 week visit, while five (1.4%) components in the remaining 369 cases (without intraoperative repositioning) were found to have shifted ($P=0.5$).

CONCLUSION: Use of an intra-operative X-ray allowed us to place the acetabular component within a previously demonstrated safe zone for HRA. The risk of postoperative acetabular component shifts was small.

H532**Long-term Postoperative Changes and Correlation of Risk Factors in Metal Ion Concentration after Metal-on-Metal THA***Primary Author: Yudo Hachiya**Institution: Hachiya Orthopaedic Hospital**Coauthors: Hiroki Watanabe (Hachiya Orthopaedic Hospital), Hideaki Murata (Hachiya Orthopaedic Hospital), Koichi Muramatsu (Hachiya Orthopaedic Hospital), Kenichiro Tanaka (Hachiya Orthopaedic Hospital), Syoichi Taniguchi (Hachiya Orthopaedic Hospital)*

INTRODUCTION: Higher concentrations of metal ion levels after metal-on-metal (MoM) total hip arthroplasty (THA) are a cause for concern. Elevated cobalt (Co) and chromium (Cr) ion levels in the blood indicate metal wear, and may predict secondary soft-tissue damage (adverse reaction to metal debris; ARMD). It is well known that concentrations of metal ion levels are elevated in the short term after MoM. However, the long-term consequences of the ion concentration and the other risk factors have not been clarified. We sequentially investigated the postoperative Co and Cr ion levels after MoM THA and the relationship between the metal ion levels and several risk factors.

MATERIALS AND METHODS: We reviewed the data on one hundred and eighty six patients of two hundred ninety one MoM THA cases. Concentrations of metal ion levels were measured at least three times. Serum cobalt and chromium levels were measured by inductor coupled plasma – mass spectrometry in follow-up period, (measured at the preoperative period, the third month, the sixth month, the first year, the second year, and the fourth year after surgery). Furthermore, we investigated the correlation between the metal ion levels and various factors which might influence the release of metal ions, such as body mass index (BMI), renal function, femoral head size, unilateral or bilateral THA, the cup position, and postoperative activity. The renal function was evaluated by measuring estimated glomerular filtration ratio (GFR) at preoperative examination. A postoperative activity was assessed with a pedometer measurement counting number of steps a day. A Cup position was evaluated by lateral inclination measured by X-ray or computed tomography.

RESULTS: Average serum Co and Cr concentrations in preoperative period were 0.69 ng/ml and 0.50ng/ml, re-

spectively. Postoperative serum Co and Cr ion levels were significantly increased compared with preoperative value throughout the postoperative period. There was no significant correlation with regards to BMI, renal function to the metal ion level measurement. In bilateral THA cases, Co and Cr ion concentrations were significantly increased compared with unilateral THA cases. In cases that its cup inclination was more than 50 degrees, Co and Cr ion concentration were significantly increased compared with cases less than 50 degrees in the first year after surgery. There was a trend for higher metal ion levels in the group of patients who walked more than 7000 steps a day, but this did not reach statistical significance. In the large femoral head group (over 40mm), Co and Cr ion concentrations were significantly increased compared with the small femoral head group.

CONCLUSION: Metal ion concentrations of almost patients were increased after MoM THA surgery. Side effects related to elevation of serum Co or Cr concentration were currently not identified and overall clinical results were good. However, longer follow-up would be necessary if the patients have overlapping risk factors, because those patients may experience elevation of the level in postoperative late stage.

H533**Conversion of Bilateral Hip Ankylosis to Total Hip Arthroplasty***Primary Author: M. Hafez**Institution: Department of Orthopaedics, October 6 University*

AIM: To review the outcome of total hip arthroplasty (THA) in the treatment of bilateral hip ankylosis of different causes: surgical, septic or spontaneous.

PATIENTS AND METHODS: 20 THA procedures in 10 patients were included in the study (5 males and 5 females), all had bilateral fusion. Previous pathologies included ankylosing spondylitis, AVN, septic arthritis and surgical arthrodesis. Flexion deformity ranged from 10°-45°. Shortening, as compared to normal anatomy, was up to 6 cm, and leg length discrepancy (LLD) ranged from 1cm to 2.5 cm. The most unified X-ray finding was massive osteophytes formation, with 3 patients showed severe narrowing of the femoral canal. Operative time averaged

147 minutes (70-210); lateral approach was used in all patients; general anesthesia was used for 7 patients while the other 3 patients underwent spinal anesthesia.

RESULTS: Serious complications were reported and were related to the correction of LLD: 1 incidence of sciatic nerve injury that recovered within one year, another incidence of femoral nerve injury (sensory>motor) that recovered within 3 months, and one case of incomplete correction of LLD. On 5-year follow-up (minimum 6 month), no loosening or revision was reported.

CONCLUSION: The conversion of bilateral fused hip joints to THA is a very rewarding surgery but with a higher risk of complications.

H534 Hemiarthroplasty Within Twenty-four Hours for Elderly Aged 80 Years and Older

Primary Author: Kyuichi Hashimoto

Institution: Department of Orthopaedics, Kochi Prefecture Hata-Kenmin Hospital

Coauthors: Yusuke Okanoue (Department of Orthopaedics, Kochi University), Kenichi Kitaoka (Department of Orthopaedics, Kochi Prefecture Hata-Kenmin Hospital), Makoto Komatsu (Department of Orthopaedics, Kochi Prefecture Hata-Kenmin Hospital), Yoshinori Satake (Department of Orthopaedics, Kochi Prefecture Hata-Kenmin Hospital)

BACKGROUND: Japan has been faced with the super-aged society. The number of hip fractures in the elderly is estimated to increase nearly twice over the next 30 to 40 years. One-year mortality rate is 10-30%, although early surgery has been associated with better function outcome, reduction postoperative complications and quality of life. Some reports recommend earlier surgery as soon as possible, because the general condition of the elderly may get worse gradually after the injury. However, surgery within twenty-four hours after admission remains controversial, especially in elderly patients aged 80 years and older. The objective of this study was to evaluate the effects of early hemiarthroplasty surgery for hip fractures in elderly patients.

PATIENTS AND METHODS: We conducted retrospective study of 89 patients who underwent bipolar hemiarthroplasty for the femoral neck fracture between March 2009 and September 2012. Mean age was 85.9 years (range, 80-100). The early group consisted of 46 patients who had surgery within twenty-four hours after admission, and the delayed group included 43 patients who had surgery more than two days (range, 2-14days). We measured medication rate of the antiplatelet / anticoagulant drugs, intraoperative blood loss, blood transfusion, length of hospital stay after surgery, time to ambulation, and postoperative complications in the both groups.

RESULTS: Medication rate of the antiplatelet / anticoagulant drugs was 9 patients (19.6%) at early group, 14 patients (32.6%) at delayed group. Average of intraoperative blood loss was 109ml vs 120ml. Transfusion was performed 14 patients (30.4%) at early group, and 10 patients (23.2%) at delayed group. Average of time to ambulation was 3.4 days at early group, and 4.4 days at delayed group. There was no significant difference between the groups in these factors. Length of hospital stay after surgery in early group was 16.1 days, in delayed group was 19.1 days ($p<0.05$). Postoperative complications showed a significant difference between the groups; the early group was 5 patients (10.9%) and the delayed group was 13 patients (30.2%, $p<0.05$). Most common complications were deep venous thrombosis (DVT); 4 patients of the delayed group, as none of early group ($p<0.05$). There was no significant difference other complications, such as cerebral vascular disease, cardiac failure, chest infection, urinary tract infection, deep infection, pressure ulcer, intraoperative fracture, dislocation. Deaths during hospitalization, there was one patient in both groups.

CONCLUSIONS: Early surgery significantly reduced postoperative complications even in the patients over 80 years old. Deep venous thrombosis occurred significantly more, and caused to longer length of hospital stay after surgery in the delayed group. There was no significant difference other factors between the both groups. This study showed the advantage of early surgery in elderly patients, thereby bipolar hemiarthroplasty for the femoral neck fracture within twenty-four hours after admission should be considered as an appropriate treatment even in the patients over 80 years old.

H535

Estimation of Femoral Stem Length in Revision Total Hip Arthroplasty Based on Preoperative Factors

Primary Author: Daniel N. Huff

Institution: DePuy Synthes Joint Reconstruction

INTRODUCTION: Releasing fewer muscles to access the hip joint is thought to expedite the postoperative recovery period and result in shorter hospital stays. To accommodate MI interests, femoral hip prostheses are generally trending shorter and utilize a broach-only surgical technique to prepare the femur for implantation in the presence of soft tissue constraints and sub-optimal femoral access and visualization.

It has yet to be seen how the trending reduction in stem length will affect eventual revision stem lengths. The current study is to characterize preoperative and postoperative factors of revision THA, with goal of establishing a relationship between some preoperative factor and revision stem length. This relationship would then be used to estimate the effect of reduced primary stem length on revision stem length.

METHODS: In this study, several measurements were taken from pre-operative and films of 53 patients who required revision of a primary femoral hip prosthesis. The same measurements were then gathered from the same patients after revision. Measurements were compiled for statistical analysis.

Each set of measurements was found to fit a Gaussian distribution acceptably within a 5% significance level using the Kolmogorov-Smirnov test. Each sample was characterized by finding the mean, standard deviation, max and min values, and 95% Confidence Interval (CI). Additionally, variation of each sample was evaluated by finding dividing the mean of each sample by the C.I. This provides a quantitative analysis of the variability in the sample, taking into account the number of samples.

After each population distribution was characterized, correlations between variables were analyzed. R values were

Distribution Characterization					
Measurement		Mean(mm)	95% Confidence Interval	Percentage of Mean Value	Acceptable normal distribution at 5% significance level? (KS test)
HC - Fixation	preop	202.1	± 10.27	± 5.08	Yes
	postop	216.1	± 11.60	± 5.37	Yes
Lateral Offset	preop	41.2	± 3.04	± 7.36	Yes
	postop	41.1	± 1.99	± 4.84	Yes
Crotch to Distal Tip	preop	167.4	± 14.54	± 8.69	Yes
	postop	216.2	± 13.55	± 6.27	Yes
HC - distal tip	preop	200.1	± 15.26	± 7.63	Yes
	postop	250.3	± 13.51	± 5.40	Yes
Distal Stem Dia.	preop	11.7	± 1.19	± 10.18	Yes
	postop	14.3	± 0.85	± 5.95	Yes
Distal Medial Cortical thickness	preop	7.3	± 0.73	± 10.00	Yes
	postop	6.0	± 0.43	± 7.12	Yes

Table 1. Distribution Characterization of measured preoperative and postoperative variables.

		Postoperative					
Preoperative		Head center to fixation	Lateral offset	Crotch distal tip	Head center to distal tip	Distal Stem Diameter	Distal Medial Cortical Thickness
	Head center to fixation	r=0.233 p=0.115	r=0.115 p=0.436	r=0.200 p=0.173	r=0.255 p=0.083	r=0.101 p=0.495	r=0.251 p=0.085
	Lateral Offset	r=0.178 p=0.225	r=0.263 p=0.065	r=0.094 p=0.516	r=0.114 p=0.441	r=0.208 p=0.151	r=0.358 p=0.011
	Crotch - distal tip	r=0.370 p=0.016	r=0.139 p=0.372	r=0.280 p=0.069	r=0.242 p=0.123	r=0.215 p=0.167	r=0.044 p=0.781
	Head Center to distal tip	r=0.403 p=0.008	r=0.050 p=0.753	r=0.276 p=0.077	r=0.262 p=0.094	r=0.230 p=0.143	r= -0.002 p=0.991
	Distal Stem Diameter	r=0.253 p=0.090	r= -0.050 p=0.738	r= 0.296 p=0.044	r=0.334 p=0.023	r=0.384 p=0.008	r=0.102 p=0.493
	Distal medial Cortical thickness	r=0.122 p=0.409	r=0.252 p=0.080	r=0.089 p=0.542	r=0.120 p=0.418	r= -0.047 p=0.746	r=0.610 p=0.000

Table 2. Analysis of correlation between preoperative and postoperative variables.

used to measure the correlation, or strength of linear dependence, of preoperative and postoperative variables. To further describe relationships, p values were included as a measure of statistical significance of the correlation. Both r and p values were found using MINITAB statistical software. Where significant correlations were found, the variables were plotted as a scatterplot and a best fit line was placed.

RESULTS: The summarized results of the initial distribution characterization for each variable can be seen as Table 1. Confidence intervals were found using a t-test as previously described. Each distribution was found to have an acceptable normal distribution at a 5% significance level.

Next correlation coefficients were found between variables. A table of interactions can be found as Table 2. A few logical indexes were created in an effort to find an interaction between preoperative variables and postoperative stem length.

DISCUSSION: The intent of this analysis was to allowing the prediction of revision stem length based on changing trends in primary THA stems. Unfortunately the strongest correlation found to postoperative crotch-distal tip length was from the preoperative distal stem diameter variable, with an r value of only 0.296. Based on this weak correlation, the trend to shorter primary stems may not necessarily result in a trend of shorter revision femoral stems.

H536

Introduction of Collapsible Elements for Finite Element Analysis on Hip Prosthesis Design

Primary Author: Hirotaka Iguchi

Institution: Nagoya City University

Coauthors: Hiroto Mitsui (Nagoya City University), Satoru Murakami (Nagoya City University), Yumeji Takeichi (Aichi Medical University), Hisato Motai (Motai Clinic), Masaaki Masaaki (Nagoya City University), Yuko Nagaya (Nagoya City University)

INTRODUCTION: A Finite Element Analysis (FEA) is often used for prosthetic design. Ordinary, bone elements are defined as a elastic material. But using elastic element type for FEA, the result often cannot reach at conversion. The result means that the stems would jump out and fly away when the load is removed even friction was defined. To prevent the jumping out, some software add small spring which does not exist. But this is not the reality. It happens because elastic elements return to the original shape without the load. But the bone is impacted by the load without returning to the original shape. Then the stem is settled. Meshing the trabecular bone with a collapsible element, it can collapse and be hardened by the stem pressure then the results can always reach at conversion.

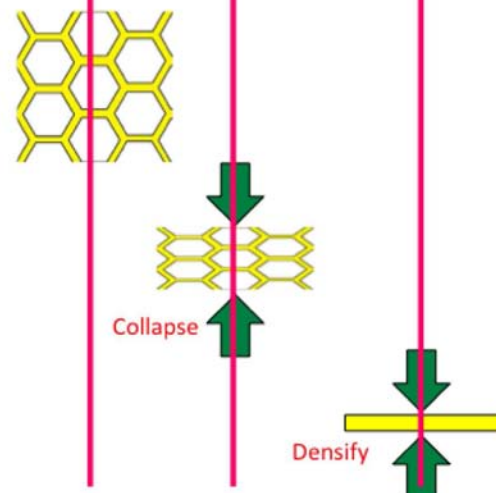
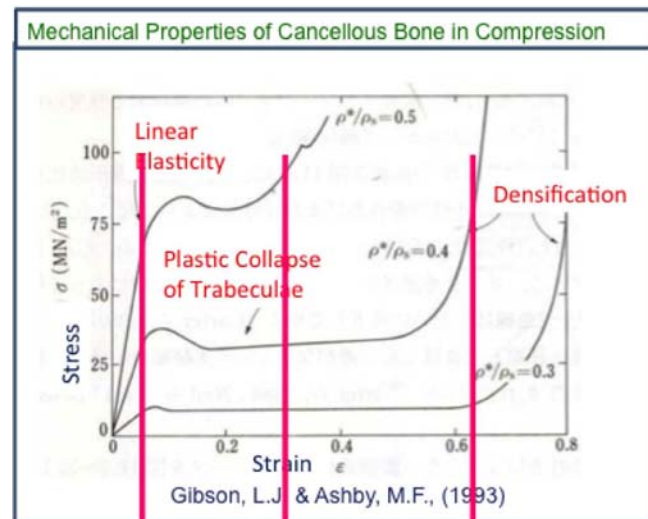
We have been using Revelation (DJO, USA) with lateral flare for the primary cases. We were going to shorten its length to secure proximal load. We have been using Modulus (Lima Corporate, Italy) for revision cases. We were going to extend its length for wider load transfer area. For these modifications, examination, examination of load transfer of the designs the collapsible FEA.

OBJECTIVES: Our objectives are to examine load transfer between stems with different length and canal by collapsible FEA.

MATERIALS AND METHODS: CAT scan data performed before Hip Arthroplasty were used. Each case had different preferable size, so preoperative planning was done for each case to determine preferable size and approximate end point of insertion. Then Finite Element analysis with collapsible element was done. For cortical bone and stems conventional elastic elements were used. To simulate permanent deformity of the trabecular bone, collapsible elements were used. On the other hand, stems are made of titanium, and cortical bone is kept as it had been in ordinary surgery, these two materials were defined as conventional elastic elements.

The analyses were done at heel strike phase of walking. Because it is the most severe moment during the gait. Muscle force were referred to Bergmann et al. (2001).

Data conversion was done by Mimics®. Preoperative planning was done by Magics®, then LS Dina was used for FEA.



As the result, contact pressure were mapped on the stem surface, for visualization. Micromotion between stem and trabecular bone were calculated dividing stem surface into three longitudinally (proximal, middle and distal) and into four (medial, lateral, anterior and posterior.)

RESULTS: With lateral flare stem, more stable proximal load transfer was obtained. And the micromotion was decreased. With conical stems, contact pressure on the boundary between stem and bone was widely distributed and no local stress concentration was observed. During stem insertion, trabecular bone was gradually collapsed up to a stable end point. After removing the load, stems were slightly elevated then settled as observed in reality.

CONCLUSIONS:

1. Stem modification for each purpose, load transfer we had expected was obtained.
2. FEA with Collapsible elements has shown results which are closer to the reality.

H537

Total Hip Arthroplasty Following Resection Arthroplasty

Primary Author: Satoshi Ikebe

Institution: Department of Orthopaedic Surgery, Faculty of Medicine, Saga University

Coauthors: Satoshi Ikebe (Saga University), Motoki Sonohata (Saga University), Syunsuke Kawano (Saga University), Masaru Kitajima (Saga University), Masaaki Mawatari (Saga University)

Septic arthritis and infection after bipolar hip arthroplasty (BHA) and total hip arthroplasty (THA) are devastating complications after surgery. Resection arthroplasty of the hip is effective for eradicating infection; however, THA after resection arthroplasty is a difficult procedure. The complications associated with reimplantation of a THA after resection arthroplasty for the treatment of an infected hip are not well-documented. In the present study, twenty hips in 20 patients (10 males and 10 females), including infected THA and BHA in seven hips and primary septic arthritis in 13 hips, with a minimum 2-year follow-up (range, 2-13 years) from the time of reimplantation THA were evaluated retrospectively. In all patients, resection arthroplasty was performed at another hospital. The average age of the

patients who underwent resection arthroplasty at each hospital was 38 (range 10 to 73) years old, and was 59 years old (range, 33 to 82) at the first THA in our hospital.

The average time interval between the resection arthroplasty of the hip and THA was 26 years (range, seven months to 67 years). Sixteen patients (16 hips) had undergone prior surgery for a hip infection. Eight hips presented with an infected primary total hip arthroplasty or hemiarthroplasty. Investigations were carried out pre-operatively and intra-operatively for evidence of continuing infection.

The average Japanese Orthopaedic Association (JOA) hip rating score changed from 49 preoperatively to 78 at the latest followup. The average preoperative leg-length discrepancy was 48.5 mm (range, 10-130mm). Postoperatively, nine hips were corrected to an equal leg length, whereas the others were corrected to an average leg-length discrepancy of 2.7 mm (0.5-10 mm). A radiographic analysis was completed for all 20 patients with retained components from the index procedure. There was septic loosening in two acetabular components, with the other 18 acetabular components had no loosening. There was no loosening in all 20 femoral components. The complications related to the prosthesis consisted of dislocations in six patients (30%), recurrent infections in five patients (25%), an intraoperative fracture in one patient (5%) and contracture in one patient (5%). Four patients needed re-revision; one patient underwent re-revision surgery for a persistent infection, two patients underwent re-surgery for recurrent dislocation and another patient was surgically treated for both dislocation and infection.

In the current series, 100% of the patients were free of infection at the latest follow-up. However, there was a 30% dislocation rate and a 25% recurrent infection rate, so alternative approaches need to be evaluated which might reduce these complications.

H538

Results of Total Hip Arthroplasty Using S-ROM Following Proximal Femoral Osteotomy

Primary Author: Takashi Imagama

Institution: Department of Orthopedic Surgery, Yamaguchi University Graduate School of Medicine

Coauthors: Atsunori Tokushige (Department of Orthopedic Surgery, Yamaguchi University Graduate School of Medicine), Kazushige Seki (Department of Orthopedic Surgery, Yamaguchi University Graduate School of Medicine), Akihito Sakka (Department of Orthopedic Surgery, Yamaguchi University Graduate School of Medicine), Toshihiko Taguchi (Department of Orthopedic Surgery, Yamaguchi University Graduate School of Medicine)

INTRODUCTION: Long-term favorable results have been reported for proximal femoral osteotomy, including varus osteotomy or valgus osteotomy for osteoarthritis of the hip associated with acetabular dysplasia, and transtrochanteric rotational osteotomy for avascular necrosis of the femoral head. However, total hip arthroplasty (THA) is indicated for patients who have developed terminal stage osteoarthritis of the hip. In such cases, stem insertion is comparatively difficult. We examined the postoperative results and issues of patients who underwent THA at our hospital using S-ROM following proximal femoral osteotomy.

MATERIALS AND METHODS: We studied 25 hip joints of 22 patients with osteoarthritis who underwent THA using S-ROM (DePuy) following proximal femoral osteotomy. There were 6 men and 16 women with the mean age of 50.4 years. With regard to proximal femoral osteotomy, varus osteotomy was performed in 6 hips, valgus osteotomy in 6, and transtrochanteric anterior rotational osteotomy of the femoral head in 13 hips, and the mean period from osteotomy to THA was 18.7 years. The mean follow-up period was 3.6 years. The evaluation parameters were the presence or absence of bone sclerosis of proximal femur as assessed by radiography, intraoperative or postoperative complications, JOA scores before THA and at final observation as functional evaluation, and sinking, spot welds, and radiolucent lines for stem fixation; with regard to stem alignment, the varus-valgus angle was measured and 2 degrees or more was identified as poor placement.

RESULTS: In the preoperative radiograph evaluation, a bone sclerosis was observed at the osteotomy site of the proximal femur in 24 hips. As intraoperative complication, calcar fracture was observed in 1 hip who underwent valgus osteotomy. The mean preoperative JOA score of 45.3 points improved to 88.9 points at the final evaluation, showing significant improvement in all patients. Stem sinking, while spot welds and radiolucent lines were observed in 2 (8%), 22 (88%) and 0 of the 25 hips, respectively. With regard to stem alignment, varus insertion and

valgus insertion were observed in 3 hips each; 2 hips with varus insertion had the greater trochanter deviated medially while 2 hips with valgus insertion had valgus deformity of calcar.

DISCUSSION: The S-ROM femoral component is useful for many deformities from the level of the greater trochanter to the diaphysis. Postoperative satisfactory results of THA following proximal femoral osteotomy at our hospital were achieved. However, attention should be paid to the fact that a bone fracture and abnormal stem alignment were observed. Abnormal stem alignment was observed at a significantly lower incidence (4 of 48 hips) in patients with primary THA at our hospital who did not undergo osteotomy. In this study, bone sclerosis and morphological abnormality of the greater trochanter or the calcar was present in almost hips. It is considered to have resulted in a calcar fracture and abnormal stem alignment. In THA following proximal femoral osteotomy, it is necessary to perform adequate reaming on the inside of the greater trochanter and to pay careful attention to the location for placing the sleeve.

H539

Anterior Coverage after Rotational Acetabular Osteotomy for the Treatment of Developmental Dysplasia of the Hip

Primary Author: Hiroshi Imai

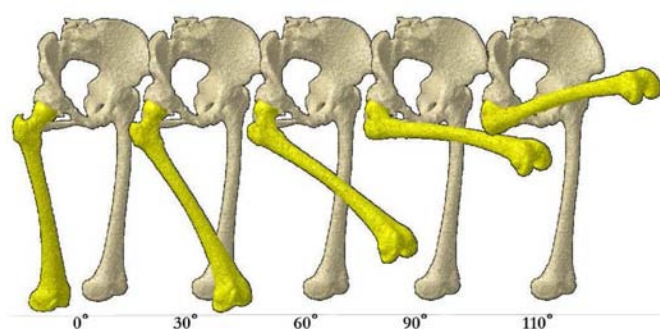
Institution: Ehime University Graduate School of Medicine

Coauthors: Tomomi Kamada (Ehime University Graduate School of Medicine), Jun Takeba (Ehime University Graduate School of Medicine), Yoshitaka Shiraishi (Ehime University Graduate School of Medicine), Naohiko Mashima (Ehime University Graduate School of Medicine)

OBJECTIVES: In rotational acetabular osteotomy (RAO) for the treatment of developmental dysplasia of the hip, impairments in ADL due to limitations in hip flexion can occur when anterior displacement is added to lateral displacement in order to obtain sufficient femoral head coverage. This study was conducted to determine, by the ROM simulation, the minimum angle of hip flexion that is necessary to avoid ADL impairments after RAO and to identify these indices in plain radiography to achieve the above hip flexion.

METHODS: Of 47 hips treated with RAO at our hospital from December 2007 to May 2012, 27 hips for which CT imaging was possible were retrospectively examined. ROM was simulated using three-dimensional computer-aided design software to measure the flexion angle when the displaced fragment of bone and femur causes impingement. The relationship between this angle and resulting ADL impairments or X-ray findings was examined.

RESULTS: 5 out of 27 hips with a postoperative VCA angle of 46° or larger showed impingement at 110° or less in ROM simulation and ADL impairments associated with limitations in hip flexion (Fig 1).



CONCLUSION: Excessive anterior coverage of femoral head after RAO may increase the incidence of ADL impairments.

H540

Early Repair of Necrotic Lesion After High Degree Posterior Rotational Osteotomy – A Study Evaluated by Volume Measurement Using Magnetic Resonance Imaging

Primary Author: Tsubasa Ishikawa

Institution: Showa University Fujigaoka Hospital

Coauthors: Takashi Atsumi (Showa University Fujigaoka Hospital), Satoshi Tamaoki (Showa University Fujigaoka Hospital), Ryosuke Nakanishi (Showa University Fujigaoka Hospital), Minoru Watanabe (Showa University Fujigaoka Hospital), Yasuoki Kobayashi (Showa University Fujigaoka Hospital)

INTRODUCTION: If the necrotic lesion size of the femoral head is extensive on loaded portion, collapse will occur in progress. In high degree posterior rotational osteotomy for femoral head necrosis, necrotic focus is moved

away from the major loaded portion below the acetabulum. The transferred viable area receives the weight-bearing forces. We thought that collapse was prevented and the lesion could be repaired by this procedure. We investigated the repair of the lesion in volume after the operation by using magnetic resonance imaging.

METHODS: Between the end of 2003 and 2012, high degree posterior rotational osteotomies were performed on 25 hips. The mean age was 30.4 years old. 17 patients were men and 8 were women. The causative factor was steroid administration in 8 hips, and alcohol abuse in 11, after acute slipped capital epiphysis in 4 and no cause in 2. The degree of the posterior rotation ranged from 110 to 135 degrees (mean 118 degrees). 10 to 25 degrees (mean 20 degrees) of intentional varus positioning was applied in addition to the rotation in all 25 hips. The necrotic area was extensively involved laterally to medially, anteriorly to posteriorly. Magnetic Resonance Imaging was taken after one month, 6-8 month and twelve months postoperatively. The coronal slice on T2 fat suppression image was observed. We measured the volume of low intensity areas on each slice, and added as total volume. The volume of necrotic area were measured before the operation (A) and after the operation (B). The ratio of volume of necrotic area was defined as B/A (%)

RESULTS: The necrotic area was decreased 69.5% (99-40%) after one month, 47.8% (92-22%) after six months, 36.2% (90-10%) after twelve months comparing with the mean volume of necrotic area of before the operation. We compared the rate of decreased volume of necrotic area after the operation in each decades. One year after the operation, teenager's mean volume of necrotic area was decreased to 19.4%. In the 20 decade: 35.3%, 30 decade: 41.7%, and in 40 decade: 59.5% was performed. The degree of repair of necrotic lesion in younger patients was better than in elder patients.

CONCLUSIONS: From this study, high degree posterior rotational osteotomy appeared to be effective from the aspect of repair of extensive necrotic focus in young patients. We believed that this procedure could make a femoral head necrosis alive again.

H541

Radiographic Analysis of Cemented Collarless Polished Triple-Taper Stem in Short Term

Primary Author: Michitaka Kato

Institution: Gifu Municipal Hospital

Coauthor: Takashi Shimizu (Gifu municipal hospital)

BACKGROUND: We occasionally came across cortical atrophy of femur with cemented collarless polished triple-taper stem in a short term period. This study aimed to estimate radiographs of cemented collarless polished triple-taper stem taken at 6 months after the initial operation.

METHODS: Between May 2009 and April 2011, 97 consecutive patients underwent primary total hip arthroplasty and hemiarthroplasty using SC-stem or C-stem implant. At 6 months follow-up, radiographic examination was performed on 70 patients (71 hips). 44 hips had total hip arthroplasty for 35 osteoarthritis, 5 idiopathic osteonecrosis, 2 others and 27 hips had hemiarthroplasty for femoral neck fractures. Cementing grade was estimated on the postoperative radiographs. These 6 months postoperative radiographs were analyzed for changes in stem subsidence, cortical atrophy and cortical hypertrophy. According to the system of Gruen, cortical atrophy and cortical hypertrophy were classified on the femoral side. We defined no cortical atrophy as grade 0, cortical atrophy less than 1 mm as grade 1, more than 1 mm and less than 2 mm as grade 2, more than 2 mm as grade 3.

RESULT: A cortical atrophy adjacent to the stem was found in zone II according to Gruen on grade 0 thirty-five radiographs (49%), grade 1 twenty (28%), grade 2 eleven (16%), grade 3 five (7%). in zone III grade 0 twenty-seven (38%), grade 1 thirty (42%), grade 2 ten (14%), grade 3 four (6%), in zone V grade 0 fifty (70%), grade 1 twenty (28%), grade 2 one (1%), grade 3 zero (0%), in zone VI grade 0 forty-nine (69%), grade 1 twenty (28%), grade 2 two (3%), grade 3 zero (0%). Cortical hypertrophy was only demonstrated in zone V in one case. In all cases, stem subsidence was less than 1 mm. Cortical atrophy including grade 1 was recognized in 38% of THA, and in 52% of femoral neck fracture. In one case the slight radiolucent line of the postoperative radiograph disappeared after 6 months.

DISCUSSION: Cortical atrophy was recognized more in

the femoral neck fracture group than in the THA group. And cortical atrophy was recognized in zone 2 and zone 3 more frequently than in zone 5 and zone 6. According to the finite element analysis of SC-stem more stress is received on the medial aspect of the stem during weight bearing, so it is suspected that more cortical atrophy on the lateral aspect is associated with stem design. It is compatible with the cortical hypertrophy reported with Exeter stem in zone 5.

CONCLUSION: Cortical atrophy including minor degree occurred in 65% of cemented collarless polished triple-taper stem in short term after implantation. Cortical atrophy occurred in the lateral aspect of the stem more than in the medial aspect. Cortical atrophy was recognized in the femoral neck group fracture more than in the THA group.

H542

Nerve Palsy Following Primary Total Hip Arthroplasty

Primary Author: Shunsuke Kawano

Institution: Department of Orthopaedic Surgery, Faculty of Medicine, Saga University

Coauthors: Motoki Sonohata (Saga University), Satoshi Ikebe (Saga University), Masaru Kitajima (Saga University), Masaaki Mawatari (Saga University)

We evaluated the prospective study of the incidence rate and risk factor of nerve palsy following cementless total hip arthroplasty (THA) in a consecutive series of patients using posterior approach. The retrospective study consists of 6123 hips. The following variable were considered in the current study: age, gender, body height, body weight, body mass index (BMI), preoperative range of motion of hip joint, preoperative diagnosis for THA, preoperative leg length discrepancy, operative time, bleeding volume. We performed Mann-Whitney rank sum test, Fisher exact test to evaluate the factors influencing nerve palsy. Significance was defined as a p value of Nerve palsy following THA occurred 14 hips (0.22%). All nerve palsies were peroneal nerve palsy, femoral and tibial nerve palsy was none. Although 8 nerve palsy recovered completely, and 4 nerve palsy remained. Between the patients with and without palsy, there was significant in body weight, BMI and preoperative diagnosis. Nerve palsy following THA had occurred completely dislocated hip, osteonecrosis of the

femoral head, and lower weight cases. However, a significant difference was not observed in the cases in which poor preoperative range of motion and previous surgery of hip joint. In the complete dislocation hip, it nerve palsy had occurred three cases, which were not using femoral shortening osteotomy. There is no case of nerve palsy 243THA with femoral shortening osteotomy. In postero-lateral approach, caution is required also for pressure of the sciatic nerve at the time of an operation. It was suggested that a lower weight case is a risk. Although nerve palsy does not influence long-term result, it gets worse functionally, and we think that prevention is most important.

H543

The Results of CT Based Custom-made Cementless Stems after Intertrochanteric Femoral Osteotomy in Japanese Patients

Primary Author: Kenji Kawate

Institution: Department of Artificial Joint and Regenerative Medicine, Nara Medical University

Coauthors: Mitsuru Munemoto (Nara Medical University), Tomoyuki Ueha (Nara Medical University), Yoshinobu Uchihara (Nara Medical University), Yasuhito Tanaka (Nara Medical University), Ikuo Kawahara (Tominaga Hospital), Katsuya Tamai (Oyama Saiseikai Gose Hospital)

INTRODUCTION: To obtain strong early fixation and proximal fixation, we used CT based custom-made stems for femora after intertrochanteric femoral osteotomy in Total Hip Arthroplasty.

METHODS: Fifty hips of 44 Japanese patients were reviewed. The average age at surgery was 64 years (range, 29 to 77 years), and the average follow-up period was 10 years (range, 3 to 18 years). The underlying etiology was secondary osteoarthritis in 48, CDH in 1 and post traumatic osteoarthritis in 1. Intertrochanteric varus osteotomy was performed in 25 hips and intertrochanteric valgus osteotomy in 25 about 30 or 40 years ago. The Ti-6Al-4V stems designed with CT data (Japan Medical Material, Osaka) were inserted without rasp in some patients, and with individual rasps in some patients, and with CT based navigation system in some patients. Harris hip score was used for evaluation of clinical symptoms.

RESULTS: The average preoperative Harris hip score was 49 points (range, 19 to 74 points). At the most recent follow-up, the score was 82 points (range, 51 to 97). Forty-nine stems were evaluated as bone-ingrown fixation and one stem as stable fibrous fixation by Engh's criteria. Six femora were evaluated as Grade 3 or 4 stress shielding by Engh's criteria. Stress shielding was observed in femora with low cortical ratio.

DISCUSSION AND CONCLUSIONS: In conclusion, the results of a custom-made cementless stem after intertrochanteric femoral osteotomy were excellent in Japanese patients, but stress shielding is still a problem.

H544

The CT-Based Patient Specific Hip Joint 3D-Modeling; Pre-Op Planning Finite Element Model Based

Primary Author: Seyed Morteza Kazemi

Institution: Akhtar Hospital, Shahid Beheshti University of Medical Sciences

Coauthors: Amir Hoss Saveh (Akhtar hospital, Shahid Beheshti University of Medical Sciences), Seyed Mohammad Jazaeri (Akhtar hospital, Shahid Beheshti University of Medical Sciences), Mahmoud Chizari, Kazuyoshi Gammada (Akhtar hospital, Shahid Beheshti University of Medical Sciences)

INTRODUCTION: The salvage proximal femoral osteotomy is performed in mild or moderate osteoarthritis when the articulating surfaces are normal and relieves the subject's pain. Because the importance of angular mal-alignment of the femur bone at the hip junction accurate pre-op planning based on patient specific anatomy is required to prevent any lower misalignment and joint problem pre-op.

METHOD: In this study a virtual CT-Based modeling technique is used to a 3D-Model of the patient's pelvis and proximal femur. The registration stage using angio-fluoroscopy was performed to calculate the proximal femur kinematic and input it into a finite element model to achieve the stress distribution pattern of femoroacetabular joint.

Because the patient is feeling some pain in his proximal femur specially during sitting when he is gotten 90 degree flexion, then 3 proximal femur varus osteotomy resections

were performed on his specific proximal femur model in 15, 20 and 30 degrees varus osteotomy to achieve the best stress distribution pattern in compare with its virgin proximal femoroacetabular joint in finite element analysis.

RESULTS: To assess the biomechanics of the joint contact surface it is necessary to have the stress distribution in the articulating surfaces of the hip joint. The decision about the salvage surgical approach and receive the appropriate plan for the wedge excision will be made based on the biomechanical results at the joint. FE model also provides additional information on the stress profile of the contact surface when the joint moves from the full extension to full flexion.

CONCLUSION: Use of a non-invasive 3D modeling method will remediate the surgical approach in pre-op stage. Here the in-vivo modeling and assessment of the patient femoroacetabular contact is approved. It has been shown that the accuracy of the proposed model is comparable with the existing surgical pre-op planning.

H545 Safe Range of Motion During Put-on-socks Motion After THA

Primary Author: Hagio Keisuke

Institution: Osaka Minami Medical Center Dept. of Orthopedics

Coauthors: Saito Masanobu (Osaka Minami Medical Center), Tazaki Naotaka (Osaka Minami Medical Center), Kushimoto Kohei (Osaka Minami Medical Center), Egami Hiroshi (Osaka Minami Medical Center)

BACKGROUND: Few clinical hip score include toe-reach motion after THA (put-on-socks, nail-cutting, ...). Some reports have shown whether THA patients can put on socks or not in daily activity, and not shown how they can do it. The purpose of this study is to investigate real pattern of put-on-socks motion in daily activities after THA, and to evaluate safe range of motion for prevention of hip dislocation.

MATERIALS AND METHODS: Reviewing clinical chart, we investigated highly frequent pattern in wearing socks motion that would cause hip dislocation in ADL in 100 patients with normal lower extremities except for hip

joint more than one year after THA, then, we classified the motion pattern. Using an optical 3-D motion analysis (MAC3D system, Motion Analysis, USA), we measured necessary angle of the hip in 10 THA subjects (mean age at operation 61 years old) one year postoperatively, while the patients make such frequent patterns of movement as above. Simultaneously, individual 3-dimensional skeletal model was reconstructed from CT data and implant CAD data. Driving 3-D skeletal model combined with motion analysis data on display (Zed Hip, LEXI), we calculated angle from posture that hip flexion angle was maximum during wearing-socks motion to impingement point (implant and/or bone) for each direction. ALL joint angle was defined as “zero” in supine position.

RESULTS: Resulting from clinical chart, high incident pattern of the motion was “Leg raising pattern” (26%), and “Trunk flexion pattern”(23%). For above two pattern of the socks-wearing motion, 3-D motion analysis showed that maximum hip flexion angle was 85 ± 13 degrees for leg raising pattern, 88 ± 14 degrees for trunk flexion pattern. Hip angle of abduction/adduction or external/internal rotation was within mean 15 degrees during each motion. 3-D model simulation combined with motion data showed that 39 ± 15 degrees, 33 ± 9.7 degrees for direction of hip flexion, 34 ± 17 degrees, 32 ± 11 degrees for direction of hip adduction and 78 ± 21 degrees, 51 ± 21 degrees for direction of hip internal rotation from posture on maximum hip flexion angle to impingement point for each motion, respectively. All cases showed safe range of more than 20 degrees for all direction and impingement occurred between cup and stem in all cases. (Figure 1,2).

DISCUSSION: Recently, there have been trend to decrease limitation of motion in ADL after THA. Safe range of motion without impingement have been enlarged resulting from development of implant design, proper alignment and operative technique. This study showed safe range without impingement in frequent socks-wearing pattern in daily living among THA patients one year after surgery. More research for motion in ADL can lead to remove post-operative restrictions in THA patients.

Safe range of motion (Leg raising pattern)		
n=10		
hip angle at maximum hip flexion position		
flexion	85 ± 13	
adduction	3.0 ± 11	
int.rotation	-15 ± 8.6	
angle to impingement		
direction of flexion	39 ± 15 (24~65)	
direction of adduction	34 ± 17 (20~62)	
direction of int.rotation	78 ± 21 (43~97)	
(mean±SD degrees)		



Safe range of motion (Trunk flexion pattern)		
n=10		
hip angle at maximum hip flexion position		
flexion	88 ± 14	
adduction	-1 ± 6.8	
int.rotation	-6 ± 4.5	
angle to impingement		
direction of flexion	33 ± 9.7 (21~51)	
direction of adduction	32 ± 11 (20~55)	
direction of int.rotation	51 ± 21 (28~72)	
(mean±SD degrees)		



H546

Short-term Use of Enoxaparin for Venous Thromboembolism Prevention after Hip and Knee Arthroplasty

Primary Author: Hiroaki Kijima

Institution: Department of Orthopedic Surgery, Akita University Graduate School of Medicine

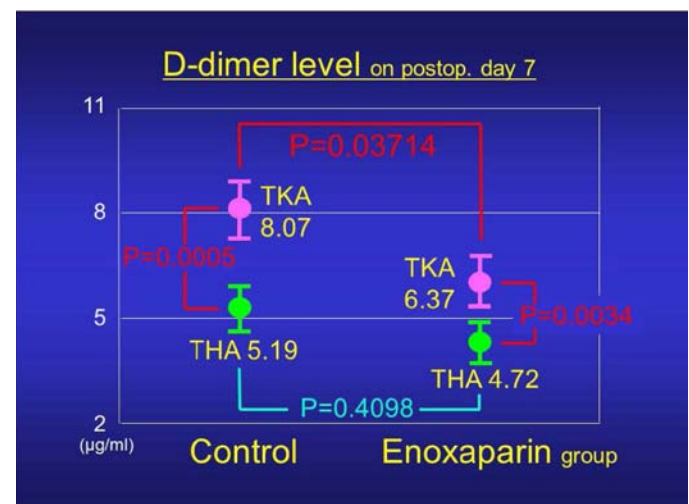
Coauthors: Shin Yamada (Department of Orthopedic Surgery, Akita University Graduate School of Medicine), Nat-suo Konishi (Akita Hip Research Group), Hitoshi Kubota (Akita Hip Research Group), Hiroshi Tazawa (Akita Hip Research Group), Takayuki Tani (Akita Hip Research Group)

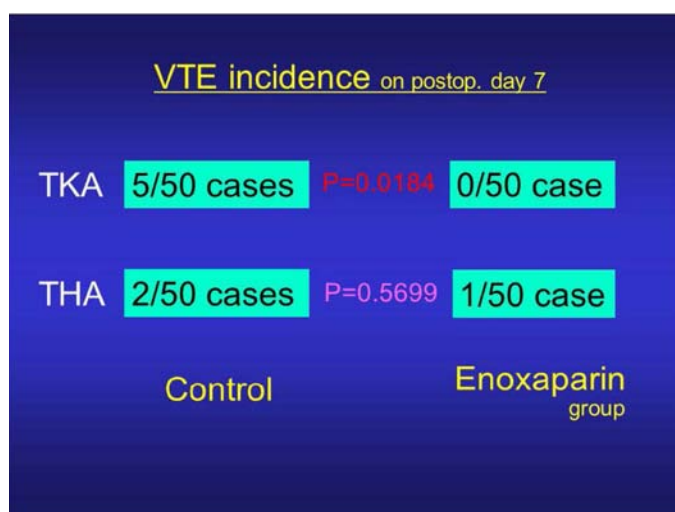
INTRODUCTION: Enoxaparin sodium (ENO) reportedly prevents venous thromboembolism (VTE) after total knee arthroplasty (TKA) or total hip arthroplasty (THA). We examined the usefulness and safety of ENO for preventing VTE by comparing VTE incidence between patients with and without use of ENO and between THA and TKA.

METHODS: This study examined 100 THAs and 161 TKAs performed between June 2007 and December 2009. Among these, ENO was not used for 50 THA and 78 TKA (Group C) performed until the end of September 2008, but ENO was used for 50 THA and 83 TKA (Group E) performed from the start of October 2008. ENO was used from the next day when the absorption drain was removed to the day the patient could walk (mean, 7.1 days; range, from day 3.2 to day 9.3). When D-dimer level on postoperative day 7 exceeded 10 µg/ml, contrast-enhanced computed tomography (CT) was performed to confirm whether VTE was present.

RESULTS: After TKA, D-dimer level was lower in Group C ($8.07 \pm 4.51 \mu\text{g/ml}$) than in Group E ($6.37 \pm 2.62 \mu\text{g/ml}$; $P=0.0371$). However, D-dimer level after THA did not differ significantly between groups (Group C, 5.19 ± 3.02 ; Group E, 4.72 ± 2.52 ; $P=0.4098$) [Fig.1]. VTE was detected after TKA using contrast-enhanced CT in no cases in Group E and five cases in Group C ($P=0.0184$). Conversely, VTE was detected after THA using contrast-enhanced CT in one case in Group E and two cases in Group C ($P=0.5699$) [Fig.2]. Neither hematoma at the operative site nor decline in hemoglobin $>2 \text{ g/dl}$ were detected in any cases.

CONCLUSION: Short-term use of ENO from about day 3 to about day 9 reduced D-dimer levels and VTE incidence after TKA. This method did not significantly reduce these findings after THA, presumably because VTE incidence is lower after THA than after TKA. The protocol for prophylaxis against VTE needs to be considered according to the specific operation and individual patient.





H547 Ten Year THA Survivorship with a Modular Cup: Results of a Large Multi-Center Study

Primary Author: Kirk Kindsfater

Institution: Orthopaedic Center of the Rockies

Coauthors: William Barrett (Proliance Orthopedic Associates), James Dowd (Jordan-Young Institute), James Lesko (DePuy-Synthes)

INTRODUCTION: The Pinnacle modular acetabular cup accommodates polyethylene, ceramic, and metal liners in various sizes. This provides surgeons with options in primary THA, and may reduce the need to revise an otherwise well positioned, ingrown cup in the revision scenario. Survivorship of this modular cup in its various articulations is of interest.

METHODS: Between July 2000 and June 2007, seventeen surgeons implanted 1,592 Pinnacle acetabular cups in consecutive primary THAs, in a prospective multi-center, IRB-approved, non-randomized study. Nine different stems were used. Bearings included ceramic-on-polyethylene (2%), metal-on-metal (42%), and metal-on-polyethylene (56%). Non-inflammatory disease was diagnosed in 98%. Mean age was 62 years (range 18 to 100); 831 patients were female. Mean BMI was 29.7 (range 15.7 to 65.4). Kaplan-Meier survivorship estimates were reported for post-op years in which at least 40 subjects had later follow-up. Data collection for this study was closed in December 2012.

RESULTS: There were 40 revisions, 18 of which included revision of the cup. There were 16 revisions in 667 MoM hips, of which 7 were for adverse local tissue reaction. There were 23 revisions in 896 MoP hips, of which 13 were for instability. Survivorship estimates for all articulations combined were 97.0%, 95.8%, and 94.8% at 5, 8 and 10 years, respectively (95% CI 92.2 to 96.5 at 10 years). There were no revisions for osteolysis, polyethylene wear or liner dissociation.

Survivorship estimates

for MOM subjects were 97.1%, 94.7% and 94.7% at 5, 8 and 9 years, respectively (95% CI 90.9 to 96.9 at 9 years). Survivorship estimates for MOP subjects were 96.9%, 96.6% and 95.2% at 5, 8 and 10 years, respectively (95% CI 92.0 to 97.2 at 10 years).

DISCUSSION AND CONCLUSION: This modular cup system yielded excellent survival with both MoM and MoP bearings in the study. The modularity of this cup was beneficial as the shell was retained in 22 of 40 revisions.

H548 A Case of Pseudotumor Detection by Contrast Enhanced Tomosynthesis After Metal-on-Metal Total Hip Arthroplasty

Primary Author: Kenji Kitamura

Institution: Sonoda Joint Replacement Medical Center Hospital

Coauthor: Kazutaka Sugimoto (Sonoda Joint Replacement Medical Center Hospital)

INTRODUCTION: Pseudotumor is known as one of the complications associated with the Metal-on-Metal (M-M) THA. MRI is usually used to visualize any pseudotumors. However, small pseudotumors closed to the THA components may not be observed in MRI due to the image distortion by the interaction between the metallic objects and magnetic fields. CT will also degrade image quality with M-M THA components inducing X-ray beam hardening effects. So, we have tested contrast enhanced (CE) tomosynthesis. Tomosynthesis is known as the X-ray tomography technique to provide much less metal artifact images with lower X-ray dose for the patients. The aim of this report was to investigate the detectability of pseudotumors by tomosynthesis.

METHODS: We used Sonialvision-Safire X-ray Radiography/Fluoroscopy System (Shimadzu Corporation, Japan). A case of pseudotumor after M-M THA was scanned by tomosynthesis and MRI. Plain tomosynthesis was obtained before the contrast media injection and followed by CE-tomosynthesis. Then, subtraction tomosynthesis between plain and CE-tomosynthesis were calculated in order to increase the image contrast.

RESULTS: The subtraction tomosynthesis could enhance the pseudotumor which was considered to be equal to the same one depicted in MRI. However, cystic lesions in the pseudotumor appeared as very high signal in T2 weighted images of MRI, whereas the CE-tomosynthesis resulted in no image contrast. The image distortion and metal artifacts in tomosynthesis image were fewer than MRI even in the area close to the hip implants.

DISCUSSION: MRI can provide wide variety of soft tissue contrast with pseudotumors. On the other hand, MRI images will be distorted with the M-M THA components. That is why CE-tomosynthesis is considered to be promising imaging technique to detect small pseudotumors at early stage. Tomosynthesis has another advantage such as lower X-ray dose for the patients and better spatial resolution than CT in coronal plane.

H549

A Quantitative Method to Calculate the Volume of Material Loss from the Taper-Trunnion Junction

Primary Author: Sevi B. Kocagoz

Institution: Drexel University, Philadelphia PA

Coauthors: Daniel W. MacDonald (Drexel University), Richard J. Underwood (Exponent Inc.), Judd S. Day (Exponent Inc.), Steven M. Kurtz (Exponent Inc.)


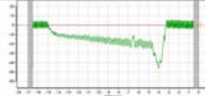

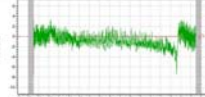

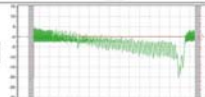

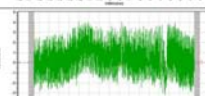
INTRODUCTION: Adverse reactions to metal ion debris from femoral head taper and stem trunnion junctions in recent hip implant designs has become a clinical concern. In the past, fretting-corrosion damage on the component interfaces has been investigated using visual scoring of the taper surfaces of explants. Visual fretting-corrosion scoring is widely used and accepted in the literature as a method to evaluate damage to the surface; however, it's semi-qualitative and does not provide a quantitative measure of

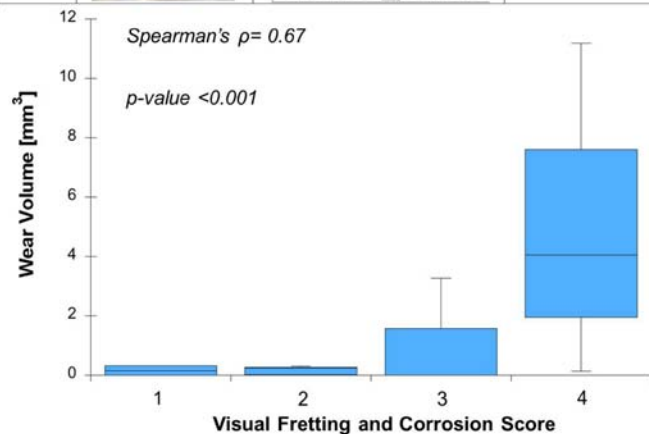
the amount of material removed from the surface. The purpose of this study was to develop a quantitative method to measure and calculate the volume of material removed from the surfaces at the taper-trunnion junction in order to accurately assess the damage and mechanisms leading to corrosion.

METHODS: Taper surfaces were measured using a roundness machine (Talyrond 585, Taylor Hobson, UK). The volume of material removal was initially estimated using 8 equally spaced axial traces measured on the surface of 25 femoral head tapers. The volume of material loss is calculated using a least squares line fitted through the unworn surfaces of each profile using a customized Matlab program. Fretting corrosion was also assessed using a visual semi-quantitative scoring scale of 1 to 4, where a score of 1 was given for the least severe and 4 given for the most severe corrosion.

RESULTS: The measured volumetric material removal was positively correlated with the visual corrosion scores (Spearman's $\rho = 0.67$; $p < 0.001$). However, there was considerable variation in the volume of material lost among components with the same visual corrosion score, particularly for tapers with high corrosion scores (Figure 1). The variation in the volume of material removal was higher for components with a score of 3 or 4 compared to components with a score of 1 or 2. The volume of material lost for components with a score of 1 ranged from 0.00 – 0.32 mm³, whereas components with a corrosion score of 4 had material removal that ranged from 0.1-11.2 mm³ (Figure 2).

DISCUSSION: These results show that visual corrosion score is a useful screening method; yet, insufficient for evaluating the amount of material lost. The increased clinical concern about the adverse effects of metal ion release requires an accurate method to evaluate the damage mechanisms taking place at the head-trunnion taper junction. We have developed a quantitative method to measure and calculate the volumetric material removal from the taper surfaces and we are currently working on validation. Having a validated quantitative method to assess the volume of material loss will help isolate the mechanisms and device factors leading to fretting-corrosion in future studies.

Score	Photo	Example Axial Trace	Estimated wear parameter
4			Max Depth: 52.2 μ m Ave. Depth: 17.2 μ m Volume: 8.1mm ³
4			Max Depth: 12.2 μ m Ave. Depth: 0.3 μ m Volume: 0.1mm ³
3			Max Depth: 51.2 μ m Ave. Depth: 5.9 μ m Volume: 3.3mm ³
3			Max Depth: 0 μ m Ave. Depth: 0 μ m Volume: 0 mm ³



H550 Utility of Muscle Evoked Potential Monitoring in Total Hip Arthroplasty

Primary Author: Daisuke Koga

Institution: Tokyo Medical and Dental University

Coauthors: Shigenori Kawabata (Tokyo Medical and Dental University), Tetsuya Jinno (Tokyo Medical and Dental University), Takeshi Muneta (Tokyo Medical and Dental University), Atsushi Okawa (Tokyo Medical and Dental University)

INTRODUCTION: In total hip arthroplasty (THA), postoperative nerve palsy is rare. This condition, however, is one of the most severe complications and therefore requires attention, especially in cases involving greater leg lengthening. The monitoring of muscle evoked potentials elicited by transcranial electric stimulation (BR (E)-MSEP) has been performed at our department in cases involving a high risk of postoperative nerve palsy during the intraoperative period.

OBJECTIVE: Here, we estimate the utility of BR (E)-MSEP monitoring procedure in total hip arthroplasty.

METHODS: Since 2006, BR (E)-MSEP has been used during THA surgeries in eleven joints (nine joints from seven females, two joints from two males). The average age of the patients was 59.4 years (range, 38-71 years). A total of 10 cases involved leg lengthening greater than 3 cm in planning. One case involved leg lengthening less than 3 cm. This patient, however, displayed sciatic nerve palsy during surgery of the contralateral joint.

Only intravenous anesthesia was used during MSEP monitoring, because inhalational anesthetics have an inhibitory effect on synaptic activity.

Measurements of MSEP (quadriceps femoris, tibialis anterior, and flexor hallucis brevis) were performed prior to beginning surgery, pre- and post-reduction of the hip joint, and following surgery at 5-min intervals. Additional measurements were taken if needed.

We investigated the relation of depression of BR (E)-MSEP amplitude during surgery and the postoperative nerve palsy, and also investigated the amount of intraoperative leg lengthening.

RESULTS: In 3 of the 11 patients, the post-reduction period showed more than 50% depression in amplitude compared to the pre-reduction period. In each case, there was no disappearance of the electrical potential. In 2 cases, reducing the lengthening of the legs resulted in intraoperative recovery of the electrical potential. In addition, postoperative nerve palsy was observed in neither case. In one remaining case, we gave priority to leg lengthening and performed the operation under low electrical potential conditions. Transient postoperative tibial nerve palsy was observed in that case, and the palsy was recovered 1.5 years after the operation. In the eight cases that did not show depression of the potential amplitude, postoperative nerve palsy was not observed. The depression in the amplitude of the electric potential was perfectly correlated with postoperative nerve palsy. The average leg lengthening was 3.4 cm (range, 1.5-4.8 cm).

CONCLUSIONS:

1) BR (E)-MSEP monitoring at the end of surgery indicated that changes of electric potential amplitude were correlated with postoperative nerve palsy.

2) Using BR (E)-MSEP monitoring, it was possible to lengthen the legs to a maximum of 4.8 cm without postoperative nerve palsy.

3) The results suggest that BR (E)-MSEP monitoring is useful for patients who are at high risk of nerve palsy in THA.

H551

Prevalence of Iliopsoas Bursitis in Patients with Hip Disease

Primary Author: Makoto Komatsu

Institution: Department of Orthopaedics Surgery, Kochi Prefectural Hata-Kenmin Hospital

Coauthors: Junpei Dan (Department of Orthopaedics Surgery, Kochi University), Kenichi Kitaoka (Department of Orthopaedics, Kochi Prefectural Hata-Kenmin Hospital), Yusuke Okanoue (Department of Orthopaedics Surgery, Kochi University), Yoshinori Satake (Department of Orthopaedics Surgery, Kochi University)

INTRODUCTION: Iliopsoas bursitis is a relatively rare condition that is associated with hip diseases, including hip osteoarthritis and rheumatoid arthritis. We report the prevalence of iliopsoas bursitis in patients undergoing total hip arthroplasty (THA) by examining their preoperative CT.

SUBJECTS AND METHODS: The subjects of the present study were 125 patients who underwent THA at our hospital between May 2010 and June 2013. There were 29 men and 96 women, with a mean age of 68 years (range, 29 to 87 years). The underlying disease included hip osteoarthritis in 104 patients, avascular necrosis of the femoral head in 18 patients, and other diseases in 13 patients.

We reviewed the CT images of the hip in the 125 patients and examined the prevalence and size of iliopsoas bursitis. We defined iliopsoas bursitis as a swelling of the iliopsoas bursa located superior to the femoral head, pubic symphysis, or lesser trochanter.

RESULTS: Of the 125 patients, iliopsoas bursitis was found in 12 (9.6%) patients, consisting of 3 men and 9 women, with a mean age of 72.5 years. The underlying diseases included hip osteoarthritis in 10 patients and avascular necrosis of the femoral head in 2 patients. The iliopsoas bursitis was observed on the affected side in all the 12 pa-

tients. One patient with significant swelling had a blood circulatory disorder of the legs.

DISCUSSION: The iliopsoas bursa is the largest bursa in the body and is present bilaterally in 98% of adults. Anatomically, the iliopsoas bursa is located anterior to the hip joint, having an average size of 3°–6 cm, and communicates with the hip joint in 15% of adults. In some cases, an enlarged bursa may affect the femoral artery, vein and nerve in the adjacent area, leading to swelling of the leg or femoral neuropathy. Treatment of iliopsoas bursitis usually consists of rest and conservative treatments, including steroid injections and aspiration of fluid. Surgery becomes an option when conservative treatment fails. Iliopsoas bursitis was first described in 1834 by Fricke. In Japan, about 80 cases had been reported by 2007. In a prevalence study using ultrasound by Sandro et al., the prevalence rate was reported to be 2.2%.

In the present study, iliopsoas bursitis was found in 12 (9.6%) of the 125 patients undergoing THA. In all the patients, the bursitis was observed on the affected side. The results of the present study revealed that iliopsoas bursitis is not a rare condition in patients undergoing THA for hip disease. We propose to conduct a study with a larger number of cases to examine the influence of iliopsoas bursitis on the clinical results.

H552

Development of the Software “ACX Dynamics” to Evaluate the Acetabular Coverage Using a Radiograph of Pelvis

Primary Author: Hiroshi Koyama

Institution: Department of Orthopaedic Surgery, Hamamatsu University School of Medicine

Coauthors: Hiroki Furuhashi (Orthopaedic Surgery, Hamamatsu University School of Medicine), Mitsuru Hanada (Orthopaedic Surgery, Hamamatsu University School of Medicine), Masaaki Takahashi (Orthopaedic Surgery, Jyuzen memorial Hospital), Hironobu Hoshino (Orthopaedic Surgery, Hamamatsu University School of Medicine)

BACKGROUND: In 1990, Konishi developed the software “ACX” to evaluate the three dimensional acetabular coverage using a plain radiograph of pelvis. The software allows us to calculate acetabular coverage by the geomet-

rical method and represent it by cranio-caudal projection. However, ACX was impossible to correct the pelvic rotation. Therefore, we have developed new software “ACX dynamics” which includes the algorithm of correction for pelvic rotation.

PURPOSE: We investigated which radiographic index of pelvic rotation was useful for the calculation of the acetabular coverage by ACX dynamics.

MATERIALS AND METHODS: We reviewed CT images from 30 patients (30 non-operative hip joints with no osteoarthritic changes) and used DICOM data from the CT images. Utilizing the software (Zed Hip, LEXI Corp, Tokyo, JAPAN) for THA preoperative three-dimensional planning, we created a virtual three dimensional bone model and digitally reconstructed radiographic images (DRR), substituting for plain AP radiographs, of the pelvis with five degrees rotation anteriorly or posteriorly to anterior pelvic plane. Then we calculated the acetabular coverage by ACX dynamics, utilizing 60 DRR images of the pelvis in the rotational positions. In calculation by the algorithm to correct the pelvic rotation in ACX dynamics, three radiographic indices of pelvic rotation (A: the horizontal distance between pubic symphysis and center of sacrococcygeal joint, B: the ratio which was represented the distance between pubic symphysis and the midpoint of inter-teardrop distance divided by inter-teardrop distance, C: the ratio of transverse diameters of bilateral obturator foramen) were used. Using these three indices, pelvic rotation was calculated and corrected to neutral pelvic position. The acetabular coverage ratio in the three areas (total, anterior 1/2 and posterior 1/2) were calculated by ACX dynamic in neutral pelvic position and compared with those directly measured by three dimensional CT model (3D-CT).

RESULTS: In the images of the rotational pelvis of five degrees, the average rotational angle of index A was 8.4°, 4.8° for B and 1.0° for C, which suggested that index B indicated the closest rotation values. The percentage difference between the acetabular coverage rate calculated by ACX dynamics and by 3D-CT, revealed no significant differences among three indices in all areas (total: A -3.3%, B -3.1%, C -3.3%, anterior 1/2: A 3.2%, B 3.4%, C 3.6%, and posterior 1/2: A -9.8%, B -9.9%, C -9.9%).

CONCLUSIONS: We tested rotational correction using three different indices in combination with ACX dynamics to calculate the acetabular coverage. There were no signifi-

cant differences among three indices in the acetabular coverage rate by ACX dynamics. Index B showed the closest value of pelvic rotational angle.

H553

Results of Total Hip Replacement in Patients Having Post Traumatic Arthritis Following Acetabular Fractures

Primary Author: Vijay Kumar

Institution: All India Institute of Medical Sciences

Coauthors: Bhavuk Garg (AIIMS), Rajesh Malhotra (AIIMS)

INTRODUCTION: Total hip arthroplasty is a treatment option for patients who present with symptomatic post-traumatic arthritis following acetabular fractures.

MATERIALS AND METHODS: Twenty total hip arthroplasty were performed with use of a cementless cup in 17 patients and cemented cup in a cage in 3 patients for the treatment of posttraumatic osteoarthritis following acetabular fracture. The average age of the 4 women and 16 men was 49 (range, 26 to 86 years) at the time of the arthroplasty. The median interval between the time of injury and the total hip arthroplasty was 37 months (range, 8 to 144 months). The average operative time was 120 minutes and average intraoperative blood loss was 700 ml. Eight patients had previous open reduction and internal fixation of the acetabular fracture and twelve had been treated non-operatively. Following total hip replacement, each patient was evaluated clinically and radiographically at six weeks, three months, six months and twelve months, and then yearly following total hip replacement. The average duration of clinical and radiographic follow-up was 46 months (range, 26 to 60 months).

RESULTS: At the time of final follow-up, of twenty acetabular components, 10 had no evidence of periacetabular radiolucency, 7 components had a partial radiolucency that was 2 mm in width without showing component migration. According to Engh's criteria, 16 (80%) femoral stems had bony ingrowth and 4 (20%) stems had stable fibrous ingrowth. The average preoperative Harris hip score improved from 35 points to 78 points at the time of final followup.

CONCLUSION: Total hip arthroplasty for arthritis following acetabular fractures, technically difficult because of extensive scarring, heterotopic bone, retained internal fixation devices, and residual deformity of the acetabulum.

H554

Results of Use Two-stage Revision of Infected Hip Arthroplasty

Primary Author: Vijay Kumar

Institution: All India Institute of Medical Sciences

Coauthors: Bhavuk Garg (AIIMS), Rajesh Malhotra (AIIMS)

INTRODUCTION: An infected Total Hip replacement requires long-term treatment and eventually may lead to amputation or arthrodesis, involving immeasurable physical and psychological suffering for the patient.

We report the treatment outcome of two-stage revision THA for infected hip arthroplasty, including hemiarthroplasty, using an antibiotic-impregnated cement spacer for the interval between the first and second stages.

MATERIAL AND METHODS: To fabricate the spacer, antibiotic-loaded cement was inserted into a specially designed mold. A central rod pin was superficially imbedded as an endoskeleton once the cement reached a doughy state. After polymerization, the final product was removed from the mold and inserted as an articulating spacer. The first stage operation involved complete debridement, removal of infected prosthesis, implantation of cement spacer with antibiotics, and concomitant administration of 3 weeks of intravenous (IV) and 1 month of oral antibiotic. After eradication of infection, it was converted to THA in the second stage.

RESULTS: 27 patients with infected Total hip replacement were treated in 2 stages using an antibiotic impregnated spacer. The mean duration of follow-up was 32 months (range 10-45 months). Average Harris hip score improved from 38 before surgery to 95 at final follow-up. The mean interval between the first and second stages was 10.1 weeks (range 6-19 weeks). Of the 27 hips, 24 were successfully converted to THA whereas resection arthroplasty was done in 3 cases. Complications with the spacer included 2 fractures and 2 dislocations.

DISCUSSION: This cost-effective technique provides efficient local antibiotic delivery, early mobilization, facilitation of reimplantation, prevents leg-length discrepancy and atrophy of bones or muscles and improved patient satisfaction.

SUMMARY: Two-stage revision THA using an antibiotic-impregnated cement spacer is a useful technique for treating infected hip arthroplasty.

H555

Trabecular Metal Cup-cage Construct in Management of Acetabular Bone Defects

Primary Author: Vijay Kumar

Institution: All India Institute of Medical Sciences

Coauthors: Bhavuk Garg (AIIMS), Rajesh Malhotra (AIIMS)

INTRODUCTION: The management options of type 3B Paprosky acetabular defects are limited with allograft and conventional cages. Trabecular metal technology has evolved to address these bone defects. Trabecular metal acetabular revision system (TMARS) cup-cage construct is an innovative technique to address massive acetabular defects. We describe the results of cup cage construct used for acetabular revision at our centre.

MATERIALS AND METHODS: 10 cases of failed total hip arthroplasty were revised using a trabecular metal cup-cage construct on the acetabular side between 2007 and 2009. Six out of these cases were second stage reconstruction for a septic failure of THA. A cementless femoral stem was used in all of these patients. The patients were assessed clinically and radiologically at 6 monthly intervals.

RESULTS: The average age of the patients was 66 (range, 62-74). There were 8 males and 2 females. The mean follow-up was 3 (4-6) years. The mean Harris Hip Score improved from 34 points preoperatively to 76 points at the last review. There was no migration, or, loosening or osteolysis around the acetabular cup and cage at the time of final follow up and all acetabular components were well osteointegrated. All femoral stems also showed evidence of osteointegration.

DISCUSSION: In the face of a severe acetabular osseous

deficiency incapable of providing support to the acetabular component, additional fixation of a cage over the trabecular metal shell helps in anatomic restoration of hip centre and provides stability and support to the trabecular metal cup till osteointegration. Trabecular metal cup -cage construct can be used to address massive acetabular bone deficiencies. The properties of high porosity (80%), coefficient of friction, and intrinsic strength of trabecular metal cup provides greater stability and an environment conducive for bone in growth defects encountered at the time of acetabular revision.

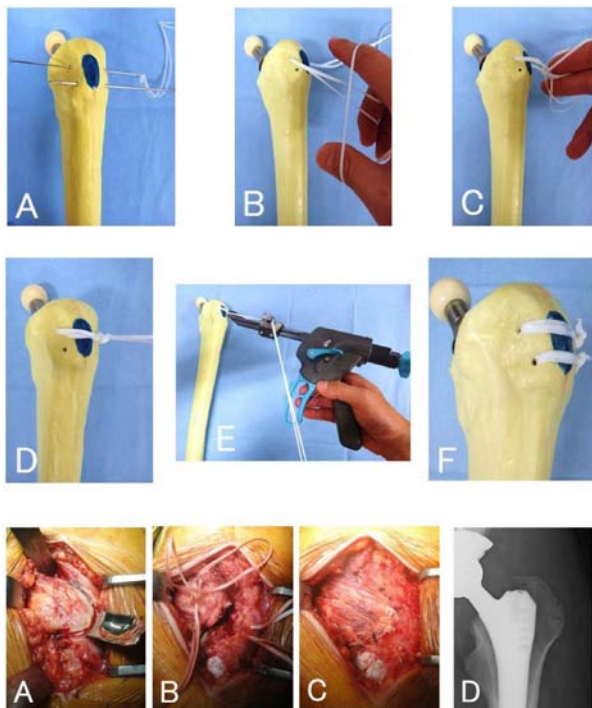
H556

A Novel Technique Using Ultra-High Molecular Weight Polyethylene Tapes for the Minitrochanteric Approach in THA

Primary Author: Yutaka Kuroda

Institution: Department of Orthopaedic Surgery, Graduate School of Medicine, Kyoto University

Coauthors: Manabu Nankaku (Rehabilitation Unit, Kyoto University Hospital), Kazutaka So (Department of Orthopaedic Surgery, Graduate School of Medicine, Kyoto University), Shuichi Matsuda (Department of Orthopaedic Surgery, Graduate School of Medicine, Kyoto University)



Lateral approaches such as Hardinge or Bauer are still com-

monly used in total hip arthroplasty (THA) due to good overview and low complication rates. The only drawback of these approaches is that the abductor mechanism may be broken because they damage the important tendinous insertion of abductor muscles using an electrocautery. For the promising anatomical repair, we describe an improving mini-trochanteric technique using flexible ultra-high molecular weight polyethylene (UHMWPE) tapes instead of conventional polyester sutures. The minitrochanteric fragment, which is a half-ellipsoid body, can be reattached easily by inducing bone-to-bone contact using 3 mm-wide UHMWPE tapes. By the antero-lateral approach, blunt dissection is performed through the anterior one-fourth of the gluteus medius. To retain the tendinous junction of gluteus medius and minimus, the minitrochanteric osteotomy, a half-ellipsoid body about 15 mm long, 10 mm wide, and 5 mm deep, is performed using a curved chisel. The trochanteric fragment and its muscle attachments, including gluteus minimus and medius, are mobilized anteriorly and medially. By splitting gluteus medius in 1/4 of its anterior, most of the gluteus medius is left intact adding the vastus lateralis completely intact. At the end of the operation, the anterior trochanteric fragment is anatomically reattached easily by inducing bone-to-bone contact. Using 2.4 mm Kirshner wire, two sets of drill holes are created below the trochanteric bed of the femur. Two No.5 Ethibond sutures (Ethicon, Somerville, NJ) or two 3-mm wide Nesplon tapes (Nesplon; Alfresa Pharma, Osaka, Japan) are passed through each drill hole and penetrated over the trochanteric fragment. The trochanteric fragment is restored by two No.5 Ethibond sutures or two Nesplon tapes. Ethibond suture is tied using a double-loop sliding knot manually avoiding bony cutout and loosening. Nesplon tape is knotted and tightened in the same way using a special tensioner device. Nesplon tape is knotted once and tightened using a special tightening gun tensioner up to 20 kgf. We evaluated 120 consecutive primary THAs performed the minitrochanteric approach involving trochanter reattachment using braided polyester suture (Ethibond group, n=60) and using UHMWPE tape (Nesplon group, n=60). The abductor repair was assessed by the recovery rate of abductor strength examined at four weeks after THA and the radiographs at six months postoperatively. Clinical score were assessed one year postoperatively. For the patients in Nesplon group (0%, 1.7%), statistically significant lower incidence of nonunion and cutout was seen compared with Ethibond group (8.3%, 15%). Recovery rate of the hip abductor strength was significantly higher in the union group than those in the cutout and nonunion group.

H557**Acetabular Medial Wall Displacement Osteotomy in THR for Dysplastic Hips***Primary Author: Suc-hyun Kweon**Institution: Wonkwang University Hospital**Coauthors: Tae-gyun Kim (Wonkwang University Hospital), Jeong-woo Kim (Wonkwang University Hospital), Jeong-geun Kim (Wonkwang University Hospital)*

PURPOSE: This study evaluated the results of acetabular medial wall osteotomy to reconstruct the acetabulum in dysplastic hip during total hip arthroplasty.

MATERIALS AND METHODS: We clinically and radiologically evaluated 30 hips of 30 patients with secondary hip osteoarthritis caused by congenital hip dislocation or acetabular dysplasia who underwent total hip arthroplasty (THA) between March 1999 and October 2002. The average age of subjects was 46.5 years (17 to 73 years), and the mean follow-up period was 5 years (5.3 to 8.7 years). In 26 cases, a cementless hemispherical acetabular cup was inserted in the true acetabulum; in 4 cases a reinforced ring was inserted. Only 2 hips needed structural bone grafting.

RESULTS: The average Harris hip score improved from 56.3 points preoperatively to 93.2 points at the last follow up. Radiographic analysis revealed no aseptic loosening or radiolucent line, and showed stable bony fixation at the true acetabulum. The mean thickness of the medial acetabular wall postoperative was 20.5 mm (10 to 36 mm). Bone union of the medial wall was observed at a mean of four months postoperatively.

CONCLUSION: Acetabular medial wall osteotomy can maintain the integrity of the acetabular medial wall while achieving enhanced acetabular coverage and more normal hip biomechanics.

KEY WORDS: Acetabular dysplasia, Acetabular medial wall osteotomy, Total hip arthroplasty

H558**Smart PEEK Modified by Self-Initiated Surface Graft Polymerization for Orthopedic Bearings***Primary Author: Masayuki Kyomoto**Institution: The University of Tokyo**Coauthors: Toru Moro (The University of Tokyo), Shihori Yamane (KYOCERA Medical Corporation), Kenichi Watanabe (KYOCERA Medical Corporation), Yoshio Takatori (The University of Tokyo), Sakae Tanaka (The University of Tokyo), Kazuhiko Ishiha (The University Of Tokyo)*

Poly (ether-ether-ketone) (PEEK) is considered a promising novel biomaterial for orthopedic applications because it exhibits excellent mechanical properties and non-magnetic nature. However, conventional PEEK cannot satisfy the requirements, e.g., wear resistance and biocompatibility for use in the fabrication of an artificial joint. We propose here, a new and safer method for constructing a nanometer-scale modified surface on the PEEK and carbon-fiber-reinforced PEEK (CFR-PEEK) substrates by self-initiated photoinduced graft polymerization. The graft polymerization was brought about by the generation of semi-benzopinacol-containing radicals of the benzophenone units in PEEK molecular structure, which acted as a photoinitiator. This polymerization system was realized in the absence of a photoactive low molecular compound and in an aqueous medium; these are human-friendly and exhibit excellent biocompatibility. In this study, we have demonstrated the fabrication of modified surface with biocompatible polymer, i.e., poly(2-methacryloyloxyethyl phosphorylcholine) (PMPC) using the graft polymerization.

PEEK and CFR-PEEK specimens were fabricated without the use of stabilizers, and were immersed in an MPC aqueous solution. Photo-induced graft polymerization was carried out on the PEEK and CFR-PEEK surfaces under UV irradiation. The surface properties of the PMPC-grafted PEEK and CFR-PEEK were examined using Fourier transform infrared spectroscopy (FT-IR), X-ray photoelectron spectroscopy (XPS), atomic force microscope, transmission electron microscope, static water-contact angle measurement, and friction test. The wear test of the PMPC-grafted PEEK and CFR-PEEK liner against the Co-Cr alloy femoral head was performed using a 12-station hip joint simulator according to ISO14242-3. The mechanical (tensile, flexural, small punch, and creep deformation)

properties of PMPC-grafted PEEK and CFR-PEEK were evaluated according to ASTM F2026.

After grafting, the peaks ascribed to the PMPC unit were clearly observed in both FT-IR and XPS spectra. Smooth 100-nm-thick PMPC layers were clearly observed on the surface of the PEEK substrate [Fig. 1]. The contact angle and coefficient of dynamic friction of PMPC-grafted PEEK decreased markedly to 7° and 0.010, respectively, after PMPC grafting; these values imply a reduction of more than 90% as compared to those for untreated PEEK. The gravimetric wear in the PMPC-grafted PEEK was significantly lower than that in the untreated PEEK [Fig. 2]. The mechanical properties remained unchanged even after PMPC grafting, and met the ASTM requirements.

We successfully demonstrated the fabrication of a highly hydrophilic and biocompatible nanometer-scale modified surface by PMPC grafting onto the PEEK and CFR-PEEK surfaces. The hydrophilic PMPC-graft layer caused a significant reduction in the sliding friction of the bearing interface because the thin water film and hydrated PMPC layer that were formed acted as extremely efficient lubricants, so called fluid-film lubrication (or hydration lubrication). The fluid-film lubrication suppressed the direct contact of the counter-bearing face with the PEEK substrate to reduce the frictional force. Thus, the PMPC-graft layer was expected to significantly increase the durability of the bearings. The retention of the mechanical properties was important for clinical use because the PEEK acted not only as surface-functional materials but also as structural materials. The smart PEEK by using the self-initiated surface graft polymerization of PMPC will bring novel orthopedic bearings.

H559

Development of an Inverse Solution Hip Model to Determine In Vivo Kinetics During Hip Separation

Primary Author: Michael T. LaCour

Institution: University of Tennessee Knoxville

BACKGROUND: A continuing goal of implant design companies is to develop implants that accurately mimic native joint kinematics and avoid irregular complications. For total hip arthroplasty (THA), the most common complication is separation and dislocation of the femoral head

within the acetabular cup, and it has been shown that this problem occurs most frequently in gait and adduction/abduction activities.

QUESTIONS/PURPOSES: The objective of this study was to develop an inverse mathematical model of the hip to analyze hip separation by accepting known hip separation kinematics and calculating the resultant muscle and ligament forces that ensue.

METHODS: The mathematical model was developed using the symbolic manipulation program known as Autolev. The model currently incorporates 7 bodies (toes, foot, tibia, patella, femur, pelvis, torso) and 7 muscles (vastus medialis, vastus intermedius, vastus lateralis, rectus femoris, gluteus maximus, gluteus minimus, gluteus medius). Each muscle is represented as multiple lines acting over an attachment area and includes a realistic wrapping algorithm. The model assumes that the THA components are rigidly attached to the bones. Additionally, the model incorporates vital knee and hip capsular ligaments (patellar ligament, ACL, PCL, ischiofemoral ligament, iliofemoral ligament, etc.) which were modeled as nonlinear springs under the notion that ligaments cannot exert compressive forces. A validated 3D-to-2D registration technique was used to extract the relative motion of the bones and implant components throughout activity duration. The current mathematical model is equipped to handle the stance phase of a gait cycle, and kinetic parameters of interest included knee forces, hip forces, quadriceps and gluteus muscle activations, and hip capsular ligament responses.

RESULTS: During a normal gait activity, maximum compressive knee forces ranged from $1.5 - 2.0 \times \text{BW}$ and maximum compressive hip forces ranged from $1.7 - 2.3 \times \text{BW}$. The quadriceps muscle group applied between $0.9 - 1.1 \times \text{BW}$, and the gluteus muscle group applied between $0.6 - 0.8 \times \text{BW}$. The iliofemoral ligament was the primary hip capsular ligament to exert a force throughout the activity, with a maximum tensile force ranging between $0.8 - 1.2 \times \text{BW}$. During a hip-separation gait activity, each aforementioned force followed similar patterns initially until the separation occurred. Hip separation caused a spike in compressive hip forces of $0.3 - 0.5 \times \text{BW}$, a spike in the gluteus muscle group of $0.1 - 0.3 \times \text{BW}$, and a spike in the iliofemoral ligament tensile force of $0.2 - 0.4 \times \text{BW}$. Compressive knee forces and the quadriceps muscle group experienced negligible change.

CONCLUSIONS: This study demonstrates the ability of a mathematical model to predict muscle and ligament responses to hip separation kinematics during gait. This mathematical model can therefore be used as a tool to develop a greater understanding of the causes and effects of hip separation. Furthermore, the success of this inverse model provides the groundwork for the development of a forward solution model, which can ultimately be used as a more powerful tool to aid in the comparison between surgical techniques and the development of new implant designs.

H560

Novel Femoral Stem Design for Non-Traumatic Avascular Necrosis: Biomechanical Investigation

Primary Author: Yu-Shu Lai

Institution: Orthopaedic Device Research Center, National Yang Ming University

Coauthors: Wen-Chuan Chen (Orthopaedic Device Research Center, National Yang Ming University), Cheng-Kung Cheng (Institute of Biomedical Engineering, National Yang Ming University)

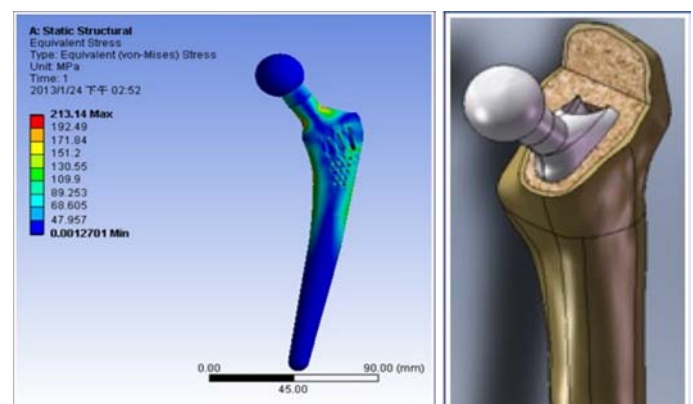
INTRODUCTION: In total hip replacement surgery, many clinical reports showed a lower implant survival rate when comparing the non-traumatic avascular necrosis (AVN) patients with the osteoarthritis patients. Inferior bone quality and young age (more active) are the key factors that cause the poor outcome. In addition, non-traumatic AVN is the main disease (47%) in total hip replacement in China. However, the major indication for most of the commercial hip prostheses is osteoarthritis. The primary aim of this study was to design and develop a new hollow femoral stem which can provide enough medullary space for revascularization and decrease the stress shielding effect for non-traumatic AVN patients. In order to provide a good initial and long-term stability, the stem was designed to fit the canal geometry of Chinese population. The mechanical properties, stress shielding levels, and initial stabilities were then evaluated by using 3-D finite element models.

METHODS: Finite element models of a proximal femur and the hollowed stem were built and utilized to evaluate the stem fatigue strength and initial stability. In the stem fa-

tigue strength test, a loading condition which followed the ISO7206-4 was applied on the femoral head of the stem. In the initial stability evaluation, the stem was inserted into a femur model and the loading condition was set to simulate the bearing status of the hip joint during heel strike. The initial stability was evaluated by the micro motion at the contact surface between the stem and bone.

RESULTS: The medial canal curve of the hollowed stem was designed to conform to our previous measurement of Chinese patients. A 3-D model was then built with a better-fitted contour. The stress distribution of the new hollowed stem is shown in the attached figure. The maximum von Mises stress, 213.14 MPa, was located on the stem neck. The fatigue test of 5° — 106 cycles showed the results of a minimum safety factor of 1.83 and a predicted life of 109. The stress shielding effect around the medial canal was reduced by 10% comparing with the solid stem. A 12% increase of initial stability on the new hollowed stem was demonstrated.

DISCUSSION AND CONCLUSION: The solid stems that commonly used in current market are short of medullary space for revascularization. In this study, we developed a new 3-D model of a hollow femoral stem and proved that it is mechanically applicable. By comparing with the solid stem, we concluded that our hollowed stem was able to reduce the stress shielding effect and increase the initial stability. Furthermore, our modified contour is able to fit the medial canal geometry of Chinese population.



H561

Adverse Wear Related Failure for Metal-on-Metal Hip Resurfacing

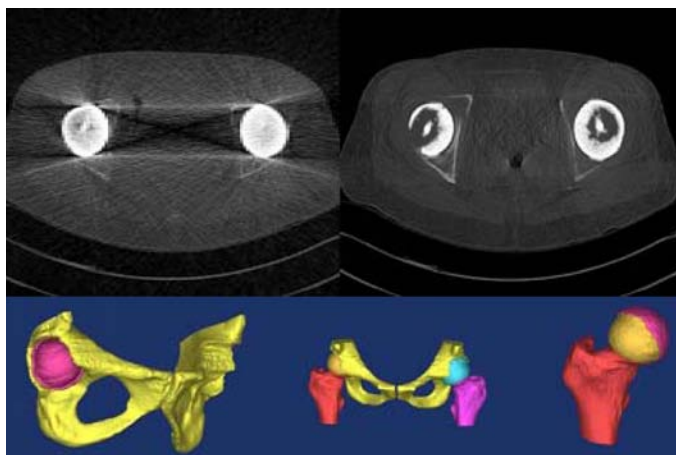
Primary Author: Fei Liu

Institution: Midlands Orthopaedics, P.A.

Coauthor: Thomas P. Gross (Midlands Orthopaedics, P.A.)

INTRODUCTION: Adverse wear related failure (AWRF) after metal-on-metal hip resurfacing arthroplasty (HRA) has been described as a new failure mechanism. We describe the results of revision of these failures.

METHODS: Between July 1999 and Jan 2014, a single surgeon performed 3407 HRA. Nine (9/3407; 0.3%) cases in 8 patients were revised due to AWRF. In two additional revisions for AWRF the primary HRA was done elsewhere. There are a total of 11 revisions (9 women, 2 men) for AWRF cases reported in this study. The primary diagnoses were OA in 7 and dysplasia in 4. At the time of the primary surgery, the average age was 50 ± 5 years and the average BMI was 27 ± 4 . The average femoral component sizes were 46 ± 3 mm. Only the acetabular component was revised in eight cases, both components were revised in 4 cases (revised to THA), three of these four used metal on metal bearings. A postop CT was requested for all patients after revision. 4 scans were of sufficient quality to analyze implant positions. Algorithms for metal artifact reduction were utilized to obtain high quality 2D images (Figure 1); 3D CAD models of the bones and implants were regenerated in order to calculate the acetabular inclination and anteversion angle (Figure 2).



RESULTS: Prior to revision, all 11 cases had acetabular inclination angles on standing radiographs (AIA) great-

er than 50° (mean 56° range: 51° - 60°) and Cobalt blood levels greater than $10 \mu\text{g/L}$ (mean $94 \pm 64 \mu\text{g/L}$, range: 12 - $173 \mu\text{g/L}$). Chromium levels were a mean of $50 \pm 33 \mu\text{g/L}$ (range: 8 - $111 \mu\text{g/L}$). 3D studies showed fluid collections and metallosis was seen in all cases. The mean follow-up length after revision was 2.4 ± 1 years. In 4 cases the postop CT could be used to accurately measure implant positions resulting in a mean $\text{AIA} = 34^\circ \pm 9^\circ$ and a mean anteversion angle of $18^\circ \pm 4^\circ$. Metal ion tests were available for 7 cases at least 1 year after revision. Cobalt levels were reduced to a mean of $4.1 \pm 3.1 \mu\text{g/L}$ (range: 1.5 - $6.2 \mu\text{g/L}$) and Chromium levels fell to $6.3 \pm 2.9 \mu\text{g/L}$ (range: 3.4 - $10.9 \mu\text{g/L}$). The mean HHS was 93 ± 15 . There was one failure of acetabular component fixation, which required repeat revision. Her latest HHS was 100 one year after the second surgery. For all revisions, the mean operative time was 123 ± 15 min, incision length was 5 ± 1 inch, estimated blood loss was 258 ± 82 cc, and hospital stay was 1.3 ± 0.5 days. There were no other major complications including no nerve palsies, vascular injuries or abductor mechanism disruptions. No patients limped.

CONCLUSION: Our study suggests AWRF in HRA can successfully be revised with metal-on-metal surfaces. Revision of the femoral component is not necessary despite the abnormal wear. Correction of the steep AIA is the key to success. This confirms the concept that edge loading, leading to a high wear state, rather than allergy to metal is the cause of these failures.

H562

High Impact Sports After Metal-on-Metal Hip Resurfacing Arthroplasty

Primary Author: Fei Liu

Institution: Midlands Orthopaedics, P.A.

Coauthor: Thomas P. Gross (Midlands Orthopaedics, P.A.)

INTRODUCTION: One reason that young and active patients choose hip resurfacing arthroplasty (HRA) rather than stemmed total hip arthroplasty (THA) is that they wish to return to high impact sports after their operation. Few studies have addressed the outcome in hip arthroplasty patients who choose to participate in high impact sports post-operatively. We therefore wanted to determine if the durability of HRA in highly active patients was decreased.

METHODS: From 5/2001 to 5/2011, a single surgeon per-

formed 2434 HRA cases in 2013 patients. The study group consists of all patients that had a UCLA Activity score of 9 or 10 at any point after surgery in our prospective database. There were 936 (38%) cases in 776 patients who reported participating in high impact sports at some point after surgery. This group was compared to the entire database. The mean age of the study group was 50 ± 8 years, which was significantly younger than the entire group ($P = 0.0007$). 82% of the study group was male compared to 73% in the entire group ($P < 0.0001$). 85% of the primary diagnoses were osteoarthritis in the study group compared to 78% in the entire group ($P < 0.0001$), followed by dysplasia (8%) and osteonecrosis (4%).

RESULTS: For the study group, the average follow-up length was 4 ± 2 years. 389 (42%) cases had at least 5 years follow-up. 10 (1%) revisions were identified: five (0.5%) due to femoral component loosening; two (0.2%) due to adverse wear; two (0.2%) for acetabular component loosening; one (0.1%) for acetabular fracture. There was no difference in the failure rate due to any specific complication type. The Kaplan-Meier survivorship rate was 99.5% at 5 years and 95.8% at 10 years, which compared to 96.9% at 5 years and 91.6 at 10 years for the entire group. 61 cases had the acetabular inclination angles $>50^\circ$; 2 of which were revised for adverse wear related failures. Metal ion test results were available for 52% cases in the study group. Metal ion levels were $\geq 7 \mu\text{g/L}$ in 18 (1.9%) cases and $\geq 10 \mu\text{g/L}$ in 11 (1.2%). Excluding the failed cases, the average Harris hip scores were 99 ± 3 for the study group which was significantly better than the entire group ($P < 0.0001$).

DISCUSSION: When compared to the entire database, hip resurfacing patients that participate in high impact sports after surgery have a significantly higher HHS; they have a similar 10-year survivorship of 95.8%; they have a similar low adverse wear failure rate of 0.2%. We therefore conclude that a patient's activity level has little effect on the 10 year outcome of HRA and that restrictions are therefore not necessary after hip resurfacing.

H563 Long Term Results of Acetabular Reconstruction with Mueller Reinforcement Ring

Primary Author: Akihiko Maeda

Institution: Showa University Northern Yokohama Hospital

INTRODUCTION: Mueller reinforcement ring is one of the popular device for acetabular reconstruction. Since 1990 we have started to use this implant for acetabular reconstruction with morcellised bone allograft impaction. This study is to report the long term results of acetabular reconstruction with this ring.

MATERIALS AND METHODS: Between December 1990 and December 1994, total 57 rings (54 patients) were used for revision surgery in our institution. Mean age at the surgery was 59(31-78). 11 patients died during follow up and 13 patients were lost to follow up. 31 joints (30 patients) could be evaluated by direct medical examination after January 2006. Average follow up period for these patients was 14.9 years(11Y11M-19Y1M).

RESULTS: There are no breakage of the rings and screws and ring-inlay interfaces. 1 patient went to re-revision surgery by acetabular side loosening. 5 patients went to re-revision by stem loosening. Mean Japan Orthopaedic Association Hip score was 78.8 points at post operative one year and 73.2 at the last follow up. Radiolucent lines according to DeLee and Charnley were observed 2 joints in zone 2 and 4 joints in zone 3.

CONCLUSION: Long term results of acetabular reconstruction with mueller ring is acceptable. This method is reliable and long term results can be expected.

H564 Over 20 Years Results of Cementless Total Hip Prosthesis

Primary Author: Akihiko Maeda

Institution: Showa University Northern Yokohama Hospital

Coauthors: Noriyuki Hemmi (Showa University Northern Yokohama Hospital), Koji Sunami (Ebina General Hospital), Atsushi Kusaba (Ebina General Hospital), Saiji Kon-do (Ebina General Hospital)

INTRODUCTION: Long lasting osteointegration is one of the important key to achieve the success of cementless implant. In 1982, cancellous bone like porous struc-

ture made with cobalt, chromium and molybdenum cast alloy was developed. Pore size was between 800 and 1500 microns with 60% porosity. The pore depth of the inter-connecting surface structure reached up to 3000 microns. Based on this porous structure, cementless total hip system with a hemi-spherical cup and an anatomically adapted stem were introduced in 1983. The purpose of this retrospective study is to report the long term results of this cementless total hip arthroplasty.

MATERIALS AND METHODS: Between 1986 and end 1990 total 113 prostheses were implanted and consecutive 106 implants could be evaluated. Single surgeon had done all surgery with antero-lateral approach. The all evaluated prosthesis combined 28mm alumina ceramic head and asymmetric polyethylene inlay.

RESULTS: Average follow up period was 22.1 years. 3 cups and 1 stem were revised by aseptic loosening. 2 stem breakage and 9 ceramic head fracture were seen while following up. 86% of the patients had retained the original prostheses (cup, stem, ceramic head and inlay) post operative 20 years. Survival rate was investigated by Kaplan-Meier method. Survival rate for the cup component was 95%, and for the stem component was 91.7% at post operative 20 years.

DISCUSSION: Main reason of the revision surgery was the ceramic head fracture (9 implants 8.5%) On the other hand, few aseptic loosening was seen while following up. These results suggest that this system can bear for long term of use.

CONCLUSION: 86% of the patients had retained the original cementless hip prostheses average 22.1 years following up period. This cancellous bone like porous structure made with cobalt, chromium and molybdenum cast alloy can hold long time osteointegration and good fixation.

H565

Proximal Femoral Allograft - Prosthesis Composite in Treatment of Recurrent Giant Cell Tumour of Proximal Femur

Primary Author: Rajesh Malhotra

Institution: All India Institute of Medical Sciences

Coauthors: Vijay Kumar (AIIMS), Bhavuk Garg (AIIMS)

INTRODUCTION: Giant cell tumors usually affect young patients and conservative surgical treatment often leads to local recurrences. Radical excision creates the challenge of a massive bone defect and long life expectancy of the patient where a cure is achieved.

OBJECTIVE: To report the result of use of proximal femoral allograft in treatment of recurrent giant cell tumor of proximal femur.

METHODS: 6 patients with recurrent Giant cell tumor of proximal femur were treated with proximal femoral allograft composite with a total hip replacement. The allograft-prosthesis composite was made by cementing cementless femoral stem in the allograft and implanting the composite in a cementless manner in the host femur through a stepcut junction. Cementless cup was implanted in the acetabulum in all cases using the largest possible femoral head size. Postoperatively, the patients were kept on protected weight bearing for 6 months.

RESULTS: The average age of the patients was 45 years (range, 42 to 47 years). The average number of surgeries before presentation was 2.4. The average follow up was 40 months (range, 30-48 months). There was no local recurrence, graft failure and infection in any case. There was no dislocation in any case. The Harris Hip score at the time of final follow up was 90.

DISCUSSION: Proximal femoral allografts restores bone stock after resection of giant cell tumor and offers the advantage of longevity.

H566

Results of Short Metaphyseal Cementless Stem in Young Patients

Primary Author: Rajesh Malhotra

Institution: All India Institute of Medical Sciences

Coauthors: Vijay Kumar (AIIMS), Bhavuk Garg (AIIMS)

INTRODUCTION: There has been an introduction of short femoral stems with the aim of conserving bone. We present the short term results of short metaphyseal cementless stem ('Proxima'®, Depuy).

MATERIAL AND METHODS: 25 patients in age group

(25-40yrs), 15 males, 10 females were implanted with a short metaphyseal cementless stem ('Proxima'®, Depuy) and cementless acetabular cup. The average follow up was 4.3 years (3.4-5.5 yrs). Clinical evaluation using Harris Hip Score, Radiological evaluation and Bone Mineral Density were evaluated at 2 weeks, 6 months, 12 months and yearly thereafter. A new zonal method suitable for short stem was used for radiological evaluation.

RESULTS: The mean Harris Hip score improved from 44 to 95 at final follow up. There was no evidence of any radiolucent lines or osteolysis around the stems. All the stems showed evidence of osseointegration at one year follow up. There was no decrease in bone mineral density around the stems.

DISCUSSION: The Short Metaphyseal cementless femoral stem is a bone conserving as well as bone preserving option for young patients especially in those in whom surface replacement is not an option.

H567

Sagittal Pelvic Tilt Does Not Change After Unilateral Total Hip Replacement

Primary Author: Joseph D. Maratt

Institution: Hospital for Special Surgery

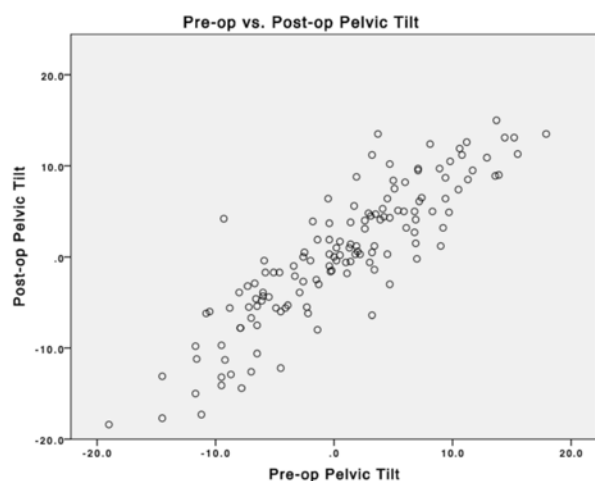
Coauthors: Christina Esposito (Hospital for Special Surgery), Alexander McLawhorn (Hospital for Special Surgery), Kaitlin M. Carroll (Hospital for Special Surgery), Seth A. Jerabek (Hospital for Special Surgery), David J. Mayman (Hospital for Special Surgery)

INTRODUCTION: Sagittal pelvic tilt (PT) has been shown to effect the functional position of acetabular components in patients with total hip replacements (THR). This change in functional component position may have clinical implications including increased likelihood of wear or dislocation. Surgeons can use computer-assisted navigation intraoperatively to account for a patient's pelvic tilt and to adjust the position of the acetabular component. However, the accuracy of this technique has been questioned due to the concern that PT may change after THR. The purpose of this study was to measure the change in PT after THR, and to determine if preoperative clinical and radiographic parameters can predict PT changes after THR.

MATERIALS AND METHODS: One hundred and thirty-eight consecutive patients who underwent unilateral THR by one surgeon received standing biplanar lumbar spine and lower extremity radiographs preoperatively and six weeks postoperatively. Patients with prior contralateral THR, conversion THR and instrumented lumbosacral fusions were excluded. We measured sagittal PT as the difference between the anterior pelvic plane and the coronal plane [1]. We calculated the pelvic incidence (PI) angle as the sum of (1) the angle between the vertical and the line joining the middle of the sacral endplate and (2) the angle subtended by the horizontal and the superior S1 endplate [2]. A negative value for PT indicated posterior pelvic tilt. Both PT and PI were measured preoperatively for each patient, and PT was measured on the postoperative imaging. Patient demographics were collected from the chart.

RESULTS: Average age was 56.8 ± 10.9 years, average BMI was 28.3 ± 6.0 kg/m², and 67 patients (48.6%) were female. Mean preoperative pelvic tilt was $0.6^\circ \pm 7.3^\circ$ (range: -19.0° to 17.9°). We found greater than 10° of sagittal PT in 23 out of 138 (16.6%) patients in this sample. Mean postoperative pelvic tilt was $0.3^\circ \pm 7.4^\circ$ (range: -18.4° to 15.0°). Mean change in pelvic tilt was $-0.3^\circ \pm 3.6^\circ$ (range: -9.6° to 13.5°). PT changed by less than 5° in 119 of 138 patients (86.2%). The mean difference in pre-operative and post-operative PT is not statistically significant ($p = 0.395$). Pre-operative PT was strongly correlated with post-operative PT ($r^2 = 0.88$, $p = 0.0001$) (Figure 1). There was not a statistically significant relationship between pelvic incidence and change in pelvic tilt ($r^2 = -0.16$, $p = 0.06$).

DISCUSSION: In the majority of patients who underwent THR, there was little change in sagittal PT postoperatively, showing that preoperative PT may be used to adjust acetabular position and possibly improve the functional position of the component. There were a small subset of patients where an unpredictable change in PT occurred, and the reason for this warrants further investigation.



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H568

Investigation of Patient Specific Acetabular Cup Malorientation in Functional Positions in the Failing Total Hip Replacement

Primary Author: Ed Marel

Institution: Peninsula Orthopaedics

Coauthors: Leonard R. Walter (Peninsula Orthopaedics), Michael Solomon (Sydney Orthopaedic Specialists), Jim Pierrepont (Optimized Ortho)

Malorientation of the acetabular cup in Total Hip replacement (THR) may contribute to premature failure of the joint through instability (impingement, subluxation or dislocation), runaway wear in metal-metal bearings when the edge of the contact patch encroaches on the edge of the bearing surface, squeaking of ceramic-ceramic bearings and excess wear of polyethylene bearing surfaces leading to osteolysis.

However as component malorientation often only occurs in functional positions it has been difficult to demonstrate and often is unremarkable on standard (usually supine) pelvic radiographs. The effects of spinal pathology as well as hip pathology can cause large rotations of the pelvis in the sagittal plane, again usually not recognized on standard pelvic views. While Posterior pelvic rotation with sitting increases the functional arc of the hip and is protective of

a THR in regards to both edge loading and risk of dislocation, conversely Anterior rotation with sitting is potentially hazardous.

We developed a protocol using three functional positions – standing, supine and flexed seated (posture at “seat-off” from a standard chair). Lateral radiographs were used to define the pelvic tilt in the standing and flexed seated positions. Pelvic tilt was defined as the angle between a vertical reference line and the anterior pelvic plane. Supine pelvic tilt was measured from computed tomography.

Proprietary software (Optimized Ortho, Sydney) based on Rigid Body Dynamics then modelled the patients’ dynamics through their functional range producing a patient-specific simulation which also calculates the magnitude and direction of the dynamic force at the hip and traces the contact area between prosthetic head/liner onto a polar plot of the articulating surface. Given prosthesis specific information edge-loading can then be predicted based on the measured distance of the edge of the contact patch to the edge of the acetabular bearing.

RESULTS AND CONCLUSIONS: The position of the pelvis in the sagittal plane changes significantly between functional activities. The extent of change is specific to each patient.

Spinal pathology can be an insidious “driver” of pelvic rotation, in some cases causing sagittal plane spinal imbalance or changes in orientation of previously well oriented acetabular components.

Squeaking of ceramic on ceramic bearings appears to be multi factorial, usually involving some damage to the bearing but also usually occurring in the presence of anterior or posterior edge loading. Often these components will appear well oriented on standard views [Fig 1].

Runaway wear in hip resurfacing or large head metal-metal THR may be caused by poor component design or manufacture or component malorientation. Again we have seen multiple cases where no such malorientation can be seen on standard pelvic radiographs but functional studies demonstrate edge loading which is likely to be the cause of failure [Fig 2].

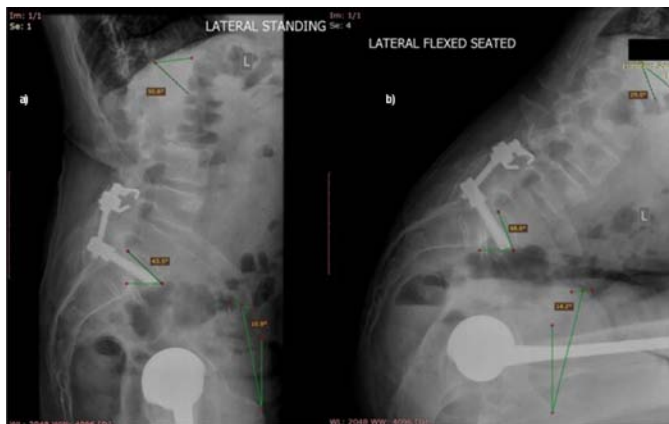


Fig. 1. Lateral radiographs of one of the squeaking patients a) The standing position. The patient has a pelvic tilt of -10.9° and a cup orientation of 35.7° and 24.4° for radiographic inclination and anteversion respectively. b) The flexed seated position. The patient's pelvic tilt is now 14.2° , a 25.1° change from the standing position, resulting in the cup's fictional anteversion being reduced to only 3.5° at the time of "seat-off".



Fig. 2a: Pelvic X-ray shows calcar loss but no malorientation of components in a patient with large head metal-metal THR pseudotumour. 2b: Lateral X-ray shows the stiff arthritic spine driving the pelvis into anterior rotation with sitting. 2c: Polar plot showing predicted posterior edge-loading (blue circles) at "seat-off".

Clinical examples of all of these will be shown.

H569

Assessment of the Performance of Four Commercially Available Orthopaedic Tapers on a Single Hip Stem Design

Primary Author: Timothy E. Marriott
Institution: Biomet

Coauthors: Tony Lane (Biomet), Imran Khan (Biomet)

INTRODUCTION: Some reports in the literature¹ have suggested that certain THR taper designs are more susceptible to wear and fretting during in vivo loading due to instability at the taper interface. This study investigated the torque and axial force required to disengage different types of tapers on a single design of hip stem under conditions of optimal assembly.

PATIENTS & METHODS: Four different commercially

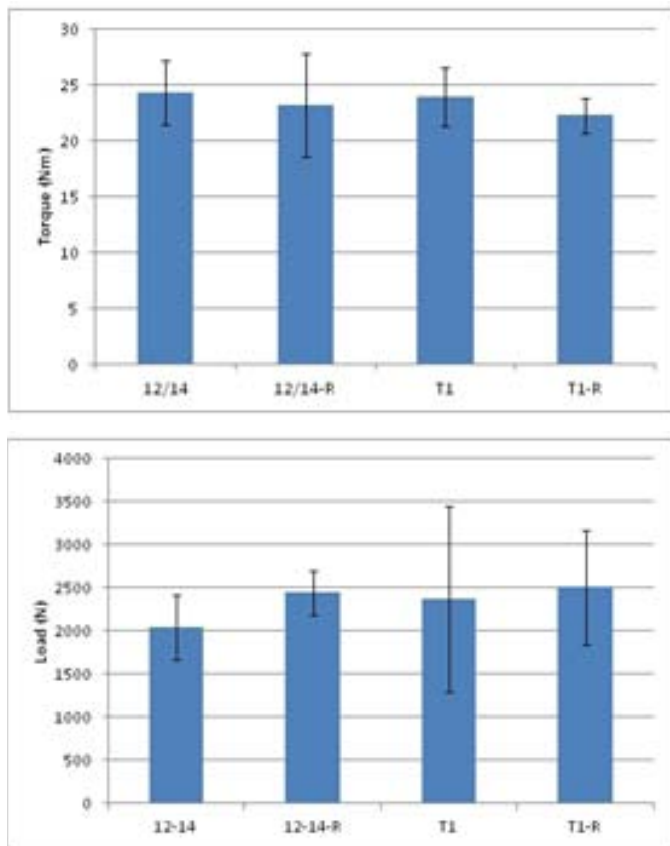
available tapers (Type 1 standard profile (T1), 12/14, standard profile, Type 1 optimised reduced profile (T1-R) and 12/14 optimised reduced profile (12/14-R), Biomet) were tested with the same stem type (Taperloc, Biomet). 6 samples of each combination were tested.

TORQUE TESTING: The taper adaptors were modified with flats so that a torsional force could be applied. The described method was based on ISO 7206-9:19942. Each taper was cleaned of debris and contaminants before assembly with a Magnum taper adaptor under a 4kN load, applied at 1mm/min. Each assembly was placed within a torque test frame where it was immersed in deionised water at 37°C and subjected to a preload of 1kN – these conditions were maintained throughout the testing duration. A torque rate of $10^\circ/\text{min}$ was then applied to each adaptor in a clockwise direction, until either rotation commenced or the machine limit was attained. Maximum torque (τ_{max}) was calculated.

AXIAL DISASSEMBLY TESTING: The described method was based on ISO 7206-10:19933. The components were assembled in the same manner as for the torque testing. Each assembly was then loaded within an electro-mechanical test machine and disassembled at a crosshead speed of 0.48 mm/min. Axial force values required for disassembly were recorded.

RESULTS: (Figures 1 and 2, mean values shown in red) indicate little variation in both τ_{max} and axial force required for the disengagement of the taper interface, despite the different angles, surface finish and length of the tapers. Any differences which were present were deemed statistically insignificant (ANOVA 95% confidence). There was no difference between the optimised reduced profile and standard length taper designs in both the Type 1 and 12/14 geometries.

DISCUSSION/CONCLUSION: The torque and axial force required to disengage the taper interface showed no significant relation to taper geometry for the designs of taper and stem investigated for clean, well assembled taper junctions, suggesting that the performance of the taper junction is not solely dependent upon the profile and geometry; surgical factors including taper cleanliness and assembly may have a greater impact.



H570

Investigation of Taper Design and Assembly on Fretting/Wear Performance Using a Novel Accelerated In Vitro Test

Primary Author: Timothy E. Marriott
Institution: Biomet

Coauthors: Tony Lane (Biomet), Dave Schroeder (Biomet), Imran Khan (Biomet)

INTRODUCTION: Recent literature has implicated poor assembly amongst other factors as a potential root cause contributing to fretting and corrosion at modular taper interfaces of large diameter metal-on-metal total hip replacements [1-4]. The effects of different taper geometries and material combinations are not well understood and existing in vitro test methods [4] are not able to reproduce some of the clinically relevant fretting wear and corrosion damage described in the literature. Following a review of the literature describing taper damage features and patterns, a new test method was developed with the aim of more closely replicating in vivo fretting and corrosion damage in

order to investigate the effects of different taper variables.

METHODS: An accelerated test based on the ISO 7206-6 test method for examining the endurance properties of the neck region of stemmed femoral components [6] was devised. This replaces the head with a modified rocking fixture comprising an extended lever arm and sliding bearing setup that generates a toggling motion about the taper interface, while providing an additional element of axial torsion. Particles of hydroxyapatite (60-75 μm) are applied to the taper surface to simulate bone debris contamination and to provide instability at the interface, as suggested by Jauch et al. [7]. The potting fixture is manufactured entirely from acetyl co-polymer and the stems are potted using PMMA, both of which are used to avoid any additional galvanic effects or exogenous metal ions. The test is performed in 90 gl-1 saline solution containing PBS and adjusted to a pH of 3 [8]. The stems are subjected to 0.4 – 4 kN cyclic loading for 10 million cycles at 5 Hz.

Three different commercially available taper geometries (Type 1 standard (4°, smooth finish), 12/14 standard (5°42', microgrooved finish) and optimised reduced profile Type 1) and a non-commercially available CoCr Type 1 taper adaptor were also compared using a 15 kN assembly load.

In order to assess the effects of assembly load on taper fretting and corrosion, Ti-6Al-4V stems with Ti-6Al-4V adaptors with a Type 1 (4°, smooth) taper were tested using different assembly conditions: 4 kN (well assembled) and 2 kN statically loaded and hand assembled (poorly assembled).

Volumetric wear of both taper surfaces was measured using a Talyrond 365 (Taylor Hobson Ltd, UK) at the University of Huddersfield.

RESULTS AND DISCUSSION: The comparison of taper geometries shown in figure 1 demonstrate a trend for reduced volumetric wear for the optimised reduced profile Type 1 taper as compared to the full length tapers although the differences were not shown to be statistically significant. In addition to this the comparison between the Ti-6Al-4V adaptor and CoCr adaptor indicated a lower volumetric material loss for the Ti-6Al-4V coupling which may indicate a greater role of galvanic corrosion in the mixed material taper junction. The use of different assembly conditions indicated less volumetric wear loss from taper in-

interfaces that were assembled with higher loads shown in Figure 2. This result shows the importance of firm taper assembly.

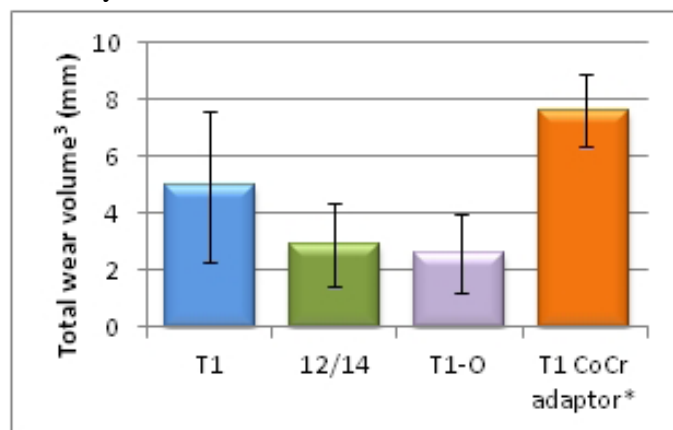


Fig. 1. Measured wear volume after taper fretting tests showing reduced material loss from optimized taper geometries and an increase with a CoCr taper adaptor. *Not commercially available.

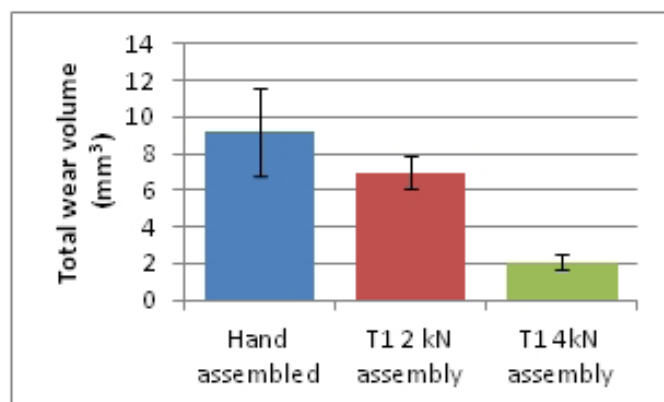


Fig. 2. Measured wear volumes from comparative Ti-6Al-4V and CoCr tapers tested.

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H571

EBRA is more Accurate than Crosstable Lateral Radiographs when Compared to Intraoperative Measurement of Acetabular Version

Primary Author: David J. Mayman

Institution: Hospital for Special Surgery

Coauthors: Peter K. Sculco (Hospital for Special Surgery), Alexander S. McLawhorn (Hospital for Special Surgery)

INTRODUCTION: Postoperative radiographs are frequently used to assess acetabular component version after total hip arthroplasty (THA), but their accuracy may be affected by sagittal pelvic tilt and other patient-specific factors. Imageless computer-assisted surgery (CAS) uses the anterior pelvic plane (APP) to determine pelvic tilt. Intraoperative "adjusted anteversion" corrected for pelvic tilt may more accurately reflect true acetabular anteversion. The purpose of this study was to compare the accuracy and precision of anteversion measured on postoperative cross-table lateral (CL) radiographs and anteroposterior (AP) radiographs with intraoperative adjusted anteversion.

METHODS: Inclusion criteria for this study were primary, cementless, THA using the same hemispherical acetabular component (R3TM Acetabular System, Smith & Nephew, Inc., Memphis, TN, USA). Sixty-five hips in 61 patients

between February and September of 2012 satisfied these criteria. Patients without 6-week postoperative AP and CL radiographs were excluded. All patients underwent THA with an imageless CAS system (AchieveCASTM, Smith & Nephew, Inc., Memphis, TN, USA). Intraoperative pelvic tilt was determined using CAS in the supine position using bilateral anterior superior iliac spines and the pubic symphysis to establish APP. Intraoperative navigated acetabular inclination, anteversion, and adjusted anteversion were recorded. Target implant positioning was 20°-25° of adjusted anteversion.

Six weeks postoperatively, supine AP pelvis and CL radiographs were performed. Ein-Bild-Röntgen-Analyse (EBRA; University of Innsbruck, Austria) software was used to measure anteversion on the AP pelvic radiograph. Version was also measured on the CL radiograph using standard methods. EBRA and CL version measurements were compared to intraoperative adjusted anteversion values, and the mean difference (accuracy) for each method was calculated using a paired two-tailed Student's t-test. Bartlett's test was used to compare the variances of the mean differences (precision). Correlation coefficients (*r*) for each method compared to adjusted anteversion were calculated using Pearson regression analyses. Alpha level was set at 0.05 used for all tests.

RESULTS: Navigated intraoperative measurements were 41.1° ± 2.4° inclination, 20.0° ± SD 5.5° anteversion, 22.5° ± SD 4.2° adjusted anteversion, and -3.1° ± 9.1° pelvic tilt. The mean EBRA version measurement was 22.0° ± SD 4.5° versus 26.7° ± 3.9° for CL radiograph for a difference of 4.7° which was statistically significant.

CONCLUSION: Acetabular component version assessment using EBRA was more accurate than CL and more closely correlated with the navigated intraoperative adjusted anteversion. CL radiographs showed a significant increase in anteversion measurements compared to EBRA and intraoperative values. This may be secondary to patient positioning for CL radiographs, during which the contralateral hip is flexed, increasing posterior pelvic tilt and thus apparent anteversion. In the absence of axial imaging, EBRA anteversion best correlates with intraoperative adjusted anteversion and should be used instead of version calculated with CL radiographs, when assessing component positioning postoperatively.

H572 Radiographic Parameters Correlate with Change in Sagittal Pelvic Tilt after Hip Replacement

Primary Author: David J. Mayman

Institution: Hospital for Special Surgery

Coauthors: Joseph D. Maratt (Hospital for Special Surgery), Christina Esposito (Hospital for Special Surgery), Kaitlin M. Carroll (Hospital for Special Surgery), Seth A. Jerabek (Hospital for Special Surgery)

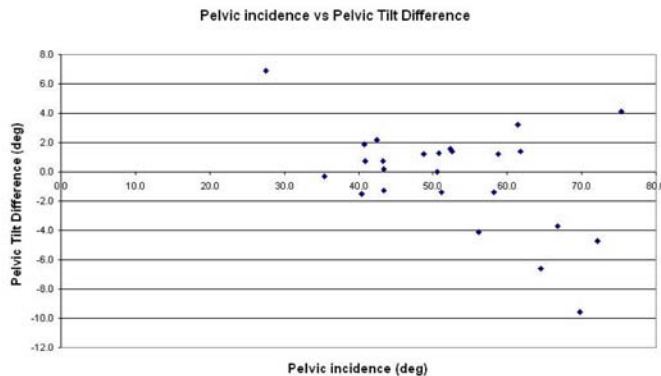
INTRODUCTION: Changes in sagittal pelvic tilt (PT) has been shown to effect the functional position of acetabular components in patients with total hip replacements (THR). Surgeons can use computer assisted navigation intraoperatively to account for a patient's pelvic tilt, and customize the position of the acetabular component. We sought to measure whether PT changes following THR. This change in PT may have clinical implications, such as increasing the likeliness of wear or dislocation. The purpose of our study was to consider whether PT changes after a patient has a THR, and whether a patient's pre-operative pelvic incidence (PI) angle can be used to identify these patients with PT changes postoperatively.

MATERIALS AND METHODS: Twenty-five consecutive patients who underwent THR with one surgeon underwent standing biplane lumbar spine and lower extremity imaging pre-operatively and six weeks post-operatively using the EOS Imaging System (EOS Imaging Inc, Paris, France). Patients with prior THR, hip surgery and spinal instrumentation were excluded from the study. We measured sagittal PT as the difference between the anterior pelvic plane and the coronal plane [1]. We calculated the pelvic incidence (PI) angle as the sum of (1) the angle between the vertical and the line joining the middle of the sacral endplate and (2) the angle subtended by the horizontal and the superior S1 endplate [2]. A negative value for PT indicates posterior pelvic tilt. Both PT and pelvic incidence were measured pre-operatively for each patient, and PT was measured on the post-operative imaging. Patient demographics were collected from the chart.

RESULTS: Mean age was 61.9±9.1 years. Fifteen patients were female. Mean pre-operative and post-operative PT were 0.2°±6.7° and -0.1°±6.7° respectively (*p* = 0.70). Mean change in PT was 0.3°±3.5° (range 0° to 9.6°). None

of the patients in this study had a change in PT greater than 10° . Mean PI angle was $52.3^\circ \pm 12.1^\circ$. PI was moderately correlated with post-operative PT ($r=0.47$, $p=0.02$) and change in PT ($r=0.47$, $p=0.02$).

DISCUSSION: In the majority of patients who underwent THA there was a very small change in pelvic tilt post-operatively. However, in subset of patients there was a significant change in pelvic tilt that could impact functional acetabular component position. Pelvic incidence may be predictive of a change in pelvic tilt postoperatively, and in these patients a pre-operative plan may be used to adjust for this. Further investigation of additional sagittal balance parameters may improve the reliability of predicting change in post-operative pelvic position.



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H573

Accuracy and Precision of Acetabular Component Placement with Imageless Navigation in Obese Patients

Primary Author: Alexander S. McLawhorn

Institution: Hospital for Special Surgery

Coauthors: K. Durham Weeks (Hospital for Special Surgery), Denis Nam (Hospital for Special Surgery), Peter K. Sculco (Hospital for Special Surgery), David J. Mayman (Hospital for Special Surgery)

INTRODUCTION: Obesity is a risk factor for acetabular malposition when total hip arthroplasty (THA) is performed with manual orientation techniques. Conflicting

evidence exists regarding the accuracy of imageless navigation systems in obese patients. This study compares the accuracy and precision of imageless navigation for acetabular orientation in obese and nonobese patients.

METHODS: 556 consecutive primary THAs for osteoarthritis (OA) using imageless navigation were reviewed from a single surgeon's IRB-approved database. THAs were excluded if a metal-on-metal implant was used, or if adequate 6-week radiographs (XR) were unavailable.

459 THAs were included (Table 1). During surgery the supine anterior pelvic plane was referenced superficially. THA was performed via posterolateral approach in the lateral position. A hemispherical acetabular component was used, with target inclination of 40° and anteversion of 25° .

TABLE 1. Demographics

	Nonobese	Obese
Hips	280	179
Patients	243	150
Laterality		
Right	157 (56.1%)	99 (55.3%)
Left	123 (43.9%)	80 (44.7%)
Bilateral	37 (26.4%)	29 (32.4%)
Gender		
Male	105 (37.5%)	98 (54.7%)
Female	175 (62.5%)	81 (45.3%)
Mean Age \pm S.D. (years)	60.4 \pm 11.4	58.8 \pm 8.8
Mean BMI \pm S.D. (kg/m ²)	25.5 \pm 2.9	35.5 \pm 5.0

TABLE 2. Radiograph Parameters

	Nonobese		Obese		p-value
	Mean	S.D.	Mean	S.D.	
Inclination (degrees)	41.9	4.6	43.0	4.9	0.02
Anteversion (degrees)	23.8	6.6	24.9	6.3	0.08
Inclination Error (degrees)	3.9	3.0	4.5	3.6	0.06
Anteversion Error (degrees)	5.4	4.0	4.9	4.0	0.19

Einsel-Bild-Roentgen Analyse determined acetabular orientation on postoperative AP XRs. A single observer measured all XRs, and a second observer measured a subset of 150 XRs. Interobserver intraclass correlation coefficients (IICC) were calculated.

Patients with BMI ≥ 30 were classified as obese. A 5° difference in mean inclination or anteversion was clinically significant. Orientation error was defined as the absolute difference between the target orientation and that measured. Mean orientation error (accuracy) for obese and nonobese patients were compared. Two-tailed student's t tests compared means. Hartley's test compared variances of the mean differences (precision). Fisher's exact tests examined the relationship between obesity and component placement in the target ranges (target + 10°) for inclination and version. $P < 0.05$ was significant.

RESULTS: IICCs were 0.926 for anteversion and 0.948 for inclination. The difference in mean inclination between study groups was 1.04° ($p=0.02$) (Table 2). Accuracy trended toward improvement for nonobese patients versus obese patients ($p=0.06$). Inclination precision was better for nonobese patients ($p=0.006$). Accuracy and precision for anteversion were equal between the 2 groups ($p=0.19$ and $p=0.95$, respectively).

There was no relationship between obesity and placement of the acetabulum outside of the target ranges for inclination ($p=0.13$), anteversion ($p=0.39$) or both ($p=0.99$), with a trend toward more inclination outliers in obese patients versus nonobese patients (7.3% vs 3.9%).

DISCUSSION: The observed differences in mean acetabular orientation angles were not clinically significant ($< 5^\circ$), although inclination orientation was less accurate and precise for obese patients. In contrast to existing literature, we found no difference in the accuracy and precision with regard to anteversion in obese and nonobese patients. We propose that accurate superficial registration of landmarks in obese patients is achievable, and the use of navigation likely improves acetabular positioning in obese and non-obese patients equally.

H574 Targeting A New Safe Zone — A Step Towards Development of Patient-Specific Component Positioning in Hip Arthroplasty

*Primary Author: Alexander S. McLawhorn
Institution: Hospital for Special Surgery*

Coauthors: Peter K. Sculco (Hospital for Special Surgery), Durham Weeks (Hospital for Special Surgery), Denis Nam (Hospital for Special Surgery), David J. Mayman (Hospital for Special Surgery)

INTRODUCTION: Surgeons often target Lewinnek's zone ($40^\circ + 10^\circ$ of inclination; $15^\circ + 10^\circ$ of anteversion) for acetabular orientation during total hip arthroplasty (THA). Its applicability to preventing hip instability using modern implants and surgical techniques is unknown. Moreover, matching native anteversion (21° - 25°) may achieve optimal stability. The purpose of this study was to determine the impact of increasing targeted acetabular anteversion on postoperative THA stability.

METHODS: 671 consecutive primary THAs performed using imageless navigation were reviewed from a single surgeon's IRB-approved database. THAs were excluded if a metal-on-metal implant was used, or if adequate 6-week radiographic or 6-month clinical follow-up were unavailable.

		%	S.D.	MIN	MAX
Hips	553				
Patients	479				
Laterality					
	Right	299	54.1%		
	Left	254	45.9%		
	Bilateral	74	26.8%		
Gender					
	Male	226	40.9%		
	Female	327	59.1%		
Mean Age (years)	57.7		12.1	16.7	89.5
Mean BMI (kg/m^2)	29.2		6.4	17.5	59.1
Primary Diagnosis					
	OA	460	83.2%		
	AVN	35	6.3%		
	Childhood Hip Disease	29	5.2%		
	Posttraumatic Arthritis	14	2.5%		
	Inflammatory Arthropathy	10	1.8%		
	Acute Hip fracture	3	0.5%		
	Prior Arthrodesis	2	0.4%		
Mean Acetabular Size (mm)	52.6		3.0	48	62
Mean Femoral Head Size (mm)	34.9		2.2	28	40

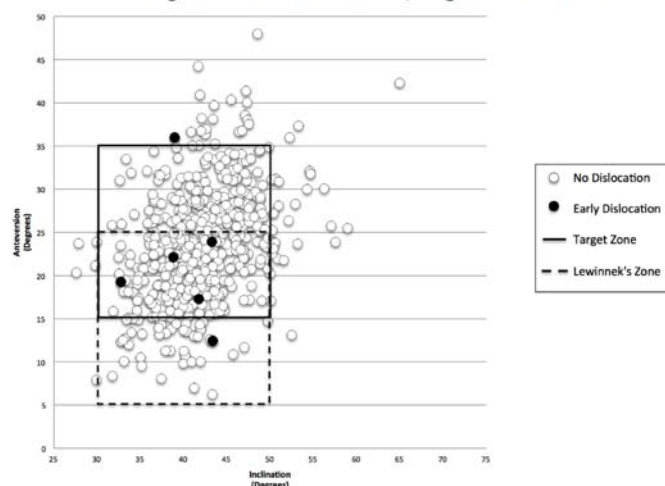
553 THAs (mean follow-up of 2.4 ± 1.4 years) were included (Table 1). A posterolateral approach with repair of the posterior capsule and short external rotators was performed. A hemispherical acetabular component was used, with target inclination of 40° and target anteversion of 25° . Target femoral anteversion was 15° .

Einsel-Bild-Roentgen Analyse was used to measure acetabular orientation on postoperative AP radiographs. The incidence of early dislocation (instability within 6 months of surgery) was determined.

Orientation error was defined as the absolute value of the difference between the target orientation and radiographic measurement. Logistic regression analysis examined the influence of perioperative factors on cup position outside the target range. Fisher's exact tests examined the relationship between dislocation and component placement in the Lewinnek zone or our target zone. Significance was set at $p < 0.05$.

RESULTS: Mean inclination was $42.2^\circ + 4.9^\circ$, with mean orientation error of $4.2^\circ + 3.4^\circ$. Mean anteversion was $23.9^\circ + 6.5^\circ$, with mean orientation error of $5.2^\circ + 4.1^\circ$. 46.5% of components were placed outside of the Lewinnek zone for either inclination or anteversion, versus 17.7% for our target zone (Figure 1). Variation in anteversion accounted for 66.3% of outliers. Logistic regression showed that only prior arthrodesis was significantly associated with component anteversion outside of our target range (odds ratio of 1.7, $p=0.036$).

Figure 1. Acetabular Position, Targets and Dislocations



Six patients (1.1%) experienced early posterior instability, at an average of $58.3 \text{ days} + 13.8 \text{ days}$ postoperatively. There was no relationship between the incidence of dislocation and component placement in either the Lewinnek zone ($p=0.224$) or our target zone ($p=0.287$). Three THA (0.54%) were revised for multiple episodes of instability.

CONCLUSION: This study demonstrates that increasing target acetabular anteversion using the posterolateral approach does not increase posterior or anterior THA instability. However, the long-term effects on bearing surface wear must be elucidated. The occurrence of instability even in patients within our target zone emphasizes the importance of developing patient-specific targets for component alignment in THA.

H575 Short Stems in Total Hip Arthroplasty

Primary Author: Timothy McTighe

Institution: Joint Implant Surgery & Research Foundation (JISRF)

Coauthor: Declan Brazil (JISRF), John Keggi (Orthopaedics New England), S. David Stulberg (Feinberg School of Medicine Northwestern University), Robert T. Kennon (Orthopaedics New England), Louis Keppler (The Spine and Orthopaedic Institute at St. Vincent Medical Center), Edward J. McPherson (L.A. Orthopedic Institute)



A variety of short stems.

The past 10 years have witnessed increased interest in more conservative approaches to hip surgery. During this time, second-generation hip resurfacing and minimally invasive surgery (MIS) enjoyed extensive marketing attention. After a decade of this renewed interest, both of these approaches to THA have met with serious concerns. As hip resurfacing numbers decline, both patients and surgeons are looking for alternative conservative approach to THA. The search has led to increased attention in short-stem designs. A number of advantages have been argued to justify the design and clinical usage of short Stems: Elimination of femoral proximal-distal mismatch, tissue preservation (hard & soft), facilitation of less invasive surgical exposures, less invasive surgical violation into the femoral canal, less violation into the trochanteric bed, improved proximal bone remodeling, less intraoperative blood loss, less postoperative rehabilitation, less instrumentation and less inventory cost. All of these advantages are worthwhile if they can be proven to be significant benefits to the clinical outcome and increased survivorship of the device. The real question is can these shorter length devices obtain strong and long-lasting stability of the implant without diaphyseal anchoring? There are little published outcomes on short stems and most information has appeared as oral

papers and posters at CME meetings. The European experience precedes that of the United States (U.S.). The initial response by the U.S. market was simply to modify certain current standard cementless stems by truncating them.

Short and mid-term follow up studies of a number of these stems suggest that stable, durable fixation and excellent clinical outcomes can be achieved. Today, a variety of short-stem implants are available with very little clarification as to design rationale, features, required surgical technique, and clinical outcomes. Virtually every major implant company now offers a short stem, often with a variety of different designs. It is important to note that not all short stems achieve initial fixation at the same bone interface region, use the same surgical technique, or present the same postoperative x-ray appearance. Additionally, the surgeon may not be aware of the surgical preparation difference for a short metaphyseal-style stem versus a neck-persevering style stem. The purpose of this presentation is to review past, present, and potential future developments of short stems and to present a classification system that can offer guidance when reporting on the many different variations.

H576

Periacetabular Osteotomy Performed with Combined CAD-CAM Osteotomy Guiding Jigs and Navigation

Primary Author: Rene Mihalic

Institution: Orthopaedic Hospital Valdoltra

Coauthors: Rihard Trebse (Orthopaedic Hospital Valdoltra), Darij Kreuh (Ekliptik Ljubljana)

BACKGROUND: Periacetabular osteotomy (PAO) is an effective treatment method for developmental dysplasia of the hip with no or mild osteoarthritis. Despite the procedure is performed from late eighties of the past century it is still a very demanding procedure performed only by high skilled surgeons in high volume orthopaedic centres. We already implemented a custom-made surgical tool to improve the accuracy of the two osteotomies of the iliac bone, but ischium osteotomy was not yet navigated. In order to perform a safe and accurate ischium osteotomy we developed navigation tools to guide the placement and advancement of the osteotome.

METHODS: A CT scan of a cadaveric pelvis was performed. DICOM format file was up-loaded into EBS software (Ekliptik d.o.o., Ljubljana, Slovenia), a multipurpose application for preoperative planning, constructing and designing different templates where the three-dimensional (3D) model of pelvis was created. On the virtual pelvis model the PAO lines on each of two acetabula were planed and virtual PAOs were performed [Fig.1]. For the execution of the two iliac bone osteotomies the osteotome and saw guiding jigs were virtually created and exported in STL format in ProJet 3500 HDPlus printer which created custom made jigs made from VisiJet Crystal biocompatible plastic material (3Dsystems, Rock Hill, South Carolina, USA) for each of the two acetabula. Jigs were equipped with referencing sensors, which are necessary for the navigation of the ischium osteotomy. Then we initiated the procedure on the aforementioned cadaver. Extended Smith-Peterson approach was used on each of two cadaveric hips and Bernese PAOs were performed using custom-made jigs and Guiding Star E-Hip navigation tool (Ekliptik d.o.o., Ljubljana, Slovenia). The osteotomy of the ischium was accomplished with Ganz osteotome equipped with the guiding sensor. The position of the osteotome and the depth of the ischium osteotomies were confirmed on the monitor of the E-Hip navigation tool [Fig 2]. After performing the acetabular correction the cadavers were carefully dissected to study the osteotomy planes, the posterior column and the acetabular walls.

RESULTS: Visual inspection revealed that none of the acetabular walls were damaged and the osteotomy planes were performed according to the virtual plan.

CONCLUSION: Navigation of ischium osteotomy improves the accuracy of the PAO, and helps us to avoid inadvertent intraarticular osteotomies of the acetabulum and preservation of the integrity of the posterior column.

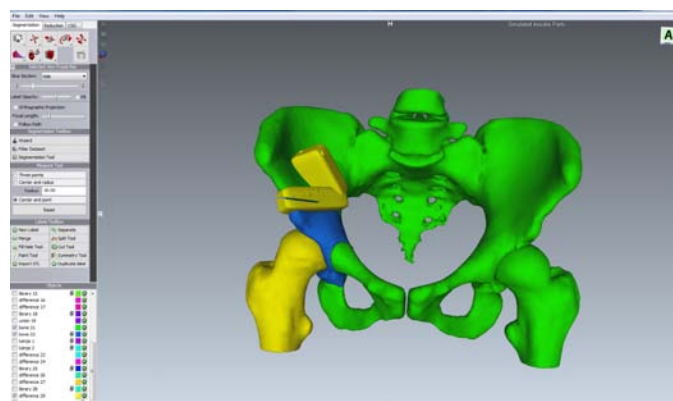


Figure 1.



Figure 2.

H577 Early Periprosthetic Femoral Fractures with Short Tapered-wedge Stems Following Total Hip Arthroplasty

Primary Author: Yoko Miura

Institution: Funabashi Orthopaedic Hospital

Coauthors: Kazuhiro Oinuma (Funabashi Orthopaedic Hospital), Tatsuya Tamaki (Funabashi Orthopaedic Hospital), Hideaki Shiratsuchi (Funabashi Orthopaedic Hospital)

INTRODUCTION: While periprosthetic fracture of the femur is sometimes experienced following total hip arthroplasty, and when it occurs, it becomes a serious complication. Short tapered-wedge stems are reported with low complication rates and good long-term results, but are there any pitfalls with these stems?

OBJECT: Short tapered-wedge stems are now frequently used for its easier insertion with less invasive surgery and preservation of native bone. But in some cases we experienced intraoperative and early post-operative femoral fractures. The purpose of this study is to evaluate the risk factors and frequency of intraoperative and early post-operative femoral fractures with the use of these stems.

METHODS: We retrospectively reviewed 1460 consecutive primary THAs with short tapered-wedge stems from 2009 to 2013. All patients were performed through direct

anterior approach (DAA). We evaluated potential risk factors of early periprosthetic femoral fractures. In this study, short tapered-wedge stems were defined as short, flat-wedge, tapered, proximal fitting, collarless, cementless stems.

RESULTS: We observed periprosthetic femoral fractures in 37 hips (2.5%). Fourteen fractures (38%) were operated through simultaneous bilateral procedure. Fractures were observed intraoperatively in 29 hips (2.0%) and all managed with application of cerclage cables. Fractures were observed postoperatively in 8 hips (0.5%), and 6 hips were managed operatively with cables and 2 hips were treated conservatively. All fractures were achieved complete bone union and there were no stem subsidence over 2mm.

DISCUSSION: The short tapered-wedge stems were achieved good initial fixation and good results, and the rate of early periprosthetic fractures was very low. But 6 of 8 fractures which observed postoperatively were very unstable and needed additional operative procedures.

CONCLUSION: Our results suggests that when using short tapered-wedge stems, we have to pay more attention to early periprosthetic fracture caused by oversize stem than stem subsidence caused by undersize stem.

H578 Skin Crease Oblique Incision for Direct Anterior Approach in Total Hip Arthroplasty

Primary Author: Yoko Miura

Institution: Funabashi Orthopaedic Hospital

Coauthors: Kazuhiro Oinuma (Funabashi Orthopaedic Hospital), Tatsuya Tamaki (Funabashi Orthopaedic Hospital), Hideaki Shiratsuchi (Funabashi Orthopaedic Hospital)

OBJECTS: In total hip arthroplasty (THA) with direct anterior approach (DAA), longitudinal skin incision is usually used. However longitudinal skin incision does not follow the anatomic skin creases and sometimes results in scar widening. We modified our incision to be parallel to skin crease of the groin following anatomic skin crease. We evaluated these incisions compared with longitudinal skin incisions.

METHODS: We performed THAs in 20 patients with new oblique incision with supine DAA. The new oblique skin incisions starts approximately 1.5cm distally from the crease of the groin and 1cm laterally from the medial border of the tensor fascia lata muscle, and is extended approximately 6cm laterally, parallel to the crease of the groin. Average post-operative observation periods were 6 months. We compared objective and subjective scar results, functional and pain scores, complications, blood loss, implant position, and lateral femoral cutaneous nerve symptoms.

RESULTS: Objectively the oblique incision resulted in shorter and narrower scars at 6 months. Functional and pain scores were also excellent in both groups. In one patient an early periprosthetic femoral fracture occurred, and additional operation was needed. In this case, the skin incision was curved and extended longitudinally. Finally the total length of the incision became about 12cm. Blood loss and implant position did not differ, and no lateral femoral cutaneous symptoms.

CONCLUSIONS: Although patients with severe deformities were not selected in this series, the new oblique incision for direct anterior approach THA resulted in narrower and better scars in aesthetically, and found to be safe in blood loss, implant positioning and nerve injury. But when a periprosthetic fracture occurred, the skin incision had to be extended longitudinally and length of scar became longer. A larger randomized trial comparing both incisions would be desirable for future investigation.

H579 Proximal Femoral Cement Mantle Optimization by Pressurization Device?

Primary Author: Takkan Morishima
Institution: Aichi Medical University

Coauthor: Kautaka Watanabe (MD)

INTRODUCTION & AIMS: The most important clinical measure of implant performance is implant longevity, a multi-factorial equation where a proxy for implant fixation is the level of cement pressurization. Our aim was to examine the pressures generated at the bone-cement interface with two different types of femoral seal.

METHOD: The study was designed to allow a direct com-

parison between the Exeter MIS Half-moon Femoral Cement Seal and the Femoral Canal Pressurizer, an intramedullary pressurizer, in a synthetic bone model. Two groups of 5 femurs were instrumented with 6 pressure sensors and tested. Pressure was recorded over the pressurization phase, and the maximum pressure and pressure time integral calculated.

RESULTS: Pressure was recorded over the pressurization phase, and the maximum pressure and pressure time integral calculated. Both pressurizers generated pressures well above back bleeding pressures in most locations. The Exeter Half-moon seal had the larger mean maximum pressure proximally, 211kPa, compared to the intramedullary style pressurizer recording 26kPa.

CONCLUSIONS: This study demonstrated that a difference in cementation pressure is obtained by different proximal femoral seals particularly around the proximal implant body, which is considered to be critical to implant rotational stability. This may have implications for the survivorship of cemented femoral stems.

H580 Clinical Results of PMPC-grafted Highly Cross-linked Polyethylene Liners

Primary Author: Toru Moro

Institution: Division of Science for Joint Reconstruction, Graduate School of Medicine, The University of Tokyo

Coauthors: Yoshio Takatori (Division of Science for Joint Reconstruction, Graduate School of Medicine, The University of Tokyo), Hiroshi Kawaguchi (Orthopaedic Surgery, Sensory and Motor System Medicine, Surgical Sciences, Graduate School of Medicine, The University of Tokyo), Kazuhiko Ishihara (School of Engineering, The University of Tokyo)

Healthy human articular cartilage surface is covered with a nanometer-scaled phospholipid layer that protects the articulating surface from mechanical wear and facilitates a smooth motion of joints during daily activities. Hence, the phospholipid-like layer on the acetabular liner surface may realize the surface conditions that are similar to healthy articular cartilage. Aiming at reduction of wear particles and elimination of periprosthetic osteolysis, we prepared a highly cross-linked polyethylene (HXLPE) liner with a

surface grafting (100–200 nm in thickness) of phospholipid polymer, poly(2-methacryloyloxyethyl phosphorylcholine) (PMPC). Our recent study on the mechanical and biological effects of PMPC revealed that the grafting dramatically decreased the production of wear particles during 20 million cycles in the hip joint wear simulator and suppressed the bone resorptive responses in the murine osteolysis model. However, in vitro findings do not always translate to clinical success. The purpose of this study was to investigate clinical safety and wear-resistance of PMPC-grafted HXLPE liner in the primary total hip replacement (THR).

Eighty consecutive patients underwent cementless THR using a 26-mm cobalt–chromium–molybdenum alloy femoral head and a PMPC-grafted HXLPE liner for the bearing couplings. In the present study, we evaluated the clinical and radiographic outcomes of 76 patients (M/F, 14/62) at 3 years after the index surgery. The mean age of the patients was 64.4 years and mean BMI was 22.9 kg/m². The preoperative diagnosis was osteoarthritis in 72 hips and osteonecrosis in 4. Their Charnley category designation was A or B.

There were no reoperations for any reasons. No adverse events were evaluated to be in correlation with the implanted liners. The average of hip joint function score authorized by the Japanese Orthopedic Association, improved from 43.2 preoperatively to 93.2 at 3 years postoperatively [Fig. 1]. These mean scores corresponded to Harris hip scores of 46.7 and 95.6, respectively. On radiographic analyses, no implant migration, nor periprosthetic osteolysis were detected. Femoral head penetration showed a biphasic pattern. The mean amount of bedding-in was 0.210 mm. Between 1 and 3 years, the mean amount of the steady wear rate was 0.0017 mm/year, representing a nearly 90% reduction compared with the mean wear rate of other HXLPE liners (0.01–0.06 mm/year) [Fig. 2].

The MPC polymers are biocompatible and hydrophilicity-controllable due to phosphorylcholine groups in the side chain resembling phospholipids of biomembrane. Thus, the MPC polymers can suppress biological reactions even when they are in contact with living organisms, and is now clinically used on the surfaces of many medical devices. Although the safety of MPC polymers as a biomaterial is well established, the influence of PMPC-grafted HXLPE liners on the health of patients remains an open question. In the present study, clinical and radiographic examina-

tions demonstrated results comparable to other contemporary THRs. Moreover, two-dimensional linear wear rate was dramatically improved. Thus, we concluded that the lines of results obtained in this study clearly demonstrate safety and wear-resistance of PMPC-grafted HXLPE liners. This preliminary observation is still short clinical term. Hence, future observations may be to support this result.

H581

Effect of Larger Femoral Head on the Wear-resistance of the Biocompatible PMPC-grafted Highly Cross-linked Polyethylene Liner

Primary Author: Toru Moro

Institution: Division of Science for Joint Reconstruction, Graduate School of Medicine, The University of Tokyo

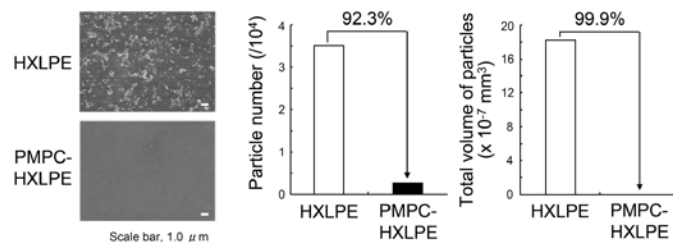
Coauthors: Yoshio Takatori (Division of Science for Joint Reconstruction, Graduate School of Medicine, The University of Tokyo), Hiroshi Kawaguchi (Orthopaedic Surgery, Sensory and Motor System Medicine, Surgical Sciences, Graduate School of Medicine, The University of Tokyo), Kazuhiko Ishihara (School of Engineering, The University of Tokyo)

Larger femoral heads have recently come into more frequent use to prevent dislocation of the artificial hip joint. However, there are concerns regarding the subsequent use of thinner polyethylene liners, and their effects on wear rates. In natural synovial joints under physiologic conditions, fluid film lubrication by the hydrated layer is essential for the smooth motion of joints, and a nanometer-scaled phospholipid layer that covers joint cartilage surface provides hydrophilicity and works as an effective boundary lubricant. Hence, the phospholipid-like layer with cartilage-mimicking structures on the liner surface may provide hydrophilicity and lubricity resembling the physiologic joint surface. Based on this hypothesis, we prepared a novel highly cross-linked polyethylene (HXLPE) liner with the nanometer-scaled graft layer (100–200 nm in thickness) of poly(2-methacryloyloxyethyl phosphorylcholine) (PMPC). The MPC polymers are biocompatible and hydrophilicity-controllable due to phosphorylcholine groups in the molecular structure resembling phospholipids of biomembrane. Thus, the MPC polymers can suppress biological reactions even when they are in contact with living organisms, and are now clinically used on the surfaces of many medical devices. Hence the safety of MPC polymers

as a biomaterial is well established.

Our recent study on the biological and mechanical effects revealed that the PMPC-grafted particles were biologically inert and did not cause subsequent bone resorptive responses. We also showed that the PMPC-grafting dramatically decreased the production of wear particles in the hip joint simulator. However, in those simulator studies, we used metal or ceramic femoral heads with a diameter of 26 mm. The present study therefore investigated the wear-resistance of the PMPC-grafted HXLPE liner with the 40 mm femoral head during 10 million cycles of loading in the hip joint simulator.

The load-soak liners showed comparable weight gains during the test, irrespective of the presence or absence of PMPC layer; this observation confirmed that weight gain was attributed to the absorption of the fluid by the liner material, and not to that retained on the surface PMPC layer. The gravimetric analysis performed in the hip simulator study showed that the HXLPE liners suffered from a total weight loss of 89.0 mg after loading. In contrast, it was found that the PMPC-HXLPE liners suffered from a total weight loss of 6.1 mg [Fig. 1: left]. Three-dimensional morphometric and the scanning laser microscopic analyses of PMPC-HXLPE liner surface revealed no or very little wear, while substantial wears were detected in HXLPE liners [Fig. 1: right]. SEM analyses of the wear particles isolated from the lubricants revealed total number, area and volume of the particles produced from PMPC-HXLPE liners were dramatically less than those from HXLPE liners [Fig. 2].



The lines of results obtained in this study clearly demonstrate that PMPC-grafting onto HXLPE liner surface markedly decreased the production of wear particles during 10 million cycles of loading even when coupled with larger femoral heads. Hence, we believe that the PMPC-grafting will prolong the longevity of the artificial hip joint not only by preventing periprosthetic osteolysis but also by improving wear-resistance of the liner in total hip arthroplasty.

H582

A Case of Coxarthrosis with Congenital Insensitivity to Pain Characterized by Joint Effusion Extending to Pleura

Primary Author: Ryo Munakata

Institution: Department of Orthopedic Surgery, Shinonoi General Hospital

Coauthors: Masaaki Maruyama (Department of Orthopedic Surgery, Shinonoi General Hospital), Kazumi Kitagawa (Department of Orthopedic Surgery, Shinonoi General Hospital), Hiroyuki Hashidate (Department of Orthopedic Surgery, Shinonoi General Hospital), Kentaro Kasama (Department of Orthopedic Surgery, Shinonoi General Hospital)

INTRODUCTION: Orthopedic manifestations of congenital insensitivity to pain with anhidrosis (CIPA), which is an autosomal recessive inheritance disease, include delayed diagnosis of fracture, nonunion, malunion, Charcot arthropathy, acro-osteolysis, avascular necrosis, osteomyelitis, heterotopic ossification and joint dislocation. We report the case of a patient with CIPA, who had huge amount of joint effusion extending to retroperitoneum and pleura, treated with cemented total hip arthroplasty.

CASE PRESENTATION: A 34-year-old Japanese woman was admitted to our hospital complaining of painless swelling in her left hip to thigh, limping and dyspnea. She had been diagnosed as CIPA at 2 months old and suffered dislocation of the left hip joint with nonunion of greater trochanter fracture at the time of elementary school student. After then, she had presented symptom of claudication. She had felt swelling of the left hip to thigh from November 2008 and had had dyspnea from April 2009. There was a huge cystic lesion from the left hip joint to retroperitoneum and pleura by Computer Tomography (CT) examination (Fig. 1). Radiographs showed the left coxarthrosis with large bone defect due to rapidly destructive acetabulum and femoral head (Fig. 2). We performed cemented total hip arthroplasty with reconstruction of acetabulum by using rim mesh, hydroxyapatite granules and large amount of allograft in July 2009 (Fig. 2). The cystic lesion was diminished and she used no crutches for ambulation, although dislocation of the hip joint was occurred several times during 6 months postoperatively. The cystic lesions had not been recognized again at 4 years 6 months after surgery. However, the acetabular rim was fractured and the

cemented socket was proximally migrated about 20 mm in January 2014.

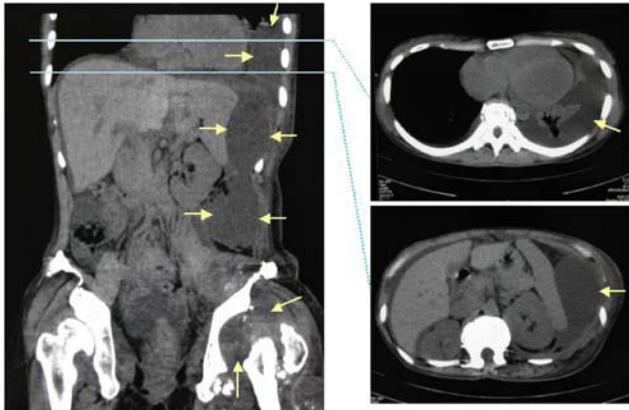


Fig. 1. Preoperative CT scan. A huge cystic lesion (arrow) was recognized from the left hip joint to pleura (thoracic cavity).



Fig. 2. Pre- and post-operative radiographs. Cemented total hip arthroplasty was performed with reduction and fixation of greater trochanter.

CONCLUSIONS: CIPA associated with severe orthopedic problem such as coxarthrosis with huge amount of joint effusion extending to pleura is a rare condition. To the best of our knowledge, this is the first report of such a CIPA patient treated with cemented total hip arthroplasty. This case report, which will be of particular interest to orthopedic surgeons, presents several difficulties in the management of Charcot arthropathy of the CIPA patients with the arthroplasty.

H583 Accelerated Fretting Corrosion Testing of Modular Necks for THA

Primary Author: Satya N. Nambu
Institution: MicroPort Orthopedics

Coauthors: Richard M. Obert (MicroPort Orthopedics),

Michael A. Roark (MicroPort Orthopedics), Jon Moseley (Wright Medical Technology), Doug Linton (Wright Medical Technology), Scott Bible (Wright Medical Technology)

INTRODUCTION: Modular necks allow intra-operative adjustment of neck length, offset, and version, enabling the surgeon to better match leg length and accommodate anatomical differences. However, there have been recent reports of early fatigue failures of the neck initiating from the neck/stem taper, and some retrieved components exhibit severe fretting corrosion.¹ Fatigue testing in the 10/9 orientation according to ISO 7206-6 has been shown to replicate the clinical fatigue failures, but results in relatively minor fretting and corrosion. The purpose of this pilot study was to evaluate techniques for accelerating fretting corrosion with the goal of replicating the most severely corroded clinical retrieval cases.

METHODS: Constructs tested in this study consisted of a single stem and neck design (PROFEMUR® modular, MicroPort Orthopedics). The worst case long varus neck design was evaluated in two materials: Ti6Al4V and wrought CoCrMo. In vitro fatigue testing in the 10/9 configuration was conducted at 10Hz in unbuffered, aerated saline. Fretting mass loss, distraction force, and assessment of taper corrosion via SEM/EDS were measured. Methods used to exacerbate fretting corrosion are shown in Table 1.

Sample	Neck Mat'l	Assembly	Temp (°C)	Cycles-Mc	Mass loss (mg) @ 5 Mc	Distraction force-N	Result
1	TAV	Hand	37	1.751	Na	Na	Neck Fx
2				>5	2.2	1956	Ro
3				1.975	Na	Na	Neck Fx
6					1.1	DNR	
7		Impaction			0.37	10597	Ro
8					0.37	6223	
10					0.87	2931	
14					7.97	DNR	
B1		Gentle Impaction			-0.13	3567	Ro
B2					-0.67	1335	
B3					-0.43	3411	
17	CoCr	Hand	80	10	10.33	1917	10 Mc- Fx
18				>10	4.43	1409	10 Mc- Crack
19		Impaction			0.93	9290	Ro
C1					1.93	1398	
C2		Gentle Impaction			1.83	1827	
C4					2.93	2658	

RESULTS: Test results are shown in Table 1. All of the constructs impacted per surgical technique survived 5Mc and were similar to constructs tested under standard conditions (Figures-1c, f). In contrast, Ti neck constructs that were hand assembled failed in fatigue after a surprisingly small number of cycles. The hand-assembled constructs that survived 5Mc of loading exhibited lower distraction forces, higher than normal fretting mass loss, and moderate to severe corrosion of the taper. In particular, constructs

that were hand-assembled and tested at elevated temperature with a rest period had much higher fretting mass loss and a level of corrosion that is qualitatively similar to corroded retrievals (Figures-1a, g). The CoCrMo necks that were hand assembled survived 10Mc, but one of them fractured during distraction, and they exhibited higher fretting and corrosion at 5Mc (Figure-1d). The effect of adding acidified saline/contamination to the stem pocket was unclear, but elevating the temperature and adding a rest period resulted in a substantial increase in fretting and corrosion. The constructs that were assembled by gentle impactation (1500 N) exhibited moderate fretting. Although the mass loss of gently impacted titanium necks was comparatively lower than the hand assembled constructs the qualitative appearance of corrosion at 5 Mc for both Ti and CoCrMo constructs (Figures- 1b,e) was worse than that of the well impacted devices. It is also notable that while the CoCrMo necks performed substantially better (in cyclic fatigue) than Ti necks after hand-assembly, their performance was still markedly reduced compared to well-impacted constructs.



CONCLUSION: This study has shown conclusively that failure to impact modular neck connections can have a substantial effect on taper fretting and corrosion, leading to early fatigue failure. Applicability to other designs requires further study.

H584 Friction of Total Hip Replacement Bearings and Rotational Strength of Four Contemporary Tapers

Primary Author: Jim Nevelos
Institution: Stryker Orthopaedics

Coauthors: Laura Scholl (Stryker Orthopaedics), Lokesh Raja (Stryker Orthopaedics), Lizeth Herrera (Stryker Orthopaedics), LaQuawn Loving (Stryker Orthopaedics), Jason Longaray (Stryker Orthopaedics), Christopher Hefernan (Stryker Orthopaedics)

INTRODUCTION: The purpose of this study was to evaluate the influence of bearing material and bearing size on the frictional torque of hip bearings utilizing a physiologically relevant hip simulator model and to then mechanically test the torsional resistance of 4 contemporary taper design/materials in order to evaluate if the friction forces were of the same order of magnitude as the torsional resistance.

METHODS: A total of four hip bearing combinations (Sequentially Crosslinked (SXL) PE/CoCr, Conventional PE/CoCr, SXL/Delta and Alumina /Alumina) with various bearing sizes were evaluated. The sizes tested in this study range from 22mm to 44mm. A total of three samples per bearing combination were tested, with the exception of conventional PE, which included a total of 4 samples. All components were oriented anatomically with the femoral head mounted below on a rotating angled block which imparts a 23° biaxial rocking motion onto the head.

For the torsional testing CoCr femoral heads were tested with trunnions that were machined with both a large and small taper geometry, replicating commercially available stem taper designs, V40TM (small) and C (large) (Stryker Orthopaedics, NJ). Four trunnion groups were tested, three small tapers made of TMZF, Ti6Al4V, and Stainless Steel, and one large taper made of Ti6Al4V. Each head-trunnion combination was dynamically loaded with a torque of $\pm 5\text{Nm}$ and a constant axial load of 2450N for 1000 cycles at 1.5 Hz. Upon completion of the dynamic test, a static torque to failure test was performed on the same head-trunnion specimens where the axial force of 2450N was maintained and the trunnion was rotated to 40° at a rate of 3°/sec. From the data acquired, torque required to rotate the trunnion by 1° was determined for all the specimens. In addition, the torsional resistance, which was defined as change in torque / change in angle in the linear region of the torque-angular displacement data curve, was determined.

Testing was performed in Alpha Calf Fraction Serum (Hyclone, UT) in both studies.

RESULTS: Frictional torque increased with the increase of head size regardless of head material for all polyethylene combinations ($p>0.05$). However, results showed no change in frictional behavior for the Alumina /Alumina combination regardless of the bearing size. The results of this test did not show any significant difference between SXL and conventional PE materials for sizes 28mm and 32mm when paired against a CoCr head ($p>0.05$) (Figure 1).

The $\pm 5\text{Nm}$ of torque applied during the dynamic test did not generate any rotation between the trunnion and the head. Figure 2 contains the results of the Torque at 1 degree of rotation and the torsional resistance. There was no statistical difference in these values for the trunnions tested.

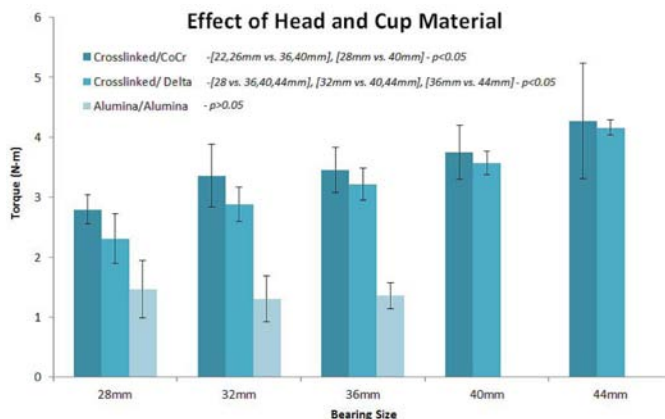


Figure 1.

DISCUSSION: Frictional torques generated by even large head (44mm) CoCr and delta on Cross-linked PE articulations are of the order of 4Nm. The torsional resistance of the tapers tested here was a minimum of 6 times greater than that.

Figure 2 Results – Static Torque to Failure Test		
Specimen Group	Torque at 1° rotation (Nm)	Torsional Resistance (Nm/°)
1	23.53 ± 0.72	24.49 ± 7.49
2	27.45 ± 4.51	32.08 ± 19.03
3	25.59 ± 3.06	29.94 ± 2.95
4	23.35 ± 0.89	31.69 ± 8.49

Figure 2.

H585

Use of a Novel CT Database and Analysis Tools in Femoral Hip Stem Design

Primary Author: Jim Nevelos

Institution: Stryker Orthopaedics

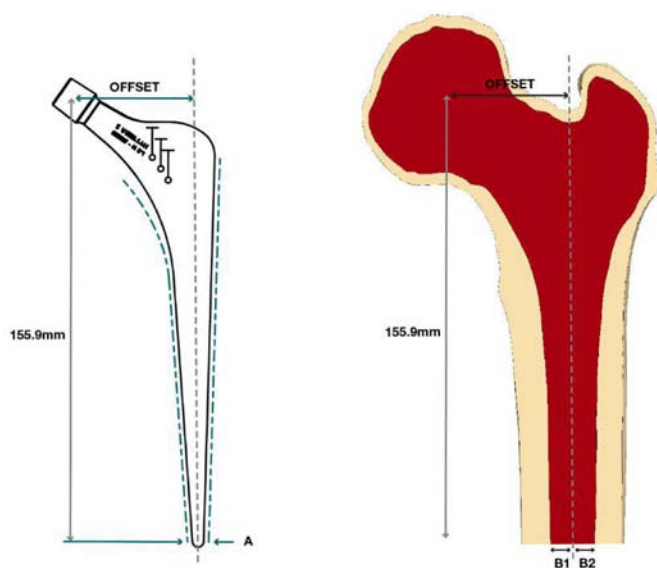
Coauthors: Emmalynn Connor (Stryker Orthopaedics), Thies Wuestemann (Stryker Orthopaedics), Adam Bastian (Stryker Orthopaedics), Ross Crawford (Holy Spirit Northside Hospital, Brisbane, Australia)

INTRODUCTION: Historically, femoral hip stem design has been based on limited datasets of X-rays or CT scans. A large database of high resolution, segmented, CT scans has been collected and, critically, three software tools have been developed to allow for selecting different demographic and ethnic groups, accurate analysis of bony dimensions and measurement of implant fit following virtual implantation.

METHODS: The analysis presented here used the custom CT based program SOMATM (SOMATM V.3.2, Stryker Orthopaedics, Mahwah, NJ). The program SOMATM contains large database of 3D models created from CT scans. Anatomic analysis and implant fitting tools are also integrated into SOMATM to perform morphometric analyses and implant design optimization analyses.

Study 1 was initiated as part of the design process for a novel tapered wedge stem with reduced length (Accolade II, Stryker, Mahwah, NJ). The reduction in length may theoretically lead to reduced stability and so a better fit with the femoral canal was desired. We evaluated the proximal offset of the canal (20mm above the lesser trochanter (LT) and distal width 130mm below the LT in a study of 556 left femurs 57% male, 43% female). The ethnicity of the scans were 69% Caucasian, 16% Asian and 14% unknown. The average age was 66 years, ranging from 40 to 93 years.

Study 2 Evaluated the fit of a cemented stem rasp at 2 different lengths (125mm and 150mm). Rasps for 37.5, 44, 50mm offset, No.1, 150mm length stems (Exeter, Stryker Orthopaedics, Mahwah NJ) were compared with shortened length models using SOMATM. The sample size of appropriate patients for these stems totaled 238 femora. These femora were analyzed for distal contact (rasp to cortices) for 150mm and 125mm models (Figure 1).

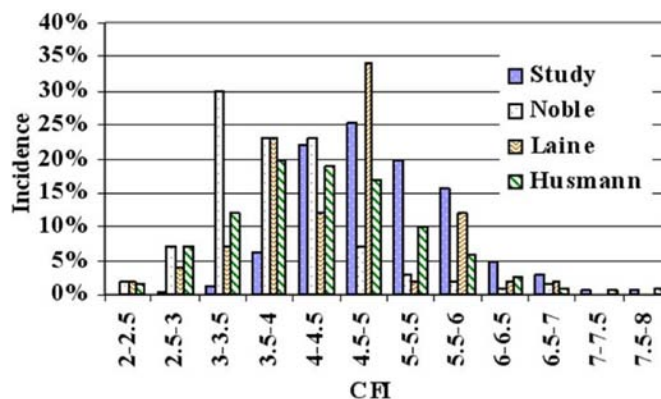


RESULTS: Study 1. The mean mediolateral width at 20mm above the lesser trochanter was 47.0 ± 4.5 (35.1-61.8; n=556). Noble reported 45.4 ± 5.3 (31.0-60.0; n=200), Husmann reported in a neck oriented study 46.3 ± 6.9 (27.6-63.6; n=310) and Laine reported 47.1 ± 4.9 (n=50). The mean medial offset at a section 20mm above the lesser trochanter was 25.1 ± 2.9 (16.7-33.4). In the study by Husmann, a mean of 25.0 ± 5.2 (9.4-45.5) was reported. The mean canal flare index was $4.49 \pm .8$. Noble reported a mean canal flare index of $3.80 \pm .074$, Husmann $3.81 \pm .83$ and Laine $4.3 \pm .93$. Figure 2.

Study 2. In the AP view, the rasp exhibited contact in 43 cases for a 150mm stem but in 0 cases for a 125mm stem; 95% of bones with contact were Champagne Fluted. In the ML view, rasp distal contact occurred in 52 femora for a 150mm stem and in 1 femur for a 125mm stem (Table 1). The difference was significant in both views with $p < 0.001$.

	MLW + 20mm LT			MLW at Isthmus		
	Mean	SD	Range	Mean	SD	Range
Study (n=556)	47.0	4.5	35.1-61.8	10.8	2.1	5.4-17.1
Noble (n=200)	45.4	5.3	31.0-60.0	12.3	2.3	8.0-18.5
Husmann (n=310)	46.3	6.9	27.6-63.6	11.2	2.3	5.6-18.4
Laine* (n=50)	47.1	4.9	n/a	14.8	2.9	n/a

Table 1. Mean values, standard deviation and range of mediolateral width compared to previous studies (all dimensions in millimeters). *Neck oriented study.



DISCUSSION: These two studies have shown the effectiveness of a CT based analysis system in assessing both femoral morphology and the fit of rasps into the femoral canal using large sample sizes. This system is currently being used for further morphometric analysis and implant design.

H586

31 to 26 Year Clinical Results of THA by Interface Bioactive Bone Cement (IBBC) with HA

Primary Author: Hiroyuki Oonishi

Institution: H. Oonishi Memorial Joint Replacement Institute, Tominaga Hospital

Coauthors: Hironobu Oonishi (H.Oonishi memorial Joint Replacement Institute, Tominaga Hospital), Ikuo Kawahara (H.Oonishi memorial Joint Replacement Institute, Tominaga Hospital), Yoshifumi Hanaoka (H.Oonishi memorial Joint Replacement Institute, Tominaga Hospital)

INTRODUCTION: The essentials for the long term longevity of THA are 1) low wear and 2) supporting the implants with continual rich new bone formation by osteoconduction around the implants even after onset of osteoporosis. For this purpose we have used the interface bioactive bone cement (IBBC) technique which involves interposing not-resorbable crystalline HA granules at the interface between bone and bone cement at the time of cementing during surgery.

MATERIALS AND METHODS: In IBBC, crystalline HA granules (300~500 μ m) were smeared on the bone surface within three layers just before packing bone cement.

Group 1: IBBC was used in 12 joints from 1982 to 1983. Conventional bone cement (Non-IBBC) was used in 79 joints.

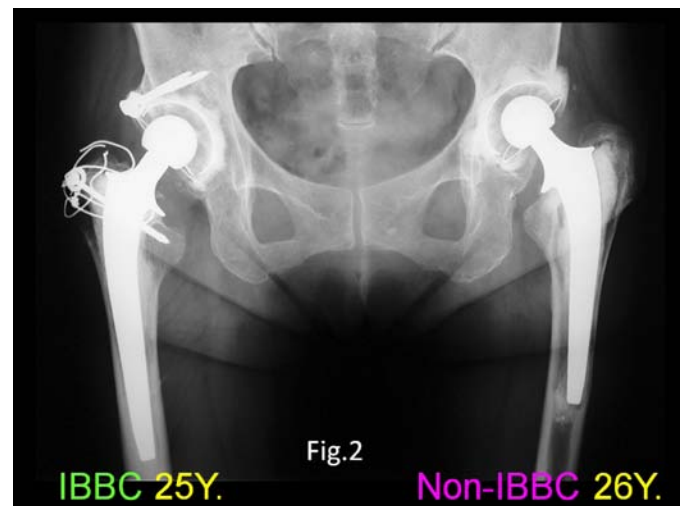
Group 2: In 25 patients Non-IBBC in the one hip (in 1985 to 1986) and IBBC technique in the other hip (in 1986) were performed in the same patients.

Group 3: In 285 joints, IBBC were performed (in 1987).

RESULTS: In group 1, follow-up rate was 100%. Neither radiolucent line nor osteolysis appeared in all cases even in the case with polyethylene wear in high rate, except for on the area where HA granules were not smeared and IBBC was performed on the bleeding area. We have no revision case [Fig.1]. In Non-IBBC cases, follow-up rate was 89%. 61 joints (82%) were revised.

In group 2, follow-up rate was 91%. In the hip joints with Non-IBBC the appearance rate of radiolucent line and osteolysis were high and 75% of the joints loosened. However, in the hip with IBBC they were extremely low [Fig.2]. However, they appeared on the area where HA granules were not smeared. The spaces appeared between bone cement and HA on the area where IBBC was performed on the bleeding area.

In group 3, follow-up rate was 92%. The radiolucent line appeared only 0.9 and 1.4% in zone 3 and 4, respectively, in the acetabulum, and 1.8 and 0.4% in zone 1 and 7, respectively, in the femur. The osteolysis appeared only 0.5% in zone 1 and 2, respectively in the acetabulum and 0.5% in zone 7 in the femur. They appeared only on the area where HA granules were not smeared.



DISCUSSION: In IBBC, as not-resorbable osteoconductive HA granules were used, osteoconduction will continue eternally and the occurrence of radiolucent line and osteolysis will be defended or repaired eternally. As a result, the appearance rate of both radiolucent line and osteolysis were extremely low even in the cases of progressing of polyethylene wear in high rate, and in the cases after onset of osteoporosis due to aging and in the cases of pathological low activity of osteoconduction. These results were confirmed by the histological studies in retrieved cases over 20 years.

CONCLUSION: In IBBC rich new bone formation with HA granules around bone cement could be continued and prostheses could be expected super long term longevity.

H587 Cementless Stem with Interlocking Screws for Fragile Femoral Cortex Patients

Primary Author: Tomotaro Sato

Institution: Department of Orthopaedic Surgery, Nagoya Medical Center

Coauthors: Atsushi Kaneko (Nagoya Medical Center), Daihei Kida (Nagoya Medical Center)

Revision Total Hip Arthroplasty can be challenging in case of thin or fragile femur. Primary Bipolar Hip Prosthesis (BHP) is also difficult in severe osteoporosis case. We have used titanium alloy cementless stem with interlocking screws for revision THA since 2003, and primary BHP in senile case since 2007.

Thirty-nine cementless THA were performed with interlocking stem (31 S-LOCK and 8 Delta-LOCK) since 2007, and 29 cases were followed for more than one year. Two for primary THA and 27 for revision THA, 5 were male and 24 were female. Seven primary Bipolar Hip Prosthesis with interlocking screw stem for femoral neck fracture were also followed more than one year. All seven BHP cases were female.

Stress shielding in X-ray film were observed in 3 revision THA cases during follow up, but no pain were complained. No breakage of screws and stems were observed, and no infections and no fractures were occurred.

In case of loosened stem, long interlocking stem can bypass the weak point of femur after removal of cement or metal stem tip. Patients can walk immediately after revision THA or primary BHP.

Cementless interlocking stem in THA and BHP is useful for management of thin or fragile femoral cortex.

H588

National Trends of Occurrence of Pulmonary Embolism After Total Hip Arthroplasty

Primary Author: Brian E. Schwartz

Institution: University of Illinois Department of Orthopaedic Surgery

Coauthors: Nicholas Schraut (University of Illinois), Vincent Moretti (University of Illinois), Ritesh R. Shah (Illinois Bone and Joint Institute)

INTRODUCTION: Pulmonary embolism (PE) is an infrequent, yet devastating complication after total hip arthroplasty (THA). Recently, there has been tremendous focus and allocation of healthcare resources to reduce or prevent PE after THA. Despite significant scrutiny and effort devoted to preventing PE after THA, limited national data exists regarding the early results of this effort. The purpose of this study was to assess recent national trends in PE occurrence after THA and evaluate patient outcomes related to this adverse event.

METHODS: International Classification of Disease - 9th Revision (ICD-9) procedure codes were used to search the National Hospital Discharge Survey (NHDS) for all

patients admitted to surveyed US hospitals after primary THA for each year between 2001 and 2010. ICD-9 diagnosis codes were then used to identify patients from this population who developed an acute PE during the same admission. Data regarding patient demographics, hospitalization length of stay, discharge disposition, lower extremity deep vein thrombosis (DVT), mortality, and hospital size/location were gathered from the NHDS. Statistical analysis was performed using linear regression with Pearson's correlation coefficient (r), Student's t -test, z -test for proportions, and chi-square analysis with a significance level of 0.05.

RESULTS: 18,186 patients admitted for a primary THA were identified. 46 (0.25%) of these patients developed an acute PE during the same admission. The development of PE after THA demonstrated a weak positive correlation with time ($r=0.067$), increasing from an average rate of 0.25% between 2001-2005 to 1.1% between 2006-2010 ($p<0.01$). No significant differences in PE incidence were noted based on US region ($p=0.18$). There was no significant difference in PE rates when comparing the PE rate in hospitals under 200 beds (0.18%) and those with over 200 beds (0.30%, $p=0.09$).

There was no statistically significant difference in PE rates comparing gender ($p=0.53$) or age ($p=0.06$). The mean age of patients with PE and without PE after a THA were 68.4 years (22 men, 24 women) and 65.2 years (7849 men, 10291 women), respectively. The average number of medical co-morbidities was significantly higher in patients with PE (6.63 diagnoses) than without PE (5.25 diagnoses, $p<0.01$). The rate of DVT was significantly higher in patients with PE (4.3% versus 0.07%, $p<0.01$). Mortality was also significantly higher in patients with PE (3.9% versus 0.09%, $p<0.01$). Patients without PE were more likely to be discharged home (47.4% versus 30.4%, $p=0.02$), and had a shorter hospital length of stay (4.0 versus 7.9 days, $p<0.01$).

DISCUSSION/CONCLUSION: This study demonstrates that PE after THA can have a significant impact on patient outcomes and potential healthcare costs, with an associated 32-fold increase in mortality, a near doubling of the inpatient admission duration, and a diminished rate of being discharged directly home. The risk of PE after THA appears to be greatest in patients with multiple medical co-morbidities and established DVTs. Although the risk of PE after primary THA remains rare, our results demonstrate

that recent preventive efforts have not had a significant impact on its occurrence at the national level.

H589

Perioperative Outcomes in Patients with Workers' Compensation Claims After Primary Total Hip Arthroplasty

Primary Author: Brian E. Schwartz

Institution: University of Illinois Department of Orthopaedic Surgery

Coauthors: Nicholas Schraut (University of Illinois Department of Orthopaedic Surgery), Vince Moretti (University of Illinois Department of Orthopaedic Surgery), Ritesh R. Shah (Illinois Bone and Joint Institute, University of Illinois Department of Orthopaedic Surgery)

INTRODUCTION: Workers' Compensation (WC) status has been shown to correlate with worse long-term outcomes after total hip arthroplasty (THA) procedures. Although a variety of factors have been identified, perioperative results in WC population have not been well analyzed. The purpose of this study was to evaluate perioperative outcomes after primary THA for WC and non-workers' compensation (NWC) patients, when matched for age and sex.

METHODS: The National Hospital Discharge Survey (NHDS) database was searched using International Classification of Diseases - Ninth Revision (ICD-9) codes for patients admitted to US hospitals for primary THA between 2001 and 2010. ICD-9 codes were then used to analyze patient demographics, hospital length of stay (LOS), discharge disposition, and in-hospital adverse events [deep vein thrombosis (DVT), pulmonary embolus (PE), blood transfusion, and mortality]. Patients were identified by their principle expected method of payment with WC for the WC group, and all other methods of payment for the NWC group (Medicare, Medicaid, Other government, Blue Cross/Blue Shield, HMO/PPO, Other private insurance, Self pay, No charge, Other, Not stated) included all other types of insurance. Age and sex were limited to male patients between the ages 25-63 in both groups to limit confounding variables. Trends were evaluated by linear regression with Pearson's correlation coefficient (r), and statistical comparisons were made using Student's t-test and z-test for proportions with a significance level of 0.05.

RESULTS: 66 WC THA patients and 3,976 NWC THA patients were identified. The WC group had a mean patient age of 50.6 years versus 52.5 years in the NWC group ($p=0.06$). The average hospital LOS was not significantly longer for the WC group versus the NWC group (4.1 days versus 3.6 days, $p=0.07$). The rate of discharge to home was insignificantly lower in the WC patients (62.1% versus 70.3%, $p=0.15$). A significant difference was found between WC and NWC in regards to both the rate of PE (0% versus 0.17%, $p<0.01$), and DVT (0% versus 0.15%, $p=0.01$). No significant difference was found for the rate of blood transfusion between WC and NWC (12.1% versus 15.6%, $p=0.43$). Mortality rate was found to be zero in both groups. The average number of medical co-morbidities between the WC and NWC (4.24 versus 4.13) was not significantly different ($p=0.67$). WC accounted for 1.60% of the THA performed between 2001-2005 and remained relatively unchanged between 2006-2010 at a rate of 1.66% ($p=0.87$).

CONCLUSIONS: Compared to NWC patients, WC patients who underwent a THA were found to have lower rates of both PE and DVT. There was no significant difference found between WC and NWC for LOS or rate of discharge to home. Likewise, no significant differences were found in the rate of blood transfusions, number of medical co-morbidities and deaths while hospitalized between WC and NWC patients who underwent a THA. This study suggests that the potential of inferior long-term results in WC patients after primary THA is not related to the immediate post-operative period.

H590

Fibrous Tissue Generated by Ceramic on Ceramic Couple Play a Relevant Clinical Role

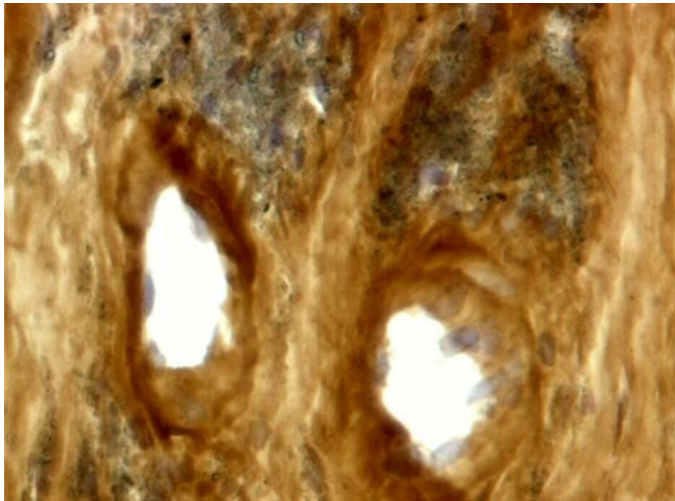
Primary Author: Laurent Sedel

Institution: APHP and University of Paris Denis Diderot

Coauthor: Thierry Hoc (ITVT Ecole Centrale Lyon)

Since more than 40 years, Ceramic on ceramic (COC) bearings proved to be interesting in young and active population. Limited number of debris generation resulting in the absence of osteolysis and remarkable resistance to wear and friction are the most common recognized qualities of the construct. Noise and fracture although anecdotic are of limited consequence. The subject we would like to express

here is the very specific histological reactions to ceramic. In contradiction to other materials, ceramic on ceramic developed a very strong fibrous tissue. This fibrous tissue encountered at revision formed the new capsule. This was documented in different retrieval analysis studies. This explains why during revision of such couple, surgeons have to fight against a very thick and resistant fibrous material. This tissue is very different from the ones observed during other retrieval involving either ceramic or metal on polyethylene or metal on metal.



This fibrous capsule might explain as well different behavior of prosthetic joint. Douglas Dennis and Richard Komistec did not find subluxation when they examined under fluoroscopy patients with COC material, and compared the data's with patients operated with metal or ceramic on polyethylene. More recently, P. Hernigou looking in a prospective manner to patients operated bilaterally with COC on one side and COP on the contralateral, found statistical differences regarding the frequency of late dislocation with no dislocation in the COC group. This fibrous material might explain lack of late dislocation, and be part of the explanation for long term survival rate without any adverse effects in patients practicing heavy activities and observed over period of more than 30 years. At the moment a new laboratory study did start. It concerned analysis of capsules taken during revision surgery and observed in a blind manner with various apparatus including micro-mechanical measurements and confocal multifoton microscope images. The latter is a very precise method to look at collagen organization. First data's confirmed large differences between capsules depending on the friction couple.

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H591

Midterm Results of Uncemented Acetabular Reconstruction for Posttraumatic Arthritis Secondary to Acetabular Fracture

Primary Author: Bin Shen

Institution: Department of Orthopaedic Surgery, West China Hospital, West China Medical School, Sichuan University

Coauthors: Oujie Lai (Department of Orthopaedic Surgery, West China Hospital, West China Medical School, Sichuan University), Jing Yang (Department of Orthopaedic Surgery, West China Hospital, West China Medical School, Sichuan University), Zongke Zhou (Department of Orthopaedic Surgery, West China Hospital, West China Medical School, Sichuan University)

At an average of 6.3 years after surgery, we evaluated midterm results of uncemented acetabular reconstruction in 31 hips with posttraumatic arthritis that developed after acetabular fracture. Patients were categorized by previous fracture treatments (open-reduction group and conservative-treatment group) and fracture patterns (simple group

and complex group). Surgery duration and blood loss were greater in the open-reduction and complex groups than in the conservative-treatment and simple groups ($P < .05$). The mean Harris Hip Score increased from 49 before surgery to 89 after surgery. Survival with revision or radiographic acetabular loosening as an end point was 100%. Fracture treatments and patterns were associated with increased surgery duration and increased blood loss. Open reduction and internal fixation of a fracture favor anatomical restoration of the hip's rotational center.

H592

Stability of Micro MAX Stem

Primary Author: Yoshihiro Shibata

Institution: Dept. of Orthop. Surg., Kainan Hospital

Coauthors: Isato Sekiya (Dept. of Orthop. Surg., Kainan Hospital), Naoya Takada (Dept. of Orthop. Surg., Kainan Hospital), Yuka Mukofujiwara (Dept. of Orthop. Surg., Kainan Hospital), Hirotaka Iguchi (Nagoya City University), Satona Murakami (Nagoya City University)

BACKGROUND: While short stems have the advantage that they are suitable for Minimally Invasive Surgery, thanks to their ease of insertion and reduced thigh pain risk, good clinical outcomes depend on sufficient initial fixation in the proximal femoral component. Revelation stems are designed to increase medullary cavity occupancy in the proximal femoral component and allow physiological load transmission within this component. On theoretical initial fixation of the proximal part of the stem, fixation remains unaffected by cutting the distal part of the stem. Recently, the Revelation micro MAX stem has become available. In this system, only the distal part of the stem is removed. To prepare for the introduction of the Revelation micro MAX stem, we evaluated its rotational stability by installing the short stem in the femurs of formalin-fixed cadavers. We then evaluated the time course of changes in bone density at the stem circumference and stem position by CT in the first eight patients undergoing hip arthroplasty.

SUBJECTS AND METHODS: Micro MAX stems were inserted into the left femurs of one male and six female cadavers (76 to 95 years of age). A commonly used torque meter was mounted on the stem, and stem fixation was evaluated by the application of clockwise torque of 6 to 12 N-m. In patients, three men and five women (age range

38-83 years, mean 67 years; two cases of femoral head necrosis, two of femoral neck fracture, and four of osteoarthritis of the hip) who underwent surgery with the micro MAX stem from July 2012 to April 2013 were evaluated at 3 weeks, and 3 and 6 months after surgery for stem insertion angle and stem subsidence by CT, and for bone density around the stem by the DEXE method.

RESULTS: Rotational stability of the micro MAX stem in cadaveric femurs was similar to that of the conventionally used Revelation stem. In CT examination after surgery, the micro MAX stem tended to be inserted in a slightly varus position. No evidence of stem subsidence was observed in eight patients, but the varus progressed in one case. Bone density in the stem circumference was maintained.

DISCUSSION: Short stem have many advantages, however problems with the first fixation might result in loosening. Although the present study was conducted in a small number of patients with limited range of clinical conditions, our findings suggest that the rotational stability of the micro MAX stem is similar to that of the conventional stem. Postoperative CT measurement indicated that the micro MAX stem tended to be inserted in the varus position, particularly in patients with a large medullary cavity. The micro MAX stem was stable, and no decrease in bone density was seen. As with other short stems, however, procedures to avoid insertion in the varus position in patients with a large medullary cavity are required.

CONCLUSION: In this investigation, the micro MAX stem was shown to have no problems in initial fixation. Clinical outcomes with this system should be favorable.

H593

Medium-term Results and Radiographic Evaluation of Cementless Vektor-Titan Stem in Hip Arthroplasty

Primary Author: Kouki Shimodaira

Institution: Department of Orthopedic Surgery, Shinshu University School of Medicine

Coauthor: Masaaki Maruyama (Dept. of Orthop. Surg., Shinonoi General Hospital)

OBJECTIVE OF THE STUDY: The objective of this study is to establish the medium-term clinical and radio-

logical results with the cementless three-dimensional Vektor-Titan stem compared with conventional cementless stem.

MATERIALS AND METHODS: From July, 2004, to May, 2010, eighty Vektor-Titan stems and 217 PerFix stems were implanted in our hospital. The results were evaluated clinically using Japanese Orthopedic Association (JOA) Scores and radiologically within the scope of a retrospective cohort study. **RESULTS:** One patient had intraoperative femoral shaft fracture and healed by conservative treatment. There was no radiolucent zones around Vektor-Titan stems evaluated by Gruen's zonal analyses. On the other hand, there were radiolucent zones of more than 90% in zone 4 with cementless PerFix stems. There was no cases of loosening or postoperative infection. Although signs of bone atrophy were found in the proximal femur and the trochanters in 66.7% of all cases, bone structure was radiologically normal without stress shielding. On the contrary, there was evidence of an even denser bone structure, such as trabeculae, at the tip of the stem and the lateral implant fixation within the greater trochanter. These findings remained unchanged over observation periods. Clinically, JOA Scores were significantly improved in the patients except for femoral neck fracture.

DISCUSSION AND CONCLUSIONS: The cementless Vektor-Titan stem is made of Ti6Al7Nb, has got the shape of a straight three-dimensional cone. It has a high proximal volume in the form of a three-dimensional taper with longitudinal ribs. This design achieves strong primary fixation in the proximal metaphysis. Radiologically, newly formed trabeculae toward the stem were indicative of direct biological fixation at the bone-implant interface. Medium-term results with the cementless Vektor-Titan stem show no implant loosening with stable metaphyseal fixation and preservation of bone structure in the proximal femur and the absence of radiolucent zones around the stem compared with conventional cementless stem.

H594

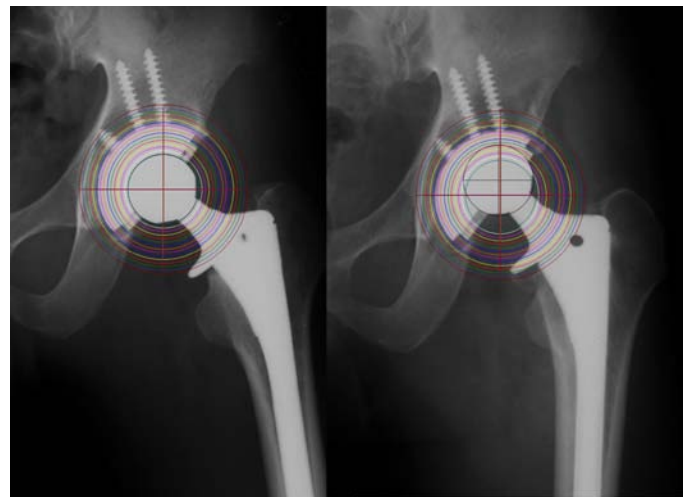
Use of Slide Presentation Software as a Tool to Measure Hip Arthroplasty Wear

Primary Author: Won-Yong Shon

Institution: Orthopedic department, Guro hospital, Korea university

Coauthors: Ho-hyun (Yun), Ho Hyun Yun, MD, Nirmal K. Jajodia, MS, DNB, Jong Keon Oh, MD, PhD

The authors propose a manual measurement method for wear in total hip arthroplasty (PowerPoint method) based on the well-known Microsoft PowerPoint software (Microsoft Corporation, Redmond, Wash). In addition, the accuracy and reproducibility of the devised method were quantified and compared with two methods previously described by Livermore and Dorr, and accuracies were determined at different degrees of wear. The 57 hips recruited were allocated to: class 1 (retrieval series), class 2 (clinical series), and class 3 (a repeat film analysis series). The PowerPoint method was found to have good reproducibility and to better detect wear differences between classes. The devised method can be easily used for recording wear at follow-up visits and could be used as a supplementary method when computerized methods cannot be employed.



H595

Transpositional Osteotomy of the Acetabulum Combined with Allogeneic Bone Grafting in Patients with Severe Acetabular Dysplasia

Primary Author: Motoki Sonohata

Institution: Department of Orthopaedic Surgery, Faculty of Medicine, Saga University

Coauthors: Masaru Kitajima (Saga University), Syunsuke Kawano (Saga University), Satoshi Ikebe (Saga University), Masaaki Mawatari (Saga University)

BACKGROUND: More than 70% of the cases of hip os-

teoarthritis in Japan are associated with acetabular dysplasia. Different techniques for performing periacetabular osteotomy to treat acetabular dysplasia have been established. The use of bone grafting to fill the large gap between the pelvis and transposed acetabulum combined with periacetabular osteotomy is essential; however, the amount of bone that can be harvested from the lateral wall of the ilium is limited. The purpose of this study was to analyze the extent of surgical correction and the early clinical results obtained using Transpositional Osteotomy of the Acetabulum (TOA) with allogenic bone grafting in patients with severe acetabular dysplasia.

METHODS: Between January 2002 and December 2008, we performed periacetabular osteotomy in a total of 358 hips in 299 patients (adolescents and adults) treated at our institution for symptomatic acetabular dysplasia lasting for at least three months. Forty-four hips in 38 patients with an average age of 27 (range: 11–49) years were confirmed to have severe acetabular dysplasia and underwent this procedure. The mean follow-up period was 4.2 (range: 1.5 to 8.2) years. Severe acetabular dysplasia was defined as a center-edge angle less than 0° , an acetabular-head index less than 50% and an acetabular roof obliquity greater than 30° . TOA was performed with transpositional osteotomy of the acetabulum, and the femoral head obtained during total hip arthroplasty was used for allogenic bone grafting. The patients were divided into two groups according to the radiographic appearance: 34 hips in the early stage group and 10 hips in the advanced stage group. Postoperatively, the hips were radiographically assessed for dysplasia correction. The clinical results and hip function were measured using the Harris hip score. All statistical analyses were performed using the Stat View software package, version 5.0 for Windows (SAS Institute, USA). Statistical significance was established at $p < 0.05$.

RESULTS: The average preoperative Harris hip score significantly improved from 70 to 91 points at the latest follow-up ($p < 0.01$). The average center-edge angle, acetabular-head index and acetabular roof obliquity significantly improved from -9° to 36° , 41% to 91% and 31° to 2° , respectively ($p < 0.01$). Continuity of the Shenton line improved from 15 to 35 hips ($p < 0.01$). No instances of non-union or of transposed segment collapse were encountered in this series; however, a grafted allogeneic bone was absorbed in one case.

CONCLUSIONS: The usage of allogenic bone grafting

combined with TOA is an effective technique for treating severe acetabular dysplasia. In this series, the early clinical and radiographic results were excellent.

H596

Using Navigation System Based on the Postoperative DICOM Data Predicted by Computer Aided Preoperative Planning and Plastic Models

Primary Author: Yumeji Takeichi

Institution: Aichi Medical University

Coauthors: Hirotaka Iguchi (Nagoya City University), Hirototo Mitsui (Nagoya City University), Satona Murakami (Nagoya City University), Hisato Motai (Motai Clinic)

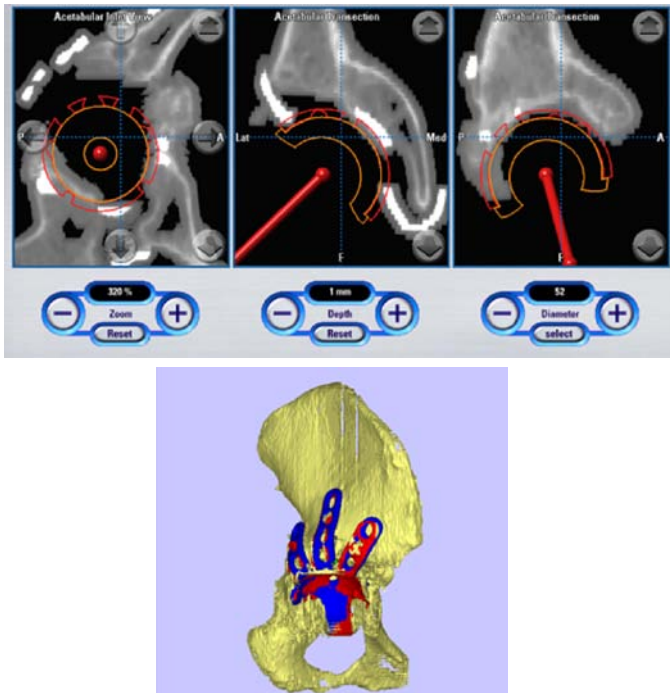
INTRODUCTION: Navigation system has been used for very accurate surgery. It can also be useful for preoperative planning. A surgeon can understand whole surgery, plan the surgery and perform the surgery three dimensionally and accurately. But the planning procedures should be installed before everything is started. When the surgery will be done in an ordinary method, the surgeon would not find particular difficulties. But in sometimes the surgeon can have unordinary situation such as massive defect that should be treated with acetabular enforcement device and bone grafted. Using postoperative DICOM data which is predicted by preoperative planning using 3D CAD software, we will be able to use the navigation system for those cases with difficulties that is not supported.

OBJECTIVES: To establish a method to use a navigation system using preoperative planning data that is processed by our 3D CAD software which is not supported by the navigation system itself, including device preparation using plastic models.

MATERIALS AND METHODS: CAT scan data performed before hip arthroplasty with acetabular enforcement plate were used. Data conversion was done by Mimics® then preoperative planning was done by Magics® (Materialize, Belgium). Plastic bone models were machined by Modella MD-40 (Roland DG, Japan). The acetabular plate was bent to fit to the plastic model. Then the plate was CAT scanned on the plastic model because the geometry is no longer same with original. This CAT scan data and original data were combined and processed and

exported as a set of DICOM data. At the surgery, the DICOM data was input. After registration, the planned acetabular plate which was not actually exist could be seen on the screen. CAT scan was done after surgery and the difference from the plan was evaluated.

RESULTS: On navigation screen, the postoperative geometry was displayed. Moving probe, the detail could be observed (Fig. 1). The difference between preoperative plan and postoperative alignment was very close.



H597 Evaluation of Hip Instability After Transtrochanteric Rotational Osteotomy for Nontraumatic Osteonecrosis of the Femoral Head

Primary Author: Satoe Tanabe

Institution: Department of Orthopaedic Surgery, Showa University Fujigaoka Hospital

Coauthors: Takashi Atsumi (Department of Orthopaedic Surgery, Showa University Fujigaoka Hospital), Satoshi Tamaoki (Department of Orthopaedic Surgery, Showa University Fujigaoka Hospital), Ryosuke Nakanishi (Department of Orthopaedic Surgery, Showa University Fujigaoka Hospital), Mino

BACKGROUND: The principal concept of transtrochanteric rotational osteotomy in the treatment of femoral head osteonecrosis is that the necrotic lesion is moved away from the acetabular loaded area and the viable area is moved to the acetabular loaded area. The purpose of this study was to evaluate the hip instability using computed tomography scans (CT scans) after transtrochanteric rotational osteotomies (either anterior rotational osteotomy (ARO) or posterior rotational osteotomy (PRO)) for non-traumatic osteonecrosis of the femoral head.

MATERIALS AND METHODS: 68 hips in 64 patients underwent transtrochanteric rotational osteotomy for non-traumatic femoral head osteonecrosis, and all patients underwent CT scans approximately six weeks after surgery. Four hips in four patients were excluded due to the extensive collapse and the nonevaluable instability. Of these 68 hips, 64 hips in 60 patients were included in this study. AROs were performed on 28 hips in 27 patients, and PROs were performed on 36 hips in 33 patients. There were 41 males and 19 females. The average age was 33 years at the time of surgery. 24 patients had a history of corticosteroid usage, 31 had a history of heavy alcoholic consumption, and five had no apparent risk factor. According to the staging system of Japanese Ministry of Health, Labour and Welfare, one hip was classified in Stage 2, 17 hips were classified in Stage 3A, 35 hips were classified in Stage 3B, and 11 hips were classified in Stage 4. According to pre-operative anteroposterior radiographs, no viable area was seen in three hips, small viable area was seen in 22 hips, and middle size viable area was seen in 39 hips.

During CT scan, the patient was placed in supine position with hip fully extended position and 45° flexed position, which were both in neutral hip rotation.

Then, using the axial view of CT scan, we measured the distance from posterior acetabular joint surface to posterior joint surface of femoral head. We measured the difference in distance of the femoral head to the acetabulum between the images of hip fully extended and that of 45° flexed position. We defined the instability of the hip joint when there is more than 1.0 mm of difference.

RESULTS: CT scan revealed the instability in seven (25%) of the 28 hips after ARO and in five (14%) of the 36 hips after PRO. With regard to the stage 3B with severe collapse, the instability was revealed in six (50%) of 12 hips after ARO and in two (9%) of 23 hips after PRO.

CONCLUSIONS: From this study, PRO seems to be less likely to cause the instability of the hip joint than ARO. After PRO, the necrotic lesion is moved posteromedially, which means necrotic lesion is moved away from acetabular loaded area, not only in the neutral hip position but also even in flexed hip position during the daily activities. Therefore, PRO is considered to be a better surgical technique in gaining the containment and congruency of the hip joint than ARO.

H598

Changes of BMD After Total Hip Arthroplasty Between Two Cementless Stems

Primary Author: Shoichi Taniguchi

Institution: Hachiya Orthopaedic Hospital

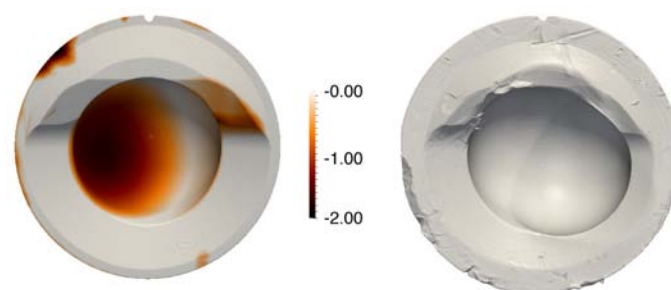
Coauthors: Yudo Hachiya (Hachiya Orthopaedic Hospital), Hiroki Watanabe (Hachiya Orthopaedic Hospital)

The primary fixation of cementless stem depends on the shape, the alignment and the coating of the stem. A decrease in bone mass destabilizes the fixation after the operation. We examined a fluctuation of bone mineral density after operation, using Excia (Tapered round type) and Taper loc (Single wedge type).

MATERIAL AND THE METHOD: Between 2009 and 2012, we performed cementless Total Hip Arthroplasty in 55 patients (63 joints) and the follow-up period was longer than 1 year. Taper loc stem, (hereinafter collectively called TL Group) was used to treat 37 patients (42 joints) including 5 male and 32 female patients with 63.9 of the average age. Their primary diseases are all hip osteoarthritis except for one joint in osteonecrosis of the femoral head. 18 patients (21 joints) including 3 male and 15 female patients used Excia, (herein after collectively called EX group). The average age was 54.5. Their primary diseases were hip osteoarthritis. We examined BMD in the 7 Zone of Gruen classification with dual-energy x-ray absorptiometry at 2 weeks, 6 months and 1 year after the operation. We also evaluated stress shielding and cortical hypertrophy in radiographic findings 1 year after the operation.

RESULT: The test results revealed that a decrease in BMD in all Zone at 6 months after the operation for both the TL and the EX group. One year after the operation, the TL group showed the recovery in every Zone excluding

Zone 4. The EX group showed the recovery in Zone 1 and 7, but the decline in other Zones. We did not observe significant differences between two groups, although the TL group showed remarkable recovery of BMD in Zone 3, 6 and the EX group also showed a similar increase in Zone 7. Stress shielding was observed in Zone 1 with 85% of the joints in TL group and 45% in EX group, and Zone 7 with 28% of the joints in TL group and 45% in EX group. We did not observe Cortical hypertrophy in both groups.



DISCUSSION: The stem in the TL group was considered to be fixed in wider and more distant area than expected. The EX group showed the post operational changes in BMD in the proximal-fixed stem and tendency to have less stress shielding proximally. We did not observe significant differences in proximal –fixed stem between both groups, but the load was transferred to the distal for TL group and to the proximal for EX group more than expected.

H599

Enhanced Wear But Not Damage Performance In Highly Crosslinked Polyethylene Acetabular Liners

Primary Author: Matthew G. Teeter

Institution: London Health Sciences Centre

Coauthors: Hee Nee Pang (London Health Sciences Centre), Richard W. McCalden (London Health Sciences Centre), Douglas D. Naudie (London Health Sciences Centre), Steven J. MacDonald (London Health Sciences Centre)

PURPOSE: The objective of this study was to compare the wear characteristics and damage scores of retrieved highly cross-linked (XLPE) and conventional non-cross-linked polyethylene (CPE) acetabular liners.

METHODS: Thirteen XLPE acetabular liners were retrieved from patients who underwent revision surgery be-

tween 1999 to 2011. All liners were from a single model and had an inner diameter (head size) of 28 mm. These retrieved liners were matched to a group of CPE liners that were retrieved in the same time period. The XLPE and CPE implants share a common design, with the only difference being the polyethylene treatment. These two groups were matched in terms of patient age, gender, liner dimensions, duration of implantation, and reason for revision. Surface damage was scored and the pattern documented. Penetration due to wear and creep in the two groups of liners were measured and compared using micro-computed tomography (micro-CT).

RESULTS: There was no difference in overall ($p = 0.18$) or regional damage scores between groups (overall damage score 15.2 ± 4.6 for CPE versus 13.8 ± 4.0 for XLPE). However, there was three times greater penetration ($p = 0.003$) in the CPE group (0.179 ± 0.093 mm/year) versus the XLPE group (0.052 ± 0.065 mm/year). The mean duration of implantation was 5.0 ± 3.4 years in the XLPE group and 5.2 ± 3.7 years in the CPE group ($p = 0.51$). Instability, infection, aseptic loosening were the primary reasons for revision in both groups.

DISCUSSION: XLPE liners undergo less wear than CPE liners based on quantitative measurements provided by micro-CT, which was not apparent using damage scoring alone. This demonstrates the utility of 3D imaging techniques (such as micro-CT, laser scanning, coordinate measuring) for quantifying wear in retrieval studies.

SIGNIFICANCE: Longer term studies are required to determine the effect on implant longevity, but the superior wear property of XLPE liners may reduce the need for revision surgery as a result of less wear and osteolysis.

H600

Calcar Bone Graft to Restore Limb Length in Comminuted Intertrochanteric Fractures - An Innovative Method

Primary Author: Savyasachi C. Thakkar

Institution: Johns Hopkins Hospital - Orthopaedic Surgery

Coauthor: Chandrashekhar J. Thakkar (Joints Masters Institute - Mumbai, India)

BACKGROUND: Management of comminuted intertro-

chanteric fractures with cemented bipolar hemiarthroplasty is an established method. However in these fractures, the medial calcar support is lacking.

OBJECTIVE: Our objective was to develop a technique using the excised femoral head bone as a graft, with cemented bipolar hemiarthroplasty. **Methods:** Between 2005 and 2010, we treated 37 patients with intertrochanteric fractures using this technique. Selection criteria were - osteoporosis using Singh's index and unstable fractures according to Evans. Patients were operated within 24 hours. We analyzed the restoration of limb length and studied the fate of bone graft postoperatively at 6 months. We also analyzed postoperative complications.

RESULTS: In one case, the graft sank during prosthesis insertion leading to limb shortening of 1.5cm, while in 36 patients the limb lengths were equalized within 5 ± 1.2 mm. From 18 patients at follow-up - in 2 patients the graft was absorbed, while in 16 the graft got consolidated. 3 patients had implant failures in the form of breakage of stem at junction of upper 1/3 with lower 2/3. One patient had a painful nonunion of the greater trochanter, while one patient had a superficial bed sore. Surgical duration was significantly shorter (45 ± 12 minutes vs. 96 ± 26 minutes), mean perioperative blood loss (150 ± 100 ml vs. 511 ± 103 ml) was significantly lower, and incidence of blood transfusions (7 out of 37 patients vs. 27 out of 29 patients) was significantly lower than those in the literature. The hospital length of stay in was significantly lower than the value in the literature (5 ± 2 days vs. 13 ± 2.6 days).

CONCLUSION: Using our technique, we have shown that the limb length can be restored in all the cases within 5 ± 1.2 mm, and that the graft gets incorporated, providing adequate support to the prosthesis.

H601

Protrusio Acetabuli and Total Hip Arthroplasty in Patients with Marfan Syndrome

Primary Author: Savyasachi C. Thakkar

Institution: Johns Hopkins Hospital - Orthopaedic Surgery

Coauthors: Jared R.H. Foran (Panorama Orthopedics and Spine Center), Simon C. Mears (Johns Hopkins Bayview Medical Center - Orthopaedic Surgery), Paul D. Spon-

seller (Johns Hopkins Hospital - Orthopaedic Surgery)

Department of Orthopaedic Surgery)

BACKGROUND: The presence of protrusio acetabuli is one of the skeletal criteria for diagnosis of Marfan syndrome by the Ghent nosology and some experts think that patients with Marfan syndrome may be at an increased risk for hip degeneration because of protrusio acetabuli.

OBJECTIVES: Our goals were: (1) to quantify protrusio acetabuli in patients with Marfan syndrome who underwent total hip arthroplasty, and (2) to identify clinical results and complications associated with total hip arthroplasty in those patients.

METHODS: There were 29 patients (38 hips) in our study. We reviewed the preoperative radiographs and analyzed the related patient operative reports, postoperative records, and self-administered questionnaires (mean follow-up, 116 \pm 102 months).

RESULTS: The mean preoperative center-edge angle of Wiberg was 50.9° \pm 14°. Loosening and radiolucent lines occurred in femoral but not acetabular components. The hips had 15 complications, including 8 reoperations. High questionnaire scores (82 \pm 13 points) indicated good hip function regardless of preoperative protrusio severity.

CONCLUSIONS: We found evidence of protrusio acetabuli in nearly one-half of adults with Marfan syndrome requiring THA because of painful hip degeneration. The degree of protrusio acetabuli seems to be more severe in those patients requiring arthroplasty at a younger age. Outcomes of THA in this series of patients revealed high frequencies of revision, infection, loosening, and dislocation. However, patients with Marfan syndrome reported improved hip function postoperatively, comparable to improvements in patients without Marfan syndrome.

H602

Revision of Total Hip Arthroplasty Using Hydroxy Apatite for Massive Bone Defect of Acetabulum

Primary Author: Soichi Tsuji

Institution: St.Luke's International Hospital , Department of Orthopaedic Surgery

Coauthor: Eishi Kuroda (St. Luke's International Hospital,

INTRODUCTION: Replenishing the bone defect is an important factor in revision THA. Various methods have been used to complement massive bone defects. In complementing bone defects, recovering the bone stock is an important issue. In this study we used a large volume of Hydroxyapatite(HA) to reconstruct the acetabulum and examined the postoperative results of these operations.

PATIENTS AND METHODS: From the patients that underwent THA at our hospital, 12 patients(12 hips) whose acetabulum showed a significant amount of bone defect by radiograph and suffered from severe pain were chosen. There were 2 men and 10 women with the mean age of 63(26-76). Eleven had osteoarthritis, one had avascular necrosis of the femoral head after traumatic injury. The mean observation period after the revision surgery was 12.8years. We constructed the acetabulum using a large amount of HA granules, and then fixed the cup with cement. With 5 patients, we also used Kerboul Cross Plate as the inner layer. Three patients also underwent revision of the femoral side. JOA score was used for clinical evaluation. A plain A-P radiogram was used for radiographic evaluation. We examined the following three factors: 1.collapse of HA, 2.conditions of bone formation in the interface of the bone bed and HA and 3. loosening and displacement of the cup.

RESULTS: The mean JOA score improved from 51 to 67 after the surgery. By radiographic evaluation, bone formation was observed after about 3months. After approximately one year, the interface of the bone and the HA was incorporated. After the incorporation, there were no further change by radiography. Collapse of the HA and the displacement of the cup were not observed during 9.3years.

DISCUSSION: Performing revision THA with cases with acetabulum bone defects, autologous bone, HA, allogeneic bone, Kerboul and a large cup could be used to complement the defects. However, with consideration to the quality, quantity and infection problems, HA is effective in massive bone defects. Initial fixation and collapse by load bearing were our conventional concerns when only HA was used in the surgery, but these were not observed in our course. We could say that using HA is effective for complementing large bone defects.

H603

Posterior Pelvis Tilt in the Supine Position Affects Hip Flexion Movement

Primary Author: Kato Tsuyuki

Institution: School Corporation Vocational School Nagoya Isen

Coauthors: Yuka Koba (School Corporation Vocational School Nagoya Isen), Shunji Sako (School Corporation Vocational School Nagoya Isen)

PURPOSE: Hip flexion movement associated with the posterior pelvis tilt is well known. However, little information on the posterior pelvis tilt in the supine position is available. We investigated the effect of the limited posterior pelvic tilt in the hip flexion movement.

METHODS: The study enrolled 24 healthy males with an average age of 20.5 ± 2.3 years. Two pelvic positions in the supine position were investigated: (1) the limited position of the posterior pelvic tilt by a 500ml polyethylene terephthalate (PET) plastic bottle with water placed under their low back, and (2) the position without placing a PET bottle. We assessed unilateral hip flexion angle with photos taken with a digital camera. For reference, we took an X-ray of a healthy female and observed the pelvic sagittal inclination in the supine position.

ANALYSIS: Data was processed by Image analysis software (Image J 1.42, NIH). Paired t-tests were used to assess the range of motion of individual joints in each position in the sagittal plane. MEPHAS software (Oosaka University, Japan) was used for all statistical processing, and the level of significance was set at $P < 0.05$. In addition, we also measured the lumbosacral angle with the X-ray.

RESULTS: The angle of hip flexion decreased an average of 22.9 degrees in the limited position with a PET bottle compared with the position without a bottle (P Discussion: The angle of hip flexion significantly decreased in the limited position with a PET bottle. Our results suggest the association movement of the posterior pelvic tilting with hip flexion movement in the supine position. This suggests that movements of the lumbosacral joint are involved greatly in hip flexion.

SIGNIFICANCE OF PHYSIOTHERAPEUTIC STUDY: Our results provide evidence that could lead to

an effective way of measurement of the primary hip joint (coxal femoral joint) flexion in the supine position for the patients with orthopedic disorders.

H604

Systemic Cobalt Toxicity in Metal-on-Metal Hip Arthroplasty

Primary Author: Catherine Van Der Straeten

Institution: Ghent University Hospital, Belgium

Coauthor: Koen De Smet (Anca Medical Center, Deurle, Belgium)

INTRODUCTION: Potential systemic toxicity of metal ions from metal-on-metal hip arthroplasties (MoMHA) is concerning. High blood cobalt (Co) levels have been associated with neurological, cardiac and thyroid dysfunctions. The aim of this research was to investigate the prevalence of systemic Co toxicity in a MoMHA population, to identify confounding factors, and to indicate a Co level above which there is a high risk for systemic toxicity.

PATIENTS AND METHODS: We conducted a cross-sectional study of patients with a MoMHA, using questionnaires validated to detect cobaltism in cobalt industry workers. We retrospectively identified 161 patients with Co levels $>4\mu\text{g/L}$ and 337 patients with Co levels $20\mu\text{g/L}$ groups.

RESULTS: There were significant correlations ($p \leq 0.003$) between increasing Co levels and prevalence of sleeping disorders, cognitive problems, equilibrium disturbances, neuropathic symptoms, fatigue, physical disorders and mood changes. More frequent and severe symptoms were found with $\text{Co} > 20\mu\text{g/L}$ ($p = 0.017$). Several years post-revision, some patients still complained of chronic symptoms possibly associated with longer exposure. Female gender and age ≤ 50 years were confounding factors. One patient had a hearing loss, confirmed on audiograms, which completely recovered after revision of bilateral failing MoMHA with decrease of the Co levels below $4\mu\text{g/L}$.

CONCLUSIONS: We demonstrated a correlation between increasing Co levels and toxicity symptoms ($p \leq 0.003$). As in the published case reports of MoMHA related cobaltism, the highest incidence of symptoms was found with $\text{Co} > 20\mu\text{g/L}$ and in patients with elevated Co levels

for a longer period of time. Patients with repeated Co measurements $>20\mu\text{g/L}$ are at risk for systemic toxicity.

H605

Impaction Auto-bone Grafting with Metal Mesh for Acetabular Reconstruction in Primary Cemented Total Hip Arthroplasty for Dysplastic Hip

Primary Author: Kazutaka Watanabe

Institution: Aichi Medical University

BACKGROUND: In cemented total hip arthroplasty (THA) for severe dysplastic hip, a massive auto-bone graft from the femoral head is required for acetabular reconstruction. However, crushing and absorption of the grafted bone can lead to cup loosening. In revision THA using the impaction bone grafting (IBG) technique with metal mesh, the long-term outcome is good. Therefore, we performed primary cemented THA using this technique for acetabular reconstruction in dysplastic hip.

PATIENTS AND METHODS: Between 2001 and 2004, we performed 17 primary cemented THAs using the IBG technique with metal mesh in 15 patients with severe dysplastic hip (17 women; mean age at operation, 60 years; age range, 48–67 years). Mean follow up was 10.1 years (range, 8.2–12.1 years), with none of the patients lost to follow up. According to Crowe's classification, subluxation was Group I in four hips, group II in 7 hips, group III in 4 hips, and group IV in 2 hips that had undergone femoral shortening osteotomy.

We used a Charnley flanged cup (DePuy, Leeds, United Kingdom), Exeter stem with a 22-mm diameter metal head (Stryker, Benoist Girard, France), and Simplex-P bone cement (Stryker, Limerick, Ireland) in all hips. A posterolateral approach was performed for all patients. For the anatomical hip center, we reamed the true acetabular fossa until reaching the acetabular floor, using a suitable hemispherical reamer. The metal mesh (Stryker, France) with AO small cortical screws was used for acetabular reconstruction in all hips. Bone chips (8 mm diameter) taken from the autologous femoral head in 11 hips and from the femoral head and trochanteric cancellous bone in 6 hips were morselized with a large rougeur to prepare for grafting. We impacted the bone tightly with impactors and a metal hammer. We made multiple 6-mm anchor holes,

cleaned the host acetabular bed with pulse lavage, and dried it with hydrogen peroxide. After using an Exeter balloon pressurizer, the Charnley flanged cup was cemented into the acetabular cavity.

RESULTS The mean Merle d'Aubigne and Postel functional hip score was significantly improved from 9.1 points (SD 1.4) preoperatively to 17.0 points (SD 1.2) at latest follow up ($p<0.05$; Wilcoxon rank-sum test). All cups were positioned at Pagnano zone 1. Mean socket center-edge angle was -19 degrees (range, -1 – 28). Radiographic outcomes showed no radiolucent lines, broken mesh or screws, or cup loosening at final follow up. Incorporation of the grafted bone, which was determined by the appearance of a continuous trabecular pattern from the host bone surface into the grafted bone, was apparent in all cases. Kaplan-Meier survival was 100% at 10 years with loosening as the end point.

CONCLUSION: IBG with a mesh is a promising method for acetabular reconstruction in primary cemented THA for severe dysplastic hip.

H606

Antioxidant-Stabilized XL-UHMWPE vs Remelted XL-UHMWPE in Mechanical Testing and Wear

Primary Author: Nathan Webb

Institution: Wright Medical Technology

Coauthors: Doug Linton (Wright Medical Technology), Mark Szymanski (Wright Medical Technology), Fred Bowman (MicroPort Orthopedics), Jon Moseley (Wright Medical Technology)

DISCLOSURE: The data presented in this abstract contains information pertaining to a medical device that has not received approval by the FDA or any other regulatory agency. Information is included for intellectual purposes.

STATEMENT OF PURPOSE: The remelting of cross-linked UHMWPE is known to reduce oxidation potential after gamma irradiation, at the cost of reducing certain mechanical properties. The addition of stabilizers, in the form of antioxidants, may reduce oxidation potential without requiring remelting, retaining some material properties that would be reduced during remelting.

This experiment compared the wear performance, lock detail strength, and fatigue crack propagation (FCP) behavior of remelted UHMWPE versus material blended with a stabilizer.

METHODS: Specimens were machined from compression-molded GUR1020. Control groups were irradiated with either 75 kGy or 100 kGy gamma and remelted. Experimental groups were machined from GUR1020 blended with a hindered amine light stabilizer (HALS), Chimasorb® 944, at 1000ppm, molded, and irradiated to either 75 or 100 kGy, without subsequent remelting. All specimens were EtO sterilized prior to testing.

WEAR: Hip wear testing was conducted using a combination of methods outlined in ASTM F1714, ISO 14242-1, and ISO 14242-2. A simulated gait profile (200 N/ 2000 N), at 1 Hz, was used. Sample size is noted in the results.

LOCK DETAIL: Lock detail testing (push-out, lever-out, and torque-out) was conducted on 75kGy control and 100 kGy experimental liners according to ASTM F1820-13 except as noted. Liners and shells (DYNASTY® acetabular system, Wright Medical) were assembled according to surgical technique via impaction. Six samples were tested for each group in each test mode.

FCP: Samples (N=3 per group) were machined according to ASTM E647-08 (compact tensile, W=25mm, B=11mm). Crack propagation rate was measured as a function applied of stress intensity, and values for the Paris coefficients and ΔK_{insep} were determined.

WEAR: There was no significant difference in wear between control and experimental groups irradiated to 75kGy. The 100 kGy stabilized group showed significantly lower wear than 75 kGy remelted. There was no significant difference between 46 mm and 28 mm liners irradiated to 100 kGy (Figure 1).

LOCK DETAIL: Results were not statistically significant between materials in push-out, lever-out, or torque-out (2 sample t-test, $\alpha = 0.05$). See Table 1.

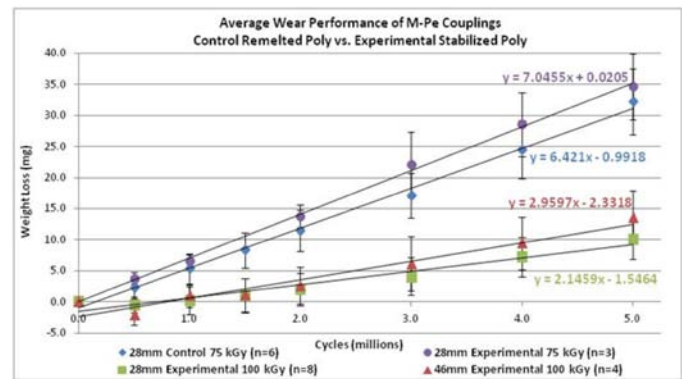


Figure 1. Gravimetric wear of 28mm hip bearings.

	Control [remelted]		Exp. [HALS]
	75 kGy	100 kGy	100 kGy
Push-out (N)	721 (93)	n/a	748 (82)
Torque-out (Nm)	3.48 (0.48)	n/a	3.98 (0.36)
Lever-out (Nm)	702 (44)	n/a	636 (92)
Paris – C	2.78E-05 (8.1E-06)	3.5E-05 (2.4E-07)	4.3E-06 (4.0E-06)
Paris – m	6.25 (0.76)	6.41 (.29)	8.61 (2.6)
ΔK_{insep} MPa \sqrt{m}	0.76 (0.06)	0.74 (0.011)	1.06 (0.15)

Table 1. Tabulated results (σ in parentheses)

FCP: The fatigue crack propagation data are listed in Table 1. Stabilized samples had a higher resistance to crack formation than remelted FCP samples.

CONCLUSIONS: The addition of HALS to the UHMWPE removes the need to remelt, increasing certain mechanical properties. By crosslinking to a higher dose and eliminating remelting following irradiation, the stabilized polyethylene exhibited superior wear and fatigue cracking properties, without sacrificing lock detail strength.

H607

New Reference Index to Resect The Femoroacetabular CAM Impingement in the Arthroscopy Using Cadaveric Hip

Primary Author: Shinya Yamasaki

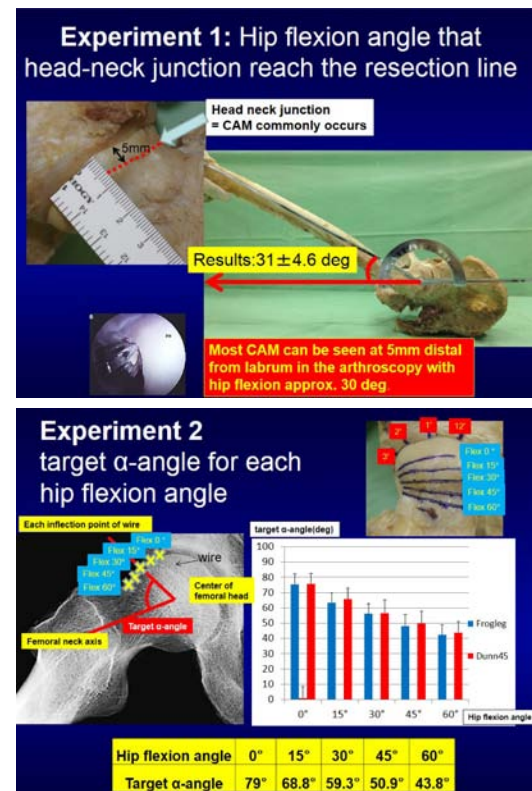
Institution: Osaka City University Graduate School of Medicine

Coauthors: Yusuke Hashimoto (Osaka City University Graduate School of Medicine), Junsei Takigami (Osaka City University Graduate School of Medicine), Shozaburo Terai (Osaka City University Graduate School of Medicine), Hiroaki Nakamura (Osaka City University Graduate School of Medicine)

OBJECTIVE: In arthroscopic resection of Femoroacetabular CAM Impingement, a fluoroscopy is only intraoperative reference method that navigate the site we mean to resect and predict the postoperative α -angle. However a fluoroscopy requires many steps to confirm the resection point precisely and exposure to more radiation. Another navigation which is safe and easy should be explored. The purpose of this study is to establish a new reference index such that resection point can reflect postoperative α -angle in real-time by utilizing hip flexion without fluoroscopy.

METHODS: We examined 12 cadaveric hip (mean age 85 ± 10.1) without degeneration and dysplasia. The mean femoral head diameter was 49.6 ± 4.0 mm. We determined the reference to start resection at 5mm distal from labrum, and changed hip flexion to guide to resection point. As the hip is flexed, the resection point moves proximal to distal. At first, the hip joint was gradually flexed until head-neck junction reached to 5mm distal from the labrum, then we measured hip the flexion angle (Head-Neck Junction Angle). Next, we attached the wire on the surface of the femoral head along the line which is drawn at 5mm distal from the labrum of the anterosuperior acetabulum in 0, 15, 30, 45 and 60 degrees of hip flexion. Then, we took two different standard radiographs of Dunn 45 and Frog-leg view, which indicate the 1-2 o'clock position that CAM commonly occurs. On the acquired images, a line was drawn from the inflection point on each soft wire on the anterior femoral head contour to the center of the femoral head, and the angle formed by this line and the femoral neck axis was measured. This angle means the size of CAM matching resection point at each hip flexion angle, so we named it target α -angle.

RESULTS: The mean angle of Head-Neck Junction Angle was 31 ± 4.6 degrees (Fig.1). The mean target α -angle of Dunn 45 and Frogleg radiographic projection in 0, 15, 30, 45 and 60 degrees of hip flexion were $75.0 \pm 6.0^\circ$ and $75.5 \pm 5.5^\circ$ in 0 degree, $65.8 \pm 6.2^\circ$ and $65.3 \pm 5.6^\circ$ in 15 degrees, $57.2 \pm 7.3^\circ$ and $56.3 \pm 5.8^\circ$ in 30 degrees, $50.7 \pm 6.9^\circ$ and $49.0 \pm 6.6^\circ$ in 45 degrees, and $44.2 \pm 5.8^\circ$ and $42.6 \pm 5.8^\circ$ in 60 degrees of hip flexion, respectively (Fig.2).



CONCLUSION: From first experiment, most of CAM appeared in the arthroscopic view in approximately 30 degrees of hip flexion because CAM commonly occurs at the head-neck junction. In addition, from second experiment, this index clarified the correlation between the resection target and a change of α -angle by reference to labrum and hip flexion angle. There has not been such an index for CAM. Therefore, with this index, we can see the intended CAM in the arthroscopic view and resect the CAM from starting point to ending point systematically by adjusting hip flexion angle depending on the α -angle of individual CAM.

H608

Mid-term Results of a Short Cemented Stem for Narrow Femoral Canal in THA

Primary Author: Hirotake Yo

Institution: Osaka Saiseikai Nakatsu Hospital

Coauthors: Hirotugu Ohashi (Osaka Saiseikai Nakatsu Hospital), Ryo Sugama (Osaka Saiseikai Nakatsu Hospital)

INTRODUCTION: The anatomical abnormalities associated with developmental dysplasia of the hip include femo-

ral anteversion and narrow femoral canal. The narrow femoral canal especially with bow restricts the choice of stem. We chose a short cemented stem for such cases. The purpose of this study was to investigate the minimum 3-year radiographic results of a short cemented stem for patients with narrow femoral canal.

MATERIALS AND METHODS: A short cemented stem (DCM-J, Zimmer, USA) was applied to a femur with less than 12 mm in diameter at isthmus. Forty-six THA were performed. One patient died and 6 patients were lost to follow-up. Therefore, we retrospectively reviewed 39 hips in 31 patients. The mean age, height and body weight were 62.3 years old, 151.1 cm and 56.9 kg, respectively. The mean follow-up was 4.4 years. The etiology was dysplastic hip osteoarthritis in all hips that were classified into Crowe type I in 12 hips, type II in 6, type III in 9, and type IV in 12. The mean femoral canal diameter at isthmus was 9.0 mm. The length of the stem used in this study (from stem-neck junction to tip) was ranged from 83 to 115 mm. Loosening, osteolysis, cortical hypertrophy and cortical atrophy were evaluated on radiographs at the final follow-up.

RESULTS: Two hips in one patient were revised due to aseptic loosening of the stem. The other stems were stable without radiolucent line or osteolysis. Cortical hypertrophy in zone 3 and 5 was observed in 2 hips (Fig.1). Cortical atrophy in zone 2 and 6 was observed in 3 hips. The patient with stem loosening in both hips was 80 kg and the canal diameter was 7 and 8 mm (Fig.2). She was the heaviest in the female patients. Two patients with cortical hypertrophy were 72 and 52 kg, and the canal diameter of 9 and 7 mm. Three patients with cortical atrophy were 72, 49 and 40 kg, and the canal diameter of 11, 9 and 9 mm.



DISCUSSION AND CONCLUSIONS: Short uncemented stems are designed to preserve bone stock and to prevent stress shielding. The mid-term clinical results are reported to be encouraging. In contrast, the clinical results of a short cemented stem were not reported. In THA for a narrow femoral canal with less than 12 mm in diameter at isthmus, we had to choose a short cemented stem. The overall radiographic results showed 2 stem loosening in one patient. The other stems were stable without radiolucent line or osteolysis. The patient with stem loosening in both hips was the heaviest in the female patients, and the femoral canal diameter was relatively small. The same tendency was observed in patients with cortical hypertrophy, while it was not observed in patients with cortical atrophy. In conclusion, the radiographic results of a short cemented stem for a narrow femoral canal were acceptable, while we have to be concerned when we select the short cemented stem for heavy patients. Longer follow-up for large number of patients should be necessary.

H609

Outcome for Periprosthetic Fracture After Total Hip Arthroplasty

Primary Author: Hirotake Yo

Institution: Osaka Saiseikai Nakatsu Hospital

Coauthors: Hirotugu Ohashi (Osaka Saiseikai Nakatsu Hospital), Ryo Sugama (Osaka Saiseikai Nakatsu Hospital)

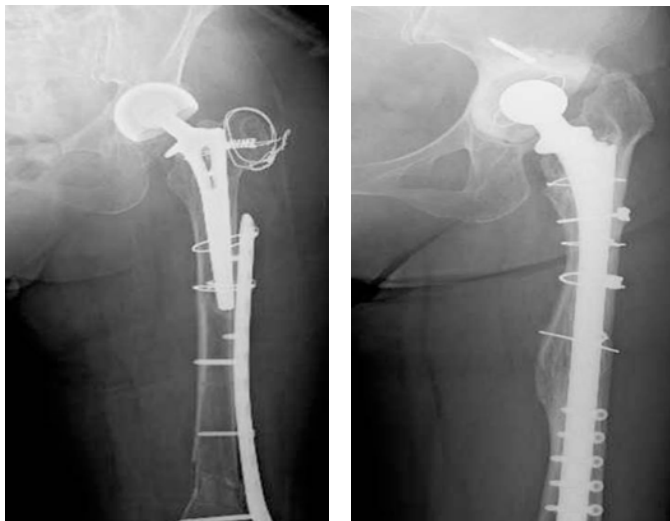
INTRODUCTION: Periprosthetic fractures are a serious complication of THA that pose a big challenge to reconstructive orthopaedic surgeons. The Vancouver classification is the most useful for predicting the required man-

agement. However, the treatment strategies depend on the nature of a fracture, implant stability, bone-stock quality, patient age and surgeon's experience.

OBJECTIVE: We therefore reviewed the outcome of our management of 19 periprosthetic fractures.

MATERIALS AND METHODS: Fifteen periprosthetic fractures after THA were treated in our hospital from December 2003 to July 2013. There were 3 men and 16 women. The average patient age was 80.8 years. The status of the arthroplasties was THA in 9 and bipolar hemiarthroplasty in 10. There were 12 primary arthroplasties and 7 revision arthroplasties. Six fractures were classified as Vancouver type B1, 4 as type B2, 3 as type B3, and 6 as type C periprosthetic fractures. The way of treatment, the percentage of united fractures, and the stability of the implants were investigated.

RESULTS: Type B1 and type C fractures were fixed with a locking plate [Fig1]. In type B2 and B3 fractures, 3 fractures were treated with a cementless modular tapered revision femoral component, one was treated with a Huckstep hip [Fig2], and one was treated with a cemented long stem fixed by impaction bone grafting. After the average follow-up period of 20.6 months, complete fracture union occurred in 14 of the 15 cases (93.3%). In one case in type B3 fracture with the shortest follow-up period of 4 months, the stem was not yet stable. The other stems were stable.



DISCUSSION AND CONCLUSIONS: We principally treated type B1 and C fractures with internal fixation with locking plate and type B2 and B3 fractures with revision THA. In 14 of the 15 cases, the fracture union occurred

and the stem was stable. The case, that the fracture union did not complete and the stem continued subsiding, was 83-year-old woman with severe osteoporosis. Besides the Vancouver classification, bone-stock quality, patient age, patient's level of physical activity should be considered to select the treatment. In conclusion, our treatment for the periprosthetic fractures after THA showed favorable outcome.

H610

Clinical Results of Ceramic on Ceramic Cementless Total Hip Arthroplasty Using a Accolade TMZF Femoral Stem

Primary Author: Hyung-Ku Yoon

Institution: Dept. of Orthopaedic Surgery, CHA Bundang Medical Center, CHA University

Coauthors: Dae-Guen Song (Dept. of Orthopaedic Surgery, CHA Bundang Medical Center, CHA University), Byung-Ho Yoon (Dept. of Orthopaedic Surgery, CHA Bundang Medical Center, CHA University)

To evaluate clinical and radiological outcomes and the complications of primary total hip arthroplasty using ceramic on ceramic non-cemented, double tapered stem (Accolade TMZF femoral stem) and Secure Fit PSL acetabular cup after eight-to ten-year follow-up.

100 cases among 127 cases underwent total hip arthroplasty by one surgeon using an Accolade TMZF femur stem and ceramic on ceramic and Secure Fit PSL acetabular cup from January 2003 to January 2006 were analyzed retrospectively after minimum 70 months follow-up. Mean follow-up was 7.6 years and mean age was 51-years. We evaluated clinical outcomes by Harris hip score and VAS score, also radiological outcomes by serial anteroposterior and lateral radiographs. The Student t test was used for statistical analysis.

The mean Harris Hip Score improved from 57 to 92 and mean VAS score improved from 7.2 to 2.8 at the last follow up. Overall both statistical scores of patients showed a significant improvement (P Primary total hip arthroplasty using ceramic on ceramic cementless Accolade TMZF femoral stem showed excellent results in mid term follow-up but more long term studies are needed.

H611

The Short-term Results of Hip Resurfacing Arthroplasty Using Personalized Instrumentation - 40 Cases Follow-up Report

Primary Author: Sunghwan Yoon

Institution: Leechuntek Orthopedic Specialty Hospital

Coauthors: Chuntek Lee (Leechuntek Orthopedic Specialty Hospital), Ohmyung Kwon (Leechuntek Orthopedic Specialty Hospital), Hangjae Lee (Leechuntek Orthopedic Specialty Hospital), Junehyuck Hur (Leechuntek Orthopedic Specialty Hospital)

INTRODUCTION: Since Smith-Peterson's glass mold arthroplasty in 1939, hip resurfacing arthroplasty was developed and introduced to orthopaedic surgery field but it had many problem like early loosening. Recently it is being popular for some indication as development of new implant design and manufacturing. There are still many suggested advantages of hip resurfacing arthroplasty. These include bone conservation, improved function as a consequence of retention of the femoral head and neck and more precise biomechanical restoration, decreased morbidity at the time of revision arthroplasty, reduced dislocation rates, normal femoral loading and reduced stress-shielding, simpler management of a degenerated hip with a deformity in the proximal femoral metaphysis, an improved outcome in the event of infection, and a reduced prevalence of thromboembolic phenomena as a consequence of not using instruments in the femur. But, there are limited or inconsistent data to support some of these claims regarding the benefits of hip resurfacing including the potential for a more natural feel because of the minimal disturbance of the proximal part of the femur resulting in a better and faster functional outcome. We evaluate the short term results of hip resurfacing arthroplasty using custom patient-specific tooling for prosthesis placement for better standardization.

MATERIALS AND METHODS: 40 cases, 36 patients (male:20, female:16) those of who were candidates of a Hip Resurfacing procedure, participated in the study. Mean follow up period was 2.5 years (8 months ~3 years). A CT scan was performed on each patient and a 3D model was generated using the computer tomography dataset. From this model a bone-surface skin was extracted and this data set was used to create a personalized jig. Detailed analysis of the native bone structure was then used to preoperative-

ly plan the appropriate size and position of the implant. A mean 7 degree corrective valgus angle was prescribed on all cases. Postoperative radiological datasets were superimposed onto preoperative plan position and offsets were measured. Operative times were recorded per step during the procedure. Surgeon comfort and ease of use was also noted.

RESULTS: Mean preop and postop implant position tolerance within 3 degrees. Mean postop implant stem-shaft angle was 136°(122°~142°) and mean acetabular inclination angle was 41°(37°~50°). Mean Harris hip scores was improved from 48.4 points preoperatively to 93.8 at final follow up. There were two cases (in one patient) of loosening of femoral metal head with angulation and migration in avascular necrosis (postoperative 6 months) and one case of femoral neck fracture (postoperative 1.5 year) so we revised to primary total hip surgery. Mean surgical time was recorded to 55 minutes (35~75). Personalized jig utility was positive with no intra-operative complications.

CONCLUSION: "Femoral neck referencing personalized jigs" provides a surgeon an easy to use, accurate alignment tool to simplify a demanding hip resurfacing procedure with very predictable outcome but long term follow up and much cases are needed.

H612

Intertrochanteric Fracture in an Arthrodesed Hip Treated by a Total Hip Arthroplasty

Primary Author: Shnji Yoshioka

Institution: Tokushima Prefecture Naruto Hospital

We experienced a case of an intertrochanteric fracture occurring 30 years after a hip arthrodesis. We assessed clinical result and muscle recovery by computed tomographic (CT) scan.

A 53-year-old man was injured in a head-on car crash and referred to our hospital. Plain radiographs showed an intertrochanteric fracture of the right proximal femur and deformity of the right hip joint. He had undergone hip arthrodesis surgery 30 years previously at the different hospital. CT scan showed marked atrophy of gluteus and iliopsoas muscles. He preferred having a total hip arthroplasty (THA) to an internal fixation. THA was performed using anterolater-

al approach with the patient in the supine position because he had undergone hip arthrodesis through Smith Petersen approach and we were concerned about gluteus muscle damage using a posterolateral approach. Femoral head was removed using curved chisels under fluoroscopy. A cementless THA (J Taper stem, Aquala polyethylene liner, Kyocera Japan) was inserted and well fixed.

Full weight-bearing with a walking frame was allowed 2 weeks after the surgery. 6 months after the operation, he was able to walk independently and had good range of movement of the hip joint but still had abductor muscles weakness. Modified Harris Hip Score was 84.7 after 1 year. CT scan showed significant muscle volume recovery.



Very few cases of a fracture of the proximal femur in a previously arthrodesed hip have been reported. Manzotti et al. reported a similar case but they performed open reduction and internal fixation. No previous reports in the literature describe THA for intertrochanteric fracture in an arthrodesed hip. The conversion of a arthrodesed hip to THA is a technically challenging procedure. It has a high risk of complications like nerve injuries and hip instability. The most important thing is estimation of muscle recovery. We were able to treat the patient successfully but surgeons should carefully decide the treatment method depending on a case.

H613

Comparison Between Intraarticular and Intravenous Administration of Tranexamic Acid in Primary Total Hip Arthroplasty

Primary Author: Masaya Ueno

Institution: Department of Orthopaedic Surgery, Faculty of Medicine, Saga University, Nabeshima, Saga, Japan

BACKGROUND: Total hip arthroplasty (THA) is often associated with significant perioperative blood loss. Tranexamic acid (TXA) is established in THA to reduce blood loss and prevent a decrease in hemoglobin level. However, there are very few reports investigating TXA administration methods in THA. This study compares intraarticular (IA) and intravenous (IV) administration of TXA on blood loss, decrease in hemoglobin level, and transfusion rate in THA.

METHODS: Five hundred and ninety-three patients undergoing unilateral primary THA received TXA. Surgery was performed using a posterior approach under spinal anesthesia. A suction drain was used in all cases, which was removed 2 days after surgery. Patients with ischemic heart disease, chronic renal failure, history of hip surgery, thromboembolic episodes, hemoglobin <8 g/dl, rheumatoid arthritis, and idiopathic osteonecrosis of the femoral head were excluded from this study. Patients in group IV (274) received 1000 mg TXA via IV administration before skin incision. Patients in group IA (319) received 2000 mg TXA via IA administration before wound closure.

Postoperative blood loss was determined by the volume of blood in the drain. Red blood cell transfusion was given


en when symptoms of anemia appeared, including vertigo, hypotension, and bradycardia. Hemoglobin levels were measured 1 day before surgery and 1 and 7 days after surgery. Blood loss (intraoperative, postoperative, and total), decrease in hemoglobin level, and transfusion rate were recorded. A p value of <0.05 was considered significant.

RESULTS: Average age was 64.7 and 65.8 in groups IA and IV, respectively. Group IA consisted of 33 males and 241 females and group IV consisted of 46 males and 273 females. Mean surgical time was 42.2 and 43.5 min in groups IA and IV, respectively. Mean preoperative hemoglobin level was 13.0 g/dl and 13.1 g/dl in groups IA and IV, respectively. Mean intraoperative, postoperative, and total blood loss were 279 g, 243 g, and 522 g in group IA and 290 g, 252 g and 543 g in group IV, respectively.

Mean decrease in hemoglobin level at 1 and 7 days after surgery was 1.9 g/dl and 2.2 g/dl in group IA and 1.9 g/dl and 2.2 g/dl in group IV, respectively. Transfusion rate was 2.2 % in groups IA and IV.

There were no significant differences between groups IA and IV with respect to age, sex, surgical time, preoperative hemoglobin level, blood loss (intraoperative, postoperative, total), decrease in hemoglobin level, and transfusions rate.

CONCLUSION: No differences were observed between IA and IV TXA administration methods in terms of blood loss (intraoperative, postoperative, total), decrease in hemoglobin level, and transfusion rate.



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Poster Session

Abstracts

– Knee –

K613

Assessment of Tibial Component Keel Location Relative to the Anatomical Axis

Primary Author: Emam ElHak Abdel Fatah

Institution: The University of Tennessee

Coauthors: Mohamed Mahfouz (The University of Tennessee), Giles Scuderi (Lenox Hill Hospital), Lyndsay Bowers (The University of Tennessee)

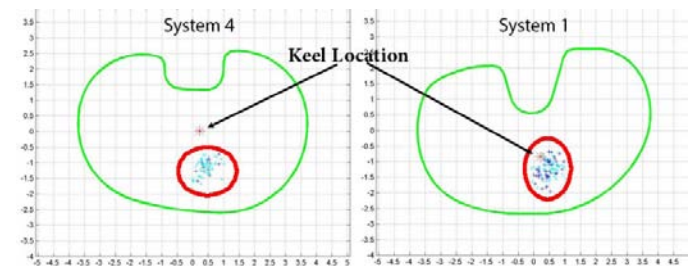
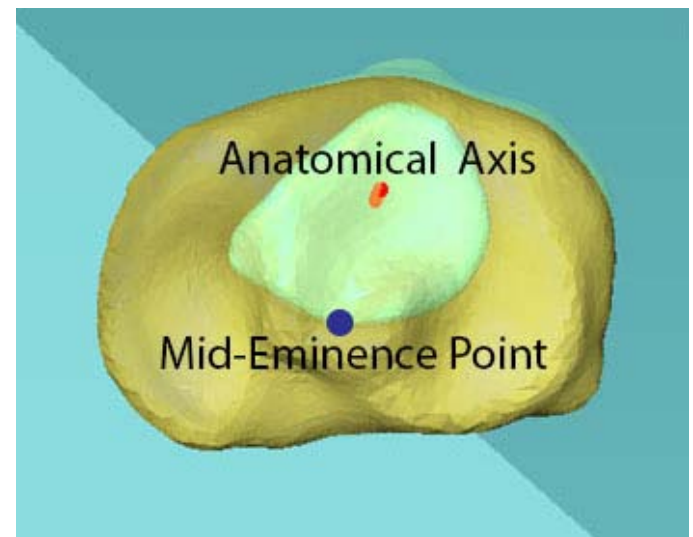
SUMMARY SENTENCE: In this study, keel location for tibial components of seven existing knee systems from five major manufacturers were assessed relative to the location of the tibial anatomical axis.

INTRODUCTION: The objective of this study was to assess the location of the keel for tibial components of existing knee systems across Caucasian and African American populations. Bones were added to a statistical atlas and components were then sized and placed. Keel location and direction was then compared to the anatomical axis of the tibia.

METHODS: The dataset consisted of 470 individuals (303 Caucasian males, 118 Caucasian females, 44 African American males, and five African American females). Tibial bones were added to the statistical atlas and automatic landmarking was performed to calculate relevant surgical reference axes. Each bone was cut in 7 degrees slope at 10 mm distally from the highest point on lateral plateau and sized initially by selecting the tibial component with the closest ML width. Components were then placed in 0 degrees internal rotations, translated to match the contour of the anterior lateral tibial bone while optimizing coverage. Size was then reevaluated to prevent any overhang of greater than 0.5 mm. Keel location and the proximal point of the anatomical axis were then projected on the resection plane. Bones were then grouped based on size, and the location of the projected anatomical axis was evalu-

ated against the projected keel point, anatomical axis location were also compared to mid-emergence point as shown in Figure 1.

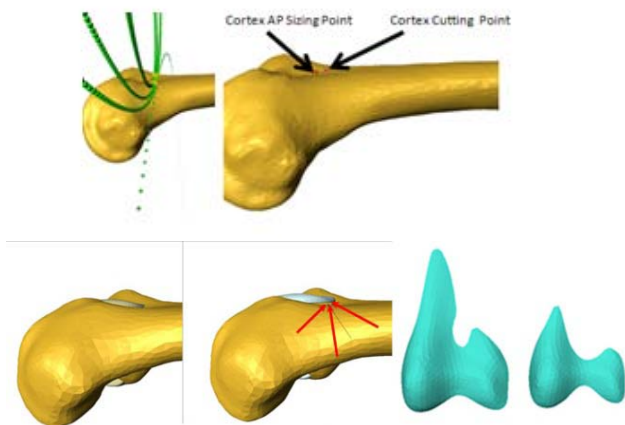
RESULTS: Anatomical axis exit points were found to be more anterior compared to the mid-emergence points. It was found that System I, with an asymmetrical tray design, had a keel location more anterior and medial compared to the mid-emergence point as shown in Figure 2.



DISCUSSION: This study investigated keel location versus anatomical axis exit location. The keel access to the canal should optimize intramedullary instrumentation, trial-ing and implant stem canal fill while mitigating the normal tradeoff with component coverage. Keel location optimization would allow better keel fit as particularly as patient size decreases, less need for bulkier offset stem constructs and less tibial component undersizing.

K614**Investigating the Effect of Location of Femoral Anterior Cortex Point on Component Sizing and Placement***Primary Author: Emam ElHak Abdel Fatah**Institution: The University of Tennessee**Coauthors: Mohamed Mahfouz (The University of Tennessee), Giles Scuderi (Lenox Hill Hospital), Lyndsay Bowers (The University of Tennessee)*

SUMMARY SENTENCE: This work introduces a new method of calculating the femoral anterior cortex point and studied its effect on implant placement and amount of resected bone anteriorly on a diverse ethnic population.



INTRODUCTION: The objective of this study was to introduce a new method for calculating the femoral anterior cortex point and investigate the effect of point variability on both sizing and placement of an implant across both Caucasian and African American populations. CT scans of bones were segmented and surface models were then added to a statistical atlas. Three-dimensional landmarking algorithms were developed to calculate the anterior cortex point in addition to other relevant surgical landmarks used for implant sizing and placement. Implants were then sized and placed using anterior referencing and placement and amount of resected bone was then evaluated across both populations.

METHODS: The dataset consisted of 470 individuals (303 Caucasian males, 118 Caucasian females, 44 African American males, and five African American females). CT scans were segmented, surface models were added to the statistical atlas, and three-dimensional automatic land-

marking was performed to calculate the anterior cortex point. Two points were defined: sizing point and resection point. Sizer instrument length and tolerance was used to define the loci of the sizing point (proximal and distal bound of search area). The saddle point was then found in this area and used to define the sizing point. The anterior cortex resection point was defined as the point proximal to the sizing point and at the level where the curvature of the femur changes from concave to convex as shown in Figure 1. The cortex point was then found as the point between the lowest and highest point on the lateral ridge; that avoids notching, minimizing anterior undercut and overstuffing of the patellofemoral joint. The anterior resection of cut generated from this point was then compared with the resection from using both the highest and the lowest points on the lateral ridge.

RESULTS: Figure 1 shows a typical example of the anterior cut (piano shape) using the suggested cortex point and traditionally using highest the point on lateral ridge. An average of 3-4 mm difference was found between the highest ridge point and the suggested cortex point. Highest ridge point was found to cause undercut on the anterior side, whereas using lowest point caused notching. Results of using the suggested cortex point leads to a complete piano shape anterior cut.

DISCUSSION: The anterior cortex point is a key landmark in placement and sizing of the femoral component which can lead to wrong sizing, notching, undercutting or overstuffing based on choosing the highest or lowest point. The goal is to achieve balanced placement with a complete piano shaped anterior cut. This was accomplished by using the suggested cortex point.

K615**Distally Locked Tibial Stem TKA for Simultaneous Arthritis and Unstable Stress Fracture Of Proximal Tibia***Primary Author: Sherif M. Abdeldayem**Institution: Ain Shams University, Cairo, Egypt**Coauthors: Wael S. Abdelmegied (Ain Shams University, Cairo, Egypt), Mohamed A. Eid (Ain Shams University, Cairo, Egypt), Zeiad M. Zararia (Ain Shams University, Cairo, Egypt)*

INTRODUCTION: Simultaneous knee arthritis and stress fracture is an uncommon problem that requires good understanding of the etiology of the problem to be able to deal with it. Our hypothesis that using a distally locked tibial stemmed total knee arthroplasty for management of advanced knee arthritis with unstable stress fracture of the proximal tibia will add mechanical stability and healing at fracture site without the drawbacks of plate fixation.

PATIENTS AND METHODS: This is a retrospective study dealing with assessment of using TKA with a distally locked tibial stem (prefabricated with two locking screws 1 and 3 cm from the tip of the stem in antero-posterior direction) in management of 17 cases with knee arthritis and simultaneous unstable stress fracture proximal tibia(fig.1). pre-operative planning and templating is important in choosing the length and diameter of the stem. Medial parapatellar approach is used in all cases. Femoral preparation done first. Intramedullary reaming of tibia is done starting with the smallest reamer under image intensifier and take care not to penetrate the cortex as most of patients are osteoporotic due to prolonged non weight bearing. Realignment of tibia at fracture site done at this stage of reaming in the form of osteotomy at fracture site if needed using image intensifier. We increase the reamer size till we get a good purchase.

RESULTS: Knee society score improved from average pre-operative of 31.6 to post-operative of 84.8 and mean functional score from 25.3 pre-operative to 89.1 post operative. All cases show radiological healing after a mean period of 3 months (8-20 wks)(fig.2). No complication in this study till last follow up of average 36 month post-operative.



CONCLUSION: TKA with distally locked stem restores normal limb alignment, decreases stresses on fracture site without the drawbacks of using plates. this technique shows excellent results as an option to solve the problem of stress fracture proximal tibia and simultaneous advanced knee arthritis, especially in unstable stress fracture.

K616

The Influence of Patellofemoral Degenerative Changes on the Outcome of the Unicompartamental Knee Replacement

Primary Author: Ali Abdulkarim

Institution: Midland Regional Hospital Tullamore

Coauthors: N. Motterlini (Royal college of Surgeons in Ireland), TM. O'Donnell (Department of Trauma & Orthopaedics, UPMC, Beacon Hospital, Dublin), MJ. Neil (Department of Orthopaedic Surgery, St. Vincent's Healthcare Campus, Sydney, Australia)

INTRODUCTION: Unicompartamental knee arthroplasty (UKA) is a recognized procedure for treatment of medial compartment osteoarthritis. Patellofemoral (PF) joint degeneration is widely considered to be a contraindication to medial unicompartamental knee replacement. We examined the validity of this preconception using information gathered prospectively on consecutive patients who underwent UKA using the Repicci II® UKA prosthesis for medial compartment osteoarthritis.

METHODS: We prospectively collected data on 147 consecutive patients who underwent the Repicci II® UKA for medial compartment osteoarthritis. All operations were performed between July 1999 and September 2000 by the same surgeon. The status of the PF joint was assessed intra-operatively in all patients, and accordingly patients were divided into two groups, one group with a normal PF joint, and the second group with degenerative changes of the PF joint.

Variables measured for outcome included the International Knee Society (IKS) score, limb alignment, and range of motion. Radiographs were assessed for progression of disease or failure of implant. The mean follow-up was 9.4 years (range: 5-10.7 years).

Patients were reviewed initially at 2 weeks, and then at

6 months post-operatively. They were subsequently re-viewed on an annual basis. All patients completed an IKS score preoperatively and at last follow-up. Age, gender, BMI, length of hospital stay, perioperative complications, all subsequent surgery, including revision of the prosthesis, and survivorship at 10 years was recorded, and results of the 2 groups compared.

RESULTS: A total of 147 patients were included in the study. None were lost to follow-up. Sixty nine had associated PF osteoarthritis (group A) while 78 patients had a normal PF compartment when assessed intra-operatively (group B).

Post-operative outcomes of the two groups were compared using the ANCOVA analysis with adjustment for pre-operation values firstly, and adjusting also for gender, age, BMI and follow-up secondly.

There were no significant differences in terms of IKS, alignment, and flexion between the two groups. However, patients in group B had significantly better extension post-operatively than patients in group A.

CONCLUSION: We concluded that damage to the articular cartilage of the patellofemoral joint to the extent of full-thickness cartilage loss is not a contraindication to the Repicci II® unicondylar knee arthroplasty for medial compartment osteoarthritis. However, extension is significantly improved post-operatively in those patients with minimal or no PF joint degenerative disease.

Group A Group B

Outcome n Mean (SD) n Mean (SD) p* p**

IKS

Pre-operation 69 76.19 (6.71) 78 76.85 (6.51)

Post-operation 69 91.57 (5.80) 78 92.23 (4.41) 0.5595 0.5927

Final 65 85.49 (8.61) 74 87.27 (7.95) 0.2283 0.4018

Alignment

Pre-operation 69 -5.99 (3.49) 78 -5.95 (4.58)

Post-operation 69 -1.86 (2.64) 78 -1.59 (2.53) 0.1418 0.1286

Extension

Pre-operation 69 -4.28 (4.40) 78 -3.59 (4.18)

Post-operation 69 -2.61 (3.28) 78 -0.96 (2.56) 0.0011 0.0004

Flexion

Pre-operation 69 130.51 (12.46) 78 129.62 (12.00)

Post-operation 69 132.54 (10.20) 78 134.10 (9.69) 0.0472 0.0738

K617

Second-look Arthroscopic Evaluation of Chondral Lesions After Anterior Cruciate Ligament Reconstruction: A Comparison by the Difference in Meniscal Treatment

Primary Author: Takanori Akada

Institution: Funabashi Orthopaedic Hospital Sports Medicine Center

Coauthors: Akihiro Tsuchiya (Funabashi Orthopaedic Hospital), Izumi Kanisawa (Funabashi Orthopaedic Hospital), Kenji Takahashi (Funabashi Orthopaedic Hospital)

BACKGROUND: While meniscal injury in anterior cruciate ligament (ACL) deficient knee leads to increase the instability, ACL reconstruction reduced anterior tibial translation and rotational laxity to the intact state. On the other hand, meniscectomy accelerates degenerative joint changes even in ACL reconstructed knee.

PURPOSE: The purpose of this study was to evaluate the incidence of chondral lesions by second-look arthroscopy after combined meniscal injury and ACL reconstruction.

MATERIAL AND METHODS: Between January 2009 to December 2011, 101 patients (54 male and 47 female) had ACL reconstruction with no chondral lesions. All patients underwent anatomical double bundle ACL reconstruction using hamstring tendon grafts. Patients were excluded if they had concomitant ligament injury, re-injury or contralateral injury, more than 3mm side-to-side difference on anterior tibial translation at the time of the second-look arthroscopy, and postoperative infection. The mean age at primary ACL reconstruction was 24.4 years, the mean BMI was 22.6, and the mean period from primary ACL reconstruction to second-look arthroscopy was 16.8 months. Of 101 patients, meniscectomy was underwent in 19 patients, meniscal repair in 20 patients, and 62 patients had no meniscal injury. Cartilage status was evaluated by second-look arthroscopy and the ICRS classification. We compared the incidence of chondral lesions among three groups.

RESULTS: Of 101 patients, chondral lesions were found in 30 patients. 14 patients were found in meniscectomy group, 7 patients in meniscal repair group, and 9 patients in without meniscal injury group. Of 20 patients underwent meniscal repair, complete healing of the meniscus were

found in 12 patients. Of the 12 patients, chondral lesions were found in 4 patients. The incidence of chondral lesion was significantly less in without meniscectomy group and complete healing group.

CONCLUSION: Chondral lesions were found in meniscectomy group at a high incidence. Meniscal repair led to less cartilage damage at short-term follow-up. We confirmed the importance of meniscal preservation.

K618

The Effect of Autologous Mesenchymal Stem Cells on the Articular Cartilage Regeneration

Primary Author: Kostrub Alexandr

Institution: Traumatology and Orthopadics

Coauthors: Zasadnyuk Ivan (Traumatology and Orthopadics), Kostogryz Oleg (Traumatology and Orthopadics), Blonskyj Roman (Traumatology and Orthopadics), Kotyuk Victor (Traumatology and Orthopadics)

For the studies of influence of application of cultures of autologous mesenchymal marrow stem cells with a different level of chondrogenic differentiation on the course of reparative chondrogenesis, a traumatic model of injured articular cartilage has been used. Mechanical application of a full-thickness defect on articular cartilage with a retained subcartilage bone plate leads to fibrous tissue formation in the defect area with pronounced dystrophy and necrosis events. Degenerative and dystrophic processes originate in joint, that are based on progressive dystrophy of an adjacent maternal articular cartilage. Intra-articular administration of a culture of autologous marrow MSC after mechanical application of a full-thickness defect on articular cartilage with a retained subcartilage bone plate leads to a hyaline-like tissue formation in defect area without general degenerative and dystrophic changes in a joint. During the analysis of the data obtained basing on alternative OS scale and ICRS (

K619

Two Year Survivorship of Unicompartmental Knee Arthroplasty Using DePuy Sigma HP Replacement

Primary Author: Jeff D. Almand

Institution: Mississippi Sports Medicine and Orthopaedic Center

Coauthors: Brian P. Johnson (Mississippi Sports Medicine and Orthopaedic Center), Trevor R. Pickering (Mississippi Sports Medicine and Orthopaedic Center), R. Kerk. Merh-le (Mississippi Sports Medicine and Orthopaedic Center), William H. Repogle (University of Mississippi Medical Center)

QUESTIONS/PURPOSES: The primary purpose of this study was to estimate the two-year survivorship of the newly introduced Sigma High Performance unicompartmental knee arthroplasty (UKA) Secondary outcomes included the mode of failure, the functional outcomes, the radiographic outcomes, and the frequency of adverse events.

PATIENTS AND METHODS: Three hundred and three unicompartmental knees (18 lateral and 285 medial) in 259 patients were included in the IRB approved, single center study from 2008-2011. One hundred and fifty eight were female. The age range was 35 to 85 years with the median being 64. The mean BMI was 32.1 and ranged from 20.1 to 57.3. No subjects died, and 7 were lost to follow-up (FU). Routine FU included Knee Society Scoring (KSS), radiographic assessments, Knee Injury and Osteoarthritis Outcomes Scoring (KOOS), and range of motion (ROM). The mean FU was 28.6 months (range 19 months to 47 months).

RESULTS: The Kaplan-Meier estimate of device survivorship at the end of 24 months was 98.9% (95 CI: 97.8% - 100.0%). There were no device failures in the first twelve months, and during the entire study period 9 of the 296 (3%) UKAs failed with 8 converted to a total knee arthroplasty. Four knees failed due to loosening of the femoral component (1.3%) and 5 failed due to progressive osteoarthritis (1.6%). Two implants that failed due to progressive osteoarthritis had additional contributors to failure including avascular necrosis (1) and pseudogout (1). The failures due to component loosening occurred shortly after introduction of the Sigma HP and are attributed to learning curve associated with surgical technique. Since the last reported failure (2011) in this study, we have had no further failures. One loose femoral component was revised due to a fall. Fourteen (4.7%) knees underwent other additional surgeries due to meniscus tears (7), excision of masses or bony overgrowths (2), effusions (1), hematomas (1), infections (1), retinacular defects (1), and manipulation

Table 1.

	Pre-op KSS	Post-op KSS	Pre-op Extension	Post-op Extension	Pre-op Flexion	Post-op Flexion	Post-op KOOS Pain	Post-op KOOS Symptoms	Post-op KOOS Function	Post-op KOOS Quality of Life
Mean Scores	42.48	88.51	1.92	.04	124.49	134.48	85.63	63.64	84.36	67.25
Score Range	8-100	40-100	-3-80	0-5	50-145	110-145	8-100	21-100	22-100	0-100

(1). Four of those involved polyethylene insert exchanges. Secondary outcome measures are shown in Table 1. There was significant ($p < 0.001$) improvement in preoperative to postoperative KSS scores, extension, and flexion.

CONCLUSIONS: The DePuy Sigma High Performance UKA appears to have a very low early failure rate. Most of these failures were due to progressive arthritic changes in the knee. This study demonstrates that this prosthesis returned good short-term results in terms of survivorship and patient satisfaction.

K620

Calculating the Position of the Joint Line of the Knee in Relationship to Anatomic Landmarks

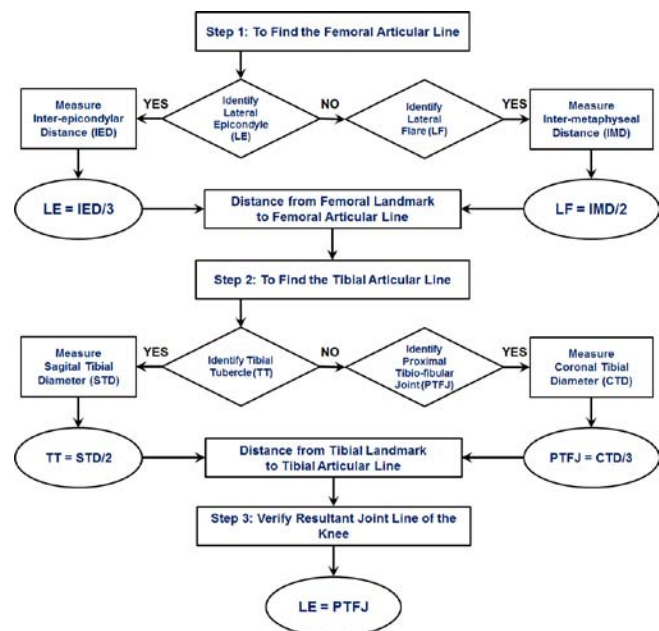
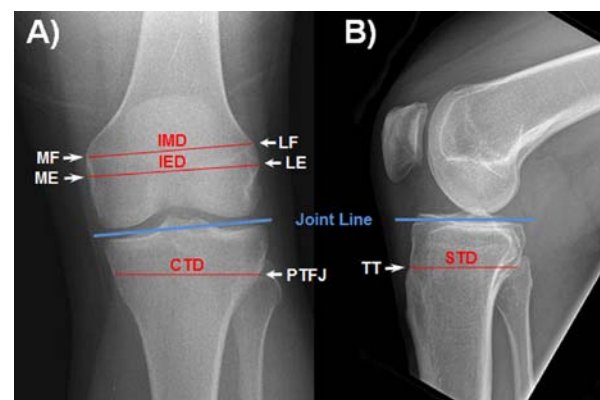
Primary Author: Derek Amanatullah

Institution: Mayo Clinic

Coauthors: Michael Alaia (NYU-HJD-Ortho), Kenneth Montini (Penn State - Radiology), Matthew Lopez (UCD-MC-Ortho), Paul Di Cesare (NYH-Queens), Gavin Pereira (UCDMC-Ortho)

Restoration of the joint line of the knee during primary and revision total knee arthroplasty is one of many critical steps that directly influence patient outcomes. In this study, fifty MRI scans were analyzed to determine a quantitative relationship between the joint line of the knee and the distal femoral epicondyles and metaphyseal flares as well as the tibial tubercle and the proximal tibio-femoral joint (Figure 1). The absolute distances of these anatomic landmarks to the joint line of the knee were highly variable due to patient size and gender. In order to negate the effect of size and gender, the ratios of these distances of the joint line of the knee were normalized to the respective bony diameters. The distance of the lateral epicondyle to the joint line of the knee was about one-third the inter-epicondylar diameter. The distance of the lateral flare of the femur to the joint line of the knee was one-half the inter-flare diameter. The distance of the tibial tubercle to the joint line of

the knee was one-half the diameter of the tibia in the sagittal plane at the level of the tibial tubercle. The distance of the proximal tibio-femoral joint to the joint line of the knee was one-third the diameter of the tibia in the coronal plane at the level of the proximal tibio-femoral joint. The spatial relationship of the joint line of the knee to the femur and tibia was made by calculating ratios across the joint line. The joint line of the knee was halfway between the lateral epicondyle and proximal tibio-fibular joint in the coronal plane. This study introduces a valuable pre-operative, intra-operative, and post-operative tool that allows the position of the joint line of the knee to be calculated in the primary and revision setting (Figure 2).



K621

Simultaneous Bilateral Total Knee Arthroplasty in the Elderly

Primary Author: Soshi Asai

Institution: Department of Orthopaedic Surgery, Showa University Fujigaoka Hospital

Coauthor: Hiroshi Takagi (Department of Orthopaedic Surgery, Showa University Fujigaoka Hospital)

BACKGROUND: It was reported that simultaneous bilateral TKA is advantageous over staged bilateral TKA in terms of hospital stay and speed of recovery. However, the usefulness of this surgical technique to the elderly is not clear. The aim of this study was to assess the clinical outcome of the simultaneous bilateral TKA in the elderly.

METHODS: From March 2010 to May 2012, fifty-seven consecutive patients with bilateral knee osteoarthritis underwent simultaneous bilateral TKA. The subjects included 7 men and 50 women, with an average age of seventy-six years. An age cutoff point at 75 years defined the 2 study groups: 25 cases younger than 75 years (U-75 group) and 32 cases older (O-75 group). In the U-75 group, average age was 70.4 years (66~75), and average Body Mass Index was 26.9 kg/m². In the O-75 group, average age was 81.5 years (76~87) and average of Body Mass Index was 25.2 kg/m². All TKAs were performed using the measured resection technique with a conventional resection block. The tourniquet was inflated on the second leg after release of the first tourniquet. We used an intramedullary alignment system for the femur and an extramedullary alignment system for the tibia. Retrograde infusion of additional 1000mg of Tranexamic acid and 20ml of saline was made through the drainage tube. The drainage tube was clamped for 2 hours. The implants used throughout the study were the cemented PFC Sigma PS type (DePuy, Warsaw, IN). We evaluated the following data; 1)operative duration, 2) preoperative and postoperative Range of Motion (ROM), 3) Hospital for Special Surgery (HSS) scores at 12 months postoperatively, 4) estimated blood loss postoperatively (Nadler, Hidalgo and Bloch), 5) rate of complication.

RESULTS: Average operative duration was 190.5 minutes in the U-75 group and 181.5 minutes in the O-75 group. Estimated average blood loss postoperatively was 993.4±365.7ml in the U-75 group and 939.5±341.7ml in the O-75 group. Preoperative HSS score was 56.3 points

in the U-75 group and 52.7 points in the O-75 group. Postoperative average HSS score was 88.3 points in the U-75 group and 80.9 points in the O-75 group. Preoperative ROM -9.3~112.9° in the U-75 group and -10.5~122.4° in the O-75 group. Postoperative ROM was -1~120° in the U-75 group and -0.9~120.5° in the O-75 group. There was a significant difference between both groups with regard to the postoperative HSS score and preoperative flexion angle. Deep venous thrombosis and asymptomatic pulmonary embolism appeared in 4 patients of the U-75 group and 5 patients of the O-75 group respectively. There were no infection and cardiologic complications in both groups.

CONCLUSIONS: Clinical results of the O-75 group were satisfactory. In addition, there were no serious complications in the O-75 group. From the results of this study, simultaneous bilateral TKA is a relatively safe and beneficial procedure in the elderly.

K622

Pre-operative Anaemia in Elective Total Knee Arthroplasty: The Post-operative Toll

Primary Author: Anouska A. Ayub

Institution: University College Hospital, London

Coauthors: Toby Richardson (University College Hospital, London), Fares Haddad (University College Hospital, London)

AIM: Preoperative anemia in patients undergoing elective total knee arthroplasty has been associated with increased allogeneic blood transfusion therapy and increased rates of in hospital morbidity, which often leads to a longer length of hospital stay. We measured the prevalence of anaemia among patients attending pre-admission clinic before elective major joint arthroplasty.

METHODS: Retrospectively, a randomized sample of all patients undergoing total hip arthroplasty between Dec 2009 and June 2010 were included. The computerized laboratory results were analysed for anaemia as defined by the local reference range (

RESULTS: 96 patients were included with an average age of 67.2 years (SD 9.1). 54% were female ; haematology data was complete for all patients. 13 (13.5%, 7 women) of these patients were anaemic on pre-admission haemato-

logical testing. There were two intra operative blood transfusions, both were in patients found to be anaemic pre-operatively. Overall, 23% of admissions were transfused an average of 2.2 (SD 0.39) units, an average of 2.2 (SD 1.2) days after surgery. Significantly, 71.4% of those patients identified as anaemic preoperatively were transfused post operatively, whereas only 23.1% of the pre-operatively non-anaemic patients were transfused ($p=0.0026$ Fisher's exact test). The average length of stay for patients who were found to be anaemic at pre-operative assessment was 6.8 days (SD 3.5, range 4 - 13 days) compared to 4.9 days (SD 1.5, range 3-10 days) for the patient group that were not found to be anaemic ($p=0.004$). Range of Motion at 6 weeks post operatively also varied significantly. Extension was significantly different ($p=0.003$), as was flexion, ($p=0.014$) by two-tailed student t-test.

DISCUSSION: A significant number of post-operative transfusions were performed in patients found to be anaemic pre-operatively. We have identified that pre-operative anaemia is associated with two negative outcomes post operatively: Increased length of hospital stay and decreased final range of movement. There is a clear indication for a standardized approach for the detection and treatment of anaemia in preparation for elective total knee arthroplasty.

K623 High-flexion Prosthesis Improves Function of TKA in Asian Patients Without Decreasing Early Survivorship

Primary Author: Seong-Il Bin

Institution: Department of Orthopedic Surgery, College of Medicine, University of Ulsan, Asan Medical Center

Coauthors: Bim-Sik Lee (Department of Orthopedic Surgery, College of Medicine Catholic University, Incheon St. Mary's Hospital), Jong-Min Kim (Department of Orthopedic Surgery, College of Medicine, University of Ulsan, Asan Medical Center), Jong-Won Chung (Barun Joint Orthopedics, Geumgwang-Dong, Jungwon-Gu), Kyung-Ah Kim (Department of Orthopedic Surgery, College of Medicine, University of Ulsan, Asan Medical Center)

BACKGROUND: Two previous studies recently raised the possibility of a high risk of early femoral components loosening with high-flexion (HF) prostheses in Asian populations and suggested that the high failure rate of HF

TKAs was associated with HF ability. However, these findings are controversial given other studies reporting a low incidence of aseptic failures in HF prostheses.

QUESTIONS/PURPOSES: We therefore determined (1) the rate of achieving postoperative HF after HF TKA; (2) whether the aseptic loosening rate of HF prostheses is high; and (3) whether the survivorship was worsened in patients who achieved postoperative deep knee flexion in our cohort of Korean patients.

METHODS: We retrospectively reviewed 488 patients who had 698 primary TKAs using the NexGen1 Legacy Posterior-Stabilized Flex system implanted from 2003 to 2010. There were 40 men and 448 women with a mean age of 68 years. We obtained Hospital for Special Surgery scores, maximal flexion, and radiographs. The minimum followup for functional and radiographic evaluations was 2 years (median, 4.8 years; range, 2–8.7 years). We performed a survival analysis on all patients for aseptic loosening.

RESULTS: Three hundred sixty knees (52%) could achieve C 135_ maximum flexion. Six of the 698 knees (0.9%) developed aseptic loosening (three femoral and three tibial). The survival at 5 years for aseptic loosening was 99.1%. The overall survival for aseptic failure did not differ between knees that achieved HF and those that did not.

CONCLUSIONS: We observed a low incidence of early aseptic loosening of HF designs in this series. Our findings suggest HF TKAs have high survival in Asian patients at 5 years although half of the patients attained maximum flexion more than 135_ postoperatively.

LEVEL OF EVIDENCE: Level IV, therapeutic study. See Guidelines for Authors for a complete description of levels of evidence.

K624 No Impact of Severe Varus Deformity on Clinical Outcome After Posterior Stabilized Total Knee Arthroplasty

Primary Author: Seong-Il Bin

Institution: Department of Orthopaedic Surgery, Asan Medical Center, College of Medicine, Ulsan University

Coauthors: Bum-Sik Lee (Department of Orthopedic Surgery, Incheon St. Mary's Hospital, The Catholic University of Korea College of Medicine), Sang-Jin Lee (Department of Orthopedic surgery, In-Je University Hae-Hu-Dae hospital, College of Medicine, In-Je university.), Jong-Min Kim (Department of Orthopaedic Surgery, Asan Medical Center, College of Medicine, Ulsan University)

PURPOSE: Severe varus deformity may lead to premature failure of total knee arthroplasties (TKAs) because of technical difficulties associated with satisfactory alignment and good ligament balance. The aim of the study was to assess whether preoperative varus severity would affect the longevity, clinical outcomes, and complication rates of TKAs.

METHODS: From a prospectively collected database, we assessed outcomes in 168 knees that underwent primary TKAs using a single posterior stabilized design. These included 86 knees with mild preoperative deformity (varus mechanical tibiofemoral angle B5_) and 82 knees with severe preoperative deformity (varus angle C15_). Survivorship was analyzed by a life-table method. Clinical outcomes were also compared, including Knee Society knee and functional scores and complication rates.

RESULTS: The postoperative tibiofemoral angle of the mild varus group was 7.1 ± 2.5 _, whereas that of the severe varus group was 6.4 ± 2.5 _ (n.s.). There were no significant differences in terms of perioperative complications. Both groups showed the same cumulative survival rate, with absence of mechanical failure, of 98% at 7 years without difference (n.s.). There were no significant between-group differences of clinical parameters throughout the each follow-up period.

CONCLUSION: The knees with preoperative severe varus deformity were achieved the results comparable to those in knees with mild varus deformity, as determined by survival rate and clinical results. These data suggest that preoperative severe varus deformities can be successfully managed and do not have any detrimental effect on the longevity and clinical outcomes after a modern posterior stabilized TKA.

KEYWORDS: Total knee arthroplasty, Varus deformity, Survivorship

K625

Femoral Bowing in Coronal Plane Has More Significant Effect Than Proximal Or Distal Variations of Femoral Shape on Coronal Alignment of TKA

Primary Author: Seong-Il Bin

Institution: Department of Orthopedic Surgery, Asan Medical Center, University of Ulsan College of Medicine

Coauthors: Soo-Heon Hong (Seoul Now hospital), Bum-Sik Lee (Department of Orthopedic Surgery, Incheon St. Mary's Hospital, The Catholic University of Korea College of Medicine), Jong-Min Kim (Department of Orthopedic Surgery, Asan Medical Center, University of Ulsan College of Medicine, Seoul, Korea.)

BACKGROUND: Distal femoral cut in total knee arthroplasty is the crucial step to restore the neutral limb alignment. the distal femoral valgus cutting angle may be affected by variations of femoral shape in coronal plane.

PURPOSE: To determine (1) the proximal, middle and distal variations of femoral shape in a series of Korean patients who had undergone TKA, (2) the preoperative relationship between these three parameters and the distal valgus cutting angle referenced off the femoral intramedullary guide, and (3) whether there was any relationship between femoral coronal shaft bowing and the proximal or distal variations of femoral shape.

METHODS The preoperative long standing AP radiographs of 316 consecutive osteoarthritis patients who underwent primary TKA from March 2009 to March 2011 were reviewed. To assess proximal, middle and distal femoral shape, the femoral neck shaft angle(FNSA), the femoral shaft bowing angle (FBA) and the mechanical lateral distal femoral angle(mLDFA) were measured, respectively. The valgus cutting angle of the femur was defined as the angle between the femoral anatomical and mechanical axes.

RESULTS: Femoral shape showed large variations in a Korean population undergoing TKA. The mean femoral intramedullary guide angle was $6.5 \pm 1.3^\circ$ (range, 4° to 13°). FBA was the associated factor most strongly correlated with this angle ($r=0.501$, $P<0.001$). mLDFA had only a weak correlation with the angle ($r=0.184$, $P=0.001$) and

FNSA had no correlation ($r=-0.094$, $P=0.097$). FBA had a weak correlation with mL DFA ($r=0.191$, $P=0.001$) but was not significantly correlated with FNSA ($r=0.10$, $P=0.07$). Apparent femoral bowing (greater than 3° of lateral or medial bowing) was found in 42 (13.3%; 37 lateral, 5 medial) cases. Cases with lateral apparent femoral bowing greater than 3° had a distal cutting angle of $8.6^\circ \pm 2.2^\circ$ relative to the femoral intramedullary guide.

CONCLUSION: The angle of femoral intramedullary guide showed wide variations in Korean patients and was mainly influenced by coronal bowing of the femur rather than proximal or distal variations in coronal plane. Therefore the preoperative measurement of the femoral intramedullary guide angle from the anteroposterior (AP) radiographs containing whole femur is necessary to plan the distal femoral cutting angle in TKA accurately using a femoral intramedullary guide.

LEVEL OF EVIDENCE: Retrospective case series, Level IV.

KEY WORDS: Coronal bowing, Alignment, Total knee arthroplasty, Intramedullary guide, Long standing AP radiograph

K626 Should Reference Lines Common to Mechanically Aligned TKA Set Component Rotation in Kinematically Aligned TKA?

Primary Author: Abheetinder S. Brar
Institution: University of California, Davis

Coauthors: Joshua D. Roth (University of California, Davis), Stephen M. Howell (University of California, Davis), Maury L. Hull (University of California, Davis)

INTRODUCTION: 20-25 percent of patients with a mechanically aligned total knee arthroplasty (TKA) report dissatisfaction with their knee function. Correctly setting internal-external rotation of the tibial and femoral components is one factor that affects function.

Setting component rotation is challenging because there is no consensus on the orientation of the ideal sagittal plane of the knee for establishing reference lines on the tibia, and because finding these reference lines intraoperatively

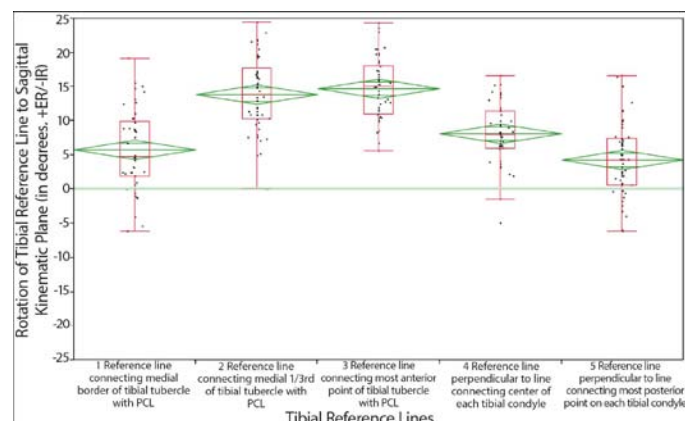
is unreliable.

Kinematically aligned TKA is an alternative alignment method for which patient-reported satisfaction and function at 2 years is better and revisions at 3 years are fewer than mechanically aligned TKA. The goal for setting the rotation of the AP axis of each of the tibial and femoral components in kinematically aligned TKA is to set them parallel to the sagittal kinematic plane.

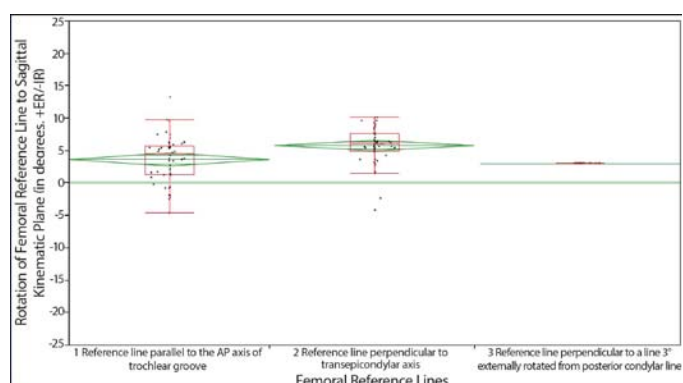
The present study determined whether any of five tibial reference lines and three femoral reference lines used in mechanically aligned TKA set the rotation of the tibial and femoral components parallel to the sagittal kinematic plane.

METHODS AND MATERIALS: Image analysis software was used to create a line parallel to the sagittal kinematic plane in fifty three-dimensional bone models of normal lower extremities from white subjects. Five tibial reference lines and three femoral reference lines used in mechanically aligned TKA were drawn. The angle that each reference line formed with a line parallel to the sagittal kinematic plane quantified component rotation.

RESULTS: The average rotation of each tibial reference line ranged from 4° to 15° external to the sagittal kinematic plane (Figure 1). On average none of the five tibial reference lines were parallel to the sagittal kinematic plane because the 95% confidence interval of the mean did not include 0° .



The average rotation of each femoral reference line ranged from 3° to 6° external to the sagittal kinematic plane (Figure 2). On average none of the three femoral reference lines were parallel to the sagittal kinematic plane because the 95% confidence interval of the mean did not include 0° .



DISCUSSION: Mechanically aligned TKA uses a variety of tibial and femoral reference lines that, on average, externally rotate the tibial and femoral components from the sagittal kinematic plane. These data suggest that these lines should not be used when performing kinematically aligned TKA. The systematic external rotation of the components away from the sagittal kinematic plane may explain in part why patients with mechanically aligned TKA have lower satisfaction, function, and survivorship at 3 years, and more pain, rotational mismatch, and abnormal kinematics than patients with kinematically aligned TKA.

K627

Knee Arthroplasty in Obese Patients: A Prospective 1000+ Enhanced- Recovery Patient Study

Primary Author: Pranai K. Buddhdev

Institution: The Hip & Knee Unit, West Hertfordshire Hospitals NHS Trust, UK

Coauthors: Neil. Davies (The Hip & Knee Unit, West Hertfordshire Hospitals NHS Trust, UK), Tim. Waters (The Hip & Knee Unit, West Hertfordshire Hospitals NHS Trust, UK)

INTRODUCTION: Obesity is a direct contributor to degenerative joint disease. As the prevalence of obesity increases we would expect the number of overweight patients presenting for knee replacement surgery to similarly increase. There are reports that overweight patients in the UK's National Health Service, typically with a Body Mass Index (BMI) over 30, are being denied operations on the premise that they are at risk of significant complications. Enhanced Recovery Programmes (ERP) are designed to enable patients to recover quickly and return home safely within a few days. The aim of this study was to compare

the outcome of obese and non-obese patients enrolled in our ERP.

METHODS: We prospectively studied 1011 patients who underwent knee arthroplasty surgery (Group 1; primary TKR, Group 2; uni-compartmental/patella-femoral replacements, Group 3; Revision knee arthroplasty) and were treated through our ERP from March 2010 to December 2012. The mean age was 69 (range 34-96 years). 532 patients (52%) were considered obese with a BMI of >30 . 21 patients (2%) were considered morbidly obese with a BMI ≥ 40 . They were age & sex-matched with the non-obese patients. Outcomes measured included: Length of stay, wound complications (including surgical site infections), deep vein thrombosis and blood transfusion requirements. Data was collected to 42 days following discharge.

RESULTS: There was no significant difference in the length of stay between the obese (BMI 30-39) and non-obese (BMI <30) patients in any of the groups. The average ages of the patients undergoing surgery were lower in higher BMI groups. Most notably, admission time was prolonged in the morbidly obese group, with an average length of stay of 5.6 days and 8.8 days in patients undergoing primary TKR and revision arthroplasty (median 5). In the morbidly obese group, 3 patients (21.5%) undergoing primary TKR and 3 patients (75%) undergoing revision surgery were documented to experience wound complications including prolonged oozing and haematoma formation which delayed discharge. There were no significant differences in surgical site infections, blood transfusion requirements, deep vein thrombosis incidence or other patient-reported outcome measures at 42 days.

CONCLUSION: There was no significant difference in the early post-operative outcome of knee replacements in patients with a Body Mass Index of less than 40 enrolled in the ERP. The morbidly-obese group however, demonstrated longer hospital stays non-infective wound complications and catastrophic early implant failure. These patients should be encouraged to optimise their weight pre-operatively and counselled that their recovery may be longer. Pre-operative bariatric surgery is becoming increasingly popular. As a result of this study we would not withhold knee replacement surgery on the basis of elevated BMI.

K628

Robotic Arm Assisted Lateral Unicompartamental Knee Arthroplasty

Primary Author: Frederick F. Buechel, Jr

Institution: Buechel Robotic Joint Replacement Center - Physicians Regional Medical Center

INTRODUCTION: Isolated lateral compartment osteoarthritis (OA) occurs in 5-10% of knees with unicompartamental OA. Lateral unicompartamental knee arthroplasty has been limited in its prevalence due to challenging surgical technique issues. A robotic-arm assisted surgical technique has emerged as a way to achieve precise implant positioning which can potentially improve surgical outcomes.

METHODS: The results of 66 consecutive lateral unicompartamental knee arthroplasties that were performed by a single surgeon with the use of a metal backed, cemented prosthesis installed with the three-dimensional intra-operative kinematics and haptic robotic guidance. The average age of the patient was 72 years (range: 59-87) and the average BMI was 27 (range: 19-39). The follow-up ranged from 1 month to 46 months. A specific Pre-Op and Intra-Op software implant planning process and surgical technique using a haptically-guided robotic system was used to perform the lateral procedure.

RESULTS: All patients recovered flexion to an average of 130° at 6 weeks post-operative, compared to an average of 127° pre-operative. There was one revision to a total knee for progression of painful OA to the patellofemoral compartment.



CONCLUSION: Early results of robotically guided lateral UKA are encouraging and provide evidence to show that lateral UKA is a viable option for patients with lateral OA disease. Three dimensional planning, intra-operative kinematic analysis and haptic robotic guidance provide a significant advantage over manual installation for lateral compartment arthroplasty of the knee. The significant anterior to posterior translation of the lateral femoral condyle along with the “screw-home” mechanism associated with the lateral compartment makes the tracking of the lateral compartment highly complex when retaining the cruciate ligaments. Intraoperative planning and adjustment to the preoperative plan, provided only with this robotic system, results in optimized lateral compartment kinematics. Further mid to long term studies are needed to determine survivorship as it compares to medial unicompartamental knee arthroplasty.

K629

Robotic-Assisted Medial and Lateral Bi-Unicompartamental Knee Arthroplasty

Primary Author: Frederick F. Buechel, Jr

Institution: Buechel Robotic Joint Replacement Center - Physicians Regional Medical Center

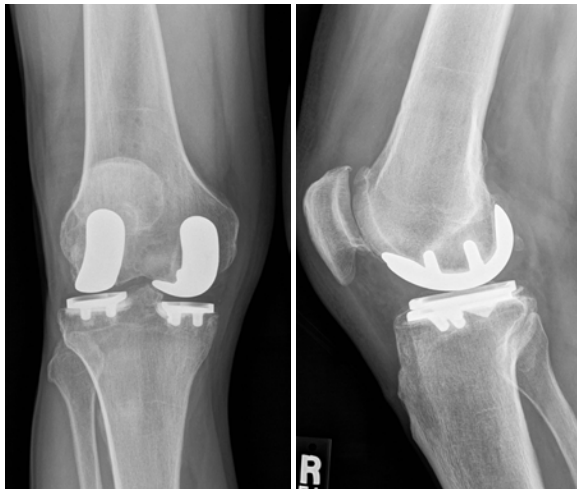
INTRODUCTION: This is a case report of a 78 year old male who underwent outpatient mini-incision medial UKA using the MAKO Surgical Rio Robotic Arm System in 2010. The patient subsequently suffered a traumatic lateral meniscus tear and underwent a lateral compartment UKA with the same robotic system instead of converting to a total knee replacement at one year post op and is now 2 years post op on the lateral side and 3 years on the medial side.

METHODS: The patient is a 74 year old male with a BMI of 27 suffering from OA of the right knee. He had a previous TKA on his left side by another surgeon that was followed with a lateral release by still another surgeon with fair to good satisfaction currently, however he did not want another TKA. He had multiple aspirations and injections of corticosteroids for arthritic effusions on his right knee that were moderate to severe and painful. On 7/6/2010 he underwent a right medial UKA using with robotic guidance. The patient had a subsequent injury to his lateral meniscus causing pain for which multiple options were discussed with the patient. The informed patient chose to have a lateral compartment arthroplasty. On 6/21/2011 a lateral

compartment UKA was performed on the same patient's right knee through a second mini-lateral incision again using robotic guidance.

RESULTS: The patient was 35 months after his right medial UKA and 24 months after his right lateral UKA. His function is excellent, his range of motion is excellent at 0-135° compared to 120° pre-operatively, his satisfaction is excellent and he has no self-reported limitations with his right knee.

CONCLUSIONS: The complexity of patient-specific planning, the ability to adjust that plan intra-operatively to optimize kinematics and the safety of implementing this plan using haptically guided robotic bone resection provides many advantages in partial knee arthroplasty. In the case presented here, a post-operative lateral meniscal injury subsequent to medial UKA in the same knee was treated with a lateral UKA. Accurate placement of the components and balancing the knee with the existing medial UKA provided by the robotic platform was critical to the excellent post-operative outcomes.



K630

Tibial Slope Reproduction in Medial Unicompartmental Knee Replacement: Individualizing Anatomic Slope Provides Optimal Ligament Balance

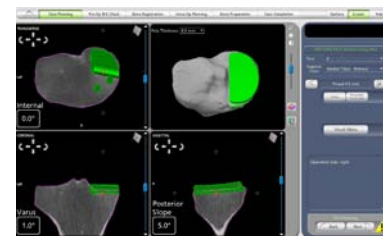
Primary Author: Frederick F. Buechel, Jr

Institution: Buechel Robotic Joint Replacement Center - Physicians Regional Medical Center

Coauthor: Frederick F. Buechel, Sr. MD

Using a robotic arm assisted partial knee replacement system that can reproduce tibial slope anatomically for each patient, optimal ligament balance can be consistently achieved. A pre-operative and intra-operative implant planning software system can plan for anatomic tibial slope of the medial compartment's tibial component. By positioning the tibial implant at the anatomic slope on the CT software, optimal ligament balance is achieved and confirmed by a ligament balancing graph that is created for each patient and shows the balance through the entire range of motion.

Optimal ligament balancing on the softwares graphical display system is achieved when the anatomic slope is utilized and not when a predetermined slope angle is chosen. Variation from the preoperatively planned anatomic tibial slope to the final intraoperatively optimized slope angle based on kinematic data input intraoperatively varies less than 2 degrees. This highly sensitive CT based implant planning system allowing anatomic implant slope planning within 1 degree, with robotic arm assisted bone preparation of the planned implant position, confirms that reproducing anatomic slope is essential for a properly balanced Medial UKA. Tibial slope is also highly variable amongst individuals and different cultures. The kinematic information gained from the use of this system has shown that tibial slope reproduction is a critical step in proper UKA installation.



K631**Compression Bandaging in Total Knee Arthroplasty: Early Results of an Orthopaedic Enhanced Recovery Program***Primary Author: Alan TL. Cheung**Institution: North West London Hospitals NHS Trust**Coauthors: Ian Holloway (North West London Hospitals NHS Trust), John Hollingdale (North West London Hospitals NHS Trust)*

We retrospectively audited the early results of our Orthopaedic Enhanced Recovery Program from November 2010 to July 2011 with regards to 180 patients undergoing TKA with and without compression bandaging following surgery.

100 patients (55.5%) were given an Actico compression bandage following TKA according to surgeon preference, 80 patients (45.5%) were given a non-compression wool and crepe bandage. There was no significant difference in length of stay (LOS) between the two groups - compression bandage group mean LOS was 3.75 days and for non-compression bandage mean LOS was 4.48 days. There was a significant difference with regards to mobility (p Our results demonstrate a high level of patient satisfaction, low complication rate and reduction of hospital stay of 2 days per patient following introduction of the enhanced recovery program. Assuming a bed day cost of \$350, at a conservative estimate, the program has saved the Trust around \$150,000 in the last 8 months. It is not clear why the compression bandage technique appears to be associated with improved postoperative mobility. This requires further investigation.

K632**Contributing Factors for Pain in OA Patients Underwent TKRA***Primary Author: Euisung Choi**Institution: Chungbuk National University Hospital*

PURPOSE: It is examined the cause associated with pain during total knee replacement arthroplasties for the osteoarthritic knees.

MATERIAL AND METHODS: There are 226 knees of

161 enrolled patients who had undergone total knee replacement arthroplasties from september 2008 to may 2013. The severity of pain(VAS score) is measured in all patients. It is performed statistical correlation analysis between the assumed causes of pain; age, gender, physical examination (Medial joint line tenderness), grade of osteoarthritis (Kellgren-Lawrence grading scale), BMI, varus deformity, mechanical axis deviation, root tear and severity of symptoms (VAS score).

RESULTS: VAS score(severity of pain) measures 6.31 on the average. VAS score had correlation with the severity of osteoarthritis(Kellgren-Lawrence grading scale) ($P<0.05$), medial joint line tenderness($P<0.05$), but other underlying factors didn't show significant correlation.

CONCLUSION: In patients undergone total knee replacement arthroplasties for the osteoarthritic knees, severity of pain corroborated by associations with severity of osteoarthritis(Kellgren-Lawrence grading scale) and medial joint line tenderness.

K633**The Value of Grand Piano Sign as Index of Femoral Component Rotation in Total Knee Arthroplasty***Primary Author: Euisung Choi**Institution: Chungbuk National University Hospital*

PURPOSE: This study evaluated the relationship between Grand piano sign observed after the anterior resection of femur and the rotation of femoral component in TKA, and the use of Grand piano sign as a index for the optimal femoral component rotational alignment.

MATERIALS AND METHODS: The study subjects included 37 patients (44 cases) with osteoarthritis who underwent TKA. We measured the height ratio of the medial and lateral condyles of Grand piano sign observed after the anterior resection of femur, and the angle between the transepicondylar axis and the posterior condylar axis by computerized tomographs.

RESULTS: The average height ratio of the medial and lateral condyles of Grand piano sign was 0.60 (range from 0.34 to 0.93) and the average angle between the transepicondylar axis and the posterior condylar axis was 2.83 de-

grees (range from 0.43 to 7.48) which showed statistically significant correlation. Moreover, when the angle between the transepicondylar axis and the posterior condylar axis was between 2 and 4 degrees, the average height ratio of the medial and lateral condyles of Grand piano sign was 0.64 (range from 0.58 to 0.76), which was considered the most optimal for the femoral component rotational alignment.

CONCLUSION: In TKA, Grand piano sign showed us the amount of femoral component rotation, and then we should use Grand piano sign as a index for the optimal femoral component rotational alignment.

KEY WORDS: Total knee arthroplasty, Anterior resection of femur, Grand piano sign, Transepicondylar axis, Posterior condylar axis, Femoral component rotation

K634

Clinical and Arthroscopic Outcome of the Remnant Preservation Technique in Anterior Cruciate Ligament Reconstruction

Primary Author: Sungwook Choi

Institution: Jeju National University Hospital

Coauthors: Myung Ku Kim (Inha University Hospital), Seong-il Bin (Asan Medical Center, Ulsan University)

PURPOSE: The purpose of this study was to compare the clinical outcome and relate the results with the second look arthroscopic finding of the synovial coverage and intraoperative laxity for remnant preserving ACL reconstruction with conventional ACL reconstruction in single bundle anterior cruciate ligament (ACL) reconstructions.

METHODS: 142 consecutive patients underwent ACL reconstruction in our hospital from which 75(53%) patients underwent ACL reconstruction with remnant preservation technique (Group P) and 67(47%) patients with conventional ACL reconstruction technique (Group C). Their follow up mean was 27months (range, 19 to 38 months). Clinical outcomes were assessed with Lysholm scores, International Knee Documentation Committee form and Tegner evaluation. The stability was evaluated by manual knee laxity, pivot shift test and Telos device. At least 1 year after surgery, 23(34%) patients (group P) and 39(52%) patients (group R) underwent second-look arthroscopic eval-

uation for grading of tension, synovial coverage and laxity measurements.

RESULTS: Difference in postoperative stability (manual knee laxity, pivot shift test and Telos device) was not significant between the two groups ($P = .488$, $P = .542$, and $P = .422$, respectively). No significant difference was noted with respect to International Knee Documentation Committee form but the latest median score of the Lysholm and Tegner scores for remnant preservation technique (Group P) were an average of 92 and 9.1, respectively. Conventional ACL reconstruction (Group C) resulted at an average of 82 and 8.4, respectively ($P 0.08$ and $P 0.08$). In terms of second-look arthroscopic findings, synovial coverage resulted in 82% (32/39) of patients in the remnant preservation technique (Group P) and 13% (3/23) in the conventional ACL reconstruction (Group C) had excellent grade synovial coverage. The average laxity measurement were 3.8 mm in the remnant preservation technique (Group P) and 4.1 mm in the conventional ACL reconstruction (Group C).

CONCLUSIONS: The ACL reconstruction with remnant preservation was evaluated with an acceptable result in stability, clinical outcomes and second-look arthroscopic findings. Remnant preservation technique is a more reliable treatment of ACL tears.

LEVEL OF EVIDENCE: Level III, retrospective comparative study.

K635

Postoperative Corticosteroid Reduces Postoperative Rebound Pain After TKA

Primary Author: Yoowang Choi

Institution: Yensesarang Hospital

Coauthor: Saekwang Kwon

INTRODUCTION: Multimodal analgesic protocol including preemptive medication and periarticular injection is known to reduce immediate pain at operation night after TKA, however, it cannot hold rebound pain after 24 hours after surgery. We determined (1) whether postoperative dexamethasone at 24 hours after surgery reduces rebound pain at second night and maintains reduced pain after TKA; (2) whether sequential prednisolone intake has

an additional effect for maintenance of reduced pain during last period; (3) whether postoperative corticosteroid increases complications after TKA.

METHODS: We randomized 150 patients undergoing TKAs to receive dexamethasone (10 mg) injection at 24 hours after surgery (Dexa group, n=50) or sequential prednisolone 5mg intake every 12 hours from 3 day after surgery (Dexa-Pred group, n=50) or none (None group, n=50). We assessed pain VAS score (operation night, PO 2nd night, 3rd night, 4th night and 8th night), frequency of acute rescue, functional recovery (ability to straight leg raising, maximal flexion), amount of hemovac drainage, satisfaction score and any complication.

RESULTS: The pain level was significantly lower in the Dexa group and Dexa-Pred group at PO 2nd night (VAS 2.00 vs. 1.54 vs. None group 4.61, $p < 0.001$). Rebound pain was observed only in None group from PO (postoperative) 2nd night. Patients in the Dexa group and Dexa-Pred group experienced lower pain during the overall study period (PO 1 week) compared with None group, however, there is no difference in pain relief between Dexa group and Dexa-Pred group. Functional recovery (ability to SLR) was significantly earlier in the Dexa group and Dexa-Pred group. No significant differences regarding hemovac drainage, frequency of acute rescue and satisfaction were identified. There was no significant difference in incidence of complications among three groups.

CONCLUSION: We found that postoperative dexamethasone injection at 24 hours after surgery reduces rebound pain from PO 2nd night and maintains during one week after TKA without increased complications. Sequential prednisolone intake after dexamethason does not have additional effect of pain relief compared with Dexa alone group.

K636

Proposed Method for Realtime Measurement of Patient Specific Posterior Condylar Angle

*Primary Author: Devendra K. Chouhan
Institution: PGIMER*

Coauthor: Prateek Behra (PGIMER)

Importance of alignment and soft tissue balancing in total knee arthroplasty is well understood. Guideline and meth-

ods to assess coronal alignments are well established but there is still paucity of methods to assess rotational alignment intraoperatively.

Transepicondylar axis (TEA) is identified as primary reference axis for reconstruction of knee joint, but it is at certain angle to the posterior condylar line (PCL) which vary individually, related to disease process and severity of disease. So preoperative or intraoperative identification of same is important for knee kinematics reconstruction. We advocate two simple methods to measure the axial anatomical variation during surgery in distal femur.

To validate our method we have used CT scan of 26 individual of unknown gender and primary problem. We have measure angle between TEA and PCL using our methods and compared the results with software based measurements.

All of the three methods resulted in similar if not the same angle and the mean angle by one method was not found to be significantly different from that measured by another method. The mean value of the angle between the PCL and the clinical TEA as measured by the software was 6.27° (0° - 12°) with a standard deviation of 2.97. The mean of this angle as measured by method-1 was 6.23° (0° - 11.11°) with a standard deviation of 2.90 and by the method-2, it was 6.31° (0° - 12°) with a standard deviation of 2.85.

We want to introduce the simple, accurate, easily reproducible, realtime and cost effective method to obviate the need for obtaining a pre operative CT scan for identification of patient specific posterior condylar angle.

K637

Does Femoral Component Design Risk Damaging the Popliteus Tendon? A Pilot Study

*Primary Author: Devendra Kumar. Chouhan
Institution: PGIMER*

Coauthor: Prof. Mandeep S. Dhillon (PGIMER)

Despite modern implant design and improved knowledge about joint kinematics, patellofemoral problems have been an important cause for dissatisfaction post Total Knee Arthroplasty (TKA). Implantation of the femoral complement in external rotation has been argued to be an important con-

tributing factor. The femoral component with inbuilt rotation was therefore designed to minimise this complication.

However, using this design with inbuilt external rotation we found that popliteus tendon injury occurred in some cases. Due to paucity of evidence between the relationship of implant design and intraoperative popliteus tendon injury, we prepared a study protocol research question being “Does femoral component design risk damaging the popliteus tendon? A Pilot study”.

A total of 30 patients were planned to be included in the study. Selection criteria included patients with bilateral varus osteoarthritis of knee. The study design included implanting the femoral component in 3 ° external rotation from posterior condylar axis in one knee each patient (Group A) and a femoral component with inbuilt external rotation in the other knee (Group B). The implant with inbuilt external rotation has a significantly thicker posterior condyle laterally as compared to the other design. A Vernier calliper was used to measure the distance between the insertion of the posterior edge of popliteus insertion and the posterior condylar cut. The thickness of the posteriorly resected bone pieces from both the medial and lateral condyles was also measured. Additional records were kept regarding intraoperative complete or partial popliteus tendon injury, downsizing of femoral component, patellar tracking and any posterior cartilage wear were kept.

After analysing data from the first 10 cases (10 knees in each group), injury to the popliteus tendon was noted in 3 knees (30%) in Group B, so on ethical grounds the clinical trial was aborted.

The average age of patient was 63 years, with average varus deformity of 13.4° in group A and 15.5° in group B. The average distance between posterior edge of popliteus tendon to posterior resected surface was 1.65mm in group B compare to 3.6mm in group A. In group-B 3 patients had injury to popliteus tendon. Thickness of the posterior resected medial condyle was 9mm (8.5-9.5mm) for group-A, 9.75mm (9-10mm) for group B and on the lateral side 7mm for group A, 9.7mm (9-10mm) for group B.

Conclusion: During TKA flexion resection parallel to posterior condylar axis brings the cutting edge of the saw very close to the insertion of popliteus tendon and thereby increases the risk of injuring it. Risk of popliteus tendon injury was found to be compounded by femoral component

downsizing. Implication of injury to the popliteus tendon and extra flexion resection of the lateral condyle needs further evaluation for assessment of clinical outcomes and for further revision surgery with group B implant.

K638

Early Experience with Outpatient Total Knee Arthroplasty Pilot Program

Primary Author: Richard T. Dauphine

Institution: UC San Francisco Medical School; Monterey Peninsula Surgery Center

Postoperative pain and disability management are major reasons for hospitalization after Total Knee Arthroplasty. Hospitalization may increase patient risk and is costly.

After the initial success in performing Partial Knee Replacements at a small freestanding Outpatient Surgery Center during the past 11 years (202 patients) the lessons learned by use of minimally invasive surgery, regional anesthesia and techniques to control postoperative pain were adapted to develop a comprehensive outpatient program to permit full Total Knee Replacements to be done in selected cases.

This comprehensive program empowers the patient with a team approach of preoperative teaching, specialized outpatient anesthesia with minimal narcotics and regional blocks, minimally invasive surgery, post-operative femoral nerve block indwelling pain pump and intensive physical therapy with full weight bearing and early motion.

14 patients, eight women and six men, ages 47 to 80 (average 58 years) were operated over the past 3 years. All patients were discharged to home within 24 hours.

They experienced less pain and more rapid recovery. There were no complications, including no infections, blood transfusions, emergency room visits, deep vein thromboses, pulmonary embolism or deaths. The patients were very satisfied with the procedure and would recommend it others.

The Out-patient Total Knee Replacement cost, including the prosthesis and our facility fee was \$20,422 which is much less than the cost of this surgery in a hospital.

This is a revolutionary treatment program which we will continue to develop. It may have broad application and if adopted may show improved results and economic benefits for society.

K639

Trabecular Metal Monoblock Tibial Component in Primary TKA: A 10-year Follow-up

Primary Author: Ivan De Martino

Institution: Catholic University of the Sacred Heart, Rome, Italy

Coauthors: Rocco D'Apolito (Catholic University of the Sacred Heart, Rome, Italy), Vincenzo De Santis (Catholic University of the Sacred Heart, Rome, Italy), Giorgio Gasparini (Magna GrÃcia University, Catanzaro, Italy)

Cementless fixation in total knee arthroplasty (TKA) has seen limited use since reports of high rate of complication and failures. However, with time, these problems have been overcome with new implant materials and designs, leading to a renewed interest in achieving a cementless tibial fixation to enhance a long-term survivorship of the implants. Cementless porous tantalum monoblock tibial component (Zimmer Inc, Warsaw, Ind) in primary total knee arthroplasty (TKA) has shown successful short-term results. The aim of the present prospective study was to investigate the mid-term clinical and radiographic results and the survival rate for this implant. From March 2002 to December October 2005, thirty-three cementless porous tantalum monoblock tibial components were implanted during thirty-three primary TKAs. The study group included twenty-seven women and six men with a mean age of sixty-seven years (range, 41–82 years) at the time of the procedure. All patients were followed prospectively. The average follow-up was 9.8 years (range, 8 to 11.8 years). All knees were rated good/excellent according to the Knee Society score, which improved from 39 preoperatively to 91 at latest follow-up. There were no tibia revisions. Radiographic analysis revealed no aseptic loosening, or osteolysis. There were no progressive radiographic lucencies. Kaplan-Meier analysis revealed that the eight-ten-year survival rate was 100% with revision for any reason as the end point. The mid-term results of the porous tantalum monoblock tibial component in primary TKA demonstrated excellent clinical results and survival rates with no failures due to os-

teolysis or loosening.

K640

Constrained Condylar Knee Articular Surface Spine: Influence of Physiological Loading Parameters

Primary Author: Mehul Dharia

Institution: Zimmer, Inc.

Coauthors: James D. Wenle (Zimmer, Inc.), Steven M. Humphrey (Zimmer, Inc.), Kimberly D. Minnaugh (Zimmer, Inc.)

INTRODUCTION: For patients who require additional prosthetic stabilization due to inadequate ligament function, TKA surgeons commonly use constrained condylar knee (CCK) implants to provide greater constraint and stability [1]. The CCK spine provides constraint by limiting varus-valgus (V/V) and internal-external (I/E) rotation. Further constraint is provided by the tibiofemoral bearing surfaces. The relative constraint provided by each of these features and their effect on the durability of the design has not been widely studied [2]. The present study was aimed at enhancing the understanding of the effects that various combinations of physiological loading have on the design performance of the CCK spine.

METHODS: A finite element analysis (FEA) model of a Zimmer® NexGen® LCKK design was created using Abaqus ver. 6.10 (Simulia, RI) software. The model of a right knee, arbitrarily chosen, consisted of a CoCr femoral component and a UHMWPE articular surface component with a reinforced titanium alloy post. Loading was applied through the femoral components in three axial directions as well as I/E and V/V moments. Sliding contacts were defined between the articular surface and the femoral component as well as between the polymeric spine and the central support post. From the physiological data available for nine patients with average weight of 908 N [3], five loading combinations were selected as listed in Table 1; each representing an average of maximum value of a specific loading component (marked in red), namely axial vertical force, valgus moment, varus moment, internal rotation and external rotation. For each combination, the corresponding average force or moment of other loading components were used. Nonlinear analyses were performed.

RESULTS: The peak maximum principal stress results in the spine for each model are listed on the last column in Table 1. Figure 1 presents the loading combination resulting in the highest articular surface maximum principal stress (MPa).

DISCUSSION: The predicted stress at the spine indicates that the loading combination with an externally rotated tibia (model 3 and 4) predicted higher stress in the spine compared to that using internal tibial rotation (models 1, 2 and 5). Although models 1, 3, 4 and 5 all applied higher varus moments, the models with tibial external rotation (models 3 and 4) predicted higher stresses in the spine, than the models with internal tibial rotation (models 1 and 5). Stress comparisons between models 4 and 5, which contain similar varus moments and compression forces, show that even at a significantly higher tibial internal rotation, the stresses predicted in the spine are much lower than that predicted with one half the amount of external tibial rotation.

SIGNIFICANCE: The results of this study indicate that among all the different loading components, the external moment plays a prominent role in loading of the spine and should be included in fatigue evaluation along with a varus moment, to evaluate the performance of the spine in a CCK design.

References:

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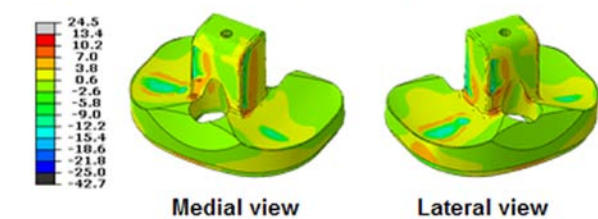
Table 1. Loading Combinations and Stress Results

model	Axial Vertical Force (N)	V/V Moment (N-m)	I/E Moment (N-m)	%Gait	Maximum Principal Stress (MPa)
1	2210	-20.4	-5.4	58	6
2	744	8.7	-0.6	68	8
3	1894	-29	0.7	43	12
4	1660	-23	4.2	33	13
5	1959	-15.4	-8.2	63	6

(-) Varus (-) Int.

(+) Valgus (+) Ext.

Figure 1. Maximum Principal Stress (MPa) for model 4



K641

Interaction of Trabecular Metal Coupled Tibial Cones with Tibial Baseplates – A Fretting Corrosion Evaluation

Primary Author: Mehul A. Dharia

Institution: Zimmer, Inc.

Coauthors: Steven M. Humphrey (Zimmer, Inc.), Keith A. Roby (Zimmer, Inc.), Kimberly D. Mimnaugh (Zimmer, Inc.), Ray Zubok (Zimmer, Inc.)

INTRODUCTION: During revision total knee replacement, segmental and cavitary tibial bony defects may be addressed by using Trabecular Metal tibial cones. A fretting corrosion study was performed to evaluate the interaction between the NexGen Trabecular Metal (TM) coupled tibial cone augments and the NexGen Legacy Constrained Condylar Knee (LCKK) tibial baseplate. A similar test performed using TM tibial half augment is provided as baseline.

MATERIALS AND METHODS: The tests were conducted in a simulated accelerated corrosion laboratory environment. The components (shown in the graphic) were assembled onto tibial baseplates and simulated cavitary defects were filled with cement per recommended surgical techniques as shown in the test setup. The experimental test method simulated the clinical environment with the evaluation conducted in Ringers saline solution. Polyurethane foam blocks represented cancellous tibial bone. Load profiles included joint axial load and an anterior-posterior (AP) shear load [1] with a safety factor of 1.7 were evaluated. Tests were conducted at a maximum of 10 Hz for 10 million cycles (Mc). Upon completion of each test, the tibial baseplate and TM augment mating surfaces were visually inspected under a light microscope at 17x magnification, using an approach established by Hood et.al. [2]. Each sample surface was ranked on a 0-4 scale with 0 being no observed corrosion and 4 being the most extensive/severe corrosion. Ranking was evaluated for both extent/severity of abrasion and the extent/severity of corrosion, by four different individuals independently.

RESULTS: Minor abrasion was observed on samples from both the TM tibial half augment and TM coupled tibial cone groups indicating that the fixation mechanism was stable and retained the components without allowing significant micromotion to occur, even under the aggressive

loading conditions. The minor abrasion observed consisted of slight scratching of the surface in local areas which was only observable under magnification. The ranking results were averaged by sample groups and are presented in Table 1. The distal surface of tibial baseplates before and after the tests is shown in the graphic.

CONCLUSIONS: The 10 Mc fretting corrosion test exhibited no visible abrasion and no observed corrosion or fretting corrosion debris from micromotion between the tibial baseplates and the TM tibial half-augments or the TM coupled tibial cones, even under the aggressive loading conditions. These results, while consistent with the 10-year clinical history [3,4] of the existing TM tibial half-augments, confirmed the hypothesis that due to similarities of locking mechanism and dimensions between the two designs, the micromotion effects would be similar in a clinical situation.

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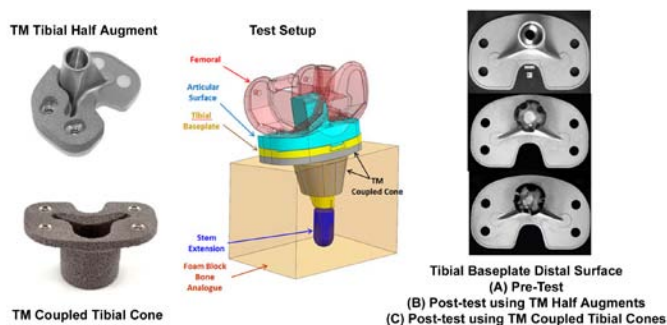


Table 1. Fretting Corrosion Ranking Results

	Augment		Distal Tibia	
	Abrasion	Corrosion	Abrasion	Corrosion
TM Half Augment	0.45	0	0.435	0
TM Coupled Tibial Cone	0.1	0	0.35	0

K642 Tibial Implant-Bone Micromotion Due To the Application of Pure Torques for Different Tibia Designs

Primary Author: Nick Dong

Institution: Stryker

Coauthors: Ananthkrishnan Gopalakrishnan (Stryker), Matt Poggie (Stryker), Michael Meneghini (Indiana School of Medicine, Indianapolis, IN), Arlen Hanssen (Mayo Clinic, Rochester, MN)

INTRODUCTION: Initial implant stability is an important factor for the success of cement-less TKA. Recent studies reported in-vivo instrumented tibial loading components including moment elements. To date, the effects of the moments to the initial stability of common tibial anchoring designs were not well studied. The purpose of this study was to investigate the tibial bone-implant micromotion under pure torque moments for a keeled and 3 peg tibial designs.

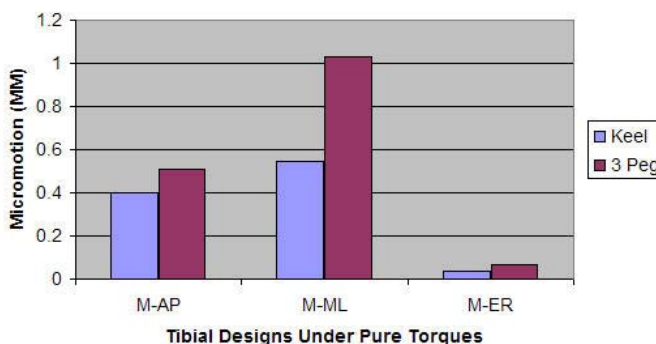
METHODS: The tibia bone was obtained from CT scan and converted to CAD files (Pro/Engineer Wildfire v2.0). The virtual bone were prepared and assembled with two generic tibial tray implants of 33mm long tri-flange stem-keel and 12mm OD - 16mm L 3 peg in the same orientation. Two assemblies were imported into ANSYS Workbench v11.0. Uniform isotropic cancellous bone properties for Young's modulus (E) = 570Mpa and the Poisson's ratio (ν) = 0.3 were selected. Both tibial trays were 6AL4VE-LI titanium alloy with 1.5mm thick CP titanium foam under the flat tray surface. The E for the titanium alloy was 95.6GPa and 5GPa for titanium foam. Both had ν of 0.34. The interfacial connections were: frictional connections of coefficient of friction = 0.4 were assumed for bone to stem-keel, pegs and titanium foam layer; bonding connections were constructed between titanium foams to solid trays and solid anchors. The moments were applied to the local coordinate system located at the center of the tray with the highest values reported by Heinlein et al as the stair descending activity: flexion MA-P = 24.920 N-M, the valgus-varus ML-M = 20.94N-M and the external rotation MER = 8.9N-M. The compression load was 875N. The distal tibia was fully fixed. The interfacial micromotion was recorded from FEA. The results were verified by the physical testing of an actual keel tray implanted in the open cell saw bone (12.5 pcf foam, E = 47.5MPa, ν = 0.3) under rotational mo-

ment MER with no compression load. The 8.9N-M torque was applied by the digital torque meter through the tibial tray holder. The micromotion was measured at lateral rim of the tray by a dial indicator. The result was compared with the FEA model in Saw Bone properties.

RESULTS: The highest micromotion was under valgus-varus moment and the lowest was in external rotation for both designs. The stem-keel design had 46.9%, 44.3% and 21.6% reductions in micromotion from 3 peg design under valgus-varus, rotational and flexion moments respectively. [Fig.1] The FEA results in maximum micromotion for the saw bone under pure external rotation was 0.276 mm. The physical verification test showed the average micromotion was 0.343mm SD=0.0845, N=3.

DISCUSSION: The length and grooves of tri-flange keel may have contributed to the higher resistance to the moments especially in the valgus-varus orientation than peg design. The pure moment is often applied intra-operatively to access tibial implant stability and it is the worse case scenario to which these finding are relevant. The modulus of bone influenced the micromotion as the lower modulus of saw bone resulted in higher micromotion than cancellous bone.

Figure 1. Tibial Mocromotion Due To Pure Torques



K643

Intraoperative Kinematics with Computer-Navigated TKA Can Predict the Functional Outcomes

Primary Author: Masataka Fujii

Institution: Department of Orthopaedic Surgery, Okayama

University Graduate School of Medicine

Coauthor: Nobuhiro Abe (Department of Orthopaedic Surgery and Sport Medicine, Kawasaki Medical School)

BACKGROUND: Computer navigation system has been reported as a useful tool to obtain the proper alignment of lower leg and precise implantation in total knee arthroplasty (TKA). This system also has shown the accurate gap balancing which leads to implants longevity and optimal knee function.

PURPOSE: The aim of this study was to determine that the postoperative acquired deep knee flexion would be influenced by intraoperative kinematics on navigated TKA even under anesthesia.

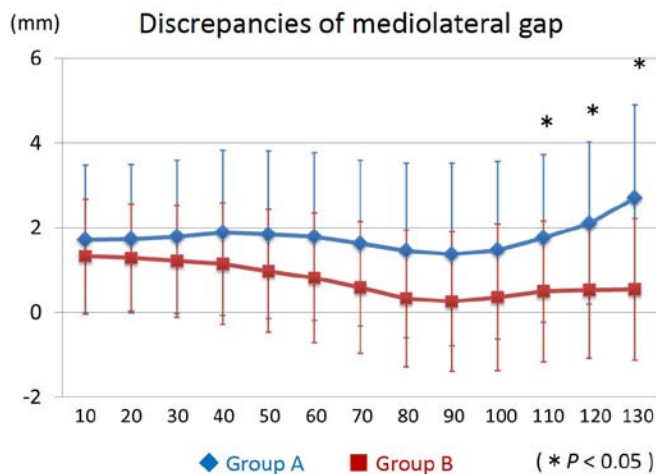
MATERIALS & METHODS: Forty knees from 40 patients, who underwent primary TKA (P.F.C. sigma RPF, DePuy) with computer-navigation system (Ci Knee, Brain-LAB / DePuy), were recruited in this study. These patients were classified into two groups according to the recorded value of maximum knee flexion at three month after surgery: 15 patients who obtained more than 130 degrees of flexion in Group A, and 25 patients less than 130 degrees in Group B. To obtain the clue for postoperative deep-flexion, we retrospectively reviewed intraoperative kinematics in each group. The measurements of intraoperative kinematics were consisted of 3 points: femoral rotation angle (degree) and antero-posterior translation (mm), which were measured as translation of the lowest points of femoral component to tibial cutting surface, and the discrepancies between medial and lateral gap (mm). All joint kinematic data were recorded at every 10 degrees of flexion from maximum extension to flexion under anesthesia.

RESULTS: There were no significant differences in preoperative diagnosis, sex, age, BMI, and preoperative range of motion between two groups. At 3 months after surgery, the recorded mean value of maximum knee flexion angle was 134.7 degrees in Group A, and 112.0 degrees in Group B. Femoral components were rotated internally up to 90 degrees flexion, and then rotated externally with flexion to the tibial plateau in the axial plane. There was no significant difference in femoral rotation angle between two groups, but slightly greater in Group A. Regarding to antero-posterior translation, femoral component had an anterior translation up to 50 degrees in both groups. The posterior translation was observed at more than 50 degrees, and

total amount of posterior displacement was significantly greater in Group A. The discrepancies of mediolateral gap during knee extension to flexion was significantly greater in Group A than that in Group B especially at more than 110 degrees of flexion [Fig. 1].

DISCUSSION: We found two parameters that can obtain greater knee flexion at more than 130 degrees in early post-operative period. There were significant differences in the femoral rollback at more than 50 degrees of flexion, and the discrepancies of mediolateral gap at more than 110 degrees of flexion between two groups. Using navigation system suggested that optimal intraoperative knee kinematics for femoral rollback and slight laxity at more than 110 degrees of flexion may obtain proper medial pivot motion. The surgeon can keep it in mind for soft tissue release to obtain the ideal postoperative function.

CONCLUSION: This study showed that optimal axial rotation and posterior translation of femoral component were important factors for postoperative deep knee flexion.



K644 A Novel Knee Sensor for Assessment of Knee Motion

Primary Author: Vivek Gulati

Institution: Imperial College NHS Trust

Coauthor: Vivek Gulati

INTRODUCTION: Accurate measurement of knee joint motion allows objective assessment of treatment strategies

implemented for knee osteoarthritis (OA). The goal of this project was to determine if a newly developed integrated clothing sensor system (ICS) provided a reproducible method for measuring sagittal plane motion of the knee.

METHODS: Ten healthy subjects were recruited to our study. All subjects wore the same ICS and were instructed to place the sensor themselves onto the lateral aspect of their knee joint. The sensor consisted of a composite material comprising 20% carbon black and 80% polymer polyurethane Texin985. The sensor was connected to a Wheatstone bridge configuration and data was collected by an A/D converter. Angles were obtained from a calibrated accelerometer that was attached to the dynamometer. All data was synchronised and sampled at 400 Hz. The knee of the participant was moved six times in the sagittal plane at speeds of 30, 75 and 120 degrees/second. The obtained raw data from the sensor system (ICS) was modelled based on the relationship with the measured angles. The difference between modelled and measured data showed the reproducibility of the sensor signal. Model outcomes and raw measurements were compared by calculating coefficient of determination (r^2) and Root Mean Square Error (RMSE) values for each subject and each trial, using Matlab 7.4.0.

RESULTS: The relationship between the sensor data produced in response to knee sagittal plane motion and angles obtained from the accelerometer, was found to be best modelled by a Fourier function. The outcomes of this predictive function were compared to the original raw values obtained for each subject. Overall measurements showed a mean r^2 value of 0.93, 0.95 and 0.92, and a mean RMSE% value of 16.42, 13.45 and 21.50 for knee flexion at 30, 75 and 120 degrees/second. For extension at these speeds mean r^2 values of 0.93, 0.91 and 0.96, and a mean RMSE% values of 17.39, 16.31 and 17.04 were found. All ICS signals displayed a trough followed by a peak value (Figure 1) when the knee was extended. Between trough and peak, only one sensor output corresponded to one joint angle. The relationship between knee angle and sensor output between trough and peak was best modelled by equation 1;

$$f(x) = a_0 + a_1 \cos(x \cdot w) + b_1 \sin(x \cdot w) + a_2 \cos(2 \cdot x \cdot w) + b_2 \sin(2 \cdot x \cdot w)$$

whereby $f(x)$ is angle in degrees, and x represents sensor output in Volts with a_0 , a_1 , b_1 , a_2 , b_2 and w depicting constants. Subject one then repeated one further trial of knee extension at 120 degrees/second. The sensor outputs again

revealed a trough and peak. For this timeframe, knee angles were calculated according to respective sensor outputs using equation 1. These computed angles were then compared with actual angles obtained at those timepoints revealing an RMSE of 1.4° .

DISCUSSION: The ICS delivered reliable, consistent signals in response to sagittal knee plane motion. A function with a low RMSE (1.4°) could be derived over a specific range of motion.

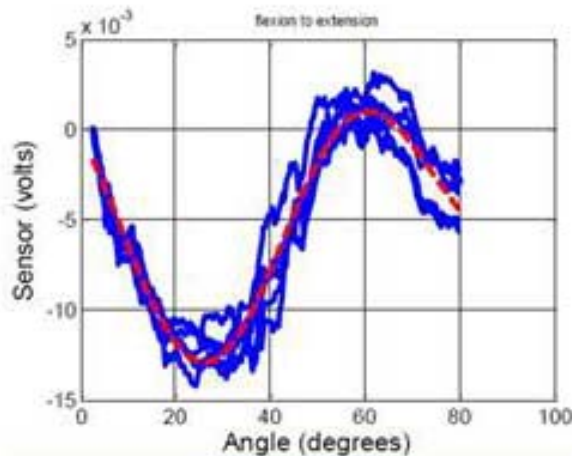


Figure 1. Typical output of ISC signal during knee extension. Data displayed is for subject 2 (30 degrees/second trial). Solid blue lines represent raw data from repeated knee extensions. Dotted red line represents derived model.

K645 PSI: An Open Platform Primary

Author: M. Hafez

Institution: October 6 University

INTRODUCTION: Total knee arthroplasty is the standard treatment for advanced knee osteoarthritis. Patient-specific instrument (PSI) has been reported on using different techniques produced by implant companies. The implant manufacturers produce PSI exclusively for their knee implants and for easy straightforward cases. PSI has become very expensive and unusable as a universal or an open platform; planning the implant is done by technicians and not by surgeons and needs long waiting time before surgery (6 weeks).

METHODS: We proposed a new technique for preparing a knee joint in TKA surgery of any knee implant. It is patient specific, based on a method comprised of image-based 3D preoperative planning (CT, MRI or computed X-ray) to design the templates that are used to perform

the knee surgery by converting them to physical templates using computer-aided or additive-manufacturing technologies. It is used for preparing a knee joint in a universal and open-platform fashion for any knee implant.

RESULTS: All patient-specific implants and any knee implant could be produced. The technique was applied on NExGen implant (Zimmer) on 21 patients, PFC implant (Depuy, J & J) on 5 patients, Scorpio NRG implant (Stryker) on 24 patients and SLK Evo implant (Implant International) on 81 patients. The >15 degrees varus gave a mean of 10.44 degrees in 56.67% of cases and the 20 gave a mean of 31.87 degrees in 24.7% of cases.

DISCUSSION: The system is based on CT images, generic data of implant sizes, average bone geometry and standard TKA parameters for bone cutting, mechanical axis and rotation (e.g., zero-degree coronal cut, adjustable posterior slope, femoral flexion, epicondylar axis, no notching or overhang, etc.). The method of planning and completing virtual surgery of TKA includes several steps based on 3D reconstruction and segmentation of computed tomography (CT) or MRI scan data. The technology is suitable for any currently available knee implant. It is used for all on-shelf implants and all patient-specific instruments.

The device is specifically designed for TKA and the planning is based on the 3D files of a universal TKA prosthesis. There are four standard sizes of the universal TKA prosthesis which were built depending on the average bone geometry. These 4 sizes are 55, 60, 65 and 70 mm. These sizes are consistent with the most common implants available: NexGen Zimmer, PFC Depuy, Sigma Knee, Triathlon Stryker, Vanguard Biomet, and Smith & Nephew Proflex. However, for extreme cases, one size above or below the maximum and minimum range is used. The device has 2 parts: a femoral part and a tibial part, both of which are independent of any commercially available knee implant.

K646 Occurrence of Osteochondritis Dissecans After Surgery is Different for Resection Pattern with Complete Discoid Lateral Meniscus in Juvenile Knees

Primary Author: Yusuke Hashimoto

Institution: Department of Orthopedic Surgery, Osaka City University, Graduate School of Medicine

Coauthors: Junsei Takigami (Department of Orthopedic Surgery, Osaka City University, Graduate School of Medicine), Shinya Yamazaki (Department of Orthopedic Surgery, Osaka City University, Graduate School of Medicine), Shozaburo Terai (Department of Orthopedic Surgery, Osaka City University, Graduate School of Medicine)

OBJECTIVE: The discoid lateral meniscus (DLM) is the common abnormality of the meniscus. The traditional treatment for a symptomatic DLM is total meniscectomy using open technique, which lead to early degenerative change and Osteoarthritis. Therefore, meniscus-preserving procedures such as partial meniscectomy are preferred in children with DLM. Nevertheless, some menisci require subtotal resection because of the tear pattern. Recently, the management of the symptomatic discoid is changed to preservation the meniscus with saucerization methods. The strategy of the symptomatic discoid was saucerization for the stable meniscus and saucerization and repair for unstable meniscus with peripheral instability during the surgical treatment. On the other hand, only case series were previously reported Osteochondritis Dissecans following total resection of the DLM. The purpose of this study is to compare the occurrence rate of OCD after meniscus resection according to four methods (subtotal, partial meniscectomy, saucerization, saucerization and repair).

METHODS: Between 2000 and 2013, 89 arthroscopic surgeries were performed for CDLM in juvenile knees under 15years. 28 of 89 cases have been followed up for more than 2 years. Average age at operation was 11.5 years (range, 6 to 15 years) and average followed up periods was 3.0 years (range, 2 to 6years). 12 cases were undergone subtotal meniscectomy within 3mm because of their peripheral instability. Four cases were partial meniscectomy with 3~5 mm of the peripheral meniscus remaining. Seven cases were saucerization with 6~8 mm remaining and nine cases were saucerization and repair with 6~8 mm remaining of peripheral instability meniscus. Plain X-ray was examined at final follow up period and determined with or without OCD of lateral condyle of the operated knee.

RESULTS: Overall occurrence rate of OCD was 18.8%. The occurrence rate of OCD with subtotal meniscectomy, partial meniscectomy, saucerization and saucerization and repair was 41.6% (5 of 12), 0% (0 of 4), 0% (0 of 7) and 11% (1 of 9), respectively. Average age at operation with OCD knees was 9.0years, while that without OCD was 12.1 years. The average duration from operation to occur-

rence of OCD was 3.0 years. No knee in the time at the operation over 12years occurred OCD.

CONCLUSION: The occurrence rate of OCD with subtotal meniscectomy was higher than the others methods. This suggested that meniscus-preserving procedures are necessary for preventing the OCD occurrence. Furthermore, Average age at operation with OCD knees was younger than that without OCD knees. According to this study, meniscus-preserving procedure should be treated especially under 10years and follow up should be done at least three years.

K647

PS-TKA Showed Larger Correlations of Laxity Between Pre and Post Surgery than CR-TKA at Flexion Range

Primary Author: Kazunori Hino

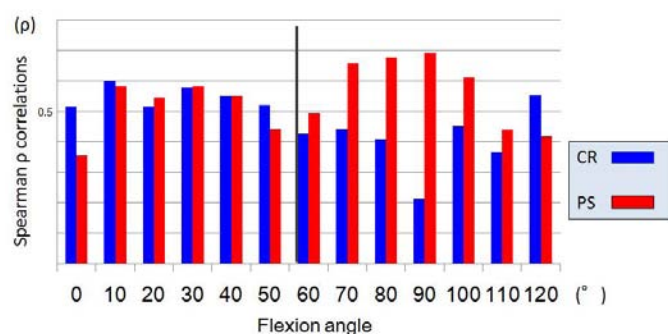
Institution: Ehime University Graduate School of Medicine

Coauthors: Hiromasa Miura, Yoshio Onishi, Masami Ishimaru

Functional joint stability and accurate component alignment are crucial for a successful clinical outcome after TKA. However, there are few methods to evaluate joint stability during TKA surgery. Activities of daily living often cause mechanical load to the knee joint not only in full extension but also in mid-flexion. Computer navigation systems are useful for intra-operative monitoring of joint positioning and movements. Previously, we reported that PS-TKA had greater varus-valgus laxity than CR-TKA, and the differences were statistically significant for the flexion range of 10 to 30 degrees. (JBJS-Br April 2013) The purpose of this study was to evaluate the correlations of varus-valgus laxity between the pre-TKA and post-TKA surgery.

34 knees that underwent TKA with computer navigation technology (precision Knee Navigation Software version 4.0, Stryker, Kalamazoo, MI) were evaluated (CR:17; PS:17 CR and PS were implanted in alternating sequence). The investigator gently applied physiologically allowable maximal manual varus-valgus stress to the knee without angular acceleration, while moving the leg from full extension to flexion, and the mechanical femoral-tibial angle

was measured automatically by the navigation system at every 10 degrees throughout the ROM. The results of the navigated measurements were used to evaluate varus-valgus laxity throughout the ROM and the differences in varus-valgus laxity between pre-TKA (Prior to bone cutting, after navigation registration and suturing of the joint capsule) and post-TKA (After confirming that the TKA components and inserts were firmly placed in an appropriate position, the surgical incision was completely closed). The correlations of varus-valgus laxity between the pre and post-TKA were evaluated using Spearman.



K648

In Vivo Kinematics of the Mobile-bearing Rotating Platform Cruciate-Retaining Total Knee Arthroplasty

Primary Author: Keiji Iwamoto

Institution: Department of Orthopedic Surgery, National Hospital Organization Osaka National Hospital

Coauthors: Tetsuya Tomita (1. Department of Orthopaedic Biomaterial Science, Osaka University Graduate School of Medicine), Takaharu Yamazaki (4. The Center for Advanced Medical Engineering and Informatics, Osaka University), Yuuichirou Kii (1. Department of Orthopaedic Biomaterial Science, Osaka University)

INTRODUCTION: Posterior cruciate ligament (PCL) preservation in total knee arthroplasty (TKA) is advocated on the grounds that it provides better restoration of knee joint kinematics as opposed to PCL sacrifice. Mobile-bearing (MB) total knee prostheses have been in the market for a long time, but the PFC-Sigma Rotating Platform (RP) prosthesis (DePuy, Leeds, United Kingdom) has been introduced in the market since 2000. Since, little is known about the in vivo kinematics of MB prostheses especially

with cruciate-retaining (CR). And the in vivo kinematics of MB RP-CR during deep knee bending under weight-bearing conditions has not been clarified. The objective of this study is to investigate the in vivo kinematics of MB RP-CR total knee arthroplasty during weight-bearing deep knee bending motion.

PATIENTS AND METHODS: We investigated the in vivo knee kinematics of 20 knees (16 patients) implanted with PFC-Sigma RP-CR. All TKAs were judged clinically successful (Hospital for Special Surgery scores >90), with no ligamentous laxity or pain. Mean patient age at the time of operation was 78.0 ± 6.0 years. Mean period between operation and surveillance was 15.0 ± 9.0 months. Under fluoroscopic surveillance, each patient did a weight-bearing deep knee bending motion. Femorotibial motion was analyzed using 2D/3D registration technique, which uses computer-assisted design (CAD) models to reproduce the spatial position of the femoral, tibial components from single-view fluoroscopic images. We evaluated the range of motion, axial rotation, and antero-posterior (AP) translation of the nearest point between the femoral and tibial component.

RESULTS: Between the femoral and tibial components, the mean minimum flexion angle was on average $2.1 \pm 5.5^\circ$. The mean maximum flexion angle was $118.0 \pm 9.9^\circ$. The average range of motion was $115.8 \pm 12.8^\circ$. The femoral component relative to the tibial component demonstrated $4.4 \pm 4.1^\circ$ external rotation for 0-120 degrees flexion. From the results of bilateral contact positions at each flexion angle, patterns of kinematic pathways were determined. The kinematic pathway pattern was externally rotated due to a central pivot pattern from extension to 90° knee flexion. Subsequently from 90° to 120° , bilateral condyles moved backward.

DISCUSSION AND CONCLUSION: In this study, we have evaluated the in vivo kinematics of MB prostheses with cruciate-retaining motion during deep knee bending motion under weight-bearing condition. The results in this study demonstrated that the kinematic pathway pattern was externally rotated due to a central pivot pattern from extension to 90° knee flexion. Subsequently from 90° to 120° , bilateral condyles moved backward. This indicated that PCL might be functioning.

K649**Three Dimensional Construct Fabrication and Mechanical Pressure Culture Enhance***Primary Author: Rihito Iwasaki**Institution: Saga University**Coauthors: Toshiyuki Oshima (Saga University), Miho Kawakatsu (Saga University), Mai Tanaka (Saga University), Koichi Nakayama (Saga University)*

PURPOSE: The meniscus is important for knee joint stabilization, and shock absorbent. Reconstruction of meniscal function is highly demanded especially for sports players. We developed a Bio-3D printing system, which is able to fabricate three dimensional cell only construct. In our laboratory, we established this printing system for scaffold free meniscus-like construct, which is made from spheroids (cell aggregates). And we are developing a method to regenerate meniscal function by the living cell only meniscus-like construct for highly damaged meniscus. Although our printer is able to fabricate any desired shape, the cell only construct's mechanical property is still more fragile than native meniscus. So, to enhance the mechanical strength of the cell only meniscus-like construct, we attempted to apply mechanical stress culture to the construct.

METHODS: We made two types of mechanical stimulators, which were provided by the static hydro pressure or the motor driven compression and tension. The mechanical stimulator with static hydro pressure was composed of a 50-mL syringe and a program controlled pump. The cell constructs were set in the syringe and filled with culture medium. They were pressed for 3 hours per day to push the plunger and kept to incubate for 7 days.

The actual force, which applied to cell constructs, was calculated from Torricelli theorem. Other stimulator with the motor driven compression and tension included a pressured stage, pressing machine and a weight-measuring instrument. Cell constructions were set on stage and pressed directly with pressing machine. The force for cell construct was calculated by a formula of pressure. For evaluations of stiffness and durability, a prototype was made that a mechanical stimulator combined with a pressure sensor. They were optimized for measurement stiff and durable.

RESULTS & CONCLUSIONS: The mechanical stimulator with static hydro pressure was able to generate about

10 kPa. The expression of collagen in meniscus-like constructs was detected more, when they was stimulated by static hydro pressure. We suggested that mechanical stimulus promoted to production of collagen. And these constructs did not lose meniscus-like shape in spite of the applying with compression and tension. Consequently, it is thought the mechanical stimulation become a clue of the enhancing of strength. Future, when the mechanical stimulation device is improved, it will be possible to create cell constructs that can implant in animals.

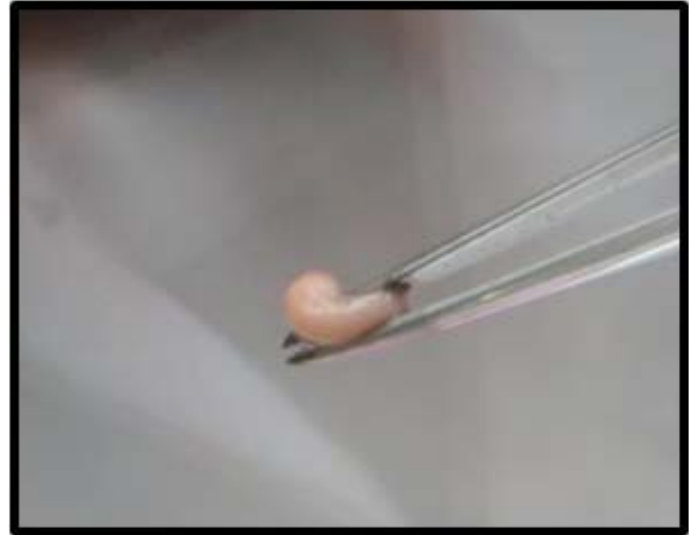


Figure 1. The cell construct picked with tweezers.

K650**Accuracy of Cup Positioning, COR Restoration and Achieving Desired Hip Length and Offset Following Robotic THA***Primary Author: Seth A. Jerabek**Institution: Hospital for Special Surgery**Coauthors: Kaitlin M. Carroll (Hospital for Special Surgery), Joseph D. Maratt (Hospital for Special Surgery), David J. Mayman (Hospital for Special Surgery), Douglas E. Padgett (Hospital for Special Surgery)*

INTRODUCTION: In total hip arthroplasty (THA), poor acetabular cup position can lead to instability, impingement, accelerated wear, and suboptimal hip mechanics. Similarly, leg length discrepancy after THA can contribute to poor hip function and patient dissatisfaction. Robotic THA has the potential to accurately place the cup, restore the center of rotation, and achieve the planned post-oper-

ative hip length and offset. This study aims to determine the accuracy of the cup inclination, cup version, hip length and offset.

METHODS: Five surgeons performed THAs on 21 cadaveric hips using press-fit implant systems using one of three approaches (posterolateral, anterolateral, or direct anterior). A pre-operative CT of each hip was taken with 1mm slices of the full pelvis and proximal femur and 5mm slices through the knee. Through pre-op planning CT views (Figure X) and the use of CAD models of the implants, the surgeon then planned the cup and stem with options for stem type (standard or high-offset), head diameter, head length, and liner type (neutral or offset). At final reduction, the MAKO hip software displayed the final cup position, hip length and offset changes relative to both the pre-operative hip and contralateral hip. Following each procedure, implants were left in the specimen and each hip was CT-scanned following the same protocol as pre-op scan. Post-operative CT scans were segmented into 3D models of the operative side pelvis, operative femur, contralateral femur, stem, and cup. Post-operatively, the post-op parameters were then compared with corresponding intra-operatively displayed and/or pre-operative planned values to determine the accuracy of the MAKO system. Absolute errors were calculated for each parameter.

RESULTS: Twenty-one robotic cadaver THAs were analyzed for cup position, hip length, and offset. Cup Position vs. Planned M/L: $1.4 \pm 1.1\text{mm}$; A/P: $1.3 \pm 1.1\text{mm}$; S/I: $1.4 \pm 1.2\text{mm}$. Cup Orientation vs. Intra-op Plane Inclination: $2.7 \pm 2.2^\circ$ and Version: $2.2 \pm 1.4^\circ$. Reduction Results: Hip Length: $1.6 \pm 1.2\text{mm}$. Combined Offset: $1.3 \pm 0.8\text{mm}$.

CONCLUSION: Robotic THA provides excellent accuracy and precision with regard to planned cup position, hip length, and offset.

K651

Can Ultrasound-Guided Nerve Block be a Useful Anesthesia Method for Arthroscopic Knee Surgery?

Primary Author: Yong Bum Joo

Institution: Chungnam National University Hospital

Coauthors: Young Mo Kim (Chungnam National University, School of Medicine), Kyu Woong Yeon (Chungnam National University Hospital)

PURPOSE: The purpose of this study was to compare general anesthesia, spinal anesthesia, and ultrasound-guided nerve block for knee arthroscopic surgery. The authors also evaluated the patient satisfaction rate up to 6 months after knee arthroscopy under ultrasound-guided nerve block and investigated whether ultrasound-guided nerve block is a useful anesthesia method for arthroscopic knee surgery.

METHODS: In this prospective, randomized study, 400 patients who underwent knee arthroscopy surgery from February 2011 to September 2012 were allocated to one of three groups: spinal anesthesia (100 patients), or general anesthesia (100 patients), ultrasound-guided nerve block (200 patients). All patients completed a questionnaire with 5 questions 6 months after surgery and all of their medical records were reviewed. For the group of ultrasound-guided nerve block, procedure duration, interval between the time for the procedure and onset of the anesthetic effect, the point of loss of the anesthetic effect, intraoperative, postoperative visual analog scale (VAS) pain score, discomfort during surgery, and perioperative vital signs were assessed. Also differences of intraoperative VAS pain score among the groups were evaluated according to age, gender, and disease.

RESULTS: There was no significant difference in the duration of surgery between the groups, and none of the cases changed to the other anesthetic method during operation. VAS pain score of postoperative 1hour showed significant difference between group of regional nerve block group, spinal anesthesia and general anesthesia ($P < 0.05$). And VAS pain score of postoperative 6hr, 12hr showed significant difference between group of regional nerve block group and spinal anesthesia, general anesthesia. One hundred ninety regional nerve block (95%), 68 spinal anesthesia (68%), and 75 general anesthesia patients (75%) stated that they would prefer same type of anesthesia if they were to have knee surgery again, showing significant difference ($P < 0.05$). One hundred fifty regional nerve block patients (75%), 78 spinal anesthesia patients (78%), and 65 general anesthesia patients (65%) considered themselves completely recovered from the arthroscopy, a nonsignificant difference ($P = 0.43$). There were no long term complications after procedure in all patients.

CONCLUSION: From this study, the authors conclude that the ultrasound-guided nerve block for arthroscopic knee surgery was highly satisfactory and safe procedure.

K652**Short term Results of Arthroscopic Subtotal Meniscectomy***Primary Author: Yong Bum Joo**Institution: Chungnam National University Hospital**Coauthors: Young Mo. Kim (Chungnam National University, school of medicine), Kyu Woong Yeon (Chungnam National University Hospital)*

INTRODUCTION: Meniscus repair, meniscectomy, non-surgical treatment can be done for management of root ligament tear of medial meniscus. Authors studied about the short term follow up result of patients who were diagnosed as root ligament tear of medial meniscus and underwent subtotal meniscectomy.

MATERIALS AND METHODS: The study included 54 knees of 52 patients who were able to follow up at least 2 years after arthroscopic subtotal meniscectomy. The numbers of cases of right knee, left knee, and both knees were 19, 33, and 2, respectively. The average age of patient was 57.6(31-70), and average follow up period was 36.2 months(24-84 months). Radiologic studies of X-ray(Kellgren-Lawrence(K-L) grade, degree of genu varum, medial joint line interval), clinical results(Lysholm, International Knee Documentation Committee(IKDC) Score) of period of preoperative and last follow up, post-operative improvement of pain, and satisfaction of patients were analyzed.

RESULTS: There were improvement of pain in 40cases(74%), and the satisfaction of patient were very good in 6, good in 19, fair in 18, and poor in 10 cases. In clinical results, average IKDC score was improved from 37.59 to 70.71($P<0.05$) and average Lysholm score was improved from 52.80 to 85.86($P<0.05$). In radiologic study, K-L grade and degree of genu varum were not increased significantly, but medial joint line interval was decreased significantly from 4.43mm to 3.96mm($P<0.05$).

CONCLUSION: Patients who underwent arthroscopic subtotal meniscectomy showed improvement in clinical results, though it showed progression of degenerative change in the radiologic study, which needs additional long term follow up study.

K653**Outcomes Following Use of Antibiotic-Eluting, Absorbable, Calcium Sulphate Beads in Revision Hip and Knee Surgery for Periprosthetic Infection***Primary Author: Rami F. Kallala**Institution: University College Hospital London**Coauthor: Fares S. Haddad (UCLH)*

Periprosthetic joint infection is a devastating diagnosis. Treatment often combines intravenous antibiotics and staged revision surgery with locally-delivered antibiotics via cement spacers. Antibiotic-eluting, absorbable Calcium Sulphate(CaSO_4) beads have had promising results in revision joint surgery and later removal is unnecessary. We report initial findings following use at a UK tertiary referral centre.

CaSO_4 beads containing 1 gram of Vancomycin and 240mg of tobramycin per 10 cc was implanted in 12 patients between August 2012 and December 2012, all having undergone revision joint surgery for PJI. Patient Demographics, ASA, indication, operation type, clinical outcomes, inflammatory markers at last follow up, isolated pathogens, length of follow up and complications were collected from clinical notes and pathology results and descriptive statistical methods used to analyse data.

In our cohort 7 patients were male and 5 female, mean age was 57 years (range 39-72) with a mean ASA grade of 2 (1-4). Indications were infected Total Hip Replacement ($n=7$), infected Total Knee Replacement ($n=4$) and infected metal on metal hip resurfacing ($n=1$). Three procedures were emergencies, with the remainder being semi-elective procedures. One patient had single-stage revision THR. At latest follow up 10 patients had made a full recovery, with normal function and inflammatory markers. Two patients were awaiting a second stage revision procedure. Mean follow up was 4 months (1-5).

Calcium sulphate beads are a new therapeutic agent for use in periprosthetic infection, with superior drug eluting properties and total absorption radiographically within two to three weeks. We report encouraging data supporting its future role in revision surgery.

K654 Weight-bearing Pressure and Pain Outcomes are Better After an Ertl Amputation vs. A Traditional Amputation

Primary Author: Kreigh A. Kamman

Institution: Indiana University School of Medicine

Coauthors: Tony Feher, MD (Department of Orthopaedic Surgery, Indiana University School of Medicine), James Pastrnak (Indiana University School of Medicine), Christina Romer (Indiana University School of Medicine), Valda Frizzell (Department of Orthopaedic Surgery, Indiana University School of Medicine)

INTRODUCTION: In the past decade, high energy or blast injuries have contributed to the dramatic increase in the number of amputations performed on military personnel. Unfortunately, there is significant functional loss and morbidity associated with lower extremity amputations, especially at the transfemoral level. In an effort to improve patient functionality and mitigate potential long-term complications, we are evaluating alternative surgical options. Contrary to standard technique, the Ertl procedure is a reconstructive technique that theoretically re-establishes intramedullary pressure, improves residual limb vascularity, restores length-tension muscle relationships, limits painful gait mechanics, and improves end-bearing capabilities. However, there is currently a lack of conclusive clinical data as to whether these benefits are realized.

METHODS: Our study enrolled 32 patients receiving a standard or Ertl, primary or revision, amputation at either the transfemoral or transtibial level. These patients completed the Short Musculoskeletal Function Assessment Injury and Arthritis Survey (SMFA) and Visual Analogue Scale (VAS) assessments to quantify their function/bothersome status and their pain status, respectively. The patients' weight-bearing pressures over their residual limb, as well as the surface area of distal residual limb, were measured with the Xsensor® pressure mapping system, recorded in three trials, and subsequently analyzed using a two-sample t-test.

RESULTS: At both transfemoral and transtibial levels, patients receiving the Ertl procedure could significantly bear more average pressure over their residual limb while experiencing significantly less pain [Fig. 1], as compared to those receiving the standard procedure. The Ertl procedure

yielded larger residual limb surface areas [Fig. 2], as well as trends for better bothersome and function SMFA scores, than the standard procedure. In one case study involving a 19-year old male who had previously suffered from a traumatic motor vehicle accident, an Ertl amputation revision at the transfemoral level resulted in a 51% increase in weight-bearing pressure, 78% reduction in pain, 57% improvement in function status, and 87% reduction in bothersome status.

DISCUSSION: The Ertl amputation procedure appears to allow patients to bear more weight comfortably on their residual limb. The increased surface area of the distal limb in the Ertl amputees tended to be larger than that of the standard amputation, which may facilitate patients' weight-bearing capacity. Indeed, our results suggest that the Ertl procedure may yield a 50% improvement in weight-bearing pressures of the amputated leg and a 55% reduction in VAS pain scores, as compared to the standard procedure. There were also trends for better functional outcomes and lower bothersome status. Thus, patients receiving an Ertl amputation appear to better tolerate weight bearing on their residual limb, which in turn may facilitate prosthetic use, perceived comfort, increased functionality, and a more reliable return to a pre-amputation level of activity.

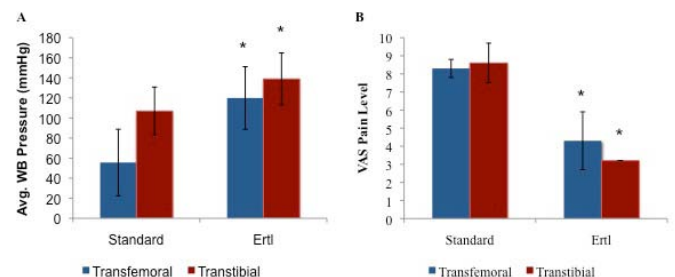


Figure 1. Weight-bearing (WB) capacity in transfemoral (blue) or transtibial (red) amputees receiving either the standard or Ertl procedure. (A) Patients receiving the Ertl procedure could significantly bear more average pressure over their residual limb, as compared to those receiving the standard procedure, at both transfemoral and transtibial levels ($p=0.03$ and $p=0.02$, respectively). (B) The Ertl procedure results in significantly lower VAS pain scores than the standard procedure at both transfemoral and transtibial levels ($p=0.02$ and $p<0.01$, respectively).

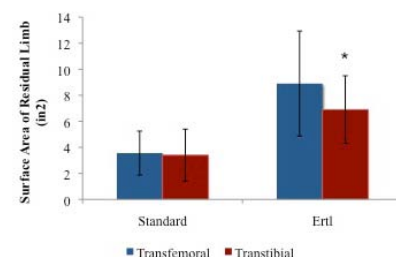


Figure 2. Compared to the standard procedure, the Ertl procedure results in larger distal surface areas of the residual limb, which is significant at the transtibial level ($p=0.01$).

K655 Efficiency of “Complete Compass®” System for Identifying the Femoral Head Center in Total Knee Arthroplasty

Primary Author: Koichi Kanekasu

Institution: Saiseikai Takaoka Hospital

Coauthor: Hiroshi Hisakado (Saiseikai Takaoka Hospital)

INTRODUCTION: Alignment and positioning of implants is important in total knee arthroplasty (TKA). However, it was thought that it was difficult to identify the femoral head center (FHC) without fluoroscope or computer navigation. “Complete Compass® (CoCo)” system is one of the femoral extramedullary guide system which is designed to identify the FHC by itself (Fig.1). This apparatus represent accurate femoral functional axis in coronal plane without computer navigation system. We compared the postoperative implant alignment of patients undergoing total knee arthroplasty with intraoperative computer navigation.

MATERIALS AND METHODS: Twenty-five consecutive TKA using CoCo were analyzed.

CoCo have a pivotal arm having a pivotal shaft arranged to extend in a direction perpendicular to the coronal plane. A marker attached to the pivotal arm for depicting a circular arc on the marking plate according to rotation of the pivotal arm. The pivotal shaft is placed at the intercondylar notch of the femur. A distance from the pivotal shaft to the marker is equal to a distance from the intercondylar notch of the femur to the FHC of the patient by preoperative measurement in coronal plane.

This apparatus has a level and the condition of the pivotal shaft is able to match as neutral position in sagittal plane and axial plane. The intersection part of two arcs that draw as the hip joint in abduction and adduction indicates the FHC position (Fig.2).

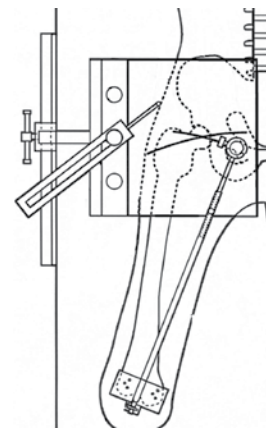
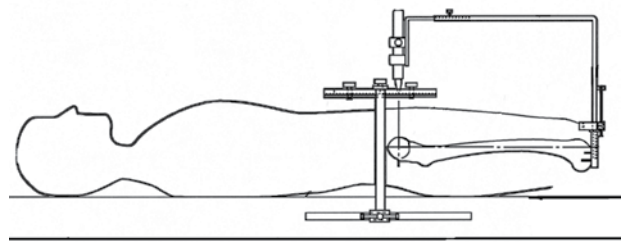
Postoperative coronal and sagittal views radiographs were obtained.

Twenty-five TKAs implanted using computer navigation were analyzed for postoperative alignment. For two groups, targeted implant position was 90 degrees in both planes for the femoral functional axis.

RESULTS: In CoCo group, mean absolute difference between planned and actual femoral placement was 0.5° (SD 0.7) in the coronal plane and 2.8° (SD 1.3) in the sagittal plane.

For the computer navigation group, difference from ideal placement for the femur was 0.6° (SD 0.7) in the coronal plane and 2.2° (SD 1.4) in the sagittal plane.

CONCLUSION: In this study CoCo group achieved accurate alignment and implant positioning without computer navigation system, and results were equal to computer navigation total knee arthroplasty. CoCo is a simple apparatus, and has the possibility to take the place of the computer navigation system of expensive cost.



K656 Posterior Soft Tissue Management for a Small Medial Extension Gap in Total Knee Arthroplasty

Primary Author: Ryutaku Kaneyama

Institution: Funabashi Orthopedic Hospital

Coauthors: Hideaki Shiratsuchi (Funabashi Orthopedic Hospital), Kazuhiro Oinuma (Funabashi Orthopedic Hospital), Hidetaka Higashi (Funabashi Orthopedic Hospital), Yoko Miura (Funabashi Orthopedic Hospital), Tatsuya Tamaki (Funabashi Orthopedic Hospital)

INTRODUCTION: In total knee arthroplasty (TKA), a small medial extension gap (EG) needs posterior soft tissue (usually, the capsule or the semimembranosus) release to avoid undesirable additional resection of the distal femur. However, the effect of these procedures on the EG is not always sufficient because the EG is influenced not only by the posterior soft tissue but also by the medial collateral ligament (MCL). We hypothesize that contracture of the posterior capsule prevents full elongation of the MCL in extension and we investigated the efficacy of posteromedial vertical capsulotomy (PMVC) on the medial EG which separate MCL from the posterior capsule (Fig. 1).

MATERIALS AND METHODS: The PMVC was performed on 76 knees in which the medial extension gap was considered too small. The EG was initially created with a standard femoral distal cut and tibial cut. To estimate the gaps more precisely before flexion gap (FG) adjustment at the final step of the surgery, we performed a 4 mm precut of the posterior femoral condyle and measured the gaps with the patella reduced after setting a precut trial component that had a usual distal part and 4 mm thick posterior part of the femoral component. This situation was the same as after setting the usual femoral trial component by using the measured resection technique with preservation of the posterior cruciate ligament (PCL) (Fig. 2). The semimembranosus tendon was not released in any cases.

RESULTS: After the precut trial was set to the femur, the average EG and FG were 5.7 ± 2.0 mm and 10.0 ± 2.1 mm, respectively (mean \pm SD). After performing the PMVC, the average increase of the EG and FG were 2.2 ± 1.4 mm and 0.1 ± 0.3 mm, respectively. The EG increase was significantly larger than the FG increase ($p < 0.001$). Seventeen knees showed a 1 mm or less increase in the EG; however, 59 (78 %) patients had a 2 mm or greater increase in the EG with little increase in the FG. Patients with a greater gap difference (i.e., $FG - EG = 7$ mm) had a significantly larger increase in the EG than the other patients ($p < 0.001$).

CONCLUSIONS: To make adequate EG and FG, it is important to understand which soft tissue management is effective to increase the FG or the EG. To increase the FG only, PCL resection is useful. However, the effective methodology of widening the EG without changing the FG is unknown. The EG of the varus knee is influenced by several factors such as tightness of the MCL, the posterior capsule, the semimembranosus tendon and protrusion of the

posterior femoral component. In this study, a precut trial component was used to take into account the effect of posterior protrusion of the femoral component and the semimembranosus tendon was not released and we achieve a constant increase in the EG without changing the FG by the PMVC which allows the MCL and the posterior capsule to act freely from each other.

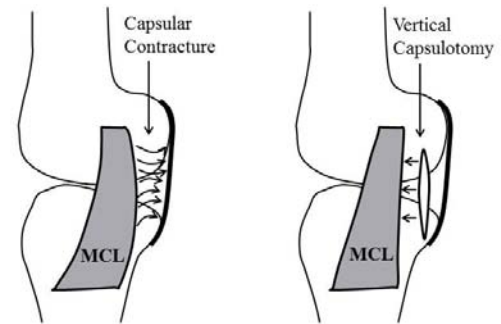


Fig 1

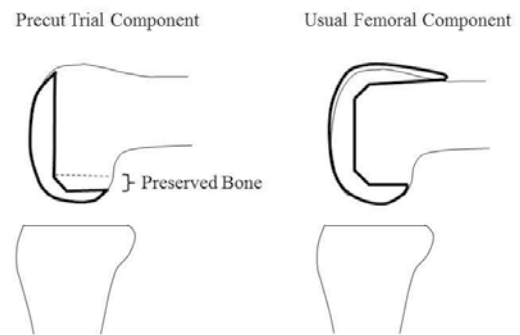


Fig 2

K657

A Comparison of Mobile-Bearing versus Fixed-Bearing Total Knee Arthroplasty

Primary Author: Seyyed Morteza Kazemi

Institution: Akhtar Hospital, Shahid Beheshti University of Medical Science

Coauthors: Reza Minaei (Akhtar Hospital, Shahid Beheshti University of Medical Science), Mohammad Ali Okhovatpoor Minaei (Akhtar Hospital, Shahid Beheshti University of Medical Science), Farshad Safdari Minaei (Akhtar Hospital, Shahid Beheshti University of Medical Science)

INTRODUCTION: Knee prosthesis can be classified into 2 groups including fixed-bearing (FBP) and mobile bearing prostheses (MBP) each with its advantages and disad-

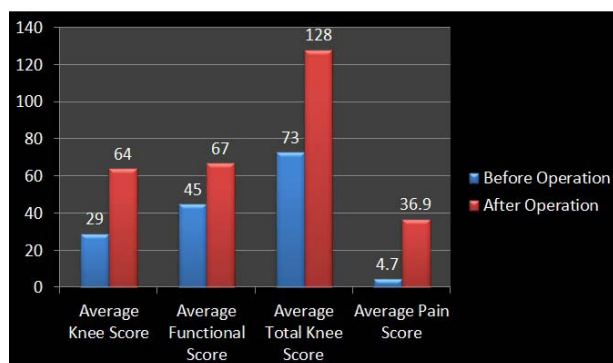
vantages. However, it is controversial which one of these types is more appropriate and associated with better clinical and functional outcomes. In current prospective study, we compared the outcomes of TKA using these two types of knee prosthesis.

MATERIALS AND METHODS: Between 2006 and 2008, there were 68 knees (50 patients) underwent TKA using MBP (30 knees) and FBP (38 knees). Two groups were matched in term of age, sex and BMI. The surgical setting and surgeon were the same. All procedures were performed through the midline incision, PCL was sustained and cement was used. Before the operation and in final visit, Patients were examined and Knee Society Scoring System (KSS) was completed. The patients were followed at least for one year.

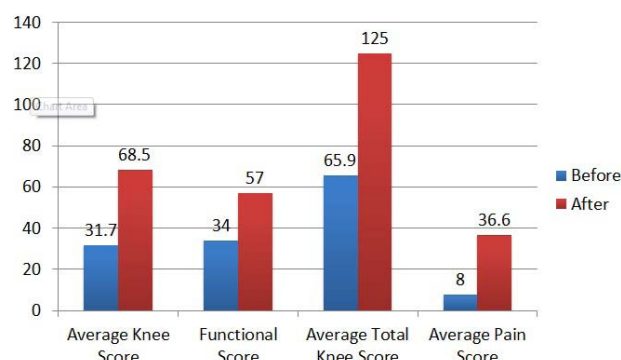
RESULTS: After the operation the average function, knee, total and pain scores improved significantly in both groups (figure 1 and 2). However, there was no statistically significant difference between two groups in any of the above-mentioned scores. $P < 0.05$ considered significant.

CONCLUSION: Based on our findings, two prostheses are associated with satisfying functional outcomes and patients experienced significantly less pain after the operation. Therefore surgeons are advised to choice the appropriate prosthesis based on other advantages and disadvantages of mobile and fixed bearing knees.

Comparison Of Scores (KSS) Before and after the operation in Mobile-Bearing Group



Comparison Of Scores (KSS) Before and after the operation in Fixed –Bearing Group



K658 Prospective Analysis of Early and Late Readmissions After Cruciate-Retaining Primary TKA and Associated Factors

Primary Author: Mark A. Kester

Institution: Stryker Orthopaedics

Coauthors: Michael A. Mont (Sinai Hospital), Kimona Issa (Sinai Hospital), Jeffrey J. Cherian (Sinai Hospital), Kristin L. Robinson (Stryker Orthopaedics), Manoshi Bhowmik-Stoker (Stryker Orthopaedics)

INTRODUCTION: Total knee arthroplasty (TKA) is a reliable procedure to treat end-stage knee arthritis that is not responsive to non-operative management. However, patients considering TKA may present with a wide range of age and comorbid medical conditions that may affect the likelihood of having an unplanned hospital readmission after surgery. The purpose of this study was to report the re-admission rate after CR TKA and evaluate the potential contributing factors.

METHODS: A prospectively collected database of 412 patients who had undergone 441 primary total knee arthroplasties using the same cruciate-retaining prosthesis at 11 institutions (13 surgeons) between 2005 and 2007 was reviewed. This included 170 men and 242 women who had a mean body mass index (BMI) of 30.5 kg/m² (range, 18 to 40 kg/m²), and a mean age of 66 years (range, 39 to 80 years). We evaluated incidence of unplanned readmissions at 30, 60, and 90 days following TKA, the underlying medical or surgical causes of the readmissions, and, the potential contributing risk factors to these readmissions such as age, BMI, and comorbidities.

RESULTS: Overall, there were 15 unplanned readmissions (3.4%) in 15 patients during the first 90 days of discharge from the hospital after the index arthroplasty procedure. This included a readmission rate of 2% (n= 9 of 441) at 30-days and 3.2% (n=14 of 441) at 60-days after discharge. The readmitted patients included 6 men and 9 women who had a mean age of 64 years (range, 42 to 80 years) and a mean body mass index of 31 kg/m² (range, 23 to 38 kg/m²). Of the 15 readmission events, 9 (2%) were due to general medical related causes. An additional 6 (1.3%) readmissions were due to operative site or surgery-related which included a case of each of the following: hemarthrosis, deep venous thrombosis, pulmonary embolism, post-operative proximal femoral fracture, revision of a tibial insert due to pain, and revision of tibial insert and femoral component due to inability to achieve full extension. All readmitted patients were successfully treated and there was no incidence of mortality. There were no significant differences in the mean age (p=0.79), men to women ratio (p=1.0), or body mass index (p=0.54) between the readmitted patients and the remaining cohort of patients that were not readmitted. However, readmitted patients had a 29.8% higher incidence of cardiovascular disorders. Medical causes were the etiology of early readmissions (within 0 to 30 days) in 66.5% (n= 6 of 9) and of late readmission (within 60 to 90 days) in 0% of patients (n=0 of 1).

DISCUSSION: Unplanned hospital readmissions are expensive and an undesired outcome for the patient, the physician, and the healthcare system. The 30 and 90 days readmission rates (2% and 3.4%, respectively) of this cohort of total knee arthroplasty patients are encouraging since these rates are lower than previously reported outcomes in the literature (4 to 8% at 30 and 90days, respectively). Further prospective studies are necessary to better evaluate these findings.

K659

Lower Limb Alignment Control: Is it More Challenging in Lateral Compared to Medial Unicondylar Knee Arthroplasty?

Primary Author: Saker Khamaisy

Institution: Hospital for Special Surgery

Coauthors: Brian P. Gladnick (Hospital for Special Surgery), Denis Nam (Hospital for Special Surgery), Keith R. Reinhardt (Hospital for Special Surgery), Andrew D.

Pearle (Hospital for Special Surgery)

BACKGROUND: Limb alignment after medial and lateral unicondylar knee arthroplasty (UKA) has a significant impact on surgical outcomes. The literature lacks studies that evaluate the limb alignment after lateral UKA or compare it alignment outcomes after medial UKA, making our understanding of this issue based on medial UKA studies.

METHODS: We evaluated the results of mechanical limb alignment in 241 patients with unicompartmental knee osteoarthritis who underwent medial or lateral UKA. There were 229 medial UKAs and 37 lateral UKAs. Mechanical limb alignment was measured in standing long limb radiographs pre and post-operatively, intra-operatively it was measured using a computer assisted navigation system. Between the two cohorts, we compared the percentage of over-correction and the difference between post-operative alignment and alignment measured by the navigation system.

RESULTS: The percentage of overcorrection was significantly higher in the lateral UKA group (11%), when compared to the medial UKA group (4%), (p= 0.0001). In the medial UKA group, the mean difference between the intra-operative “virtual” alignment provided by the navigation system, and the post-operative, radiographically measured mechanical axis, was 1.33°(±1.2°). This was significantly lower than the mean 1.86° (±1.33°) difference in the lateral UKA group (p=0.019).

CONCLUSIONS: Our data demonstrated an increased risk of “overcorrection,” and greater difficulty in predicting postoperative alignment using computer navigation, when performing lateral UKAs compared to medial UKAs.

K660

Comparisons of Kinematics During Stair Motion in Single-Radius Total Knee Arthroplasty: Cruciate Retaining vs. Substituting Designs

Primary Author: Yuichiro Kii

Institution: Department of Orthopedic Biomaterial Science, Osaka University Graduate School of Medicine

Coauthors: Tetsuya Tomita (Department of Orthopedic Biomaterial Science, Osaka University Graduate School of

Medicine), Takaharu Yamazaki (*The Center for Advanced Medical Engineering and Informatics, Osaka University*), Keiji Iwamoto (*Department of Orthopedic Biomaterial Science, Osaka University*)

PURPOSE: This study investigated the kinematics of the stair ascending and descending after single-radius TKA and to compare cruciate retaining (CR) and posterior stabilizing (PS) TKA.

METHODS: We analyzed 19 knees (CR 8, PS 11) with a clinically successful single-radius TKA (Stryker Triathlon). Under fluoroscopic surveillance, each patient performed stair ascending and descending. Motion between each component was analyzed using a two- to three-dimensional registration technique, which uses computer-assisted design models to reproduce the spatial positions of the femoral and tibial components from single-view fluoroscopic images. We determined the images of the ground touch of the TKA leg on the first step and selected the following four phases: 1) at foot strike (FS) (non-weight-bearing), 2) during stance phase before crossleg motion (full weight-bearing), 3) during stance phase after crossleg motion (still weight-bearing), and 4) at foot off (FO) (non-weight-bearing). We evaluated the knee flexion angle and anteroposterior translation of the femorotibial contact point for both the medial and lateral sides of the knee.

RESULTS: During stair ascending, the mean flexion angle at foot strike was $69.2^{\circ} \pm 7.7^{\circ}$ in PS knees and $64.2 \pm 7.2^{\circ}$ in CR knees. Knees were gradually extended from foot strike to foot off. The mean flexion angle at foot off was $9.4^{\circ} \pm 3.7^{\circ}$ in PS knees and $11.0 \pm 5.2^{\circ}$ in CR knees. The medial contact point was -4.7 ± 1.9 mm at foot strike and then it moved 1.9 ± 1.9 mm anterior while shifting weight to the leg in PS knees. On the other hand, the medial contact point was 3.2 ± 2.6 mm at foot strike and then it moved 5.3 ± 2.0 mm posterior while shifting weight to the leg in CR knees. During stair descending, the mean flexion angle at foot strike was $8.0^{\circ} \pm 3.7^{\circ}$ in PS knees and $9.1 \pm 4.3^{\circ}$ in CR knees. Knees were gradually flexed from foot strike to foot off. The mean flexion angle at foot off was $35.5^{\circ} \pm 11.8^{\circ}$ in PS knees and $40.5 \pm 7.2^{\circ}$ in CR knees. The medial contact point was -4.7 ± 2.5 mm in PS and -4.2 ± 3.0 mm in CR at foot strike and -5.0 ± 1.9 mm in PS and -4.2 ± 1.5 mm in CR at stance phase before crossleg motion. The lateral contact point was -6.2 ± 2.1 mm in PS and -7.5 ± 3.0 mm in CR at foot strike and -6.4 ± 1.7 mm in PS and -7.6 ± 2.2 mm in CR at stance phase before crossleg motion. There is no significant

difference between the positions at foot strike and at stance phase before crossleg in both knees.

DISCUSSION: During stair descending, PS TKA is similar kinematic pattern with CR TKA. On the other hand, during stair ascending, PS TKA is different kinematic pattern from CR TKA due to post-cam engagement.

K661

Factors Affecting the Osteolysis around the Components after Posterior Stabilized Total Knee Replacement Arthroplast

Primary Author: Chang Wan Kim

Institution: Department of Orthopedic Surgery, Busan Paik Hospital, College of Medicine, Inje University

Coauthors: Seung Suk Seo (Department of Orthopedic Surgery, Bumin Hospital), Chang Rack Lee (Department of Orthopedic Surgery, Busan Paik Hospital, College of Medicine, Inje University)

PURPOSE: The purpose of the present study was to evaluate factors that affect the occurrence of osteolysis through clinical and radiological comparison between a patient group in which osteolysis occurred after total knee arthroplasty (TKA) and a patient group in which osteolysis did not occur after TKA.

METHODS: The present study was conducted with 486 knees that had been followed up for at least two years after undergoing a posterior stabilized (PS) TKA. The subjects were divided into a group in which osteolysis occurred and a group in which osteolysis did not occur and retrospectively compared and analyzed. Knee Society knee score and function score, preoperative and postoperative range of motion (ROM), femoral and tibial implant positions, preoperative and postoperative femorotibial angles, posterior femoral condylar offset (PCO), level of joint line, and posterior tibial slopes (PTS) were measured and clinically and radiologically compared.

RESULTS: Osteolysis occurred in 28 knee joints (5.7%). The mean Knee Society Knee score and Function score of the patient group without osteolysis were 86.4 points and 83 points respectively and these scores of the patient group with osteolysis were 64.5 points and 65.3 points ($p < 0.001$). No significant difference was observed between the patient

group without osteolysis and the patient group with osteolysis was observed in preoperative and postoperative ROM, femoral and tibial implant positions, or preoperative and postoperative femerotibial angles. The means of preoperative and postoperative differences in PCO and level of joint line were significantly larger in the patient group with osteolysis than in the patient group without osteolysis ($p=0.01$, $p=0.007$), and regression analyses showed that the means of preoperative and postoperative differences in these two variables were related with the occurrence of osteolysis. ($p=0.021$, $p=0.018$)

CONCLUSION: The present study shows that biomechanical changes occurring after TKA are related with the occurrence of osteolysis. Therefore, operators should pay great attention to restore normal anatomical structure as much as possible with careful preoperative plans, accurate surgical techniques, and selection of appropriate implants.

K662 **The Anteroposterior Axis of the Tibia in Koreans for Total Knee Arthroplasty**

Primary Author: Chang Wan Kim

Institution: Department of Orthopedic Surgery, Busan Paik Hospital, College of Medicine, Inje University

Coauthors: Seung Suk Seo (Department of Orthopedic Surgery, Bumin Hospital), Chang Rack Lee (Department of Orthopedic Surgery, Busan Paik Hospital, College of Medicine, Inje University)

The purpose of the present study was to find anatomic landmarks for rotational alignment of the tibial component in total knee arthroplasty(TKA) through Computed tomography(CT). Preoperative CT scanning was performed on 94 Koreans(males 9, females 85) with knee joint osteoarthritis(OA) who had undergone TKA. The tibial anteroposterior(AP) axis was defined as the line that is perpendicular to the femoral surgical transepicondylar axis(SEA) and passes through the center of the posterior cruciate ligament(PCL). The angles between the defined tibial AP axis and anatomic landmarks at various levels of the tibia were measured. The average value of the angles between the defined tibial AP axis and the line connecting the anterior border and the center of the PCL at the proximal 1/3 level of the tibia was $-0.2^\circ \pm 4.1^\circ$. Regardless of lower extremity alignment and the degree of tibia bowing,

the line connecting the anterior border and the center of the PCL at the proximal 1/3 level of the tibia was closest to the defined tibial AP axis. Therefore, the anterior border at the proximal 1/3 level of the tibia is considered useful as one of reliable anatomic landmarks for rotational alignment of tibial components.

K663 **Clinical Results Associated with Changes of Posterior Tibial Slope in Total Knee Arthroplasty**

Primary Author: Chang Wan Kim

Institution: Department of Orthopedic Surgery, Busan Paik Hospital, College of Medicine, Inje University

Coauthors: Seung Suk Seo (Department of Orthopedic Surgery, Bumin Hospital), Chang Rack Lee (Department of Orthopedic Surgery, Busan Paik Hospital, College of Medicine, Inje University)

PURPOSE: The purpose of this retrospective study is to investigate the effect of posterior tibial slope (PTS) on clinical results in total knee replacement arthroplasty (TKA).

MATERIALS AND METHODS: We analyzed 801 knees in 768 patients who underwent TKA using a cruciate-retaining prosthesis for osteoarthritis from July 2003 to July 2009. PTS was measured on simple X-ray films and patients were divided into 5 groups, according to the change in PTS that was calculated by subtracting the preoperative from the postoperative PTS: group 1, $>3^\circ$; group 2, 3° to 1° ; group 3, 1° to -1° ; group 4, -1° to -3° ; and group 5, $<-3^\circ$. We analyzed the correlations between the change in PTS and clinical results, such as Knee Society knee score, Knee Society functional score, Feller patella score, Kujala score, visual analog scale score, range of motion, and complications.

RESULTS: There was no statistically significant inter-group difference; however, Feller patella score and Kujala score were significantly different in groups 2 and 3. There were no complications, such as progressive loosening of implants, fractures of polyethylene inserts and wears.

CONCLUSIONS: Clinically meaningful improvement was observed in all patients after TKA. Groups 2 and 3 (3°

to -1°) showed significant improvement compared to the other groups.

K664

A Comparison of Intra-Operative Laxity and Clinical Outcomes in Single-Radius Versus Multi-Radius Femoral Design TKA

Primary Author: Ha-Sung Kim

Institution: Center for Joint Disease, Chonnam National University Hwasun Hospital

Coauthors: Eun-Kyoo Song (Center for Joint Disease, Chonnam National University Hwasun Hospital), Jong-Keun Seon (Center for Joint Disease, Chonnam National University Hwasun Hospital)

INTRODUCTION: To reproduced the accepted anatomic femoral shape, the femoral components of total knee arthroplasties(TKA) often have a J-shaped radius of curvature in which the saggital plane geometry of the femoral component has a large radius anteriorly, which gradually reduces posteriorly. During implantation, the surgeon must balance the knee by a combination of alignment and ligament tensioning to ensure stability; this is usually established at only 0° and 90° of knee flexion. However, there may sometimes be an intermediate arc of flexion where the ligaments are more slack, leading to “mid-range instability” with the multi-radius prostheses. Knee arthroplasty prostheses with a single-radius femoral component design were introduced in an attempt to more accurately reproduce the kinematics of the natural knee. This design has been associated with improved extensor mechanism function and increased functional stability in total knee arthroplasty. One of advantages of single-radius femoral design was to offer better ligament stability based on a maintained isometry of extensor muscle during the whole range of motion. The purpose of this study was to compare intra-operative varus-valgus laxities from 0° to 90° of flexion in patients that received TKA using either a single-radius femoral design or multi-radius femoral design. We also compared the short-term results between two designs.

METHODS: One hundred-fifteen patients, who were awaiting unilateral TKAs, were enrolled into this study. The 115 knees were allocated alternatively to either a single radius femoral design TKA or a multi-radius femoral design TKA group. 56 TKAs was performed by a single

radius femoral design (Scorpio NRG, SR group) and 59 TKAs was performed by a multi-radius femoral design (Zimmer NexGen, MR group), both with a minimum of 1-year follow-up. We measured and compared intra-operative varus-valgus laxities at 0° , 30° , 60° , 90° of flexion using the navigation system (Orthopilot, Aesculap, Tuttlingen, Germany) and manual force between the 2 groups. (Fig. 1.) A series of clinical outcomes were evaluated and compared at the time of the latest follow-up including HSS scores, WOMAC scores, VAS score during stair climbing.

RESULTS: The mean total varus-valgus laxities in both groups were significantly less at 0° of flexion($3.2 \pm 1.5^\circ$ in SR group and $3.5 \pm 1.8^\circ$ in MR group) than other selected flexion angle ($p=0.011$); but the difference was not significant between 2 groups ($p=0.062$). At 30° , 60° of flexion, the mean total varus-valgus laxities in SR group ($6.2 \pm 3.5^\circ$ at 30° of flexion and $6.8 \pm 1.5^\circ$ at 60° of flexion) were significant less than those in MR group ($9.2 \pm 4.3^\circ$ at 30° of flexion and $8.3 \pm 3.8^\circ$ at 60° of flexion) ($p=0.027$ and $p=0.042$, respectively). In the clinical results with a minimum of 2 year follow-up, we could not find any significant differences between two designs interms of ROM, HSS, WOMAC and VAS scores during stair climbing.

CONCLUSION: The single-radius femoral designs for TKA showed evidently less intra-operative mid-flexion stability compared with the multi-radius femoral design. However clinical outcomes revealed no other significant dissimilarity on HSS, WOMAC scores and VAS scores during stair climbing.

K665

Rotatory Dislocation of the Rotating Platform of a Posterior-Stabilized Mobile-Bearing Knee Prosthesis: A Case Report

Primary Author: Jong Pil Kim

Institution: Dongguk University Hospital

Coauthors: Phil Hyun Chung (Dongguk University Hospital), Suk Kang (Dongguk University Hospital), Young Sung Kim (Dongguk University Hospital), Ho Min Lee (Dongguk University Hospital)

Dislocation of the rotating platform is a significant early complication of mobile-bearing total knee arthroplasty. The authors report an unusual case of acute 180° rotatory

dislocation of the rotating platform after closed reduction of a posterior dislocation of a posterior-stabilized mobile-bearing total knee prosthesis. Posterior dislocation of the prosthesis occurred at 5 weeks postoperatively, and closed reduction of the posterior dislocation resulted in complete 180° rotatory dislocation of the rotating platform. The patient was treated by open exploration and polyethylene exchange for a larger component. This case illustrates that dislocation of a posterior-stabilized mobile-bearing total knee prosthesis can occur given valgus laxity and cause a 90° spin-out of the polyethylene insert, and that closed reduction attempts may contribute to complete 180° rotatory dislocation of the rotating platform. Special attention should be given to both AP and lateral views to ensure that the platform is truly reduced and not rotated by 180°.

K666 **Effects of the Amount of Proximal Tibia Resection on the Bone Strength of Prepared Bone Surface: A FEM Study**

Primary Author: Kwangkyoun Kim

Institution: Konyang University Hospital

PURPOSE: We wanted to evaluate the mechanical strength of proximal tibia as resection distance increased from the joint surface.

MATERIALS AND METHODS: We obtained the CT images of twenty knee osteoarthritis patients undergoing total knee arthroplasty. The finite element models were created based on the computed tomography images. The 8-node hexahedron element was made from BIONIX™ (CANTIBio. Co, Suwon, Korea), which is automatic mesh generation software program. The finite element model of the proximal tibia was resected at 6 mm, 8 mm, 10 mm, 12 mm, 15 mm and 18 mm from the lateral joint surface. A 1% strain rate was applied to a model by using HyperMesh™ software (Altair Engineering. Inc, Seattle, USA). The ultimate stress was calculated from the finite element analysis with using ANSYS 9.0 (ANSYS. Inc, Orlando, USA).

RESULTS: The mean ultimate stress was 906.84 MPa, 877.22 MPa, 895.93 MPa, 852.70 MPa, 742.90 MPa and 585.51 MPa at the 6 mm, 8 mm, 10 mm, 12 mm, 15 mm and 18 mm resection levels. As compare to the 6 mm resection level, the bone strengths at 15 mm and 18 mm were

decreased with statistical significance (15 mm: $p=0.005$, 18 mm: $p=0.000$).

CONCLUSION: The ultimate stress was decreased as the resection distance increased from the joint surface. But within a 12 mm resection distance from the lateral condyle articular surface of the tibia, the ultimate stress was not significantly decreased ($p>0.05$).

K667 **Pullout Failure Strength of the Posterior Root tear of the Medial Meniscus: A Biomechanical Study in Porcine Meniscus**

Primary Author: Young Mo Kim

Institution: Chungnam National University, School of Medicine

Coauthors: Yong Bum Joo (Chungnam National University Hospital), Kyu Woong Yeon (Chungnam National University Hospital)

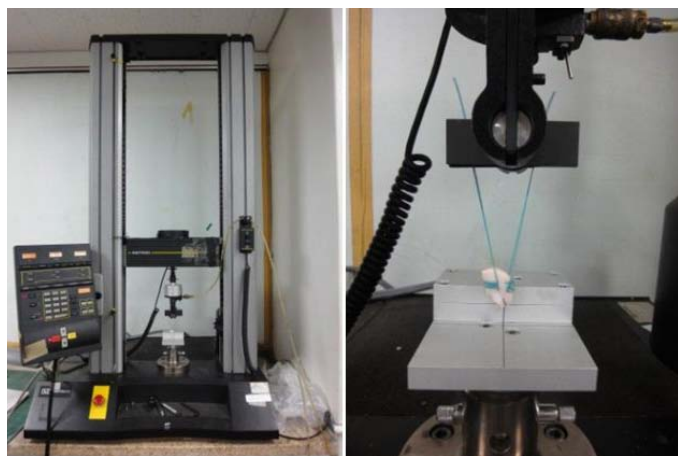
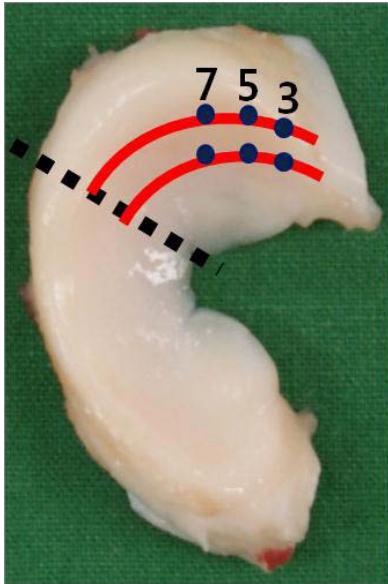
The posterior horn of the medial meniscus(PHMM) is attached to the tibia by the root ligament positioned in front of the posterior cruciate ligament, and root ligament tear of the PHMM can cause degenerative arthritis in the knee joint. This could be suggested as the theoretical background of many studies that proposed the necessity for arthroscopic repair for root ligament tear of the PHMM. The purpose of this in vitro biomechanical study was to determine the most strength point when try to repair of root tear of PHMM on the resultant pullout failure strength in a animal model.

Medial meniscus were gained from fresh porcine (Yorkshire pig) posterior left knee joints (n=60). The young adult animals were obtained from an abattoir.

The RR zone and the RW zone of the meniscus was divided by 2 lines, and those were each designated as line A and B(Fig. 1). The lines were again divided into 3 points, 3, 5, and 7 mm from the MRL root insertion and each were designated as group 1, 2, and 3, respectively. Vertical meniscal repair was done by No.2 Ethibond needle by straight needle. Realization of pullout strength was done by counter suture on the direction of vector based on root. The pull out failure strength was tested with a biaxial servohydraulic testing machine (model 8874; Instron Corp., Norwood,

MA). Specimens were tested in a random order, and the failure testing was performed at a speed of 5mm/min (fig. 2).

Conclusively, between group A and B, group A was statistically analyzed to show stronger pullout strength, and among group 3, 5, and 7mm, group 7mm was statistically analyzed to show stronger pullout strength, thus, group 7mm of group A was statistically proven to show the strongest pullout strength.



K668 Risk Factors for Medial Meniscal Root Tear

Primary Author: Young Mo Kim

Institution: ChungNam National University, School of Medicine

Coauthors: Yong -Bum Joo (ChungNam National Univer-

sity hospital), Kyu woong Yeon (ChungNam National University hospital)

INTRODUCTION: Posterior horn of the medial meniscus is attached to the tibia by ligament material and its rupture causes loss of circumferential hoop tension in epiphyseal plate leading to degenerative osteoarthritic changes. Recently, various sutures and their short term results are being reported however, reports on risk factors of this kind of ruptures are rare. We, authors, are to analyze the risks factors of patients with root ligament tear of the MM and evaluated their relative importance.

MATERIALS AND METHOD: From October 2010 to May 2013, 120 patients with root ligament tear of MM confirmed by MRI were classified as group 1, 115 patients with other tears of MM confirmed by MRI were classified as group 2. Patients' age, gender, Body Mass Index (BMI) were surveyed through medical records. Simple radiographs taken at their first clinical visit were utilized to evaluate varus deformity. Kellgren-Lawrence (KL) grade and MRI images were utilized to evaluate degenerative change of MM and medial extrusion.

RESULTS: In group 1, the mean age was 60.75 years old (42~79), M:F ratio was 14.3 : 85.7, with average BMI was 25.52.

In group 2, the mean age was 54.86 years old (40~77), M:F ratio was 45.5 : 54.5, with average BMI was 25.48.

Group 1 had mean varus angle 4.39 degrees, 10 cases of KL classification grade 4, 66 cases of grade 3, 41 cases of grade 2 and 4 cases of grade 1. There were 9 cases of grade 4 of degenerative grade of MM, 7 cases of grade 3, 41 cases of grade 2 and 62 cases of grade 1 and mean extrusion of MM was 3.59mm.

Group 2 had mean varus angle 3.46 degrees, 12 cases of KL classification grade 4, 27 cases of grade 3, 47 cases of grade 2 and 26 cases of grade 1. There were 1 cases of grade 4 of degenerative grade of MM, 12 cases of grade 3, 59 cases of grade 2 and 40 cases of grade 1 and mean extrusion of MM was 3.10mm.

Analysis showed statistical significant differences in sex, age, KL grade, MRI extrusion, MRI degeneration grade, and F-T angle (P However the gender, 1-3 KL grades were the only to show significant relative risks among ages,

gender, BMI, varus deformity, KL grade, varus deformity, MRI degeneration grade.

CONCLUSION: Comparative analysis between root ligament tear of MM and other tears of MM showed no statistically significance in age, BMI, varus deformity, MRI degeneration grade. However patients with root ligament tear of MM had significantly female sex predominance, increased KL grade(1-3) compared with persons with other types of meniscal tear.

K669

Behavior of the Ultra-Short Anatomic Cementless Femoral Stem in Young and Elderly Patients

Primary Author: Young-Hoo Kim

Institution: The Joint Replacement Center of Korea Ewha Womans University MokDong Hospital

Coauthors Jang-Won Park (The Joint Replacement Center of Korea Ewha Womans University MokDong Hospital), Jun-Shik Kim (The Joint Replacement Center of Korea Ewha Womans University MokDong Hospital)

BACKGROUND: The question arises as to whether it is possible to obtain rigid fixation of the ultra-short metaphyseal-fitting anatomic cementless stem without diaphyseal fixation in the elderly as well as younger patients.

QUESTION/PURPOSES: We investigated whether ultra-short, metaphyseal-fitting anatomic cementless femoral stem would provide similar functional improvements in the younger and elderly patients; radiographically secure implant fixation would be achieved in both groups; the bone content would be preserved in both groups; and complication rates would be similar in both groups.

METHODS: A total of 100 patients (114 hips) in the younger patient group and 100 patients (112 hips) in the elderly patient group were included in the study. Their mean age was 43.9 ± 6.11 years (range, 31 to 65 years) in the younger patient group and 78.9 ± 12.1 years (range, 66 to 91 years) in the elderly patient group. The mean duration of follow-up was 7.5 years (range, 6 to 9 years) in the younger patient group and 7.6 years (range, 6 to 9 years) in the elderly patient group.

RESULTS: The mean postoperative Harris hip scores (95 points versus 91 points), WOMAC scores (11 points versus 15 points), thigh pain (none in either group), UCLA activity scores (6.5 points versus 4.5 points), and radiographic results were not significantly different between the two groups. No hip in either group had an aseptic loosening. No hip in either group had clicking or squeaking sounds or ceramic fractures.

CONCLUSION: The cementless ultra-short, metaphyseal-fitting anatomic cementless femoral component provides stable fixation without any need of diaphyseal fixation in both younger and elderly patients. Despite the concern, the poor bone quality of bone in elderly patients did not compromise the stability and osseointegration of this ultra-short, anatomic cementless femoral stem was achieved in all elderly patients.

K670

Comparison of TKAs with Oxidized Zirconium and Cobalt-Chromium Femoral Components in the Same Patients

Primary Author: Young-Hoo Kim

Institution: The Joint Replacement Center of Korea Ewha Womans University MokDong Hospital

Coauthors: Jun-Shik Kim (The Joint Replacement Center of Korea Ewha Womans University MokDong Hospital), Jin-Woo Choe (The Joint Replacement Center of Korea Ewha Womans University MokDong Hospital), Hyoung-Jin Kim (The Joint Replacement Center of Korea Ewha Womans University MokDong Hospital)

BACKGROUND: It has been reported that there is a reduction in the polyethylene wear rates in a knee wear simulator of 42% to 89% in total knee arthroplasties (TKAs) with an oxidized zirconium (OxZr) femoral component compared with a cobalt-chromium (Co-Cr) femoral component. Although it has been claimed that TKAs with an OxZr femoral knee component had good wear properties in vitro, there are conflicting clinical results.

QUESTIONS/PURPOSES: We hypothesized that there would be no difference in the mid-term, clinical, subjective and radiographic outcomes in patients using an OxZr or Co-Cr femoral component. Furthermore, we hypothesized that there would be no difference in the weight, size

and shape of the polyethylene wear particles between the two groups.

METHODS: Three hundred thirty-one patients received an OxZr femoral component in one knee and a Co-Cr femoral component in the other. Ninety-one patients were men, and 240 were women. At the time of each follow-up (mean, 7.5 years; range, 6 to 8 years), the patients were assessed clinically and radiographically with the use of the knee-rating systems of the Knee Society. In addition, each patient completed the Western Ontario and McMaster Universities Osteoarthritis (WOMAC) questionnaire. Polyethylene wear particles were analyzed using thermogravimetric methods and scanning electron microscopy.

RESULTS: At the most recent follow-up, the mean Knee Society scores (95 points versus 94 points), WOMAC scores (22 ± 15.8 points versus 22 ± 15.8 points) and ranges of motion (126° to 127°) were similar in the two groups. Patient satisfaction scores (8.3 ± 1.7 points versus 8.2 ± 1.8 points) were also similar. The mean weight (0.0231 g versus 0.0229 g), size ($0.61 \mu\text{m}$ versus $0.59 \mu\text{m}$), aspect ratio (1.18 versus 1.21) and roundness (1.69 versus 1.64) were similar as well. Survivorship of the femoral, tibial and patellar components was 100% in both groups at 8 years after surgery.

CONCLUSIONS: The clinical, subjective and radiographic results, as well as the weight, size and shape of the polyethylene particles were similar in the TKAs performed with an OxZr or Co-Cr femoral component.

K671 Efficacy of Extramedullary Femoral Component Alignment Guide System in Total Knee Arthroplasty

Primary Author: Kazumasa Kitamoto

Institution: Aichi Medical University, School of Medicine

Coauthors: Makoto Kurisuno (Aichi Medical University, School of Medicine), Keiji Sato (Aichi Medical University, School of Medicine), Daiya Hattori (Hattori Clinic)

PURPOSE: Total knee arthroplasty (TKA) alignment is one of the most important factors in long-term prosthesis survival.

Femoral intramedullary canal referencing is used by most knee arthroplasty system, for the performing distal femoral resection. But there is a few reports of the intramedullary femoral alignment system does not always guarantee accuracy of the component position in the total knee arthroplasty. The purpose of this study was to evaluate the post-operative radiological outcomes of a new extramedullary alignment guide versus computer assisted navigation system.

METHODS: We studied the digital long-leg standing radiographs of TKA implantation in 37 patients with primary degenerative osteoarthritis who underwent an extramedullary alignment guide (EM group, n=21) or computer assisted navigation system (CAS group, n=16). The mechanical axis, femoral component coronal alignment, tibial component coronal alignment were measured and compared.

RESULTS: The postoperative mechanical axis was within 3 degree of neutral mechanical alignment in 81% of the EM group and 69% in CAS group ($p=0.007$). Femoral component coronal alignment within 3degree of the mechanical axis was in 95% of the EM group and 75% of the CAS group ($p=0.42$). Tibial component coronal alignment within 3degree of the mechanical axis was in 95% of the EM group and 88% of the CAS group ($p=0.42$).

CONCLUSION: The use of new extra medullary alignment guide resulted in similar accuracy to computer assisted navigation system.

K672 Long-term Subjective Outcomes of Oxford Phase 3 Unicompartmental Knee Arthroplasty

Primary Author: Yuichi Kuroda

Institution: Hyogo Rehabilitation Center Hospital

Coauthors: Tomoyuki Matsumoto (Kobe University Graduate School of Medicine), Kazunari Ishida (Kobe Kaisei Hospital), Koji Takayama (Kobe University Graduate School of Medicine), Naoko Shima (Hyogo Rehabilitation Center Hospital), Atsushi Kitagawa (Hyogo Rehabilitation Center Hospital)

BACKGROUND: Several reports have been published on long-term clinical outcomes of unicompartmental knee arthroplasty (UKA). However, there are few reports about

detailed long-term subjective outcomes. This study aimed to clarify the outcomes of Oxford phase 3 UKA using patient-derived scores at an eight-year minimum long-term postoperative period.

METHODS: Twenty-two knees performed UKA (Oxford Knee; Biomet Inc) were compared with 27 knees performed total knee arthroplasty (TKA) (PFC Sigma; DePuy Inc). At a minimum of eight years after surgery, range of motion (ROM), hip-knee-ankle (HKA) angle and patient-reported outcomes were assessed. Patient-reported outcomes were evaluated using Knee Society's new scoring system.

RESULTS: There was no significant difference between UKA and TKA for any section of the questionnaire, which consisted of symptoms (UKA 17.0 ± 5.8 vs. TKA 16.7 ± 7.5), patient satisfaction (UKA 23.6 ± 8.1 vs. TKA 21.9 ± 11.1), patient expectation (UKA 10.3 ± 3.8 vs. TKA 10.6 ± 3.2) and functional activities (UKA 67.9 ± 20.6 vs. TKA 59.3 ± 28.2). We found significant difference in flexion of ROM (UKA $127.5 \pm 7.3^\circ$ vs. TKA $112.2 \pm 12.2^\circ$) at final follow-up. The mean HKA angle in varus of subjects performed UKA was $3.5 \pm 2.7^\circ$ at final follow-up.

CONCLUSIONS: Despite satisfactory objective outcomes of Oxford phase 3 UKA, the patient subjective scores were relatively low values at a long-term postoperative period in this study. However, there was no significant difference in subjective outcomes between UKA and TKA.

K673 **What Preemptive Medication is Most Effective for Pain Management After TKA?**

Primary Author: Saekwang Kwon
Institution: Yonsesarang Hospital

Coauthor: Youwang Choi (Yonsesarang Hospital)

BACKGROUND: The addition of preemptive medication to the multimodal analgesic regimen is known to enhance the pain relief after total knee arthroplasty. But there is no standard preemptive protocol regarding medication sort, dosage. We determined (1) whether preemptive dexamethasone injection alone further reduces postoperative pain compared with control or oral pills; and (2) whether preemptive medication increases complications after TKA.

METHODS: We randomized 210 patients undergoing TKAs to receive dexamethasone (10 mg) before surgery (Dexa group, n=70) or oral pills (200 mg celecoxib, 75 mg pregabalin and ultracet: Oral group, n=70) or none (None group, n=70). We assessed pain VAS score (operation night, PO 2nd night, 3rd night, 4th night), frequency of acute rescue, functional recovery (ability to SLR, maximal flexion), amount of hemovac drainage, satisfaction score and any complication.

RESULT: The pain level was significantly lower in the Dexa group at operation night (VAS 1.56 vs. Oral group 2.7 vs. None group 3.25, $p=0.017$). Rebound pain was observed in three groups at PO(postoperative) 2nd night. Pain level was not different among three groups at PO 2nd, 3rd and 4th night. Frequency of acute rescue was significantly lower in the Dexa group during the PO 3 days ($p=0.048$). No significant differences regarding hemovac drainage, functional recovery and satisfaction were identified. There was no significant difference in incidence of complications.

CONCLUSIONS: We found that preemptive medication has additional effect of pain relief after TKA at operation night. The preemptive dexamethasone injection alone further reduces postoperative pain compared with oral pills without increased complications. But, any preemptive medication does not reduce rebound pain from PO 2nd night.

K674 **Does a Generalized Joint Laxity Influence a Clinical Outcomes of Total Knee Arthroplasty?**

Primary Author: Saekwang Kwon
Institution: YonSeSarang Hospital

Coauthor: Ohryong Kwon (YonSeSarang Hospital)

INTRODUCTION: Numerous studies have reported a generalized joint laxity(GJL) as a risk factor influencing the clinical outcome of soft tissue reconstruction. Although a soft tissue procedure has an important role of gap balancing in joint arthroplasty, there has been no study of correlation of a generalized joint laxity with clinical outcome of joint arthroplasty. We determined whether severity of joint laxity influences the preoperative and postoperative

clinical outcomes of total knee arthroplasty and whether the severity of GJL influences bearing thickness intraoperatively.

METHODS: The Beighton and Horan criteria were used to assess joint laxity in 338 female patients having advanced osteoarthritic knee. All criteria elements were added to give an overall joint laxity score ranging from 0 to 5. Total knee arthroplasty was performed using the modified measured resection technique with soft tissue release in all cases. We assessed the pre-operative and post-operative (at 24 months) clinical scores including patellofemoral score, AKS, WOMAC and ROM and satisfaction VAS. In addition, we compared a severity of joint laxity with polyethylene (PE) liner thickness. GJL scores were divided into two groups; Mild(M) group is from score 0 to score 3, Severe(S) group is score 4 and 5.

RESULTS: There was a significant difference in preoperative WOMAC stiffness and ROM between Mild(M) group and Severe(S) group.

CONCLUSION: The severities of generalized joint laxity dose influence the preoperative WOMAC stiffness and postoperative PF score in total knee arthroplasty. Although a severity of GJL is considered as a risk factor in ligament reconstruction, severity of GJL is not a risk factor of clinical failure in total knee arthroplasty. In case of severe GJL, surgeon should be prudent in patella tracking undergoing TKA.

K675

Two-stage Revision for Infected Total Knee Arthroplasty: Based on Autoclaving the Femoral Component and Intraoperative Molding Using Antibiotic-Impregnated Cement on the Tibial Side

Primary Author: Hee-Soo Kyung

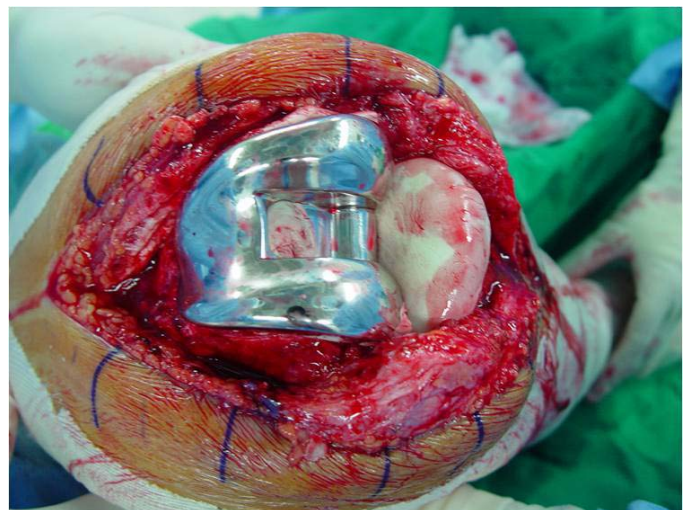
Institution: Department of Orthopedic Surgery, Kyungpook National University Hospital

Coauthors: Byoung-Joo Lee (Department of Orthopedic Surgery, Kyungpook National University Hospital), Seong-Dae Yoon (Department of Orthopedic Surgery, Kyungpook National University Hospital)

PURPOSE: In cases of chronic deep infection after total

knee arthroplasty, 2-stage revision arthroplasty has been recommended as the optimal treatment modality. Depending on the authors, there is variability in the use of articulating spacers. The purpose of this study was to determined rates of infection control and postoperative function for a new technique.

METHODS: A retrospective study of 19 patients (20 cases) underwent 2-stage revision arthroplasty using mobile cement prosthesis. Of these, were followed for a minimum of two years. This clinical series consisted of 17 women and 3 man of overall mean age 71 years. The mean follow-up period after revision arthroplasty was 29 months. During the first stage of revision, the femoral implant was removed, all adherent cement was removed, and then autoclaved and replaced. The tibial component was removed and a doughy state, antibiotic-impregnated cement was inserted on the tibial side. To achieve joint congruency, intraoperative molding was performed by flexing and extending the knee joint (Figure 1 & 2). Each patient was evaluated clinically and radiologically. Clinical assessments included range of motion, and Hospital for Special Surgery scores and Knee Society scores.



RESULTS: Mean range of knee joint motion was 70° prior to the first stage operation and 72° prior to second stage revision arthroplasty and 113° at a final follow-up following revision arthroplasty. The mean range of motion was 113° at last follow-up. The mean HSS score, KS score and Functional score were 86, 82 and 54 at last follow-up. The success rate in terms of infection eradication was 95% (19/20 knees). No patient experienced soft tissue contracture requiring a quadriceps snip.

CONCLUSION: The devised technique provides excel-

lent radiological and clinical outcomes. This technique offers a high area of antibiotic-impregnated cement and range of motion between first and second stage revision surgery for the treatment of chronic infection after TKA at reasonable cost.



K676

The Correlation of Postoperative Femoral Component Rotation Angle and Patella Tilt Angle with Clinical Results in Total Knee Arthroplasty

Primary Author: Hee-Soo Kyung

Institution: Department of Orthopedic Surgery, Kyungpook National University Hospital

Coauthors: Jae-Wook Jung (Department of Orthopedic Surgery, Kyungpook National University Hospital), Sang-Ho Cheon (Department of Orthopedic Surgery, Kyungpook National University Hospital)

PURPOSE: The aim of this study was to analyze the correlation of postoperative femoral component rotation angle and patella tilt angle with clinical results for total knee arthroplasty.

MATERIALS AND METHODS: Ninety-six cases in 48 patients who underwent total knee arthroplasty between March 2002 and February 2010 were enrolled. Femoral component rotation angle (FRA) and patella tilt angle

(PTA) were measured with postoperative computed tomography. Clinical results were evaluated using American Knee Society knee score & function score and Feller's patella score. We analyzed the correlation of FRA and PTA with clinical outcomes. We also compared clinical results between the PFC® Sigma group and the Scorpio NRG® group, and the patello-femoral symptom group and a symptom-free group.

RESULTS: The mean FRA was 1.40° of internal rotation. The patellar tilt angle was 3.79° of lateral tilt. The mean knee score was 90.5, the function score was 77.4, and the patella score was 23.9. There was a significant difference between FRA and knee scores ($p=0.031$, $r=-0.284$). There were no significant differences between FRA and function score or patella score. The correlation of PTA and clinical results was not significant. The mean FRA was 2.00° of internal rotation in the PFC® Sigma group, and it was significantly different than for the Scorpio NRG® group which had 0.81° of internal rotation; but there were no significant differences between the two groups in clinical results. The patello-femoral symptom group deviated more from the mean FRA than did the symptom-free group.

CONCLUSION: Internal rotation of the femoral component is correlated with poor clinical results after total knee arthroplasty. The correlation of patella tilt angle and clinical results was not significant.

K677

Comparison of Distal Femoral Cutting for Accurate Coronal Realignment Between Measured Cutting Technique and Guide Angle Technique

Primary Author: Beom Koo Lee

Institution: Gachon University Gil Hospital

Coauthor: Sung Soo Jun (Gil Hospital)

PURPOSE: Use of the guide angle method using intramedullary guide angle for distal femoral cutting in total knee arthroplasty may cause error when rotation of the femur occurs or the insertion point of the intramedullary guide is incorrectly positioned in preoperative radiography. On the other hand, use of the measured cutting method, in which resection of distal femoral condyles is performed according to predicted measured thickness in a

preoperative radiograph can allow for correction of these errors intraoperatively. Therefore, we compared these two distal femoral bone cutting methods for restoration of accurate coronal alignment.

METHODS: Between 2010 and 2012, 47 patients (70 knees) underwent total knee arthroplasty for treatment of osteoarthritis with varus deformity and flexion contracture less than 10 degrees. Bone resection depending on distal femur resection thickness measured before the operation was performed in 38 cases (Group I). Distal femoral cutting using the guide angle was performed in 32 cases (Group II). Radiographic evaluation, including mean value of lower leg mechanical axis angle and the frequency of errors of more than 3 degrees, was performed for comparison between the two groups.

RESULTS: In Group I, mechanical axis was corrected from 8.4 ± 4.9 degrees (-7.2 to 16.9) on average before the operation to 0.1 ± 2.4 degrees (-5.87 to 2.98) after the operation, and, in Group II, from 6.7 ± 3.6 degrees (0.4 to 14.7) on average before the operation to 0.5 ± 2.8 degrees (-5.4 to 6.9) after the operation. No statistically significant difference in mechanical axis ($p = 0.554$) was observed between the two groups after the operation, and no difference in errors of more than 3 degrees was observed between the two groups, with four of 38 cases (11 %) in Group I and six of 32 cases (19%) in Group II ($p = 0.495$).

CONCLUSIONS: No significantly different results were observed between the measured resection technique and the existing guide angle technique. Therefore, predictive measurement of distal femoral cutting thickness is another useful method for restoration of accurate coronal alignment.

KEYWORDS: Knee, Total knee arthroplasty, Mechanical axis, Resected condyle thickness, Guide angle

K678

Early Clinical and Radiographic Results of Mobile-Bearing Revision Total Knee Arthroplasty

Primary Author: Gwo-Chin Lee

Institution: Department of Orthopedic Surgery, University of Pennsylvania

Coauthors: Raymond H. Kim (Colorado Joint Replacement), Douglas A. Dennis (Colorado Joint Replacement), Charlie C. Yang (Colorado Joint Replacement), Brian D. Haas (Colorado Joint Replacement)

INTRODUCTION: Common failure modes of revision total knee arthroplasty (TKA) include aseptic component loosening and damage or wear to the constraining mechanisms, which are often required in revision TKA. Mobile-bearing revision TKA components have been developed in hopes of lessening these failure mechanisms. The purpose of our study was to evaluate the early clinical and radiographic results including the incidence of bearing complications in a group of patients undergoing revision TKA using mobile-bearing revision TKA implants.

MATERIALS AND METHODS: We retrospectively reviewed the clinical and radiographic records of 316 consecutive mobile bearing revision TKAs performed at 2 centers between 2006 and 2010. There were 183 females and 133 males with a mean age of 68 years (range 41 to 94). Indications for revision TKA included aseptic loosening, instability, infection reimplantation, failed unicompartmental knee arthroplasty, arthrofibrosis, polyethylene wear and osteolysis, component malposition, and periprosthetic fracture. The patients were evaluated clinically using the Knee Society (KS) scores and serial radiographs were evaluated for component position, radiolucent lines, component loosening or subsidence. Complications, including bearing complications (i.e. instability or dislocation), were recorded.

RESULTS: Patients were followed for a minimum of 24 months and an average of 40 months (range 24-75). The average Knee Society (KS) knee score and function scores increased from 45 points preoperatively to 83 points and from 50 points to 62 points respectively. The average knee flexion improved from 100.4 degrees preoperatively to 117.1 degrees postoperatively. Radiographic review demonstrated no evidence of component loosening or osteolysis at the latest follow-up. Eight patients required subsequent reoperation. No cases of bearing complications were observed.

CONCLUSION: Revision TKA using mobile-bearing revision components demonstrated favorable early clinical and radiographic results with no occurrence of bearing instability or dislocation. Longer follow-up is required to evaluate for potential advantages of mobile-bearings over

fixed-bearing revision components in terms of polyethylene wear reduction, reduced stress transmission across fixation interfaces, and reduced stress on the polyethylene post.

K679 **The Outcomes of Acute Avulsion Fracture of Tibial Insertion of Posterior Cruciate Ligament with “Safe Postero-Medial Approach”**

Primary Author: Jung Bum Lee

Institution: Department of Orthopaedic Surgery, School of Medicine, Konyang University

OBJECTIVES: To report clinical and functional outcomes following fixation of tibial posterior cruciate ligament (PCL) avulsion fractures through “safe postero-medial approach”

MATERIAL AND METHODS: From January 2009 to January 2013, 13 cases of tibial avulsion fracture of the posterior cruciate ligament were treated with open reduction and internal fixation through “safe postero-medial approach”. A preoperative assessment of each case was comprised of clinical examination to define the instability and other associated problems. The preoperative and the postoperative 3, 6 and 12 months Lysholm scores, Tegner activity scores and knee joint range of motion were evaluated. And we only checked posterior drawer test at 90° and evaluated the instability by posterior stress roentgenography using the Telos stress device at 90° of flexion in follow-up 12 months. We evaluated the translation of the bony fragment and arthritic changes by simple AP and lateral x-ray radiograph after 12 months.

RESULTS: Patients were followed-up for 12 to 16 months. X-ray showed that satisfactory reduction state and bone healing were achieved in all cases. There was no neurovascular complication. All patients had negative posterior drawer tests. Excellent outcomes were reported by all patients with the Lysholm score system. And there was no significant difference between the Tegner scores before surgery and last follow-up.

CONCLUSION: Surgical treatment of acute tibial avulsion fracture of the PCL with this approach can restore the stability and function of the joint safely in most patients

without neurovascular complication. Therefore “safe postero-medial approach” could be appropriate for the treatment of isolated tibial avulsion fracture of the PCL.

K680 **Blood Management of Staged Bilateral Total Knee Arthroplasty in Single Hospitalization Period-West China Experience**

Primary Author: Jun Ma

Institution: Department of Orthopaedic Surgery, West China Hospital, Sichuan University

Coauthors: Zeyu Huang (Department of Orthopaedic Surgery, West China Hospital, Sichuan University), Chen Yue (Department of Orthopaedic Surgery, West China Hospital, Sichuan University), Bin Shen (Department of Orthopaedic Surgery, West China Hospital, Sichuan University), Jing Yang (Department of Orthopaedic Surgery, West China Hospital, Sichuan University)

PURPOSE: The goal of our study was to evaluate the effectiveness and safety of the new introduced methods of blood management in the patients treated with staged bilateral total knee arthroplasty in single hospitalization period.

METHODS: 43 patients (study group) receiving the newly introduced methods of blood management were matched with the other 43 patients by age, body mass index. Patients in both groups received dietary nutrients, polysaccharide-iron complex during the whole hospitalization period. During the surgery, 15mg/Kg tranexamic acid was used intravenously once the tourniquet was deflated in the study group. Drainages were average placed for 12 hours. If the postoperative drainage volume was more than 300mL, another dose of tranexamic acid (10mg/Kg) was used again in the study group. Low molecular weight heparin (LMWH) was used routinely in both groups. Hemoglobin (HB) hematocrit (HCT) at different time points was compared between the groups. Also, the calculated blood loss, the changed knee circumferences, Hospital for Special Surgery Knee (HSS) scores, visual analogue scale (VAS) and the requirements of transfusions were also compared. What is more, according to the results of a double venous ultrasound performed on the checked out day, we obtained the incidence of deep vein thrombosis (DVT), the average postoperative in-patient days were also analyzed.

RESULTS: Despite of the similar preoperative demographics, significant decreases were found in the study group in terms of calculated blood loss (1427.1 ± 552.4 mL VS 1753.9 ± 716.4 mL, $p=0.047$), number of transfusions per patient (0.48 ± 0.13 IU VS 1.2 ± 0.21 IU, $p=0.03$), number of patients needing transfusions (6 VS 16, $p=0.025$), highest changed Hb level (43.5 ± 13.2 g/L VS 55.4 ± 8.5 g/L, $p<0.001$), highest changed Hct level (11.2 ± 4.4 VS 13.7 ± 5.2 , $p=0.042$), changed knee circumferences (0.8 ± 0.4 cm VS 1.8 ± 0.7 cm, $p=0.02$) and VAS (2.3 ± 1.7 VS 4.2 ± 1.3 , $p=0.008$). However, no significant differences were detected in terms of length of stay, HSS score and the incidence of DVT.

CONCLUSION We can perform the staged bilateral total knee arthroplasty in the same hospitalization safely and effectively by using the newly introduced blood management. The calculated perioperative blood loss can be used as a well-defined parameter to assess the surgical trauma. And the terminal goal of blood management of the total knee arthroplasty is to seek the balance between the blood loss and the anticoagulation other than reducing total blood loss unlimitedly.

K681 Preemptive Multimodal Analgesia for Total Knee Arthroplasty Pain Management

*Primary Author: Paige R. Mallette
Institution: University of Washington*

Coauthor: Paul A. Manner (University of Washington)

We evaluated the effects of preemptive multimodal analgesia (PMMA) for patients undergoing total knee arthroplasty (TKA). Beginning in January 2013, all patients undergoing TKA on the senior author's (PAM) service received PMMA which included premedication with a cocktail of analgesic medication, spinal anesthesia utilizing bupivacaine, a femoral nerve block, and postoperative oral medication with IV opioids available for breakthrough. Prior to January 2013, patients undergoing TKA received either a general or spinal anesthetic based on patient preference and patient controlled analgesia (PCA) was used for postoperative pain control. These patients undergoing TKA in calendar year 2012 served as controls in this study. The goal of this investigation was to examine the effect of this

protocol on specific outcomes during hospitalization following TKA.

Following IRB approval, a cohort of 60 consecutive patients undergoing total knee arthroplasty in the first four months of 2013 was assembled. Exclusion criteria included bilateral or revision procedures. 49 patients were eligible for inclusion. These patients were then matched by age, sex, and BMI to patients undergoing total knee arthroplasty by the same surgeon during calendar year 2012. One patient from the 2013 group was removed due to excessive pre-operative narcotic consumption exceeding 2,500 morphine equivalents per day. All patients received a posterior-stabilized implant of the same design using a mid-vastus surgical approach.

For each patient, charges, total cost, and specific cost center were recorded. We also collected post-operative data including pain score on visual analog scale (VAS), length of hospitalization, range of motion (ROM) at the time of discharge, ambulatory distance at time of discharge and total narcotic consumption, measured as morphine equivalents consumed in a 24hr period (ME).

Total costs were significantly lower in the PMMA group. Opioid consumption was also significantly lower in the PMMA group as shown by a 23% decline in opiate usage after PMMA implementation. The decrease was more pronounced in the geriatric subset (age > 65). In this group, narcotic use decreased 43% after PMMA implementation. For the entire cohort, length of stay did not change, nor did VAS scores. Range of motion was not different, although the PMMA group showed a trend towards improved flexion. Distance walked at time of discharge was similar for the two groups. These results are shown in Table 1.

Because both cohorts included subjects using opiates prior to surgery, we also examined opiate naïve subjects independently. These results are shown in Table 2. This subset showed a dramatic decline in narcotic usage of 44%, similar to the geriatric subjects. Costs were also significantly lower in the PMMA group and knee flexion again trended higher in the PMMA subjects.

In this study comparing matched TKA patients, a systematic approach to pain management decreased opiate consumption and reduced cost during hospitalization without adverse consequences for functional recovery or postoperative pain. Two separate subsets benefitted specifically

including the elderly patients who are particularly susceptible to opiate related complications.

Table 1

All Subjects

Demographics	Pre-intervention (n=30)		PMMA (n=27)		Comparisons	
	mean	± SD	mean	± SD	%-Change	p-value *
Age (y)	61.9	± 9.3	63.4	± 9.7	2	0.434
Gender (M/F)	16/33	--	16/32	--	--	>0.99
Pre-op narcotics (N/Y)	30/19	--	27/21	--	--	0.680
Operative Metrics						
Stay (days)	2.8	± 1.0	2.8	± 0.3	0	0.984
Cost (\$)	17403	± 3354	16108	± 2679	-8	0.001
Post-op narcotics (ME/day)	94.3	± 46.9	76.8	± 56.9	-23	0.027
VAS score	4.37	± 2.18	4.49	± 1.69	3	0.759
Extension (deg.)	2.13	± 3.59	1.44	± 2.28	-48	0.266
Flexion (deg.)	100.1	± 11.8	104.5	± 10.2	4	0.055
Distance Walked (ft)	171.0	± 72.3	176.1	± 87.2	3	0.754

* Student's t-tests except; Cost, Post-op narcotics are Mann-Whitney; Gender, pre-op narcotics are Fisher's Exact

Table 2

Opiate Naive Subjects

Demographics	Pre-intervention (n=30)		PMMA (n=27)		Comparisons	
	mean	± SD	mean	± SD	%-Change	p-value *
Age (y)	63.7	± 9.1	65.77778	± 8.6038	3	0.387
Gender (M/F)	10/20	--	5/22	--	--	0.241
Pre-op narcotics (N/Y)	30/0	--	27/0	--	--	--
Operative Metrics						
Stay (days)	2.83	± 0.95	2.56	± 0.34	-10	0.248
Cost (\$)	17503	± 3588	15266	± 1629	-13	<0.001
Post-op narcotics (ME/day)	86.2	± 42.2	48.3	± 30.6	-44	<0.001
VAS score	3.73	± 1.89	4.33	± 1.82	16	0.228
Extension (deg.)	2.24	± 3.73	1.67	± 2.39	-26	0.492
Flexion (deg.)	99.1	± 12.5	105.1	± 10.3	6	0.052
Distance Walked (ft)	153.5	± 59.2	172.8	± 78.3	13	0.304

* Student's t-tests except; Cost, Post-op narcotics are Mann-Whitney; Gender, pre-op narcotics are Fisher's Exact

K682

Sagittal Alignment of the Femoral Component in Total Knee Arthroplasty: Comparison of Flexible and Rigid Intramedullary Rod

Primary Author: Takamasa Matsubara

Institution: Shizuoka Municipal Shizuoka Hospital

Coauthors: Michio Sano (Shizuoka Municipal Shizuoka Hospital), Masaaki Takahashi (Jyuzen Hospital Joint Center)

INTRODUCTION: Accurate alignment is fundamental to a successful total knee arthroplasty (TKA). Flexible intramedullary rod has flexibility in sagittal plane only, not coronal plane. The purpose of this study was to compare the alignment after TKA using two different femoral intramedullary rod systems (flexible rod and rigid rod).

MATERIALS AND METHODS: This was a retrospective case control, clinical study of patients who had TKA between 2008 and 2012. We performed 89 consecutive pri-

mary TKA in 71 patients. 41 knees had the distal femoral resection using a flexible rod (F group), whereas the other group of 48 knees had this resection performed with a rigid rod (R group). F group had TKA performed using the Triathlon PS prosthesis (Stryker), R group had TKA performed using the Scorpio NRG PS (Stryker) or Nex-gen LPS-Flex (Zimmer). The mean age of patients in the F group was 73.6 years old and that in the R group was 74.5 years old at surgery. The demographic features such as age, gender, Body Mass Index, and preoperative Femoral Tibia Angle (FTA), preoperative range of motion in the knee did not differ significantly in the two groups. We measured the sagittal alignment (γ angle) of the femoral component from the lateral radiographs of the knees, the coronal alignment (α angle) from the anteroposterior (AP) radiographs, and overall alignment (postoperative FTA) from full-length standing. To determine differences between the two groups, we performed Students-t-test for α angle, γ angle, and FTA. Chi-square tests were used to determine associations between outliers in radiographic outcomes between the two groups.

RESULTS: γ angle was $2.2^\circ \pm 2.1^\circ$ in the F group and $0.8^\circ \pm 2.5^\circ$ in the R group. There was a statistically significant difference for the F group compared with the R group ($P < 0.01$). Extended position of femoral component (γ angle $< 0^\circ$) was 5 knees (10.4%) in the F group and 12 knees (29.2%) in the R group. R group was in a more extended position than F group ($P < 0.05$). Femoral anterior notching was 1 knee (2%) in the F group and 5 knees (12%) in the R group (N.S.). α angle was $83.1^\circ \pm 1.9^\circ$ in the F group and $83.4^\circ \pm 1.7^\circ$ in the R group. Postoperative FTA was $175.5^\circ \pm 2.6^\circ$ in the F group and $175.0^\circ \pm 2.9^\circ$ in the R group. There was no significant difference in the α angle and postoperative FTA between the two groups.

DISCUSSION: The femoral sagittal bowing on TKA could lead to potential errors in positioning of the femoral component if it is ignored. If the rigid rod is inserted on sagittal bowing of femur, the tip of the rod will hit the anterior cortex and the rod can be tilted anteriorly. The femoral component may end up in an excessively extended position and notching may result if the subsequent bone cuts are referenced to the guide rod. The present study suggests that sagittal alignment of femoral component with TKA using the flexible rod would have provided accurate sagittal alignment and using the rigid rod needs to be cautious of the extended position of femoral component.

K683

An Elevated Joint Line after TKA Leads to Increased Mid-flexion Laxity

Primary Author: David J. Mayman

Institution: Hospital for Special Surgery

Coauthors: Gregory Klingenstein (Hospital for Special Surgery), Michael B. Cross (Hospital for Special Surgery), Christopher Plaskos (OMNIlife Science, Inc), Angela X. Li (Weill Cornell Medical College), Kaitlin M. Carroll (Hospital for Special Surgery)

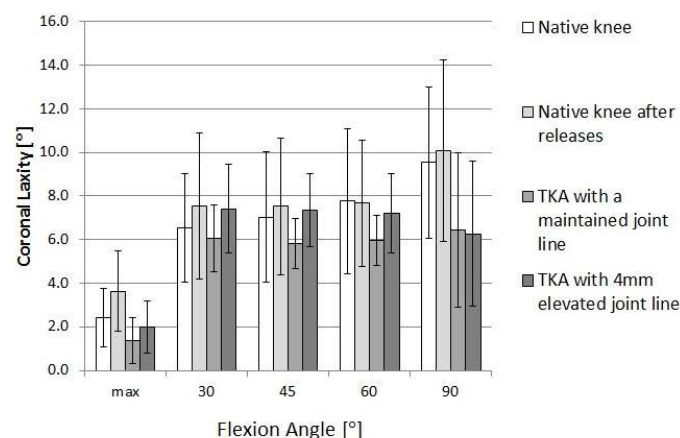
INTRODUCTION: This study aims to quantify mid-flexion laxity in a total knee arthroplasty (TKA) with an elevated joint line compared to a native knee and a TKA with joint line maintained. Our hypothesis was joint line elevation of 4mm would increase coronal plane laxity throughout mid-flexion in a distinct pattern.

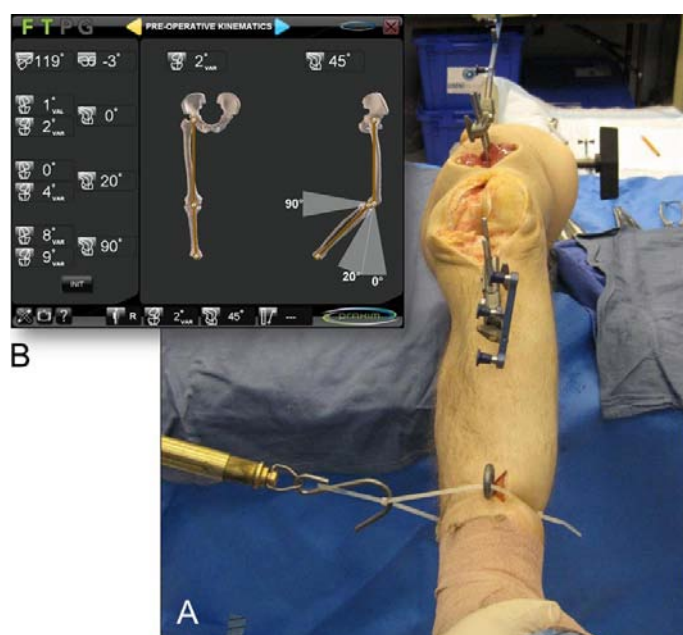
METHODS: Six fresh-frozen cadavers from hip-to-toe underwent TKA with a posterior stabilized implant (APEX PS, OMNIlife Science, Inc.) using a computer navigation system with a robotic cutting-guide. After the initial tibial and femoral resections, the flexion and extension gaps were balanced using navigation, and a 4mm recut was made in the distal femur. The remaining femoral cuts were made, the femoral component was downsized by resecting an additional 4mm of bone off the posterior condyles, and the polyethylene was increased by 4mm to create a well-balanced knee with an elevated joint line. Real implants were used to eliminate any error or laxity in the trials. Navigation was used to measure overall coronal plane laxity by measuring the mechanical alignment angle at maximum extension, 30°, 45°, 60° and 90° of flexion, when applying a standardized varus/valgus load of 9.8 [Nm] across the knee using a 4kg spring-load located 25cm distal to the joint line (Figure 1). Coronal plane laxity was defined as the absolute difference (in degrees) between the mean mechanical alignment angle obtained from applying a standardized varus and valgus stress at 0°, 30°, 45°, 60° and 90°. Generalized equations were calculated for each flexion angle to compare opening angle differences between conditions using proc genmod in the SAS System 9.2 (Cary, NC). Each of the 3 measurements were used as repeated measures for each specimen. An independent covariance structure was specified. Due to the large number of comparisons, we calculated a false discovery rate (FDR) adjusted p-value using the non-adaptive Benjamini

and Hochberg procedure, which determined that a p-value of <0.03 was statistically significant.

RESULTS: In full extension, 30°, 45°, 60°, and 90° of flexion, the native knee showed coronal plane laxity of 2.4, 6.5, 7.0, 7.8, and 9.5°, respectively. Soft tissue releases produced increased laxity in extension and 30° of flexion. After TKA, the mean coronal plane motion was decreased at all flexion angles and consistent throughout arc of motion. With 4mm of joint line elevation, coronal plane laxity increased by a mean of 1.4° at 30° of flexion ($p=0.0103$), 1.5° at 45° of flexion ($p=0.0001$), and 1.3° at 60° of flexion ($p=0.0018$) compared to the TKA with native joint line (Figure 2). There was no difference in laxity at 0° and 90° between the initial TKA and after 4mm joint line elevation.

CONCLUSIONS: The computer navigated, well-balanced TKA with a maintained joint line showed consistent coronal plane laxity throughout all flexion angles, while the native knee showed greater laxity at 90° than in mid-flexion. This study confirms that 4 mm joint line elevation results in greater coronal plane laxity in mid-flexion and suggests that maintaining the joint line in TKA is necessary to avoid increased mid-flexion, coronal plane laxity.





K684

Design And Validation of a Smart Knee Brace to Measure Varus-Valgus Stability

Primary Author: Patrick A. Meere

Institution: NYU Hospital for Joint Diseases

Coauthors: Christopher P. Bell (NYU Hospital for Joint Diseases), Ilya Borukhov (NYU Hospital for Joint), Peter S. Walker (NYU Hospital for Joint Diseases)

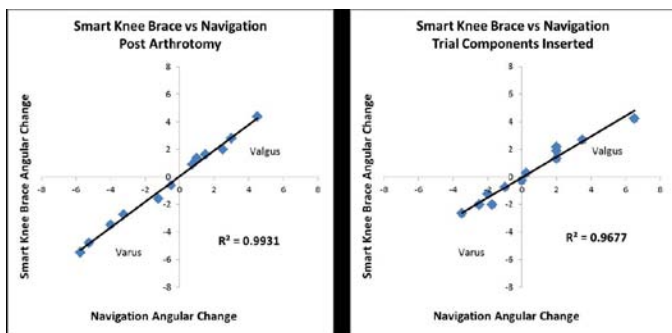
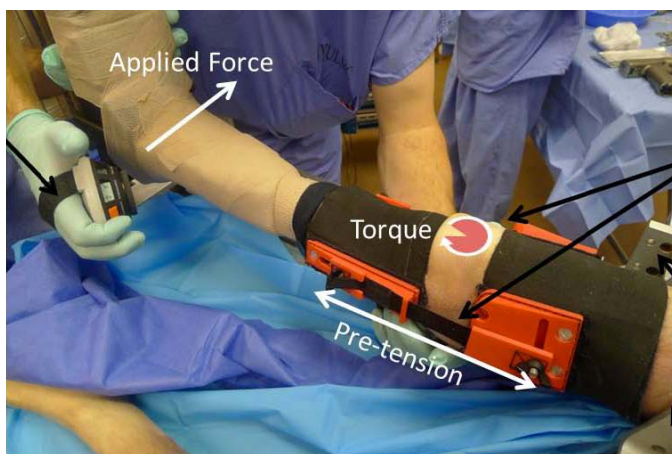
Evaluation of post-operative balancing outcomes after Total Knee Arthroplasty (TKA) and other procedures can be measured by stability tests, with Anterior-Posterior (AP) and Varus-Valgus (VV) stability being particularly important. AP stability can be quantified using a KT1000 device; however there is no standard way of measuring VV stability. This test is routinely carried out by surgeons in clinical evaluations, but there is no quantification of the moments applied or the resulting angular deviations between the femur and tibia. Therefore we sought to develop and validate a device and method for quantifying knee balancing by analyzing VV stability.

Our team developed a Smart Knee Brace to measure VV angular changes (see Figure 1) using two dielectric elastomer stretch sensors. The brace was secured in position with the leg in full extension and the sensors were adjusted to hold pre-tension readouts and locked. Therefore contraction and elongation of either sensor could be measured

simultaneously using proprietary software. The changing values were then used to calculate the VV, femur-to-tibia, angular deviations.

The Smart Knee Brace was validated using a lower body cadaver specimen by comparing the brace's calculated VV angular changes to those from an optical surgical navigation system. The pelvis was fixed to the base of the test rig and a surgical boot was firmly strapped to the foot. A spherical bearing fixed to the base of the boot was attached to a polished stainless steel rod allowing for controlled low friction VV translations of the foot when a force was applied to the malleolus. This force applied varus or valgus moments to the knee. The thigh was secured in the rig and supported by a horizontal beam that adjusted to control angles of flexion. Surgical navigation trackers were then fixed to the femur and tibia. A subvastus approach was used and the navigation system was calibrated. The arthrotomy was then closed with towel clips. The Smart Knee Brace was strapped on and secured in position. The VV tests were then carried out on the knee prior to insertion of the TKA. Force was gradually applied for both varus and valgus moments with a wireless hand-held dynamometer up to 50N (19.8Nm) at 0 and 15° flexion. At 30° flexion, force was gradually applied up to 35N (13.9Nm). A navigated TKA was then performed to test the accuracy of the brace on a trial implanted knee and the VV tests were repeated.

Collected data was later processed and the Smart Knee Brace VV angular changes were compared to those values recorded by Navigation. R2 values were then calculated to validate the Smart Knee Brace's accuracy. Excellent correlation was observed between the Smart Knee Brace and navigation angular changes (see Figure 2). The post arthrotomy R2 value was 0.9931 and the trial TKA components inserted R2 value was 0.9677. Therefore we can conclude that the Smart Knee Brace can potentially be used to accurately measure and the VV deviation of the knee in a clinical setting and hence indicate stability and balance after TKA.



K685

Thigh Pull Test in TKR: Equivalent or Different than Heel Push

Primary Author: Patrick A. Meere

Institution: NYU Hospital for Joint Diseases

Coauthors: Christopher P. Bell (NYU Hospital for Joint Diseases), Ilya Borukhov (NYU Hospital for Joint), Parthiv Rathod (NYU Hospital for Joint Diseases), Peter S. Walker (NYU Hospital for Joint Diseases)

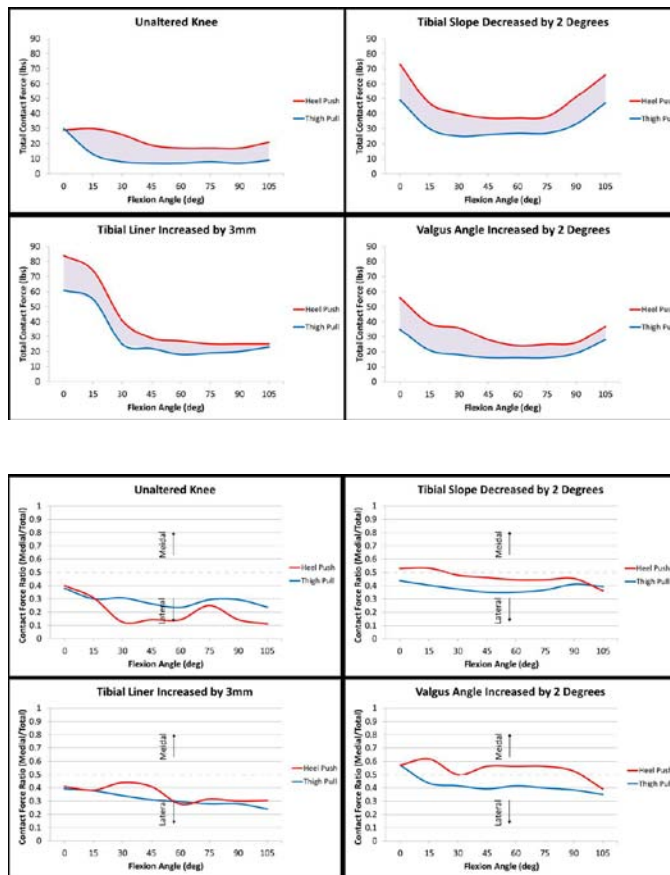
The use of smart trial components is now allowing a better assessment soft tissue balancing at the time of total knee replacement surgery. A balanced knee can be defined as one that possesses symmetry, ie. equal and centered lateral and medial forces through the full range of flexion. There is still a need for a standard reproducible surgical test to quickly confirm optimized balancing at surgery with such devices. The Heel Push test is the established standard, by pushing the foot in a cephalad direction while supporting the thigh and keeping the leg stable in the vertical plane. A common variation of this test is the Thigh Pull test where the foot is actively assisted during the cephalad pull of the thigh through deep flexion. The test is an open chain

test. The Thigh Pull test may be an improvement since the weight of the leg is alleviated and no supplemental compressive forces are introduced. The directional changes of the lower extremity are thus a result of ligamentous tension and balances. The purpose of this study is to compare the two tests using a standard testing methodology and observe the variation in kinetic parameters in a controlled biomechanical setting.

A custom mechanical rig was developed, which independently controls all six degrees of freedom about the knee joint. In addition a commercial navigation system was used to derive instantaneous alignment values and flexion angles between the tibia and femur. The pelvis was fixed to the table and the foot was fitted onto a low friction carriage along a slide rail. The knee design used was cruciate retaining. The pressure mapping system was a wireless tibial trial that provided magnitude of load per compartment.

In this experiment the leg was then tested with the Heel Push and Thigh Pull tests after obtaining optimum soft tissue balance of the cadaveric specimen. From this standard neutral state a series of single surgical variables were introduced to mimic common intra-operative surgical corrections. This was achieved through custom tibial liner and angle shims.

The results obtained from the test series defied theoretical anticipation. Though the total contact forces with heel push were generally higher than with thigh pull, the relative load distribution between compartments did not follow a trend (see Figures 1 & 2). Furthermore in deeper flexion the persistence of relatively high contact pressures would suggest that ligaments still generate intra-articular forces despite the much weaker gravitational effect. The clinical relevance lies in the asymmetry of the load distribution between medial and lateral compartment for the two methods tested. The load asymmetry as tested by the Thigh Pull test may correspond to an open chain in swing phase. This asymmetry would force some axial rotation and tibial femoral alignment deviation that can significantly affect the forces at the time of heel strike. The Heel Push test would be more representative of the compressive forces in a closed chain mode as seen during the stance phase of gait.



K686 Varus Valgus Stability Must Be Assessed Outside of the Screw-Home Mechanism

Primary Author: Patrick A. Meere

Institution: NYU Hospital for Joint Diseases

Coauthors: Christopher P. Bell (NYU Hospital for Joint Diseases), Ilya Borukhov (NYU Hospital for Joint Diseases), Parthiv Rathod (NYU Hospital for Joint Diseases), Peter S. Walker (NYU Hospital for Joint Diseases)

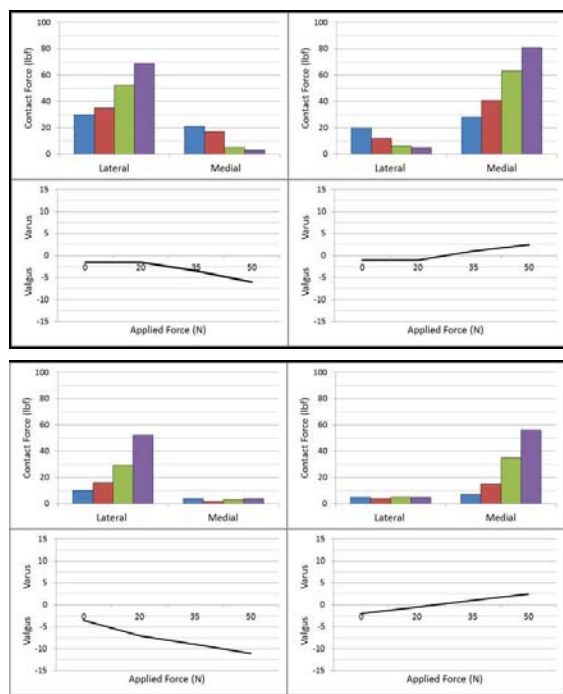
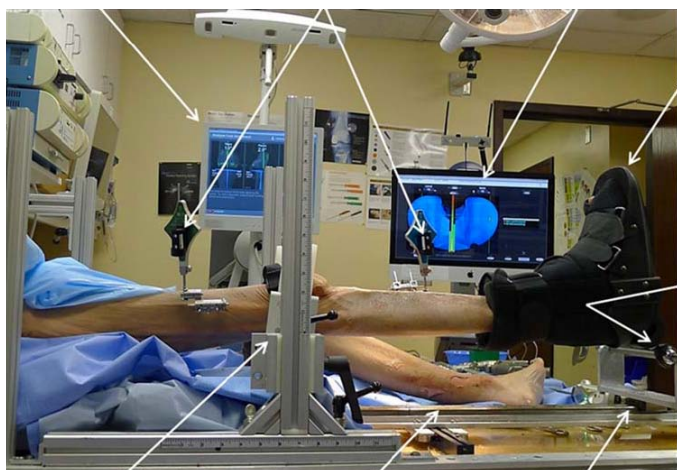
Assessing soft tissue balancing at the time of total knee replacement surgery is improving with the use of smart trial components. The use of these tools along with surgical balancing tests helps assess whether a knee is balanced. One such test, the Varus-Valgus (VV) test, focuses on the stability and balance of the collateral ligaments. A stable and balanced knee can be identified with this test as one that possesses symmetrical contact forces when equal opposing VV forces are applied. VV stability is important for stable post-operative kinematics, especially in the swing phase of gait outside screw-home mechanism (0-10°) when ground

reaction forces are present. We sought to illustrate the need to perform this test outside the screw-home mechanism to properly focus the test primarily on the collateral ligaments in a controlled laboratory study.

A test rig was developed for mounting lower body specimens to a standard operating table (see Figure 1). The pelvis was fixed to the base of the test rig and a surgical boot was firmly strapped to the foot. A spherical bearing fixed to the base of the boot was attached to a polished stainless steel rod allowing for controlled low friction VV translations of the foot when the torque force was applied to the malleoli. The thigh was secured in the rig to prevent femoral rotations and translations while resting on a horizontal beam that adjusted to control angles of flexion. Surgical navigation trackers were then fixed to the femur and tibia. A subvastus approach was used and bone cuts were made for the insertion of a posterior cruciate retaining total knee using an optical navigation system. The wireless instrumented tibial trial was then introduced. For all subsequent tests, the arthrotomy was closed with towel clips. Hip-Knee-Ankle (HKA) angles were measured by navigation and contact forces were measure by the tibial trial.

The VV tests were then carried out. Force was gradually applied up to 50N (19.8Nm) for both varus and valgus torques at 0 and 15° flexion. Applied forces were measured using a wireless hand-held dynamometer.

Looking at the 15° flexion tests in Figure 2, it can be concluded that this knee was unbalanced. The HKA deviations at the 0° flexion tests are symmetric, but at 15° flexion, outside the screw-home mechanism, the HKA deviations are not. The 15° flexion Valgus torque produced an HKA deviation of 8 degrees which is almost double that of the 15° flexion Varus torque, thus illustrating a tighter lateral side. The HKA angle discrepancy between 0 and 15° flexion demonstrates the importance of testing balancing outside of the screw-home mechanism in order to truly achieve post-operative stability.



K687 Contact Stress in High Flexion in Posterior Stabilized Total Knee Arthroplasty with Axial Rotation

Primary Author: Takaaki Morooka

Institution: Morooka Orthopaedic Hospital

Coauthors: Hidehiko Higaki (Kyushu Sangyo University), Ken Shimoto (Kyushu Sangyo University)

INTRODUCTION: Most of the TKA prostheses are designed to accommodate the tibiofemoral axial rotation in order to have longevity and natural kinematics. Some prostheses are designed to provide congruent contact during

high flexion. However, the flexion angle tends to be determined without the axial rotation. The axial rotation should be considered for safe high flexion angle especially in fixed bearing prosthesis.

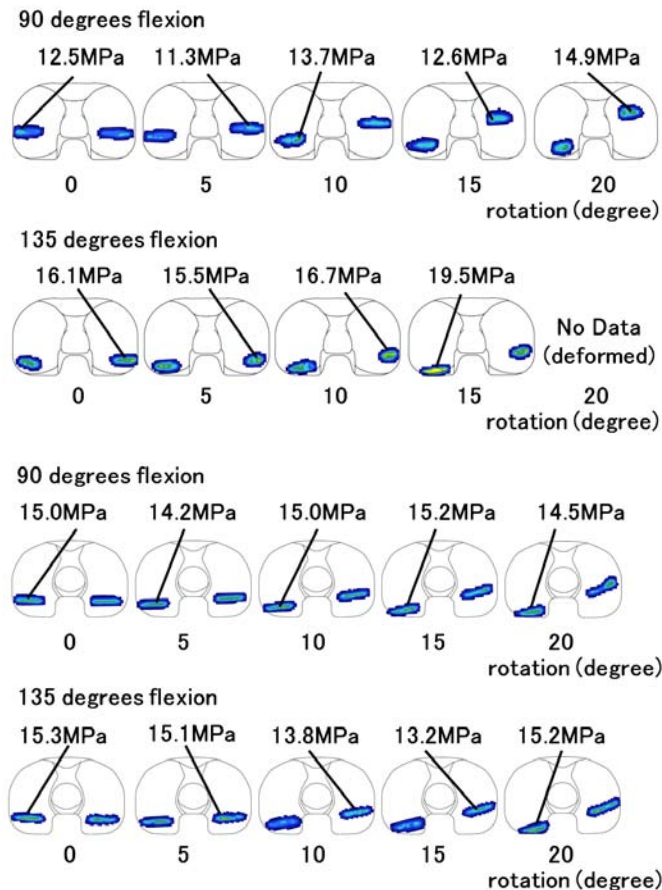
METHODS: The contact stress produced in the tibiofemoral joint from a tibial component was tested in six posterior stabilized fixed bearing total knee prostheses; the NexGen LPS-Flex, the Scorpio NRG, the Foundation, the GenesisII, the Triathlon and the PFC sigma. Contact stresses and contact area were measured with a digital electronic sensor under 1200N compressive load at 90 degrees and 135 degrees flexion. The tibial component was rotated 0, 5, 10, 15 and 20 degrees in each flexion angle.

RESULTS: The LPS flex provided low peak contact stress under 20MPa until 15 degrees rotation. However, the stress increased to 19.5MPa in 135 degrees flexion with 15 degrees rotation (see Figure 1), and the polyethylene deformed plastically in 135 degrees flexion with 20 degrees rotation. The Scorpio NRG (see Figure 2) and the Triathlon provided low contact stress under 20MPa in all testing conditions. The Genesis II provided over 20MPa stress only in 135 degrees flexion with 20 degrees rotation. The Foundation provided over 20MPa stress in 90 degrees flexion with 20 degrees rotation and in 135 degrees flexion with 10, 15, and 20 degrees rotation. The PFC sigma did not allow rotation over 10 degrees, due to the high conformity post-cam design. The PFC sigma polyethylene deformed plastically in 135 degrees with 0 degree rotation.

DISCUSSION: The plastic deformation without rotation of the PFC sigma, which is not called high flex type, suggested the importance of congruous contact between the femoral component and the polyethylene in sagittal plane. The posterior flange of the LPS flex was extended to maintain adequate contact during high flexion. Without rotation, the design features of the LPS flex functioned to keep low contact stress as planned. But the stress increased nearly 20MPa that supposed to provide more chance of polyethylene plastic deformation with 15 degrees rotation, the polyethylene deformed with 20 degrees rotation. The straight post-cam design was one of the reasons that caused the rotational mismatch. The Scorpio NRG, the Genesis II and the Triathlon have rather round post-cam designs, and these prostheses provided lower contact stress even in the rotated position. Kneeling and lunge provide more than 25 degrees rotation in the normal knee. Some TKA patients can do the same activities as healthy population. It is pos-

sible that the contact stress in their knees is in a more severe condition than that showed in this study.

CONCLUSION: The contact stress differed depending on the rotational angle. The axial rotational mismatch may be provided by the prosthesis design.



K688

Application of Micro Slurry Erosion to Bearing Surface in Artificial Joint to Inhibit Macrophage Activation

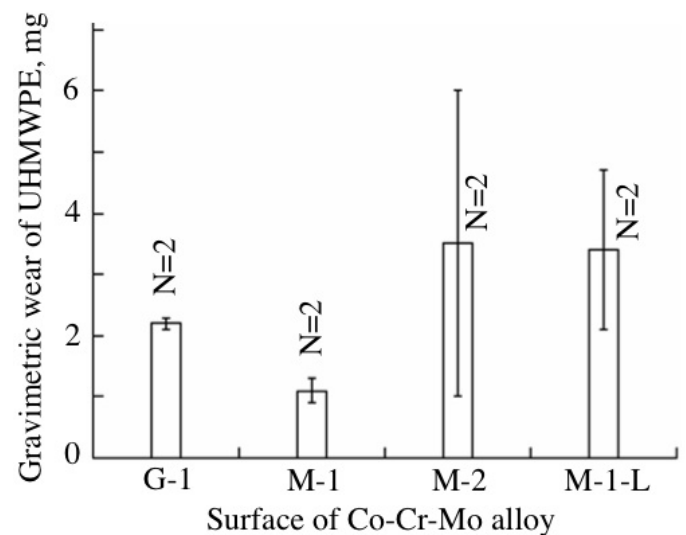
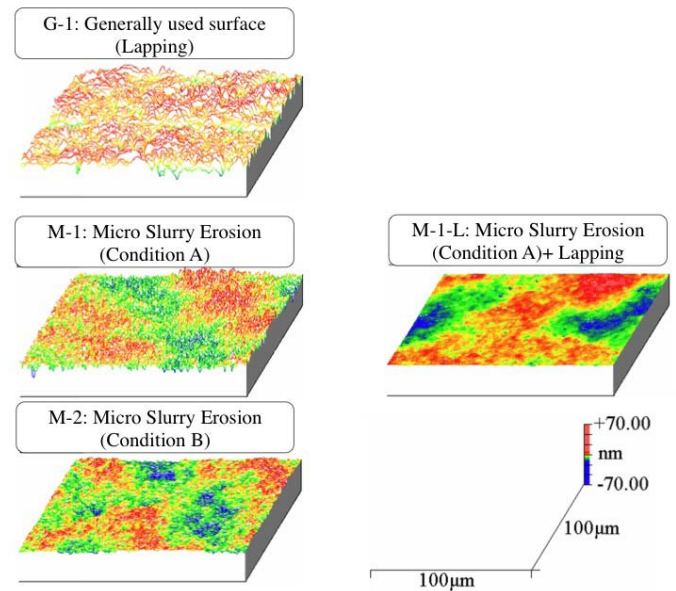
Primary Author: Yoshitaka Nakanishi

Institution: Kumamoto University

Coauthors: Yuta Nakashima (Kumamoto University), Naoki Nishi (Kumamoto University), Hiroto Chikaura (Kumamoto University), Toru Matsubara (Palmeso Co., Ltd.), Hidehiko Higaki (Kyushu Sangyo University), Hiromasa Miura (Ehime University)

An ultra-high molecular weight polyethylene (UHMWPE) is widely used as bearing material in artificial joints, how-

ever, UHMWPE wear particles are considered to be a major factor in long-term osteolysis and loosening of implants. The wear particles activate macrophages, which release cytokines, stimulating osteoclasts, which results in bone resorption. The biological activity of the wear debris is dependent on the volume and size of the particles produced. Many researchers reported that the volume and size of particles were critical factors in macrophage activation, which particles in the size range of 0.1-1



K689**The Effect of Tibial Design Parameters on the Micromotion in TKA***Primary Author: Satya N. Nambu**Institution: MicroPort Orthopedics**Coauthors: Richard M. Obert (MicroPort Orthopedics), David R. Tuttle (MicroPort Orthopedics), Irina A. Timmerman (MicroPort Orthopedics)*

INTRODUCTION: Excessive micromotion after TKA at the bone-implant-cement interface hampers the bony ingrowth on the implant surfaces or creates the wear particles responsible for implant loosening. It has been earlier reported that the threshold value for micromotion that inhibits bone growth is 100-150 microns. The purpose of the current study was to determine the effect of the tibial design parameters (symmetric vs. asymmetric base*, stem diameter/length), loading and type of distal stem bone support (modulus effects) on the micromotion using 3D finite element analyses (FEA). *The asymmetric base used in this analysis is not cleared for use in the United States. The information is provided for academic purposes only.

METHODS: A tibial lower limb model was used for the analysis. The cortical bone envelope was represented by a 2 mm shell created in the existing tibial bone computer aided design (CAD) model. Table 1 shows the evaluated tibial base designs and their parameters. The keel and the stem models utilized for the bases were identical. Prior to positioning the implants, the proximal region of the tibial bone was resected 10 mm from lowest point of the lateral condyle. The base, keel, and stem were assembled in CAD to nominal dimensions and placed on the tibial model. Rotation of the tibial base was oriented to the medial third of the tibial tubercle. Cavities were created in the bone model to account for the space filled by the implant, keel and stem. Based on the previously reported worst case studies for micromotion, a 1 mm thick bone cement layer was modeled between the tibial base and the bone surfaces while the rest of the interfaces were left uncemented. All CAD parts were exported to the Autodesk mechanical simulation software and meshed with the combination of 0.075 in. brick and tetrahedral elements. The material properties utilized in the analyses are listed in Table 2. It was earlier reported that eccentric loading can occur in the knee joint at extremes of flexion and extension, generating load magnitudes up to 2x body weight (BW). Therefore, a compressive force

equivalent to 550 lbf (2X 275 lbf) was applied on the dwell point of the medial condyle. Constraints were applied in the FEA such that the distal bony regions were fully fixed at 200 mm from the resection level of the tibia. The contact algorithms utilized for each of the different interfaces are shown in Table 3. Mechanical event simulations were conducted on all of the assemblies and the micromotion in the direction of the applied load beneath the distal stem region was evaluated.

RESULTS & DISCUSSION: Test results are shown in Figure 2. An increase in micromotion values were observed with symmetric tibial base, cancellous bone support, and decrease in stem length. No effects of stem diameter on the micromotion values were observed. The current study also demonstrated that micromotion values increase linearly as the applied load increases signifying that tibial implants in heavier patients may be subjected to a higher risk of loosening.

Table 1: Design Parameters

Implant Dimensions & Parameters Evaluated					
Parameter- Implant Base	Implant Dimensions (mm)			Parameter- Stem Dia. & Length (mm)	
	ML	AP			
			Medial	Lateral	Dia
Symmetric	70	47.6	47.6	11	100
					140
Asymmetric	70	52.0	46.5	11	100

Table 2: Material Properties

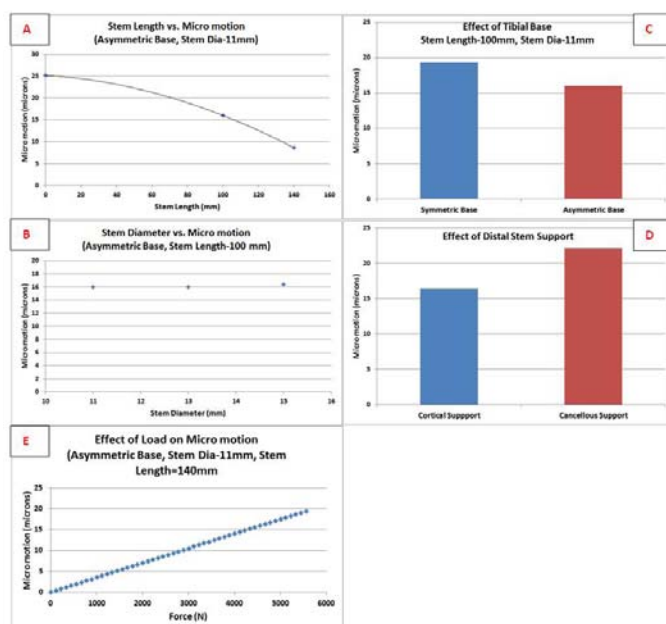
Material Properties		
Material Properties ¹	Elastic Modulus (Msi)	Poisson's ratio
Base, keel, stem- all assigned as ASTM F136 alloy	16.5	0.31
Cement	0.26	0.35
Cortical bone	2.47	0.30
Cancellous bone	65.3 ksi	0.30

Note: 1. All of the materials were assigned with homogenous isotropic material properties.

Table 3: Contact Algorithms

Contact Algorithm used in FEA	
Contact type	
Bonded	Surface-Surface Contact [*]
Base-Keel	Stem-Cortical bone
Keel-Stem	Stem-Cancellous bone
Cement-Base	Tibial Base-Cancellous bone
Cortical bone-Cancellous bone	Keel-Cancellous bone
Cement-Cortical bone	
Cement-Cancellous bone	

Note: All the surface-surface contact interfaces were set to frictionless contact as they result in the worst case.



K690

Is Component Rotation in Kinematically Aligned Total Knee Arthroplasty Performed with Generic Instruments Compatible with High Function?

Primary Author: Alexander J. Nedopil

Institution: Department of Orthopaedics, University of California, Davis

Coauthors: v Stephen M. Howell (Department of Mechanical Engineering, University of California, Davis), Maury L. Hull (Department of Biomedical Engineering, University of California, Davis)

BACKGROUND: Total knee arthroplasty (TKA) is a successful procedure for the majority of patients, however 20-25 percent of patients with a mechanically aligned TKA report dissatisfaction with their knee function. Correctly setting internal-external (I-E) rotation of the tibial and femoral components is one factor that affects function. In normal knee function, the tibia and patella flex and extend about two transverse axes perpendicular to the sagittal kinematic plane. If the goal is to restore normal knee function after TKA, then the ideal plane for setting the rotation of the tibial and femoral components is the sagittal kinematic plane. In kinematically aligned TKA, the method for setting the rotation of the femoral component is to adjust the thickness of the posterior femoral resections so they

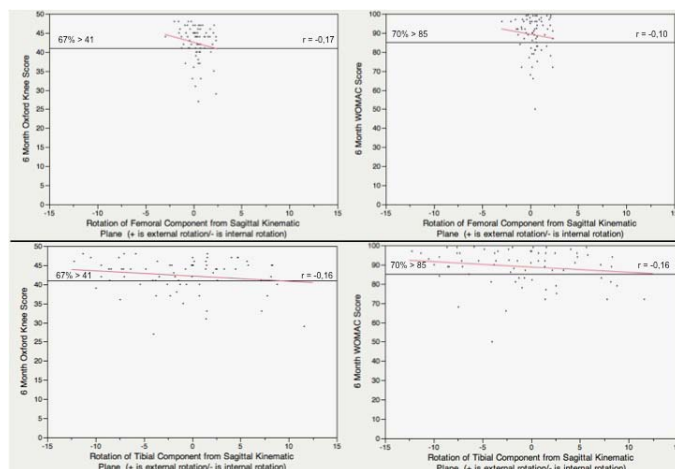
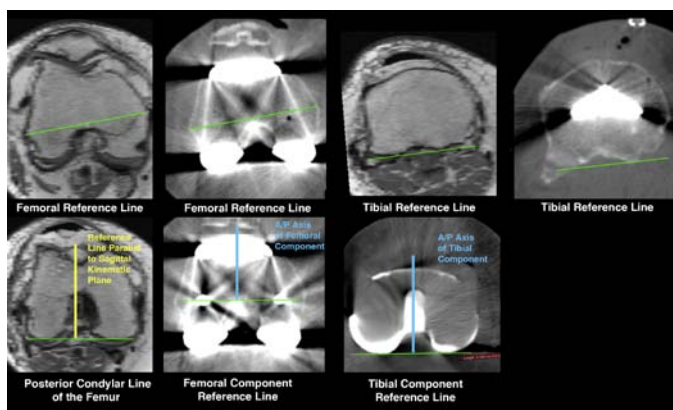
equal that of the posterior regions of the condyles of the femoral component after compensating for wear and kerf. The method for setting the rotation of the tibial component is to align the anterior-posterior (AP) axis of the trial tibial component parallel to the major axis of the nearly elliptical boundary of the lateral tibial condyle.

PURPOSE: The present study determined whether these two methods reliably set the rotation of the femoral and tibial components parallel to the sagittal kinematic plane in a case-series of patients treated with kinematically aligned TKA performed with generic instruments, and then determined whether the range of rotation achieved with these methods is compatible with high function.

METHODS AND MATERIALS: The study consisted of 71 consecutive patients treated with a kinematically aligned TKA performed with generic instruments, a preoperative magnetic resonance image (MRI) scan, and a post-operative computer tomogram (CT) scan of the knee. The femoral component was positioned by making posterior femoral resections equal to the thickness of the femoral component after correcting for wear and kerf. The A-P axis of the tibial component was set parallel to the major axis of the nearly elliptical boundary of the lateral tibial plateau. Common femoral and tibial reference lines constructed on MRI (Figure 1 A,C,D,E) and CT scans (Figure 1 B,D,F,G) enabled computation of the rotation of the femoral and tibial components from the sagittal kinematic plane (- internal rotation). An average Oxford knee score > 41 (best 48) and WOMAC score > 85 (best 100) at 6 months indicated high function.

RESULTS: For all patients, the average Oxford knee score of 42 and the average WOMAC score of 89 indicated high function. The -3° to 2° range of rotation of the femoral component (Figure 2 upper row) and the -11° to 12° range of rotation of the tibial component (Figure 2 lower row) from the sagittal kinematic plane was not predictive of the Oxford knee score or the WOMAC score.

DISCUSSION: These two described methods of rotationally aligning the femoral and tibial components are useful surgical techniques in kinematically aligned TKA as they reliably align the femoral and tibial components within a range of rotation from the sagittal kinematic plane that is compatible with high knee function.



K691

The Clinical Effects of Post-Operative Anterior-Posterior Length Mismatch in Distal Femur After Total Knee Arthroplasty

Primary Author: Masataka Nishikawa

Institution: Department of Orthopaedic Surgery, Osaka Koseinenkin Hospital, Osaka, Japan

Coauthors: Hajime Owaki (Osaka Koseinenkin Hospital, Osaka, Japan), Takeshi Fuji (Osaka Koseinenkin Hospital, Osaka, Japan)

INTRODUCTION: Recently, anatomic differences of the distal femur in gender and races were reported. Especially in total knee arthroplasty (TKA), relationship between anterior-posterior (AP) length and medial-lateral width of the distal femur is very important in implant design. Because majority of implants current used in Japan were designed using Caucasian distal femoral anatomy, anatomical size mismatch in Japanese distal femur were seen in some cases.

OBJECTIVE: The objective of this study was to evaluate the clinical effects of post-operative AP length mismatch in Japanese distal femur after TKA, by measuring the differences between pre-operative and post-operative AP length in distal femur.

METHODS: Two-hundred two Japanese patients who underwent TKA in Osaka Koseinenkin Hospital from April, 2009 to August, 2012 were included in this study. The genders and diagnoses were 28/ 174 patients (male/ female) and 162/ 40 patients [osteoarthritis / rheumatoid arthritis], respectively. The mean age, height and body weight were 73.0 years, 152.1 cm and 53.7 kg, respectively. We defined AP length as the length between top of lateral flange and bottom of lateral posterior condyle. We measured pre-operative AP length using computed tomography. We defined post-operative AP length as femoral component AP length provided from manufactures. We measured the differences from post-operative to the pre-operative AP length. We classified them into 3 groups (Smaller: difference 2mm). We evaluated post-operative range of motion (ROM) and Knee Society scores (Knee score: KS and Function score: FS) in these 3 groups at 1 year follow-up. In Statistics, Kruskal-Wallis one-way analysis of variance by ranks was assessed. Analyses were carried out with Statcel 3 software (The Publisher OMS Ltd., Saitama, Japan). For all tests, probability values (p values) of

RESULTS: The numbers of 3 groups (Smaller/ Same/ Bigger) were 54/ 112/ 36, respectively. The pre-operative knee extension angles in 3 groups (Smaller/ Same/ Bigger) were -10.9 degrees/ -12.2 degrees/ -12.1 degrees, respectively. The pre-operative knee flexion angles were 127.3 degrees/ 119.2 degrees/ 125.6 degrees, respectively. The pre-operative KS were 33.0/ 32.1/ 31.2, respectively. The pre-operative FS were 51.9/ 48.7/ 49.6, respectively. The pre-operative ROM and Knee Society scores in 3 groups were not significant. The post-operative knee extension angles in 3 groups (Smaller/ Same/ Bigger) were -2.1 degrees/ -2.6 degrees/ -4.9 degrees, respectively. The post-operative knee flexion angles were 128.1 degrees/ 124.0 degrees/ 123.9 degrees, respectively. The post-operative KS were 95.4/ 95.7/ 93.5, respectively. The post-operative FS were 77.3/ 73.2/ 72.6, respectively. The post-operative ROM and Knee Society scores in 3 groups were not also significant.

CONCLUSION: Although we hypothesized that anatomical AP length mismatch after TKA affect the ROM and

Knee Society scores because of unbalanced extension-flexion gap, there were no significant difference in 3 groups. In conclusion, the post-operative anterior-posterior length mismatch in distal femur after TKA did not affect clinical results at 1 year follow-up, however we have to pay attention to the effect of component loosening and clinical results in long-term follow-up.

K692

Severe Varus Knee Deformity is a Risk Factor for Abnormal Knee Kinematics After Fixed Bearing TKA

Primary Author: Yusuke Nishio

Institution: Department of Orthopaedic Surgery, Hokkaido University Graduate School of Medicine

Coauthors: Tomohiro Onodera (Department of Orthopaedic Surgery, Hokkaido University Graduate School of Medicine), Yasuhiko Kasahara (Department of Orthopaedic Surgery, Hokkaido University Graduate School of Medicine), Daisuke Takahashi (Department of Orthopaedic Surgery, Hokkaido University Graduate School of Medicine)

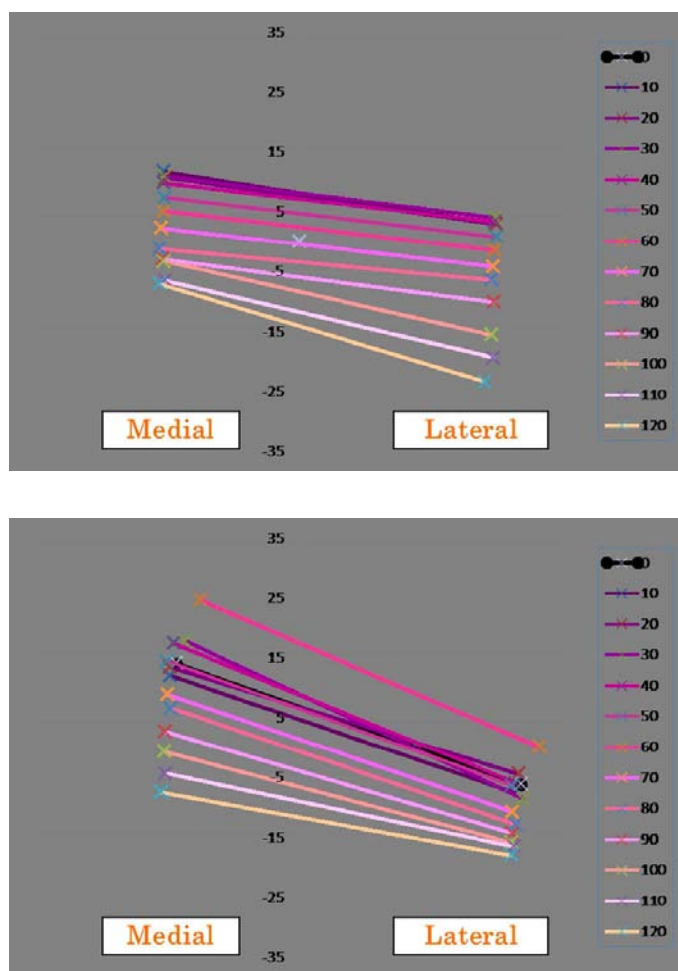
INTRODUCTION: Total knee arthroplasty (TKA) is a well-established procedure associated with excellent clinical results. We have previously reported that intraoperative knee kinematics correlate with the clinical outcome in mobile bearing TKA. In addition, the intraoperative knee kinematics pattern does not correlate with the degree of preoperative knee deformity in mobile bearing TKA. However, the relationship among preoperative knee deformity, intraoperative kinematics and clinical outcome in fixed bearing TKA has been unknown. The purpose of this study is to compare the relationship among preoperative knee deformity, knee kinematics after fixed bearing TKA and the clinical outcome including the subjective outcomes evaluated by the new knee society score (KSS).

MATERIALS AND METHODS: A cross-sectional survey of thirty-five consecutive medial osteoarthritis patients who had a primary TKA using a CT-based navigation system was conducted. All knees had a Kellgren-Lawrence grade of 4 in the medial compartment and underwent a primary posterior stabilized TKA (Genesis II, Smith&Nephew) between May 2010 and October 2012. In all cases, a computed tomography-guided navigation

system (Brain LAB, Heimstetten, Germany) was used. All surgery was performed by the subvastus approach and modified gap technique. Intraoperative knee kinematics was measured using the navigation system after implantation and closure of the retinaculum and soft tissue except for the skin. Subjects were divided into two groups based on intraoperative kinematic patterns: a medial pivot group (M group, n=19) and a non-medial pivot group (N group, n=16). Subjective outcomes with the new KSS and clinical outcomes were evaluated. Statistical analysis to compare the two groups was made using unpaired a Student t test.

RESULT: Regarding the postoperative clinical result (knee flexion angle, knee extension angle, mechanical FTA, % mechanical axis), there were no significant differences between the two groups. Although there were also no significant differences in KSS evaluation between the two groups, there was a tendency for M group to be superior to N group in current knee symptom (M group: 17.3 ± 5.6 , N group: 12.9 ± 8.2 , $p = 0.07$) and functional activities (M group: 55.1 ± 21.5 , N group: 42.7 ± 22.6 , $p = 0.10$). Regarding preoperative examination, varus knee deformity (mechanical FTA and % mechanical axis) in N group was significantly more severe than that of M group ($p=0.04$, $p=0.04$, respectively).

DISCUSSION: Over half of patients (54%) could achieve medial pivot kinematics in fixed bearing TKA with the possibility to improve a subjective clinical result. Although we previously could not detect any relationship between preoperative varus knee deformity and intraoperative kinematics in mobile bearing TKA, the preoperative varus knee deformity in the non-medial pivot group was significantly severer than that of the medial pivot group in fixed type TKA. Our results indicate that if a TKA is done to a severe varus knee deformity the postoperative knee kinematics tend to result in a non-medial pivot pattern. In conclusion, because it tends to result in a non-medial pivot pattern, extra care needs to be taken to avoid postoperative abnormal knee kinematics in the performance of a fixed type TKA to a severe varus knee deformity.



K693

An In Vivo Biomechanical Characteristics of Soft-Tissue Stiffness in Osteoarthritic Knees Undergoing Posterior-Stabilized Total Knee Arthroplasty

Primary Author: Hitoshi Nochi

Institution: Asahikawa Medical University

Coauthors: Satomi Abe (Asahikawa Medical University), Takuya Ruike (Asahikawa Medical University), Yu-suke Sasaki (Asahikawa Medical University), Hiroshi Ito (Asahikawa Medical University)

INTRODUCTION: The assumption that symmetric extension-flexion gaps improve the femoral condyle lift-off phenomenon and the patellofemoral joint congruity in total knee arthroplasty (TKA) is now widely accepted. For these reasons, the balanced gap technique has been developed. However, the management of soft tissue balancing during surgery remains difficult and much is left to the surgeon's

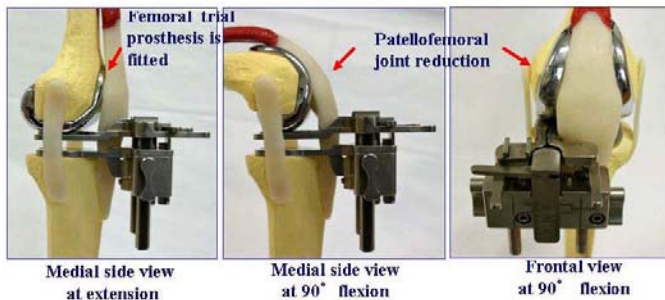
feel and experience. Furthermore, little is known about the differences of the soft-tissue stiffness (STS) of medial and lateral compartment in extension and flexion in the both cruciate ligaments sacrificed knee. It has a deep connection with the achievement of appropriate gaps operated according to the balanced gap technique. Therefore, the purpose of this study was to analyze the STS of individual compartment in vivo.

MATERIALS AND METHODS: The subjects presented 100 osteoarthritic knees with varus deformity underwent primary posterior stabilized (PS) -TKA (NexGen LPS-flex, Zimmer, Warsaw, USA). All subjects completed written informed consent. The patient population was composed of 14 men and 68 women with a mean age of 74.5 ± 7.5 years. The average height, weight, BMI, weight-bearing femoro-tibial mechanical angle (FTMA), the patella height (T/P ratio), extension and flexion angle of the knee under anesthesia were 151.9 ± 7.8 cm, 62.1 ± 9.4 kg, 26.9 ± 3.7 kg/m², $167.7 \pm 5.6^\circ$, $0.91 \pm 0.15^\circ$, $-12.0 \pm 6.7^\circ$ and $129.4 \pm 13.8^\circ$, respectively. After finishing osteotomy and soft tissue balancing, the femoral trial prosthesis was fitted with patello-femoral joint reduction. Then, the medial and lateral compartment gaps (CG) were measured at various distraction forces (89 – 178 N) using a newly developed versatile tensor device at full extension and 90° flexion positioning, respectively. (Fig.1) The STS (N/mm) was calculated from a load displacement curve generated by the intra-operative CG data and joint distraction force. Comparisons were made by Wilcoxon signed-ranks test. Correlations were analyzed with Pearson's correlation coefficient. Predictive variables were analyzed with Stepwise regression. A value of P

RESULTS: The CG discrepancy between the medial and the lateral compartments significantly increased as the force dependent manner in the knee at extension ($P < 0.0004$) and 90° flexion position ($P < 0.0001$). Significant differences ($P < 0.0001$) were observed in the STS among all compartments respectively; extension medial (71.0 ± 33.9), flexion medial (26.1 ± 11.6), extension lateral (60.2 ± 36.4) and flexion lateral (19.4 ± 8.2). The ratio of medial to lateral compartment STS ($R = -0.54$) and the difference of the STS between the medial and lateral compartments ($R = 0.385$) were significantly correlated with the flexion CG discrepancy ($P < 0.0001$). The predictive variables of the STS could be acquired in extension medial, extension lateral and the ratio of flexion lateral to flexion medial.

DISCUSSION: We should notice the significant difference of the STS between the medial and lateral compartments and the ratio of the medial to lateral compartments STS, especially when the balanced gap technique is used. It suggests the importance of refinement of the joint distraction force for individual patients based on their own characteristics of soft tissue.

Figure 1



K694

Radiographic Analysis of a Degenerative Change in the Flexion Coronal Alignment of the Lower Extremity

Primary Author: Hitoshi Nochi

Institution: Asahikawa Medical University

Coauthors: Satomi Abe (Asahikawa Medical University), Takuya Ruike (Asahikawa Medical University), Yu-suke Sasaki (Asahikawa Medical University), Hiroshi Ito (Asahikawa Medical University)

INTRODUCTION: Achieving physiological alignment of the lower extremity is important to surgeons who perform reconstructive surgery. However, little has known the coronal alignment of the knee at a sitting position. For these reasons, the aim of this study was to assess the physiological flexion coronal alignment of the lower extremity and its degenerative change by radiographic analysis.

MATERIALS AND METHODS: All patients provided informed consent.

PATIENTS: In this prospective study, 100 knees in 82 patients who visited our hospital with complaints about suffering around their knees. The range of age was from 19 to 86 years old. The patients who had collagen disease or malunion fracture in their lower extremity were excluded. The patients were classified into two groups by the degree

of knee deformity according to the Kellgren-Lawrence osteoarthritis classification. 50 knees, which were Grade I or less, were classified as the No-deformity group (Group N), and another 50 knees, which were Grade III or more, were classified as the Deformity group (Group D) Patient profiles of each group are shown in Table 1.

RADIOGRAPHIC EXAMINATION: To clearly visualize both the talus and the epicondyle of the femur, we modified the conventional axial radiography [1]. Using these images, the flexion coronal alignment of the knee, the angle θ between the clinical epicondylar axis (CEA) of the femur and the tibial mechanical axis, were evaluated. In addition, the femoro-tibial mechanical angle (FTMA) was evaluated using full-length weight-bearing plain radiographs.

STATISTICAL ANALYSIS: Data were expressed as mean \pm SD. Correlations were analyzed with Pearson's correlation coefficient and Fisher's z transformation of r. Comparisons were made by Mann-Whitney U test. Predictive variables were analyzed utilizing Stepwise regression. A value of $P < 0.05$ was considered significant.

RESULTS:

1. The angle θ was significantly correlated with FTMA. ($r=0.71$, $p<0.0001$. Fig.1).
2. The FTMA was significantly correlated with the flexion angle of the knee ($r=0.51$, $p<0.0001$), the extension angle of the knee ($r=0.48$, $p<0.0001$), age ($r=0.44$, $p<0.0001$), BMI ($r=-0.22$, $p=0.03$) and height ($r=0.21$, $p=0.03$), respectively.
3. The predictive variable of the angle θ was indicated as the following: The angle $\theta = 14.75 + 0.70 \times (\text{the FTMA}) - 0.19 \times (\text{the body weight})$. ($R=0.74$, $p<0.0001$).
4. The comparisons between Group N and G are shown in Table 1.

DISCUSSION: Here, we first demonstrated the coronal alignment of the lower extremity at a sitting position by newly developed axial radiography in Japanese people. The apparent results indicate that the CEA closely approximates the tibial mechanical axis of the people with apparently normal knees when the knees are in sitting position. More specifically, the FTMA is strongly correlated with the angle θ .

In conclusion, the CEA closely approximates the tibial mechanical axis of peoples with normal knees when the knees

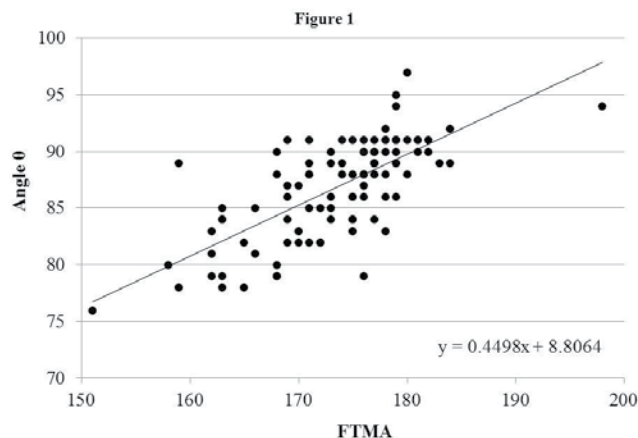
are in a sitting position. The variation of this is affected by several individual factors. Further studies are needed to clarify the relationships between the static flexion coronal alignment and the joint kinematics.

References:

1. Tokuhara Y., JBJS Br;88:1327-30, 2006.

Table 1

	Group N	Group D	P value
Age	57.2±16.5	76.4±6.0	<0.0001
Height (cm)	157.6±8.6	151.1±7.9	0.0002
Weight (kg)	59.6±11.9	60.9±8.7	0.33
BMI (kg/m ²)	23.9±4.0	26.7±4.0	0.0004
Extension angle of the knee (°)	-1.4±2.8	-13.1±4.1	<0.0001
Flexion angle of the knee (°)	144.0±6.5	18.3±16.99	<0.0001
mFTA (°)	177.3±3.2	169.7±7.5	<0.0001
Angle θ (°)	89.1±2.3	84.6±4.8	<0.0001



K695

The Flexion Coronal Alignment in Case When a Balanced Gap Technique is Used in a PS-TKA

Primary Author: Hitoshi Nochi

Institution: Asahikawa Medical University

Coauthors: Satomi Abe (Asahikawa Medical University), Takuya Ruike (Asahikawa Medical University), Hiroshi Ito (Asahikawa Medical University)

INTRODUCTION: Conventional understanding of knee kinematics suggests that the femoral component should be rotationally aligned parallel to the surgical epicondylar axis (SEA). In contrast, the balanced gap technique suggests the knee be balanced in extension and flexion to

achieve proper kinematics and stability of the knee without reference to fixed bony landmarks. To investigate the flexion-extension axis (FEA) when a balanced gap technique was used in the posterior-stabilized total knee arthroplasty (PS-TKA), the relationships between rotational alignment of the femoral component to the postoperative flexion gap balance and to the tibial mechanical axis were evaluated radiographically.

MATERIALS AND METHODS: In this prospective study, 63 consecutive knees in 50 patients were included with medial osteoarthritis undergoing a primary PS-TKA (NexGen LPS-Flex, fixed surface, Zimmer; Warsaw, USA). All subjects completed written informed consent. The patient population was composed of 8 men and 42 women with a mean age of 73.0 ± 7.7 years. The average height, weight, BMI, weight-bearing femoro-tibial mechanical angle (FTMA) and condylar twist angle (CTA) were 150.9 ± 7.2 cm, 62.3 ± 10.1 kg, 27.3 ± 4.0 kg/m², $167.8 \pm 5.5^\circ$ and $5.9 \pm 1.6^\circ$, respectively. All procedures were performed through a medial parapatellar approach and a balanced gap technique using a newly developed versatile tensor device. Pre- and post-operatively, the CTA was evaluated using computed tomography (CT). To assess the postoperative flexion gap balance, a condylar lift-off angle (LOA) was evaluated using the epicondylar view radiographs. The FTMA and coronal alignment of the tibial component in reference to the tibial mechanical axis (angle β) were evaluated using AP plain radiography. The FEA (angle θ) of the knee was calculated as the following; (angle β) + (post-operative CTA) – (LOA). Correlations were analyzed with Pearson's correlation coefficient. Predictive variables were analyzed utilizing Stepwise regression. A value of $P < 0.05$ was considered significant.

RESULTS: Only two knees (3.2%) needed a lateral retinaculum release due to poor patella tracking. The average post-operative FTMA, angle β , LOA, and CTA were $178.7 \pm 3.0^\circ$, $89.6 \pm 1.3^\circ$, $0.7 \pm 1.5^\circ$, and $1.3 \pm 2.3^\circ$, respectively. The average angle θ was $90.2 \pm 2.8^\circ$, and significantly correlated with the post-operative CTA ($r=0.77$), angle β ($r=0.42$) and the LOA ($r=-0.37$). Moreover, the predictive variables of the angle θ was the following, $68.41 + 1.04 \times$ (post-operative CTA) + $0.12 \times$ (post-operative FTMA) – $0.93 \times$ (LOA). ($R^2=0.805$)

DISCUSSION: This study demonstrated that the clinical epicondylar axis (CEA) was closely perpendicular to the tibial mechanical axis in PS-TKA with well balanced

extension-flexion gap achieved by the balanced gap technique. This result also suggests the possibility of that the femoral component which is rotationally aligned parallel to the CEA would make the flexion balance better when an anatomical measured resection technique is used in a PS-TKA.

CONCLUSION: The functional flexion-extension axis in a PS-TKA with well balanced extension-flexion gap closely approximates the clinical epicondylar axis.

K696

Is Femorotibial Angle Correctable After Oxford Unicompartmental Knee Arthroplasty?

Primary Author: Kanna Nonaka

Institution: Shonan Kamakura General Hospital Knee Joint Reconstruction Center

Coauthors: Ichiroh Tatsumi (Shonan Kamakura General Hospital Knee Joint Reconstruction Center), Takeaki Ueno (Shonan Kamakura General Hospital Knee Joint Reconstruction Center)

BACKGROUND: The indication for Oxford Unicompartmental Knee Arthroplasty (UKA) is anteromedial osteoarthritis (AMOA). AMOA is defined that cartilage loss limited to the anterior tibial plateau and the extension surface of the femur. The cartilage on the back of the tibia and femoral flexion surface is intact. In addition, correctable varus deformity by valgus stress and normal lateral compartment. In Oxford UKA, the surgical technique only seeks to create symmetric flexion and extension gaps. The femorotibial angle (FTA) is checked in other UKAs except for Oxford during the operation. The purpose of this study is to investigate that FTA could be corrected after Oxford soft-tissue balancing technique without checking FTA.

PATIENTS AND METHODS: 100 knees of 93 patients (23 male patients 70 female patients) had a hemi arthroplasty with Oxford technique between January 2011 and November 2013. All patients were anteromedial osteoarthritis as described by White et al. (1) Standing 3-foot radiography was performed preoperatively and postoperatively setting both patella and foot in front. All radiographs were taken by the same technician, and the FTA was measured.

RESULTS: The operated unilateral knees had an average preoperative FTA of 186.45° ($175\sim 200^\circ$) and postoperatively FTA of 175.52° ($166\sim 190^\circ$). The varus deformity was corrected into normal FTA without checking FTA in the operation procedure. The average correction angle is 10.93° ($3\sim 27^\circ$).

They are divided into three groups. Groupe I: 14 knees were slightly varus preoperatively. The average FTA is 178.57° ($175\sim 180^\circ$) corrected into 172.14° ($169\sim 176^\circ$). The average correction angle is 6.42° . Groupe II: 57 knees were moderate varus preoperatively. The average FTA is 186.23° ($181\sim 190^\circ$) corrected into 175.73° ($166\sim 182^\circ$). The average correction angle is 10.53° . Groupe III: 29 knees were severe varus preoperatively. The average FTA is 194.51° ($191\sim 200^\circ$) corrected into 176.68° ($166\sim 186^\circ$). The average correction angle is 15.83° .

DISCUSSION: When the osteoarthritis of the knee stay in anteromedial, the tension of anterior cruciate ligament (ACL) and medial collateral ligament (MCL) is intact in knee flexion. However the tension of MCL in knee extension is loose because the loss of cartilage only in extension. Symmetric flexion and extension gaps are created by means of measured bone removal using graduated feeler gauges. The result of this study shows the varus deformity could be corrected into normal without checking FTA in the operation procedure. And how severe the varus is, if the knee stays in AMOA, equal tension is created throughout the range of motion and the FTA is corrected without releasing any ligaments.

CONCLUSION: The Oxford soft-tissue balancing technique corrects the alignment of the knee without checking FTA in the operation procedure.

K697

In Vitro Fabrication of Scaffold-Free Meniscus-Like Constructs Using a Bio-3D Printer

Primary Author: Toshiyuki Oshima

Institution: Saga University

Coauthors: Miho Kawakatsu (Saga University), Mai Tanaka (Saga University), Rihito Iwasaki (Saga University), Koichi Nakayama (Saga University)

PURPOSE: We established a system for assembling scaffold-free cell constructs. And we also developed an automatic fabrication device named “Bio-3D printer”, with which, we can fabricate scaffold-free constructs of various cell types, such as liver, blood vessels, and cartilage. In this study, we produced meniscus-like cell constructs with this system for meniscal reconstruction.

METHODS: Articular chondrocytes (ACs) and/or mesenchymal stem cells (MSCs) were purchased and used to make the spheroids (cell aggregates). For bio-3D fabrications, spheroids and 3D data of meniscus were set on an automatic spheroid assembling device (Regenova; Cyfuse Biomedical K.K.). After about 2 hours, cell constructs were obtained, which resembled the 3D data, and kept in circulating culture for 2 weeks to promote the production of extracellular matrix (ECM). The locations of collagen and proteoglycan in these structures were analyzed by immunostaining and Safranin-O. The expressions of collagen and glycosaminoglycan (GAG) were detected by Enzyme-Linked Immunosorbent Assay (ELISA) and Blyscan Glycosaminoglycan Assay (Biocolor Ltd.).

RESULTS & CONCLUSIONS: It is possible to make meniscus-like 3D constructs by using the Bio-3D printer (Figure 1). We observed that the cell constructs contained type II collagen and GAG, the chondrocytic phenotype of which was maintained for 2 weeks at least. They had acceptable mechanical properties in spite of using scaffold-free system. These structures were hard enough to be picked up with tweezers (Figure 2), but softer than native meniscus. Our next objective is to optimize the conditions of culture to promote the production of ECM and increase the stiffness. Therefore, we consider that the scaffold-free cell constructs fabricated by using this system may have meniscal function adequate enough for clinical application.



Figure 1. Comparison of among the native meniscus, 3D data and the cell construct.



Figure 2. The cell construct picked with tweezers.

K698

The Extension Gap in Total Knee Arthroplasty Increases After Posterior Capsular Release Around the Intercondylar Area

Primary Author: Yoshinori Okamoto

Institution: Department of Orthopedic Surgery, Osaka Medical College

Coauthors: Mikio Nakajima (Department of Orthopedic Surgery, Osaka Medical College) Tsuyoshi Jotoku (Department of Orthopedic Surgery, Osaka Medical College) Hidetsugu Ohara (Department of Orthopedic Surgery, Osaka Medical College) Shuhei Otsuki (Department of Orthopedic Surgery, Osaka Medical College)

INTRODUCTION: Limited knee extension is associated with a poor outcome of total knee arthroplasty (TKA). Posterior capsular release is recognized as a valid technique to prevent the intraoperative limitation of extension, although the question is remained whether the capsular release at the posterosuperior portion around the intercondylar area contributes a gain in extension. The purpose of this study was to measure the extension gap before and after posterosuperior capsular release and to clarify whether the capsular tension around the posterosuperior area is related to the knee extension gap.

MATERIALS AND METHODS: Among the patients who underwent posterior-stabilized press-fit condylar sigma rotating-platform high-flexion (PFC sigma RP-F) TKA for the diagnosis of medial knee osteoarthritis, we enrolled 32 patients in our study who had intraoperative flexion contracture requiring capsular release of the posterosuperior portion around the intercondylar area under

a non-implantable femoral trial. The mean age of the patients was 75 (range, 59 to 83) years. Preoperative mean range of motion was 121.6 degrees of flexion (range, 80 to 150 degrees) and -12.4 degrees of extension (range, -35 to 0 degrees), and the mean femorotibial angle was 184.2 (range, 180 to 195) degrees. After the femoral and tibial osteotomy, we measured the extension gap while the patella was reversed with a knee extension of 0 degree using a knee balancer (DePuy Orthopaedics Inc., Warsaw, IN, USA) [Fig.1] with and without femoral trial. We applied a joint distraction force of 44 lbs. and measured the extension gap in the medial and lateral spaces at the osteotomy sites. After full knee extension was obtained by posterosuperior capsular release, we measured the extension gap with and without femoral trial again.

RESULTS: Before the posterosuperior capsular release, the mean medial and lateral extension gap was 11.4 mm and 11.9 mm with the femoral trial, and 22.9mm and 24.3 mm without the trial, respectively.

After the release, the mean medial and lateral extension gap changed to 13.0 mm (t-test, $p < 0.0001$) and 14.0 mm ($p < 0.0001$) with the femoral trial, and 23.3 mm ($p = 0.04$) and 24.9 mm ($p = 0.02$), without the trial, respectively.

Increment of medial and lateral extension gap was 1.6 mm and 2.1 mm with the femoral trial, compared with 0.4 mm and 0.6 mm without the trial, respectively.

DISCUSSION: Our study demonstrated that posterosuperior capsular release increased the intraoperative extension gap in our patients. Thus, in posterior-stabilized TKA, the capsular tension around the cam affects the extension gap, particularly in a RP-F with a massive cam [Fig.2]. Posterosuperior capsular release increased the extension gap by 1.6 to 1.8 mm with the femoral trial, compared with a 0.2 to 0.3 mm increase without the trial. We conclude that posterosuperior capsular release was effective to prevent postoperative flexion contracture and this capsular release should be performed under the mounted trial while checking the gap step-by-step to prevent overestimation of the extension gap and postoperative hyperextension.



K699 **The Patient-Perceived Leg Length Discrepancy After Total Hip Arthroplasty in Unilateral Hip Osteoarthritis Patients**

Primary Author: Yusuke Okanoue

Institution: Department of Orthopaedic Surgery, Kochi Medical School, Kochi University, Japan

Coauthors: Teruhiko Kawakami (Department of Orthopaedic Surgery, Kochi Medical School, Kochi University, Japan) Yusuke Murohushi (Department of Rehabilitation, Kochi Medical School, Kochi University, Japan), Masashi Izumi (Department of Orthopaedic Surgery, Kochi Medical School, Kochi University, Japan)

Leg-length discrepancy (LLD) following total hip arthroplasty (THA) is often showed as a reason for functional impairment and patient dissatisfaction. Recently, it is reported that accuracy of the leg-length can be improved using the mechanical devices, pins, tape/ruler measures, or computer navigation system. However, some patients perceived feeling of inequality leg-length, even if correction of anatomical leg-length equality after THA. In addition, it was no evident what influence has the perceived LLD has exerted on functional outcome after THA. The purpose of this study was to identify risk factors for perceived LLD and clinical outcome after THA. Between June 2012 to June 2013, 34 primary THAs were performed for unilateral hip osteoarthritis. There were 27 females and 7 males. The mean age of patients at surgery was 66 years old (range 52 to 83). Anteroposterior pelvic radiographs in standing position were obtained before and 6 months after the surgery for measurements of anatomical LLD, coronal pelvic inclination and, femoral adduction angle using CIS-image

(IBM Corporation, Tokyo, Japan). The perceived LLD was measured by the block test, which was defined by Harris et al [Fig.1]. In addition to Harris Hip Score (HHS) and Oxford Hip Score (OHS) were also obtained to assess the clinical outcome. Mean preoperative anatomical LLD was -15.9mm (-25.4 to 7.4), perceived LLD was -4.6mm (-15.0 to 15.0). Mean postoperative anatomical LLD was 2.3 mm (-3.6 to 8.8), perceived LLD was 3.3 mm (0 to 15) at 6 months after surgery. Five patients (15%) perceived feeling of inequality leg-length at 6 months after surgery. Mean differences between anatomical LLD and perceived LLD was 4.8mm (-7.4 to 15.4) at 6 months after surgery. In the multiple regression analysis, preoperative differences between anatomical LLD and perceived LLD, and postoperative coronal pelvic inclination were significant contributors to postoperative differences between anatomical LLD and perceived LLD. Furthermore, perceived LLD influenced the clinical outcome as measured by the HHS and OHS at 6 months after surgery. The most important findings in this study were: 1) fifteen percent of patients perceived feeling of inequality leg-length at 6 months after surgery, even if correction of anatomical leg-length equality 2) patients perceived LLD influenced the clinical outcome. Therefore, we recommend that surgeons should be better to pay attention to preoperative differences between anatomical LLD and perceived LLD at preoperative planning to reduce the perceived LLD after THA. There are several limitations in our study. Firstly, this was a retrospective study with a small number of patients. Secondly, preoperative spinal alignment and contractures of hips and knees were not evaluated in this study. Despite these limitations, we believe that this study provides clinically important information about reducing perceived LLD for success in THA.



K700

Short-term Outcomes of Robotic-Assisted Bicompartamental Knee Arthroplasty

Primary Author: Gary Poehling

Institution: Wakeforest University School of Medicine

Coauthors: Cuneyt Tamam (Wakeforest University School of Medicine), Johannes F. Plate (Wakeforest University School of Medicine), Marco Augart (Wakeforest University School of Medicine), Thorsten M. Seyler (Wakeforest University School of Medicine), Sarah Von Thae (Wakeforest University School Of Medicine), Riyaz H. Jinnah (Wakeforest University School of Medicine)

INTRODUCTION: Bicompartamental knee arthroplasty (BKA) may be an alternative to total knee arthroplasty (TKA) for degenerative disease limited to two knee compartments. Most commonly, BKA is a combination of medial compartment and patellofemoral compartment resurfacing. In contrast to TKA, BKA preserves the uninvolved compartment and cruciate ligaments possibly leading to advanced stability and more physiologic knee kinematics. Robotic-assisted systems for unicompartmental knee arthroplasty have shown to provide improved component positioning with dynamic ligament balancing that may improve outcomes of BKA. The purpose of this study was to evaluate the short-term outcomes of patients undergoing BKA at a single institution by a single surgeon using a robotic-assisted system.

METHODS: A search of the institution's joint registry was conducted to identify patients that underwent robotic-assisted BKA of the patellofemoral compartment and the medial or lateral compartment between 2010 and 2012. All medical records were analyzed for patient demographics and comorbidities. Patients were contacted by phone when recent follow-up was not available.

RESULTS: A total number of 29 patients (30 BKA) with a mean age of 63.6 years (range 39 to 82) were identified who received a patellofemoral resurfacing in combination with medial (25, 83%) or lateral (5, 17%) compartment resurfacing. The mean BMI was 33.7 kg/m² (range, 21.5 to 51.8), median Charlson comorbidity index score was 0, median American Society of Anaesthesiologists' (ASA) classification was 3. The mean length of surgery was 40.2 minutes (range, 23 to 151). At a mean follow-up of 15 months (range, 2 to 54), 3 patients (10%, 2 patello-

femoral and lateral compartment, 1 patellofemoral and medial compartment) underwent arthroscopic debridement of loose cement fragments following BKA. One patient (3%, patellofemoral and lateral compartment) received manipulation under anesthesia and botulinum neurotoxin injections into the hamstrings for postoperative flexion contracture and another patients (3%, patellofemoral and medial compartment) underwent open lateral retinacular release. There were no component revisions noted during the follow-up period.

DISCUSSION: Robotic-assisted BKA appears to be a viable option for patients with bicompartimental degenerative disease of the knee. In the current series, patients experienced good outcomes in the short-term without any component revisions. However, long-term follow-up will be necessary to discern outcomes of BKA from TKA.

K701

Periprosthetic Fracture After MIPO for a Femoral Stress Fracture at Tracker of Computer Navigated Total Knee Replacement

Primary Author: Kodali Siva Rama Prasad

Institution: Prince Charles Hospital

Coauthors: Rakesh Kumar (Prince Charles Hospital, Merthyr Tydfil, United kingdom), Ajay Sharma (Prince Charles Hospital, Merthyr Tydfil, united kingdom), Kyriakos K. Karras (Prince Charles Hospital, Merthyr Tydfil, United Kingdom)

INTRODUCTION: Periprosthetic fracture after Minimally Invasive Plate Osteosynthesis (MIPO) of stress fracture involving femoral pin site tract in computer assisted total knee arthroplasty is unique in orthopaedic literature. We are reporting this unique presentation of periprosthetic fracture after MIPO for stress fracture involving femoral pin site tract in computer assisted total knee arthroplasty, treated by reconstruction nail (PFNA).

METHODS: A 75-year old female, who had computer navigated right total knee replacement 6 weeks back, was admitted with increasing pain over distal thigh for 3 weeks without trauma. Prior to onset of pain, she achieved a range of movements of 0-105 degrees. Perioperative radiographs did not suggest osteoporosis, pre-existent benign or malignant lesion, or fracture. Radiographs demonstrated trans-

verse fracture of distal third of femur through pin site track. We fixed the fracture with an 11-hole combi-hole locking plate by MIPO technique. Eight weeks later, she was readmitted with periprosthetic fracture through the screw hole at the tip of the MIPO Plate. She was treated by Reconstruction Nail (PFNA), removal of locking screws and re-fixation of intermediate segment with unicortical locking screws. Then she was protected with plaster cylinder for 4 weeks and hinged brace for 2 months.

RESULTS: She made uneventful recovery and was started on osteoporosis treatment, pending DEXA scan.

CONCLUSION: Reconstruction Nail (PFNA), re-fixation of intermediate segment with unicortical locking screws constitutes a logical management option for the unique periprosthetic fracture after MIPO of stress fracture involving femoral pin site tract in computer assisted total knee replacement.



K702

The Management of Fixed Flexion Deformity of the Knee and its Effects on Total Knee Arthroplasty Outcomes

Primary Author: Rohit Rambani

Institution: Leeds Teaching Hospital NHS Trust

Coauthor: Ram Venkatesh (Leeds Teaching Hospital NHS Trust)

BACKGROUND: In the year 2011-12, 84653 patients underwent a primary total knee replacement according to the UK National Joint Registry[1]. Osteoarthritis (OA) was one of the main indications for total knee replacement

(TKR) and fixed flexion deformity (FFD) is a common sequel to OA. Due to the increase in quadriceps effort during standing and walking there is easy fatigability and anterior knee pain associated with pre-existing FFD. Hence every effort is made to correct FFD during surgery for TKR.

METHODS: We reviewed the available literature on the incidence, classification and methods of correction of fixed flexion deformity after total knee arthroplasty.

RESULTS: The causes of fixed flexion deformity of the knee and methods of correction. It also evaluates the effect of fixed flexion deformity on long term outcomes of total knee arthroplasty.

CONCLUSION: However despite corrective efforts, residual FFD following TKR is common. Increasing numbers of patients are undergoing TKR and 20% patients are dissatisfied following TKR. Residual FFD is one factor that may contribute to poor outcome and reduced patient satisfaction following TKR. Refined patient selection and employing FFD correction methods will improve outcomes of TKR.

K703

A Novel Approach to Evaluating Tibiofemoral Implant Rotational Congruency Utilizing Intraoperative Sensors

Primary Author: Martin W. Roche

Institution: Holy Cross Hospital, Orthopedic Institute

Coauthors: Leah C. Elson (OrthoSensor, Inc.), Christopher R. Anderson (OrthoSensor, Inc.)

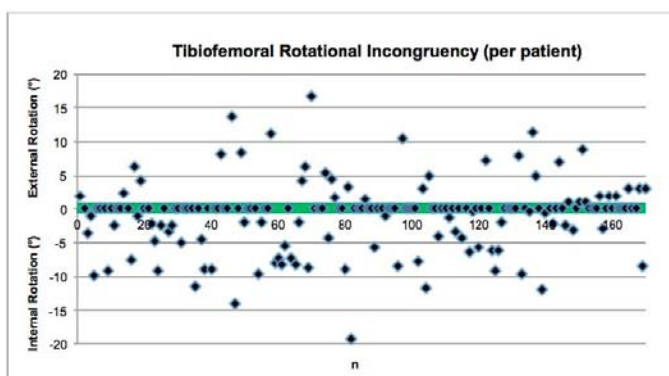
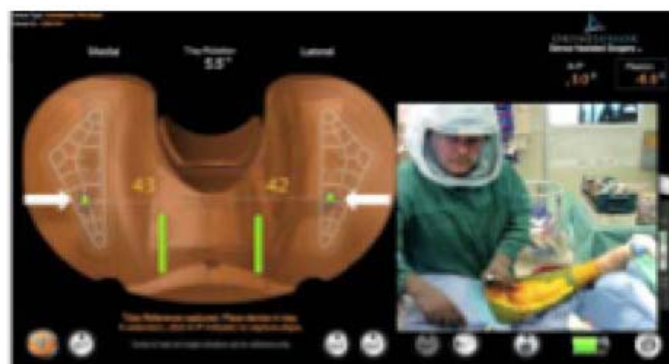
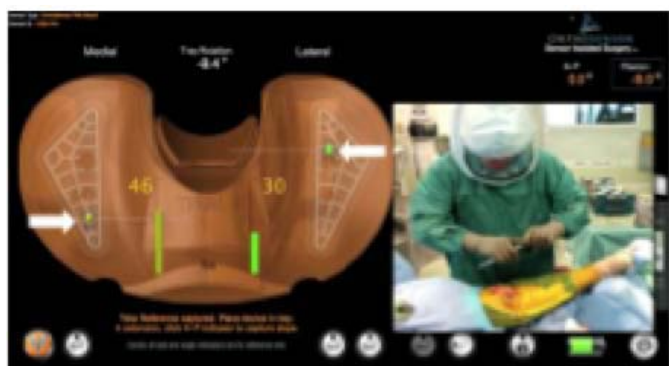
INTRODUCTION: Post-operative clinical outcomes of TKA are dependent on a multitude of surgical and patient-specific factors. Malrotation of the femoral and/or tibial component is associated with pain, accelerated wear of the tibial insert, joint instability, and unfavorable patellar tracking and dislocation. Using the transepicondylar axis to guide implantation of the femoral component is considered to be an accurate anatomical reference and is widely used. However, no gold standard currently exists with respect to ensuring optimal rotation of the tibial tray. Literature has suggested that implantation methods, which reference the tibial tubercle, reduce positioning outliers with more consistency than other anatomical landmarks. There-

fore, the purpose of this evaluation is to use data collected from intraoperative sensors to assess the true rotational accuracy of using the mid-medial third of the tibial tubercle in 170 TKAs.

METHODS: The data for this evaluation was retrieved from 170 consecutive patients who underwent primary TKA from the same highly experienced surgeon. Femoral component rotation was verified in every case via the use of the Whiteside line, referencing the transepicondylar axis, and confirming appropriate patellar tracking. Tibial tray rotation was initially established by location of the mid-medial third of the tibial tubercle. Rotational adjustments of the tibial tray were evaluated in real-time, as the surgeon corrected any tibiofemoral incongruency and tray malpositioning. The initial and final angles of tibial tray rotation were captured with intraoperative video feed, and recorded. A z-test of differences between pre- and post-rotational correction was performed to assess the statistical significance of malrotation present in this cohort.

RESULTS: All patients in this study received a primary TKA, using the mid-medial third of the tibial tubercle to dictate tibial tray rotation. After the sensor-equipped tibial trial was inserted, it was shown that 53% of patients exhibited unfavorable rotation. Of those patients, 68% were shown to have internal rotation; 32% were shown to have external rotation. The average tibiofemoral incongruency of the tibial tray deviated from a neutral position by $6^\circ \pm 4.0^\circ$, ranging from 0.5° to 19.2° . The z-test of differences yielded a p-value <0.0001 , indicating that the proportion of incongruency was statistically significant. The 95% confidence interval of this cohort was calculated to be between 39.8% and 66.8% of malrotation.

DISCUSSION: Malrotation in TKA is associated with poor clinical outcomes. While no gold standard anatomic landmark currently exists for positioning the tibial tray, the mid-medial third of the tibial tubercle is widely used as a reference. However, the data from this evaluation demonstrates that, not only is this landmark insufficient for establishing optimal rotation ($p < 0.0001$), but that it had guided the surgeon to an average of 6° outside of the optimized implant congruency zone. The large confidence interval indicates that the rotational alignment of the tibial tray—based on the location of the mid-medial third of the tibial tubercle—is not only inaccurate, but also highly variable.



K704

Post-operative Weight Gain After Total Knee Arthroplasty: Prevalence and Its Possible Attenuation Using Intraoperative Sensors

Primary Author: Martin W. Roche

Institution: Holy Cross Hospital, Orthopedic Institute

Coauthors: Gregory Golladay (aVCU Orthopedic Surgery), Gustke Kenneth (Florida Orthopaedic Institute), Leah Elson (OrthoSensor, Inc.), Christopher Anderson (OrthoSensor, Inc.)

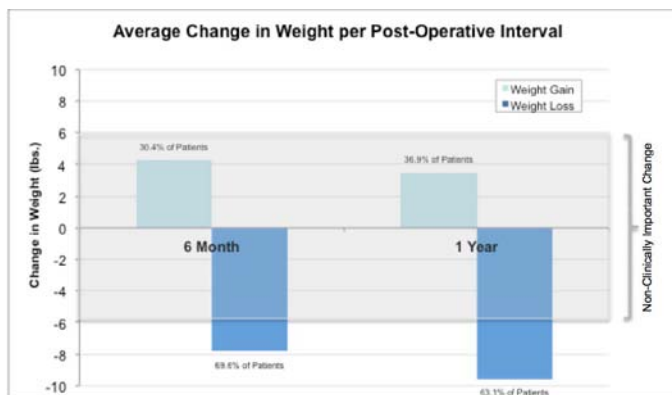
As the proportion of adults with obesity continues to climb,

so too does the need for total knee arthroplasty (TKA). Previous studies have shown that total knee reconstruction represents a risk factor for post-operative weight gain, despite a common conception by patients that TKA will aid in weight loss due to increased activity potential. It has been reported that patients with balanced knees, achieved with the use of intraoperative sensors, have shown significantly higher activity levels over patients with unbalanced knees.

The purposes of this study were twofold: 1) To execute a literature meta-analysis in order to quantify the changes in weight and body mass that are typically observed following TKA, and 2) Evaluate data from a prospective, multi-centric study to assess if patients with well-balanced TKA had less weight gain than expected at 6 months and one year.

Based upon the meta-analysis, 47-66% of patients gain weight following TKA, with an average post-operative weight gain of 9.5 lbs. (1.6 kg/m²) to 14 lbs. (2.3 kg/m²). In the sensor-balanced TKAs, 30.4% of patients and 36% of patients exhibited weight gain at 6 months and 1 year, respectively. The average weight gain was 4.3 lbs. (0.72 kg/m²) at 6 months, and 3.5 lbs. (0.58 kg/m²) at 1 year, both of which are non-clinically meaningful. At 6 months and 1 year, the patients who had not gained weight had an average weight loss of 7.8 lbs. (1.3 kg/m²) at 6 months and 9.6 lbs. (1.6 kg/m²) at 1 year. 15.1% of obese patients dropped to a lower BMI classification by the 6-month interval. 25.3% of morbidly obese (BMI>35) had dropped to a lower BMI classification at 1-year.

This evaluation demonstrates that weight gain after TKA is prevalent, but ensuring soft-tissue balance (via technologies such as intraoperative sensing) may help mitigate an increase in body mass.



K705

Normal Knee Laxity at 0° and 90° Flexion: A Benchmark for Assessing Soft Tissue Balance

Primary Author: Joshua D. Roth

Institution: University of California, Davis

Coauthors: Maury L. Hull (University of California, Davis), Stephen M. Howell (University of California, Davis)

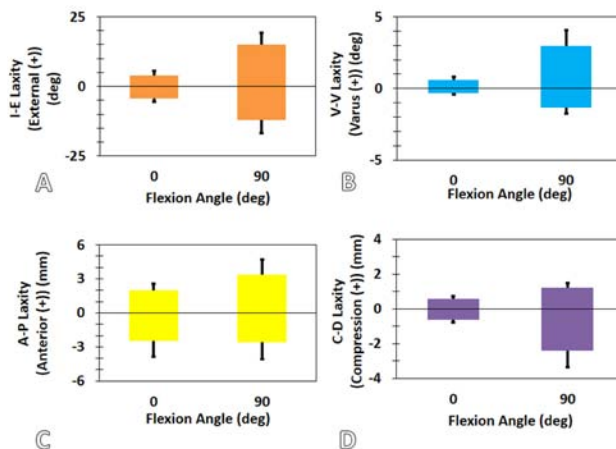
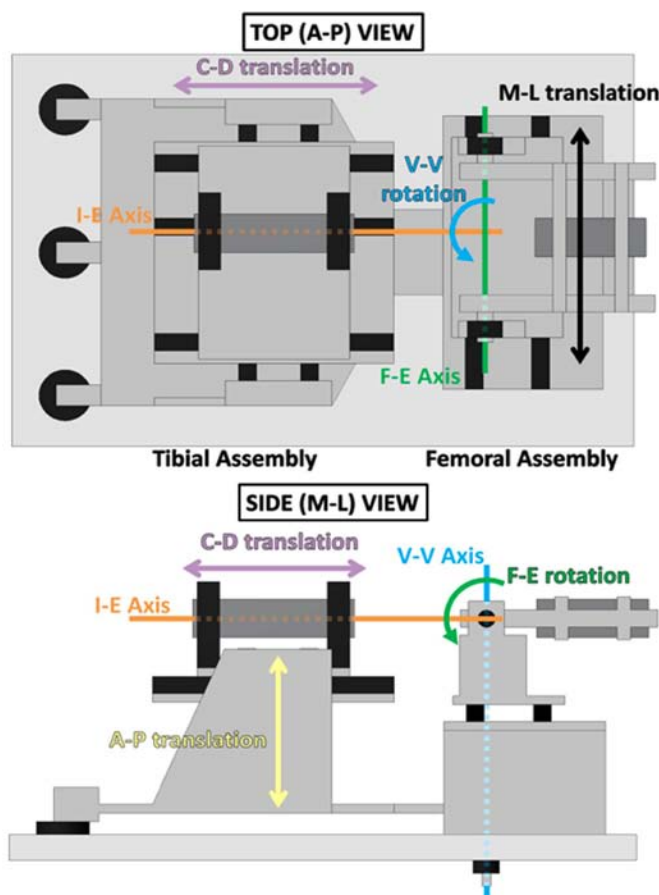
INTRODUCTION: Soft tissue balancing is a critical step in total knee arthroplasty (TKA). Surgeons often assess balance at 0° and 90° flexion primarily considering varus-valgus and distraction laxity. However both anterior-posterior translation and internal-external rotation are also important degrees of freedom. Therefore it is important for surgeons to understand the laxity of the normal knee at 0° and 90° in all four of these degrees of freedom to determine whether the soft tissues are properly balanced. Accordingly, the objective of this study was to measure the laxities of

the normal knee at 0° and 90° in internal-external (I-E) and varus-valgus (V-V) rotation and in anterior-posterior (A-P) and compression-distraction (C-D) translation to provide a benchmark for soft tissue balancing in TKA.

METHODS: Seven fresh-frozen, cadaveric knees were included (average age: 68 years, range: 57 to 85 years). Specimens were free from degenerative arthritis, chondrocalcinosis, osteophytes, soft tissue damage, and evidence of previous surgery to the knee. Following preconditioning, the laxity in I-E, V-V, A-P, and C-D were measured at 0° and 90° flexion using the load application system (Figure 1). The applied loads used to define the laxity were ± 3 N-m for I-E rotation, ± 5 N-m for V-V rotation, ± 45 N for A-P translation, and ± 100 N for C-D translation. Throughout testing, a 45 N compressive tare load was applied to the tibia to simulate the passive compression created by the soft tissues that were transected during dissection. The laxity at 0° and 90° flexion in each degree of freedom was described by the mean and standard deviation of the seven knees at each flexion angle. Differences in the laxity for each degree of freedom were analyzed using a paired t-test with a level of significance of $p < 0.05$.

RESULTS: Figure 2. Four bar charts display the laxity in (A) I-E, (B) V-V, (C) A-P, and (D) C-D for the normal knee at 0° and 90° flexion. Error bars show ± 1 standard deviation. Each asterisk signifies that the laxity at 90° flexion was significantly greater than the laxity at 0° flexion. The laxity in all degrees of freedom and both directions increased significantly at 90° flexion ($p < 0.05$) except in posterior translation.

CONCLUSION: Because the laxity of the normal knee increased in all degrees of freedom and both directions except in posterior translation, surgeons following the principle of gap balancing to balance the soft tissue in TKA should be aware that they may be over constraining the knee at 90° flexion, which may lead to stiffness, limited flexion, and abnormal contact kinematics.



K706

Principle and Results of Kinematic Alignment: A Viable Option for Total Knee Arthroplasty

Primary Author: Joshua D. Roth

Institution: University of California, Davis

Coauthors: Stephen M. Howell (University of California, Davis), Maury L. Hull (University of California, Davis)

OVERVIEW: Kinematically aligned total knee arthroplasty (TKA) has been introduced as a new alignment option for TKA with the goal of maintaining the high long term survivorship of mechanically aligned TKA and improving patient satisfaction and function after TKA. This overview of kinematic alignment 1) describes the natural knee kinematics and the principle for positioning the components in kinematically aligned TKA, and 2) discusses patient satisfaction and function, risk of early failure, and contact kinematics based on results from published studies. Natural Knee Kinematics: Natural knee kinematics are determined by the interaction between the collateral, reticular, and cruciate ligaments and the articular surfaces. These kinematics can be described by rotations about three fixed axes including the transverse axis about which the tibia flexes and extends, the transverse axis about which the patella flex and extends, and the longitudinal rotation axis about which the tibia internally and externally rotates. The two transverse axes are fixed in the femur and the longitudinal rotation axis is fixed in the tibia.

PRINCIPLE FOR KINEMATICALLY ALIGNED

TKA: The principle of kinematically aligned TKA is to position the components to resurface the articular surfaces which restores the natural angle and level of the joint lines and minimize ligament releases. Because the three kinematic axes are either parallel or perpendicular to the joint lines, resurfacing the articular surfaces should closely restore the kinematics of the knee to normal.

PATIENT SATISFACTION AND FUNCTION AFTER KINEMATICALLY ALIGNED TKA:

In a level 1 study, the WOMAC score was 11 points better, Oxford Score was 7 points better, and flexion was 12° greater in the kinematically aligned group than in the mechanically aligned group at 2 years. Both groups had similar limb and knee alignments, but the tibial component was in an average of 2° more varus in kinematically aligned group.

RISK OF EARLY FAILURE AFTER KINEMATICALLY ALIGNED TKA: In a case series, 75% of 215 patients had their tibial component categorized as a varus outlier, but had a high Oxford Knee Score of 43 and no catastrophic failures at 3 years. The concern that kinematic alignment compromises function and places the components at a high risk for catastrophic failure is unfounded. This result should be of interest to surgeons committed to cutting the tibia perpendicular to the mechanical axis of the tibia.

CONTACT KINEMATICS AFTER KINEMATICALY ALIGNED TKA: In 3 case series of consecutive patients treated by different surgeons, kinematically aligned TKA minimized both the undesirable contact kinematics of edge loading of the liner and external rotation and of the tibial component during both standing and kneeling.

SIGNIFICANCE: Kinematic alignment is a viable option for TKA because it (1) restores natural angle and level of joint line and natural alignment of the limb, (2) restores high patient function, flexion, and natural alignment, (3) has a low risk of component failure at 3 years, (4) restores desirable and consistent contact kinematics.

K707

Vitamin E Grafted HXPE Exhibits Superior Mechanical and Wear Properties to Sequentially Annealed HXPE

*Primary Author: Alicia S. Rufner
Institution: Zimmer, Inc.*

Coauthors: Dirk Pletcher (Zimmer, Inc.), Melinda Peiserich (Zimmer, Inc.), Kimberly D. Mimnaugh (Zimmer, Inc.), David M. Miller (Zimmer, Inc.)

INTRODUCTION: Recent studies of sequentially annealed crosslinked polyethylene (HXPE-SA) have exhibited a propensity for in-vivo oxidation due to lipid absorption, despite acceptable wear performance. One way to reduce lipid induced oxidation and maintain mechanical strength is to incorporate vitamin E into crosslinked polyethylene (VE-HXPE). This study evaluated the mechanical strength, oxidative stability and wear performance of HXPE-SA compared to grafted VE-HXPE.

METHODS: Samples of commercially available HXPE-SA and VE-HXPE were fabricated into ASTM D638-10 type V tensile specimens and ASTM F2183-02 small punch specimens. Specimens, non-aged and accelerated aged (ASTM F2003-02 up to 33 weeks) were tested for mechanical properties and Oxidation Index (OI) (ASTM F2102-06). Aged HXPE-SA and VE-HXPE CR knee implants were wear tested for 5.0 Mc according to ISO14243-3. Wear was measured gravimetrically with load soak controls.

RESULTS: The Ultimate Tensile Strength (UTS) for HXPE-SA exhibited a reduction after 2 weeks of aging ($p=0.002$) while the %Elongation at Break (EAB) dropped significantly between 2 and 4 weeks of aging ($p<0.1$) (Table 1). The average OI of HXPE-SA after 2 weeks of aging was elevated to 0.31 ± 0.10 ; 4-8 week groups were too brittle to analyze. Average OI was zero for all aged VE-HXPE groups up to 33 weeks of aging. After 5.0 Mc, the wear rate was 1.45 mg/Mc and 0.88 mg/Mc for HXPE-SA and VE-HXPE respectively, demonstrating a 39.6% decrease of VE-HXPE over HXPE-SA. The OI values for VE-HXPE and HXPE-SA materials at various points, confirms VE-HXPE exhibited no oxidation whereas the HXPE-SA had average OI measurements between 0.77-1.12 (Figure 1). White banding was observed on the HXPE-SA component when sectioned for OI measurements (Figure 1).

CONCLUSIONS: The results of this study confirm that after accelerated aging VE-HXPE has superior mechanical strength, oxidative stability and wear performance over HXPE-SA. The grafted VE-HXPE retained its UTS and EAB up to 24 weeks of aging and its small punch properties up to 33 weeks of aging; whereas HXPE SA showed a 45%, 95%, 68% reduction in UTS, EAB, and small punch properties respectively after 4 weeks of aging. The OI remained at zero for VE-HXPE but increased with aging for HXPE-SA. Grafted VE-HXPE demonstrated a 39.6% decrease in wear over HXPE-SA after accelerated aging. Further, oxidation was not present in the VE-HXPE samples even after accelerated aging and 5.0 Mc of in-vitro wear testing; however the HXPE-SA components exhibited detectable levels of oxidation. Based on these results, VE-HXPE maintains its oxidative resistance even in aggressive oxidative challenge conditions and may exhibit improved long-term in-vivo mechanical and wear properties over HXPE-SA.

Table 1. Mechanical Properties before and after aging

Aging Time (wks)	UTS (MPa)		%EAB		Ult Displacement [mm]		Ult Work to Failure [mJ]	
	VE-HXPE	HXPE-SA	VE-HXPE	HXPE-SA	VE-HXPE	HXPE-SA	VE-HXPE	HXPE-SA
0	60.7	58.7	284.8	306.8	5.0	4.4	212.3	197.0
2	55.4	48.4	274.5	298.3	5.2	3.4	228.6	135.9
4	56.3	30.9	277.7	14.4	4.8	2.6	205.3	71.6
6	57.3	27.1	283.2	1.5	-	-	-	-
8	59.0	23.5	286.7	0.8	-	-	-	-
24	56.4	-	282.3	-	-	-	-	-
33	-	-	-	-	4.7	-	184.1	-



Wear Testing - Oxidation Index Values

	VE-HXPE	HXPE-SA (stdev)
Unaged	0.00	0.00
2 weeks Accelerated Aged	0.00	0.404 (0.042)
After 5.0 Mc of In-vitro Wear Testing	0.00	0.633 (0.079)
After 5.0 Mc of in-vitro Wear Testing and Additional Aging	0.00	0.943 (0.139)

Figure 1. Oxidation Index values and cross section films of HXPE-SA and VE-HXPE unaged, accelerated aged and 5.0 Mc of wear testing.

K708

The Evaluation of 3D Matching Method After TKA Using Operation Support System (JIGEN)

Primary Author: Akihito Sakka

Institution: Department of Orthopaedic Surgery, Yamaguchi University School of Medicine

Coauthors: Kazushige Seki, Atsunori Tokushige, Takashi Imagama, Toshihiko Taguchi

INTRODUCTION: Total knee arthroplasty (hereinafter TKA), it is thought that the setting position of each component and the angle have a big influence on surgical results. We investigated results after operation of TKA using operation support system (JIGEN system) on x-ray and reported that the effectiveness was high. Furthermore, we reported that 3D matching evaluation method using the CT before and after operation was a useful method as a rating

system after operation. In this study, we evaluated it that the effectiveness of the JIGEN system using 3D matching evaluation method.

PATIENTS AND METHODS: We intended for 60 knees which we performed TKA used two models by August, 2013 from January, 2010. As for 10 male knees, 50 woman knees, the operation average age were 73.6 years old (62 to 82 years). Of these, it was 28 JIGEN system use group (J group) knees by the model used ADVANCE medial pivot, 32 non-use group (V group) knees by the model used Vanguard PS type. For these, we performed CT photography of the whole lower limbs after operation like preoperation and femoral component setting was located after operation using evaluation software made in LEXI company and evaluated it.

RESULTS: It was 3D evaluation than 2D evaluation result, and the error with the preoperation plan of the femoral component became more remarkable and was seen. One did not admit in the J group whereas errors more than 3 degrees admitted several in V group in coronal and sagittal plane even if we used 3D evaluation like 2D evaluation result. A more detailed evaluation was enabled by this 3D evaluation about the slightly difficult rotation by the 2D evaluation and, as for the errors more than 3 degrees, was recognized four in seven, the J group in V group.

DISCUSSION: The 3D matching evaluation method using the CT that reached this time before and after operation raises one step of reliability of precision concerned about by 2D evaluation, and, in addition, the detailed evaluation of the rotation position is possible. In the 3D evaluation, we think that it suggests the effectiveness of operation support system JIGEN some other time that a superior result was seen in J group.

K709

How Effective is Intra-Articular Tranexamic Acid In Reducing Blood Loss in Total Knee Arthroplasty? A Prospective, Randomized, Double-Blind Study

Primary Author: Usama Hassan Saleh

Institution: American Hospital Dubai

Coauthors: Samih Tarabich (American Hospital Dubai), Robin MacGillivray (American Hospital Dubai), Raouf

Nayzak (American Hospital Dubai), Marwan Hawari (American Hospital Dubai), Shaher Hasanain (American Hospital Dubai)

BACKGROUND: Total knee arthroplasty is associated with postoperative blood loss that is presumed to occur secondary to microvascular bleeding because of increased fibrinolytic activity after tourniquet removal. Tranexamic acid, a synthetic amino acid that inhibits fibrinolysis, has been shown to reduce such bleeding. We evaluated the effect of the intra-articular administration of tranexamic acid on blood loss in patients undergoing bilateral total knee arthroplasty in a double-blind fashion.

METHODS: Sixty patients underwent concurrent bilateral total knee arthroplasty in which one knee underwent intra-articular administration of tranexamic acid and the other knee underwent intra-articular administration of normal saline as a control. This design was employed to remove potential confounders. The same surgeon utilized the same surgical technique with the same prosthesis in all patients. The volume of blood loss from the surgical site drains after tourniquet removal was compared between the two groups. The hemoglobin level, hematocrit, platelet count, prothrombin time, international normalized ratio, and activated partial thromboplastin time were measured preoperatively and on days 1 and 3 postoperatively. In addition, the knee circumference was measured at three locations both preoperatively and postoperatively.

RESULTS: The main findings from this study were as follows: The mean blood loss from the drains was not significantly different between the tranexamic acid and normal saline groups. No significant differences were observed in the preoperative and postoperative circumferential leg measurements between the two groups. **Conclusions:** The intra-articular administration of tranexamic acid in patients undergoing bilateral total knee arthroplasty did not result in a significant decrease in postoperative blood loss. For reasons that remain unclear, this result is in contrast to those of previously published work, and further studies are thus required. **Level of Evidence:** This was a blinded, randomized controlled trial with an evidence level of I.

K710

Sugar Therapy for Infection and Skin Ulcer After TKA and BHP

Primary Author: Tomotaro Sato

Institution: Department of Orthopaedic Surgery, Nagoya Medical Center

Coauthors: Atsushi Kaneko (Nagoya Medical Center), Daihei Kida (Nagoya Medical Center)

Infection and skin ulcer are major problems in Total Knee Arthroplasty (TKA) and Bipolar Hip Prosthesis (BHP). Sugar (sucrose) has been used for wound care in many countries because it absorbs fluid, stimulates granulation, and suppress growth of bacteria. Trafermin

K711

Extended Sagittal Saw Cut Significantly Reduces Fracture Load in Cementless Unicompartmental Knee Arthroplasty Compared to Cemented Tibia Plateaus: An Experimental Cadaver Study

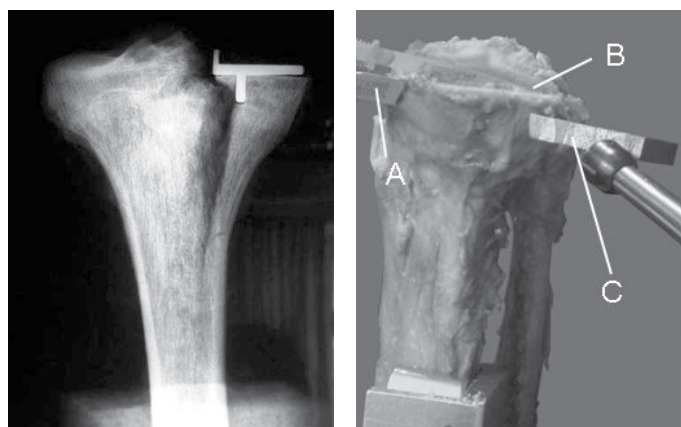
Primary Author: Jörn B. Seeger

Institution: Department of Orthopaedics and Orthopaedic Surgery – UKGM

Coauthors: Michael Clarius (Vulpius Klinik Bad Rappenau), Daniela Haas (Heidelberg University Hospital), Eric Röhner (University Hospital Jena), Sebastian Jaeger (Heidelberg University Hospital)

Periprosthetic tibial plateau fractures represent a rare but serious complication in unicompartmental knee arthroplasty and are associated with extended sagittal tibial bone cuts. These can occur during the surgery, weaken the posterior cortex of the tibia and are associated with periprosthetic tibial plateau fractures. Although excellent long-term results have been reported with cemented unicompartmental knee arthroplasty, there is high interest in cementless fixation. The aim of the study was to compare fracture loads of cementless and cemented unicompartmental knee arthroplasty. Tibial components of the Oxford Uni were implanted in six paired fresh-frozen tibiae with a defined extended saw cut (10°) at the dorsal cortex of each specimen. In one set, surgery was performed with cement fixation, and in

the other, cementless components were implanted. Vertical loads were then applied under standardised conditions to fracture the specimens. Median loads of 3.7 (0.7-6.9) kN led to fractures in the cemented group, whereas cementless fixated tibiae fractured with a median load of 1.6 (0.2-4.3) kN ($P = 0.02$). The loading capacity in tibiae with cementless components is significantly less compared to cemented fixation. The results show that in case of an extended sagittal bone cut patients especially those with poor bone quality who are treated with a cementless unicompartmental knee arthroplasty are at higher risk for periprosthetic tibial fractures.



K712 Instrumented Gait Analysis for Lateral Unicompartmental Knee Arthroplasty

Primary Author: Joern B. Seeger

Institution: Department of Orthopaedics and Orthopaedic Surgery – UKGM

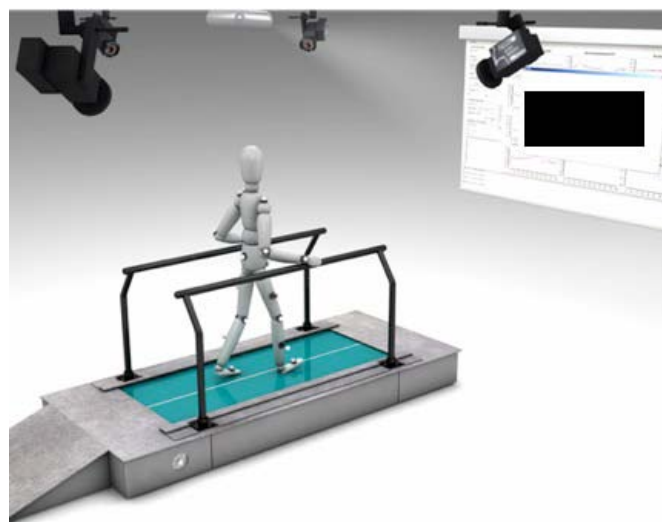
Coauthors: Janina Schickschneit (Heidelberg University Hospital), Sebastian Jaeger (Heidelberg University Hospital), Christian Schuld (Heidelberg University Hospital), Michael Clarius (Vulpius Klinik Bad Rappenau)

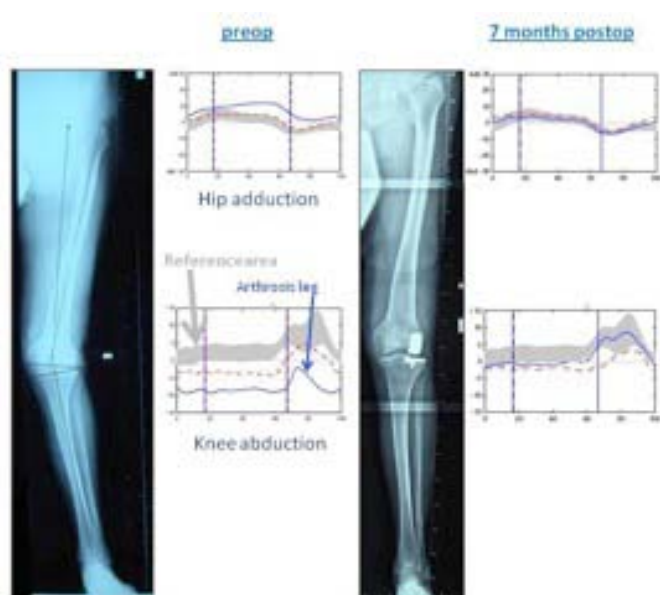
INTRODUCTION: Lateral unicompartmental knee arthroplasty (UKA) is a common treatment option of isolated osteoarthritis of the lateral compartment of the knee joint. The combined use of instrumented gait analysis and clinical scores represents a useful method to measure changes of gait characteristics for patients treated with implants. This study demonstrates how gait pattern of patients with isolated lateral osteoarthritis of the knee joint changes after lateral UKA.

METHODS: 19 patients suffering from lateral osteoarthritis underwent implantation of a UKA and were examined in a gait analysis before and after an average follow up time of 7 months. Gait analysis was used to identify gait characteristics (e.g. velocity, stride time, stride length, knee abduction or hip adduction) on a treadmill with six infrared cameras.

RESULTS: The mean velocity of the patients changed from 0.58 m/s to 0.73 m/s and further significant advancements could be found especially in knee abduction and hip adduction. Time and length of strides advanced. The clinical scores AKSS, Oxford-12, FFb-H-OA and Devane improved significantly.

DISCUSSION: The Oxford domed-lateral UKA is a very helpful and satisfying treatment method for patients with isolated osteoarthritis of the lateral compartment of the knee joint. Gait analysis represents a helpful measuring device analyzing the changes of patients' gait patterns in lateral UKA.





K713

Periprosthetic Tibial Fractures Using the Minimal Invasive Medial Unicompartmental Knee Arthroplasty “Oxford Uni”

Primary Author: Joern B. Seeger

Institution: UKGM

Coauthor: Michael Clarius (Vulpius Klinik Bad Rappenau)

Periprosthetic tibial plateau fractures (TPF) are rare but represent a serious complication of unicompartmental knee arthroplasty (UKA). As TPFs usually occur perioperatively, these can be associated with extended sagittal saw cuts during surgery. The aim of the study was to evaluate TPF as a function of extended sagittal saw cuts. The hypothesis was that extended sagittal saw cuts reduce the loading capacity of the tibial plateau and increase the risk of periprosthetic TPF. In a randomised study, standardised cemented Oxford UKA tibial component implantation was performed in six matched, paired fresh-frozen tibiae. In group A, a regular preparation of the tibial plateau was performed, whereas in group B a standardised extended sagittal saw cut was made at the dorsal cortex of the tibia. All tibiae were fractured under standardised conditions and fracture patterns and fracture loads were analysed. In group A, tibiae fractured with a mean load of $F_{max}=3.9$ (2.3–8.5) kN, whereas in group B fractures occurred at a mean load of $F_{max}=2.6$ (1.1–5.0) kN. The difference was statistically significant.

K714

Diagnostic Performance of Weight-Bearing 3D CT for the Detection of Knee Osteoarthritis Features

Primary Author: Neil A. Segal

Institution: University of Iowa

Coauthors: John A. Lynch (University of California San Francisco), Jingbo Niu (Boston University), Michael C. Nevitt (University of California San Francisco), James C. Torner (University of Iowa), Ali Guermazi (Boston University)

PURPOSE: To evaluate the sensitivity, specificity, accuracy and predictive value of weight-bearing computerized tomography (WBCT) of the knee in depicting osteophytes and subchondral cysts, in comparison with fixed-flexed radiographs, using MRI as the reference standard.

METHODS: 20 adults with knees discordant for KL grade were recruited in order to represent a range of OA features. Participants stood on the WBCT scanner platform. The scanner produced pulsed cone-beam x-ray (effective dose equivalent 10 mrem) over a 360° projection angle with total scan time of 32 seconds. A 3D axial CT dataset with a FOV of 350 mm was reconstructed from cone-beam projection images. Marginal osteophytes and subchondral cysts were scored on bilateral radiographs and WBCT images (axial reconstructed as coronal plane images) according to the OARSI grading system and dichotomized into either present (grade 1 or above) or absent (grade 0). All images were read in a random order, and radiographs and WBCT images were read during separate sessions, with a 2-week interval, to prevent simultaneous assessment, which could potentially bias readings. MRI (axial and sagittal proton density-weighted and coronal STIR sequences) of the same knees were read for the same features, also with a 4-week interval from reading other modalities. The detection rates of marginal osteophytes and subchondral cysts by conventional radiography and WBCT were compared with those detected with MRI, as a whole and by surface (i.e., medial and lateral, femur and tibia). MRI findings were used as the reference standard. Sensitivity, specificity, and accuracy were calculated and McNemar’s test was used to examine for statistically significant differences between imaging modalities. Positive and negative predictive values were calculated and, using GEE marginal

regression models, we assessed the significance of the differences.

RESULTS: The 20 participants (40% women) were age 50-59 (N=9), 60-69 (N=10) and 70-79 (N=1). The mean BMI was 30.0kg/m². Of the 160 surfaces (medial and lateral femur and tibia for 40 knees), MRI revealed 84 osteophytes and 10 subchondral cysts (Figure 1). In comparison with osteophytes and subchondral cysts detected by MRI, WBCT was significantly more sensitive and accurate than plain radiographs (Figure 2). For osteophytes, the greatest differences in sensitivity and accuracy were detected in the medial compartment. A low rate of subchondral cysts as well as a low rate of false positive osteophytes on radiographs limited ability to compare specificity between the modalities. Reading each plain radiograph required approximately 5 minutes (due to features being superimposed in the coronal view), while WBCT required less time due to greater accuracy enhancing ease of scoring features. Although no meniscal extrusions were visualized on radiographs, 24 medial meniscal extrusions were detected by WBCT.

CONCLUSIONS: WBCT imaging appears to be more sensitive and accurate for detection of osteophytes and subchondral cysts than conventional radiography. In addition, the 3D weight-bearing images also may enable participant-specific optimization of the joint-space viewing angle through customized coronal reconstructions. Additional study is indicated for assessing utility of WBCT for assessing the patellofemoral joint and 3D alignment of prosthetic components.

Figure 1: Frequency of Knee OA Features Detected by Radiography and WBCT in Comparison with MRI

Feature		X-ray vs. MRI		WBCT vs. MRI	
		MRI no	MRI yes	MRI no	MRI yes
Osteophyte	Not Detected	76	34	74	6
	Detected	0	50	2	78
Subchondral Cyst	Not Detected	150	9	148	0
	Detected	0	1	2	10

Figure 2a: Diagnostic Performance for Depicting Marginal Osteophytes

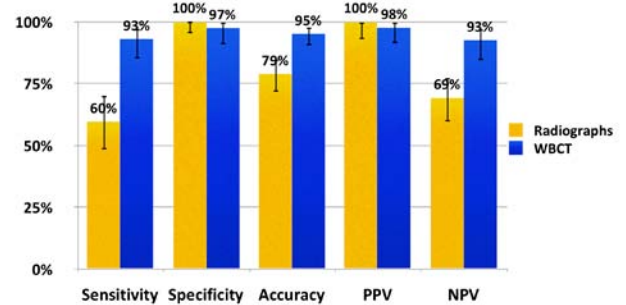
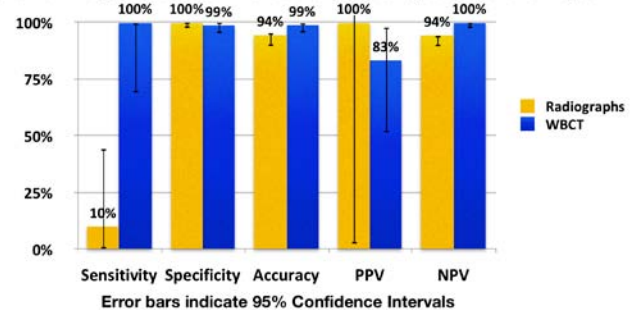


Figure 2b: Diagnostic Performance for Depicting Subchondral Cysts



K715

Preoperative Knee Kinematics Robustly Correlates With Postoperative Knee Kinematics in Total Knee Arthroplasty

Primary Author: Naoki Seito

Institution: Department of Orthopaedic Surgery, Hokkaido University Graduate School of Medicine

Coauthors: Tomohiro Onodera (Department of Orthopaedic Surgery, Hokkaido University Graduate School of Medicine), Yasuhiko Kasahara (Department of Orthopaedic Surgery, Hokkaido University Graduate School of Medicine), Yusuke Nishio (Department of Orthopaedic Surgery, Hokkaido University Graduate School of Medicine)

We have previously reported that patients who demonstrated medial pivot kinematics pattern after total knee arthroplasty (TKA) had better clinical results than that of non-medial pivot pattern. However, it is unclear how preoperative kinematics pattern affects postoperative knee kinematics. The aim of this study was to evaluate the relationship between preoperative and postoperative knee kinematics pattern in TKA.

The present study consists of 38 patients with medial osteoarthritis who underwent a primary TKA using a CT-based

navigation system from July 2010 to September 2012. All the operations were performed by a single surgeon using a subvastus approach and the same posterior cruciate ligament substituting type (PS type) of prosthesis (Genesis II™ total knee system, Smith & Nephew, Memphis, TN). The proximal tibia osteotomy and the distal femur osteotomy were set on the navigation system perpendicular to the mechanical axis in the coronal plane with 3° tibial posterior inclination in the sagittal plane. The coronal plane ligament imbalance was corrected until the gap imbalance was fewer than 2 mm. This gap balance was checked using a ligament balancer (Smith & Nephew) at 80 N in medial and lateral compartment of the knee. The navigation system was used to measure the flexion gap with the CAS ligament balancer (Depuy, Warsaw, IN, USA) at 90° knee flexion. The amount of external rotation on femoral osteotomy was adjusted by the navigation system with a balanced gap technique. The patella was resurfaced and a lateral release was not performed. Tibial A-P axis of the tibial tray was placed parallel to Akagi's line. We measured each kinematics pattern immediately after capsule incision (preoperative knee kinematics) and after implantation (postoperative knee kinematics) in TKA. Subjects were divided into two groups based on kinematics patterns: a medial pivot group (group M) and a non-medial pivot group (group N). A chi-square test was used for statistical analysis. P values less than 0.05 were considered significant.

There were 19 knees in group M and 19 knees in group N at preoperative knee kinematics measurement. Nineteen knees in group M at preoperation resulted in 14 knees in group M and five knees in group N at postoperative knee kinematics measurement. On the other hand in group N at preoperation resulted in 2 knees in group M and 17 knees in group N at postoperative kinematics. Preoperative knee kinematics significantly correlated with postoperative knee kinematics ($P < 0.01$). Our results suggest that preoperative knee kinematics robustly impacted upon postoperative knee kinematics in most cases.

In conclusion, this study revealed that a precise bone cut assisted by a navigation system and a modified gap technique could not improve the knee kinematics pattern in most cases. Further technical improvement or a new implant design is required to correct preoperative abnormal knee kinematics in TKA.

K716

Results of Total Knee Arthroplasty in Valgus Knees

Primary Author: Kazushige Seki

Institution: Department of Orthopaedic Surgery, Yamaguchi University School of Medicine, Yamaguchi, Japan

Coauthors: Akihito Sakka (Department of Orthopaedic Surgery, Yamaguchi University School of Medicine, Yamaguchi, Japan), Takashi Imagama (Department of Orthopaedic Surgery, Yamaguchi University School of Medicine, Yamaguchi, Japan), Atsunori Tokushige (Department of Orthopaedic Surgery, Yamaguchi University School of Medicine, Yamaguchi, Japan)

BACKGROUND: Approximately 10–15% of patients requiring total knee arthroplasty (TKA) present with a valgus deformity. TKA for a valgus knee is often technically challenging, and the results are considered less satisfactory compared with TKA for varus knees. An accurate soft tissue balance between the tibiofemoral and patellofemoral joints without producing instability is challenging. Many postoperative complications must be considered such as patellofemoral pain, late onset instability, and a lower functional outcome.

OBJECTIVE: The purpose of this study was to investigate the results of TKA for valgus knees.

METHODS: Nineteen primary TKAs for valgus knee were studied. TKA was performed on these patients at our institution between January 2006 and 2013. Five men and 14 women were included, and mean age at the time of surgery was 61.2 years (range, 51–74 years). The Nexgen LPS-flex (Zimmer), LCKK (Zimmer), Advance (Wright Medical), Physio knee (KYOCERA MEDICAL), and Scorpio PS (Stryker Orthopedics) were used in one patient each, and Vanguard PS (Biomet) was used for 15 patients. Clinical assessments after surgery were evaluated by the Japanese Orthopedic Association (JOA) knee score, and complications were investigated. Parameters of the radiographic examination were femorotibial angle (FTA), lateral shift rate, and tilting angle. Statistical analyses were performed by Student's t-test using the JMP software ver. 10.01. $p < 0.05$ was considered significant.

RESULT: The average JOA score improved significantly from 50.2 ± 9.1 points (range, 35–65 points) preoperative-

ly to 75.7 ± 8.7 (range, 65–95 points). Mean flexion angle was $108.2 \pm 38.8^\circ$, and mean extension angle was $-8.8 \pm 11.9^\circ$ preoperatively. Mean flexion was $118.2 \pm 13.9^\circ$, and mean extension was $-1.75 \pm 3.3^\circ$ at follow-up. Only extension was significantly improved. Radiographic evaluations are displayed in Table 1. FTA was significantly improved. No deterioration was observed in patellar congruencies postoperatively. A superficial surgical site infection was observed in two patients, and they were treated with oral antibiotics. Surgical wound dehiscence occurred in two patients, and one was resutured.

CONCLUSION: We obtained good results in patients undergoing valgus knee TKA. No deterioration in patellar congruencies was observed postoperatively. However, surgical wound dehiscence was high (10%); thus, care should be taken when treating soft tissue during TKA for a valgus knee.

Table 1

Radiographic examination

	preoperation (mean \pm SD)	Time of the follow up (mean \pm SD)	p value (student's t-test)
FTA	165.4 ± 7.6	175.2 ± 3.3	0.03
lateral shift rate	11.5 ± 4.7	12.4 ± 7.5	0.70
tilting angle	6.7 ± 4.5	7.6 ± 5.6	0.22

K717

Evaluating Outcomes of Conversion of Unicompartmental Knee Replacement and Medial Opening High Tibial Osteotomy to Total Knee Replacement - How Do They Compare?

Primary Author: Kush Raj. Shrestha

Institution: London School of Health Science, Ontario

Coauthors: James L. Howard (London School of Health Science), Steven J. MacDonald (London School of Health Science), Lyndsay Sommerville (London School of Health Science), Edward Vasarhelyi (London School of Health Science), Brent Lanting (London School of Health Science)

INTRODUCTION: Unicompartmental knee replacement (UKR) and high tibial osteotomy (HTO) have been proposed for isolated medial compartment osteoarthritis. The outcome of converting these procedures to primary total knee replacement (TKR) has been proposed to be similar to performing primary TKR. The current study investigates

how the outcomes of UKR and HTO conversions to TKR compare to matched cohorts of primary and revision TKR.

METHODS: Between 1990-2012, 50 UKR conversions to primary TKR were completed at a single institution. During the same time period, 75 HTO conversions to TKR were completed. These patients were matched to a cohort of 76 primary TKRs and a cohort of 71 revision TKRs. The medical records and radiographs were reviewed for the requirement of augments, wedges and revision implants. Demographic data as well as pre and post-operative clinical outcomes scores (Knee Society scores, Western Ontario and McMaster Universities Osteoarthritis Index(WOMAC), SF-12) were reviewed.

RESULTS: Gender distribution and body mass index (BMI) were similar in all groups. Average age was 56 years in all groups except UKR which was 71 years old. Ten of 50 UKR patients (20%) and Ten of 75 HTOs (13.3%) required revision components at the time of conversion. In the primary TKA cohort, only 1 of 76 primary TKRs (1%) required revision components while 100% of revision knee replacements required revision components. There was significant improvement in preoperative knee society and WOMAC scores at latest follow-up for all cohorts. The in WOMAC and Knee Society scores was significantly less in the revision TKR cohort compared to the other three groups. The primary TKR cohort had the greatest improvement in all outcome scores. The change in clinical outcome scores from pre to postoperative was similar for both the UKR and HTO cohorts.

DISCUSSION/CONCLUSION: The results of this study indicate that conversion of UKR to primary TKR is not always straightforward. Conversion of UKR should be considered to be more of a revision surgery than primary surgery. Conversion of UKR is also not similar to conversion of HTO, the former having higher incidence of requiring revision implants. However the clinical outcomes of UKR and HTO conversion were similar. As expected, TKR had the most improvement in outcome scores and revision TKRs had least improvement.

K718**Primary Total Knee Arthroplasty in Osteoarthritic Knees With Combined Distal Femoral Fractures***Primary Author: Jong Min Sohn**Institution: Incheon St.Mary's Hospital, Catholic University of Korea*

Distal femoral fractures in elderly patient occurred with lower energy injury due to preexisting osteoporosis. Gonarthrosis is frequently accompanied in these patients, and which is difficult to treatment and hard to restore function. Traditionally, the fractures in osteoarthritic knee are treated by open reduction and internal fixation (ORIF) and total knee arthroplasty (TKA) for osteoarthritis is considered after bone union of the prior fractures. However two-stage procedure makes some problems when TKA is performed following long immobilization, previous scar, implant removal, prolonged hospital stay, and increased cost. Several authors have reported acceptable results of primary TKA with concomitant ORIF using long stem with hinged, constrained type or posterior stabilized prosthesis, but which generally need substantial bone removal for notch preparation and is disadvantageous for the fractured extremity. We report 4 patients who were treated with primary TKA with concomitant ORIF for osteoarthritic knee accompanied by distal femoral fracture using ADVANCE Medial Pivot knee (Wright Medical, Arlington, TN) in which prosthesis stem extension can be used without notch cutting. All patents were women with mean age of 79 (69 – 87 years). There was 1 case of medial femoral condylar fracture, 2 cases of supracondylar fractures and 2 cases of supracondylar/intercondylar femoral fractures. Fracture is well reduced in all cases and well united. The range of motion was good (mean 1-112, flexion contracture 0-5, maximal flexion 90-130) at mean follow-up of 12.6 months (range, 5-33 months). We believe that one-stage primary TKA using medial pivot knee is a reasonable alternative treatment for osteoarthritic knees accompanied by distal femoral fractures if a surgeon is experienced in fracture management and arthroplasty.

K719**Accuracy of a Novel Computer-Assisted Guidance System for Total Knee Arthroplasty***Primary Author: Bernard N. Stulberg**Institution: Cleveland Clinic**Coauthors: Laurent D. Angibaud (Exactech), Xeve Silver (Exactech), Scott Gulbransen (Exactech)*

INTRODUCTION: Clinical outcomes for total knee arthroplasty (TKA) are especially sensitive to lower extremity alignment and implant positioning.¹ The use of computer-assisted orthopedic surgery (CAOS) can improve overall TKA accuracy.² This study assessed the accuracy of an image-free CAOS guidance system (Exactech GPS, Blue-Ortho, Grenoble, FR) used in TKA.

MATERIALS AND METHODS: A high-resolution 3D scanner (Comet L3D, Steinbichler, Plymouth, MI) was used to scan seven knee models (MITA, Medical Models, Bristol, UK) and collect pre-identified anatomical landmarks prior to using the models to simulate knee surgery. The image-free CAOS guidance system was then used to acquire the same landmarks. After adjusting the position and orientation of the cutting block to match the targets, bone resections were performed, and the knee models were re-scanned. The 3D scans made before and after the cuts were overlaid (see Figure 1) and the resection parameters calculated using the pre-identified anatomical landmark data and advanced software (XOV & XOR, RapidForm, Lakewood, CO and UG NX, Siemens PLM, Plano, TX). Data sets obtained from the 3D scanner were compared with data sets from the guidance system. Given the accuracy of the 3D scanner, its measurements were used as the baseline for assessing CAOS system error.

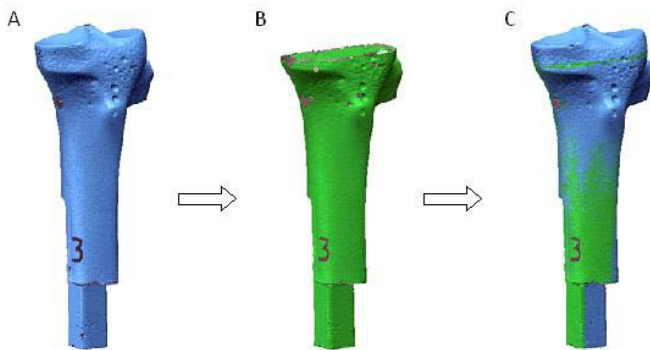
RESULTS: The CAOS system bone resection measurement errors had an overall mean of less than 0.35 mm. The mean errors for joint angle measurement was less than 0.6° (see Table I). Even considering the ranges, errors were no more than 1 mm for all bone resection measurements and no more than 1° for all joint angle measurements. The low variability is also supported by small standard deviation values.

DISCUSSION/CONCLUSION: To our knowledge, this is the first study to use a high-resolution 3D scanner to assess the accuracy of surgical cuts made with image-free

CAOS system assistance. Determining precise landmarks using CAOS for TKA has been shown to be of critical importance.³ For this reason, the anatomical landmarks used by the scanner and guidance system were carefully identified and prepared to ensure consistency. The study demonstrated that the evaluated image-free CAOS system was able to achieve a high level of in-vitro accuracy (small mean errors) as well as a high level of precision (small error variability) when making femoral and tibial bone resections during TKA.

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Bone	Parameter	Measurement errors		
		Mean	SD	[Min, Max]
Tibia	Medial resection (mm)	0.09	0.20	[-0.30, 0.30]
	Lateral resection (mm)	0.20	0.36	[-0.30, 0.70]
	Varus/Valgus (°)*	0.03	0.39	[-0.30, 0.87]
	Slope (°)*	0.16	0.36	[-0.50, 0.50]
Femur**	Medial resection (mm)	-0.32	0.39	[-0.80, 0.20]
	Lateral resection (mm)	-0.20	0.44	[-0.80, 0.40]
	Varus/Valgus (°)*	0.51	0.42	[-0.20, 1.00]
	Flexion/Extension (°)*	0.23	0.23	[0.00, 0.60]

*Varus/Valgus: varus is signed negative, valgus is signed positive; Slope: decreased slope is signed negative, increased slope is signed positive; Flexion/Extension: Flexion is signed negative, extension is signed positive

**Based on six bone models only, as the locking pins dissociated from femur #2 during preparation

K720

Evaluation of the Alignment Discrepancies During Total Knee Arthroplasty Using an Image-Free Guidance System

Primary Author: Bernard N. Stulberg

Institution: Cleveland Clinic

Coauthors: Laurent D. Angibaud, Exactech, Gainesville, FL, USA; Xeve Silver, Exactech, Gainesville, FL, USA

INTRODUCTION: From pre-operative planning to final implant cementation, total knee arthroplasty (TKA) can be defined by a succession of individual steps, each presenting potential errors that can result in devices being implanted outside the desired range of alignment. Our study used an image-free computer-assisted orthopedic surgery (CAOS) guidance system (Exactech GPS, Blue-Ortho, Grenoble, FR) to evaluate alignment discrepancies occurring during different steps of a typical TKA procedure.

MATERIALS AND METHODS: A profile was established to define resection parameters and steps for proximal tibial and distal femoral cuts (See Figure 1A) to be made on seven synthetic knee models (MITA, Medical Models, Bristol, UK). First, the guidance system was used to acquire pre-identified landmarks. Next, a cutting block was adjusted to match the resection targets and then fixed to the bone using locking pins. Bone cuts were performed and then checked. Data was collected from the guidance system at three steps: (1) cutting block adjusted but not pinned to bone (see Figure 1B), (2) cutting block adjusted and pinned to bone (see Figure 1C), and (3) after checking cuts (see Figure 1D). These data were then compared to the resection target parameters to assess potential discrepancies.

RESULTS: Discrepancies for all cuts were minimal, as the differences in bone resection thickness and angular measurement were less than 1 mm and 1°, respectively (see Table I). For each parameter, the mean value was close to nominal, demonstrating a well-centered distribution. This being said, there was a consistent derivative of the distal femoral parameters in extension (up to 0.9°), resulting in lower than expected amount of distal femur resection (up to 0.9 mm).

DISCUSSION/CONCLUSION: In general, discrepancies at each step seemed random, and there was no appar-

ent accumulation trend except for the flexion/extension of the distal femoral cut. There was a slight discrepancy in extension during the pinning of the block, possibly due to the offset weight of the tracker acting on the adjustable instrumentation. There was also a consistent discrepancy in extension during the cut, likely resulting from the saw skiving during cuts. Such a discrepancy can result in a slightly tighter joint in extension than expected.

The guidance system did not exhibit substantial alignment discrepancies during procedure steps, reflecting its robustness.

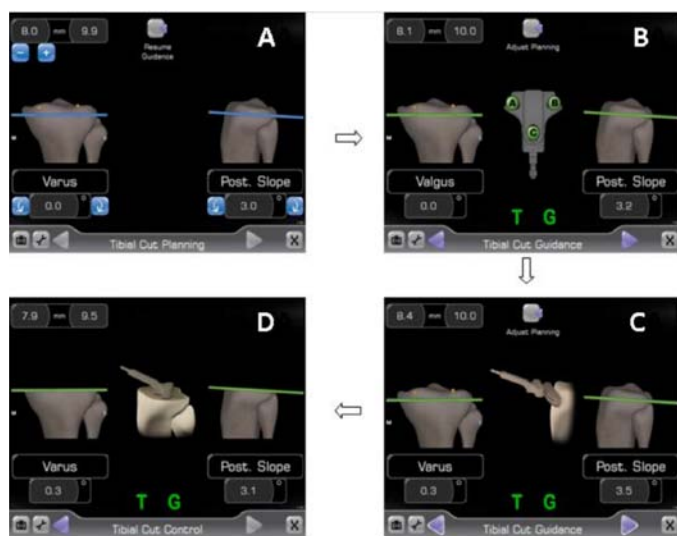


Figure 1: Alignment acquisition sequence starting from target planning (A), cutting block adjustment (B), attachment of the cutting block to the bone (C), making bone cut and final checks (D)

Bone	Parameter	Adjusted vs. targeted			Attached vs. targeted			Checked vs. targeted		
		Mean	SD	[Min, Max]	Mean	SD	[Min, Max]	Mean	SD	[Min, Max]
Tibia	Medial resection thickness (mm)	-0.03	0.10	[-0.20, 0.10]	0.00	0.24	[-0.30, 0.40]	-0.19	0.19	[-0.50, 0.10]
	Varus/Valgus (°)*	-0.09	0.07	[-0.20, 0.00]	-0.16	0.32	[-0.40, 0.30]	-0.10	0.22	[-0.30, 0.20]
	Slope(°)*	0.04	0.08	[0.00, 0.20]	-0.04	0.36	[-0.40, 0.50]	-0.09	0.11	[-0.20, 0.10]
Femur**	Lateral resection thickness (mm)	0.08	0.18	[-0.10, 0.40]	-0.20	0.19	[-0.40, 0.10]	-0.58	0.31	[-0.90, -0.10]
	Varus/Valgus(°)	0.05	0.10	[-0.10, 0.20]	0.18	0.19	[-0.10, 0.40]	-0.08	0.48	[-0.90, 0.60]
	Flexion/Extension (°)*	-0.03	0.10	[-0.20, 0.10]	0.28	0.13	[0.10, 0.40]	0.62	0.33	[0.00, 0.90]

*Varus/Valgus: varus is signed negative, valgus is signed positive; Slope: decreased slope is signed negative, increased slope is signed positive; Flexion/Extension: Flexion is signed negative, extension is signed positive

**Based on six bones only, as the locking pins dissociated from the synthetic bone during the preparation of femur #2

Table 1: Differences in data between the sequences

K721 Elastic Modulus Measurement of Posterior Cruciate Ligament in Cruciate-Retaining Total Knee Arthroplasty

Primary Author: Tanzo Sugimori

Institution: Department of Orthopaedic Surgery, Kanazawa Medical University

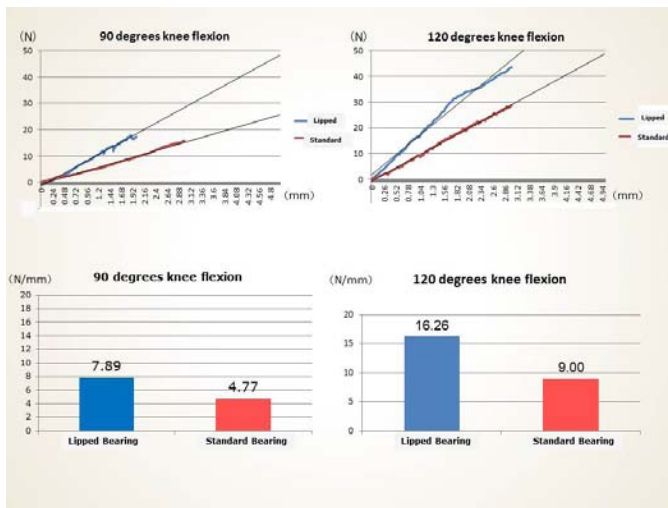
Coauthors: Yoshiyuki Tachi (Department of Orthopaedic Surgery, Kanazawa Medical University), Ryoji Tsuda (Department of Orthopaedic Surgery, Kanazawa Medical University), Ayumi Kaneuji (Department of Orthopaedic Surgery, Kanazawa Medical University), Tadami Matsumoto (Department of Orthopaedic Surgery, Kanazawa Medical University)

BACKGROUND: To prevent excessive tension on the posterior cruciate ligament (PCL) in cruciate-retaining total knee arthroplasty (CR-TKA), some knee prosthesis-systems offer the option of creating a posterior slope for the tibial polyethylene insert. Vanguard® Complete Knee System offers two different types of tibial bearing for CRTKA. CR Lipped Bearing (LB) has a slightly raised posterior lip, whereas CR Standard Bearing (SB) is recessed downward at the posterior margin and has 3° posterior slope. The objective of this study was to investigate the effect of the tibial bearing slope on PCL load using the original devise in vivo conditions.

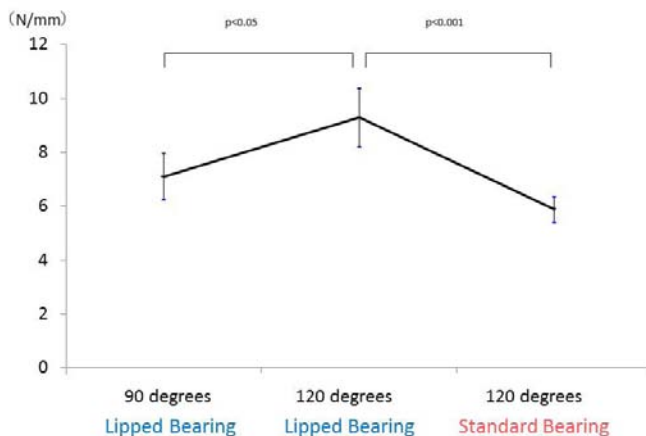
MATERIAL AND METHODS: Twenty osteoarthritic varus knees were included in this study. After implantation of the trial components, PCL stiffness was measured using the original tension analyzer intra-operatively. Elastic modulus of PCL was calculated at 90 and 120 degrees knee flexion on two types of bearing surface.

RESULTS: Elastic modulus of PCL was 7.2 ± 0.9 N/mm (mean \pm SE) at 90 degrees knee flexion, and 9.5 ± 1.1 N/mm (mean \pm SE) at 120 degrees knee flexion with the Lipped Bearing (no slope). With the Standard Bearing (3 degrees posterior slope), elastic modulus decreased to 6.0 ± 0.5 N/mm (mean \pm SE) at 120 degrees knee flexion.

CONCLUSION: Higher PCL stiffness was observed at 120 degrees knee flexion than 90 degrees knee flexion with Lipped Bearing surface (no slope), but using the Standard Bearing (3 degrees posterior slope), PCL stiffness decreased significantly at 120 degrees knee flexion. Therefore a posterior tibial slope of bearing insert prevents an excessive load on PCL at high knee flexion angles.



Elastic modulus of PCL



K722 Early Administration of Fondaparinux and Enoxaparin After Total Knee Arthroplasty in Japanese Patients

Primary Author: Tanaka Takaaki

Institution: Okayama University Graduate School of Medicine

Coauthors: Furumatsu Takayuki (Okayama University Graduate School of Medicine), Miyazawa shinichi (Okayama University Graduate School of Medicine), Okada Yuki-masa (Okayama University Graduate School of Medicine), Fujii Masataka (Okayama University Graduate School of Medicine)

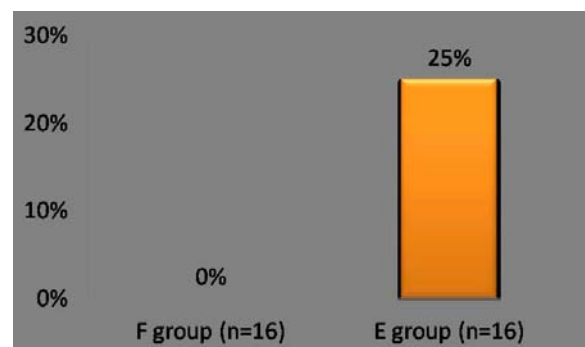
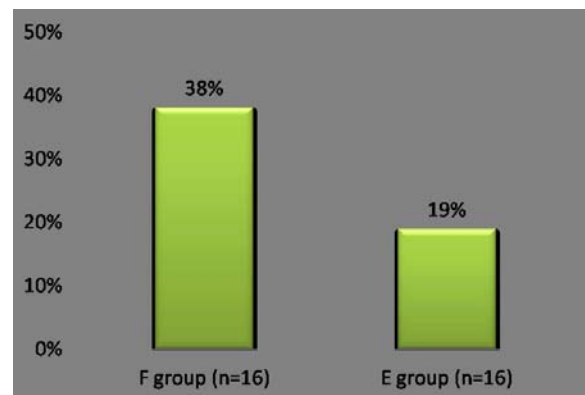
BACKGROUND: The validity of fondaparinux and enoxaparin has been reported in the prevention of deep vein thrombosis and pulmonary embolism (DVT/PE) after

total knee arthroplasty (TKA) in Japan. We compared the effectiveness of early administration of these two drugs after TKA in Japanese patients.

METHODS: We studied 32 Japanese patients who underwent TKA in the period between May 2009 and May 2010. The operations were performed under general anesthesia and femoral nerve block, using an air tourniquet, and using cements for implant fixation. These patients were divided in two groups, use of 2.5mg fondaparinux once daily (F group), and use of 2000IU of enoxaparin twice daily (E group). The initial dose was administered between 12 and 21 hours after surgery and continued for 14 days. We compared the incidence of DVT/PE, bleeding complications, D dimer level, and hemoglobin (Hb) loss.

RESULTS: DVT/PE occurred in 6 patients (38%) in the F group, and 3 (19%) in the E group. (See Fig.1) Bleeding complications occurred in none of the Fa group and 4 (25%) in the Ex group. (See Fig.2) There were no significant differences in D dimer level and Hb loss.

CONCLUSION: Our study showed that there are some differences in the characteristics of fondaparinux and enoxaparin, and that consideration should be given to their mode of administration to Japanese patients.



K723**Assessment of OCD Coincident With Discoid Lateral Meniscus and Relationship With Shape of Discoid Lateral Meniscus***Primary Author: Junsei Takigami**Institution: Osaka City University Graduate School of Medicine**Coauthors: Yusuke Hashimoto (Osaka City University Graduate School of Medicine), Shinya Yamasaki (Osaka City University Graduate School of Medicine), Shozaburo Terai (Osaka City University Graduate School of Medicine), Tomohiro Tomihara (Shimada Hospital), Kunikazu Kaneda (Shimada Hospital), Hiroaki Nakamura (Osaka City University Graduate School Of Medicine)*

OBJECTIVES: Little is known about the age distribution the relationship between Osteochondritis dissecans (OCD) of the knee and shape of discoid lateral meniscus (DLM). The purpose of the study is to assessment of age distribution of OCD coincident with DLM and relationship between OCD and shape of complete DLM in children.

METHODS: From 2000 to 2013, 106 knees (92 patients aged 15 and under) were diagnosed with symptomatic complete discoid lateral meniscus. Of 106 knees with complete discoid lateral meniscus, 49 were males and 57 were female. The average age of the patients was 11.7 years (range, 6-15). All patients were Japanese. OCD in the radiography were graded by Brückl classification and shapes of DLM in MRI were graded by the Ahn's classification. Based on Ahn's classification, DLM were divided into four type: no shift type (N), anterocentral shift type (AC), posterocentral shift type (PC), and central shift type (C).

RESULTS: OCD of the lateral femoral condyle was associated with DLM in 19 of the 106 knees (17.9%). OCD were classified as Brückl's stage 1 in 4 knees, stage 2 in 11, stage 3 in 2, stage 4 in 1, and stage 5 in 1. On age distribution of OCD, the largest ratio of OCD was 9 years in 5 knees (26.3%), and 12 knees (63.2%) were found within 8 to 11 years. OCD combined with DLM were classified as Ahn type AC in 5 of 21 knees (23.8%), type PC in 0 of 21 (0%), type C in 6 of 10 (60%), and type N in 8 of 54 (14.8%). OCD was significantly more likely in association with the meniscal central shift (odds ratio, 8.63; 95% confidence interval, 1.98 to 37.6; $p=0.0041$).

CONCLUSIONS: Although the incidence of OCD with DLM was reported from 11.3% to 12.8%, this incidence was 17.9% in this study. This results may be because age in this study was younger. Most cases of OCD with DLM in this study were aged 8 to 11 years. There was a correlation between OCD and the meniscal central shift ($p=0.0041$; odds ratio, 8.63), therefore, we should particularly take care of incidence of OCD with DLM in children and DLM that the entire meniscus displaces centrally or anterocentrally on MRI.

K724**Evaluation of the Rotational Alignment of the Femoral Component in Total Knee Arthroplasty***Primary Author: Koichiro Tanaka**Institution: Sugioka Memorial Hospital**Coauthors: Ryuji Nagamine (Sugioka Memorial Hospital), Kei Osano (Sugioka Memorial Hospital)*

PURPOSE: The femoral component rotation angle in total knee replacement in (TKA), be about 3° external rotation from Posterior Condyle Line (PCL) is often in the measured resection technique. However, in Japanese, bone morphogenetic of American and European are different, there are a variety of opinions about the osteotomy at 3° uniform. We report a case of considering the relationship between the anatomical landmark and installation angle rotation of the femoral component in the case of where he used a modified gap technique method in our hospital.

METHODS: It is 54 cases that were brought against TKA varus knee OA type in our hospital in April-December 2012. 5 men, 49 women, was 74.3 years average age. Approach using all patients medial parapatellar approach in Scorpio NRG PS type, use models were operated on modified gap technique method. Shoot the CT preoperatively, Condylar Twist Angle (CTA), Posterior Condyle Angle and (PCA), the angle between the normal to the AP Axis and PCL: measured (AP angle APA), the tensor intraoperative femoral component rotation / was determined using a balancer.

RESULTS: CTA by preoperative measurement is $7.1^\circ \pm 1.6^\circ$, PCA is $3.1^\circ \pm 2.0^\circ$, APA $4.9^\circ \pm 1.9^\circ$. Intraoperative rotation installation angle was (positive external

rotation direction) $5.4 \pm 1.5^\circ$. CTA and intraoperative rotation installation angle, APA showed a weak correlation. In addition, APA and the CTA was observed a moderate correlation.

DISCUSSION: External rotation installation of the femoral component is also important in order to obtain good patellofemoral joint conformity. It is located at about 2° external rotation than PCA and 3° external rotation installation recommended by the measured resection. In this study, the angle, correlated with the APA and CTA was observed. Depends on the individual case, it external rotation disposed of about 5° is required is not enough for external rotation of 3° in many cases in Japan, the APA and the CTA is referred to as the index has been suggested. Furthermore, the suitability of the patellofemoral joint is also improved by close to APA has been considered.

K725

The Simple Lateral Radiograph Maximum Flexion Hold View of the Knee Predicts Patients ACL Status

Primary Author: Ichiroh Tatsumi

Institution: Shounan Kamakura Knee Joint Reconstruction Centre

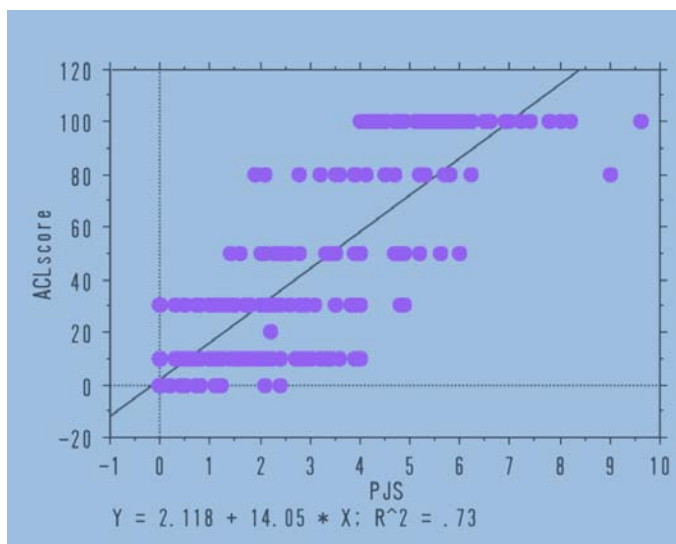
Coauthors: Takeaki Ueno (Shounan Kamakura Knee Joint Reconstruction Centre), Kanna Nonaka (Shounan Kamakura Knee Joint Reconstruction Centre)

BACKGROUND: The recent studies report the successful unicompartmental knee arthroplasty (UKA) depends on the intact anterior cruciate ligament (ACL) function. However it is difficult to assess the patient ACL status before surgery. We have assessed the ACL function only by one simple radiograph. The purpose of this study is to analyze the reliability of our ACL assessment method.

MATERIAL AND METHOD: A total of 500 consecutive patients underwent knee arthroplasty from Oct. 2010 to Dec. 2013. The average age of the patients was 75 years (ranged from 58 to 92). 125 were males and 375 were females. All participants the maximum flexion posture of the knee was hold by a technician and simple lateral x-ray was taken. The medial posterior joint space (PJS) was measured in the computer. The patients PJS less than 2mm were categorized insufficient ACL group preoperatively.

The patients PJS more than 4mm were categorized effective ACL group preoperatively. And the rest PJS 2mm to 4mm were categorized dodgy ACL group preoperatively. In addition valgus and varus stress were applied with the knee flexion 15 degree in the frontal view and the stress anterior-posterior (AP) radiograph was taken preoperatively. The reversible deformity was defined as correctable varus deformity by valgus stress. The patient who had effective ACL and reversible medial varus deformity were treated with UKA. From the intra-operative observation, the intact ACL status was graded as 100 points, partial sheath erosion as 80, only postero-lateral fiber (PL) intact and stable as 50, continuous PL but unstable as 30, only fibrous scar exist as 10 and vanished at all as 0 point. The simple linear regression analysis was done between PJS (mm) preoperatively and ACL status from intra-operative observation. The correlation factor was 0.813. The patients satisfied our UKA indication were 240 (48%) and 231 of them had an almost intact ACL. No patient was converted to TKA.

DISCUSSION: 240 cases met our UKA indication. 231 of 240 (96.3%) had a sufficient ACL and could have been achieved UKA. The correlation factor between PJS and ACL score was 0.813. This simple ACL assessment method was certifiable. In the analysis of the extreme value, we found 2 cases had no ACL (score 0 point) but PJS was more than 4mm. PJS indicates the medial posterior cartilage. There might be some time lag between ACL fade away and posterior cartilage loss. There were no cases who had a sufficient ACL in insufficient ACL group (PJS less than 2mm). In our cases we observed that the antero-medial fiber of the ACL was injured first and then postero-lateral fiber was damaged. This might be a degenerative medial osteoarthritis course. Some doctors perform arthroscope to see ACL function before UKA. Some doctors take MRI to assess ACL function however the qualitative assessment is difficult. One simple lateral radiograph enables us to assess ACL function well and the accuracy of this ACL assessment method is precise.



K726 Microimaging Throughout Wear Simulator Testing of a Total Knee Replacement

Primary Author: Matthew G. Teeter

Institution: London Health Sciences Centre

Coauthors: Amit Parikh (Smith & Nephew), Marc Taylor (Smith & Nephew), Jeff Sprague (Smith & Nephew), Douglas D. Naudie (London Health Sciences Centre)

PURPOSE: Implant wear continues to be a limitation of total knee replacement (TKR). Wear simulator studies are a valuable screening tool in new implant development. The purpose of this study was to determine the ability of micro-CT to prospectively measure wear in TKR implants during a wear simulator test.

METHODS: Three identical cruciate-retaining, fixed bearing cobalt-chromium-molybdenum (CoCrMo) on conventional EtO-sterilized ultra-high molecular weight polyethylene (UHMWPE) TKA implants underwent wear simulator testing up to 6.2 million cycles using gait inputs. Loaded-soaks were used to correct for fluid absorption. The tibial inserts were both weighed and scanned with micro-CT (at 50 micron voxel spacing) [1] before testing and after 3.1 and 6.2 million cycles. The gravimetric mass was converted to volume based on the density of UHMWPE (0.93 g/cm³). Volume change due to wear was calculated from both the gravimetric and micro-CT methods. The pre- and post-wear test micro-CT geometries were co-registered and the deviations between the two were measured [2].

RESULTS: The mean wear volume measured gravimetrically was 90.8 ± 12.2 mm³ after 3.1 million cycles and 142.3 ± 25.7 mm³ after 6.2 million cycles. The micro-CT wear volume measurements were 66.4 ± 13.3 mm³ after 3.1 million cycles and 135.0 ± 27.0 mm³ after 6.2 million cycles. Micro-CT consistently underestimated wear volume ($p = 0.01$) versus gravimetric wear. A bias of 15.9 ± 9.6 mm³ was determined by Bland-Altman analysis. Maximum penetration (from wear and creep) on the articular surface was 0.60 ± 0.24 mm after 3.1 million cycles and 0.67 ± 0.19 mm after 6.2 million cycles. On the backside surface, maximum penetration was 0.25 ± 0.04 mm after 3.1 million cycles and 0.30 ± 0.04 mm after 6.2 million cycles. No subsurface cracks were seen on the bearing and the back-side surfaces.

DISCUSSION: Micro-CT underestimation of wear volume compared to gravimetric analysis is consistent with previous reports. The discrepancy could be caused by a scaling error in the micro-CT volume reconstruction, or an error in the fluid uptake correction for gravimetric analysis. The wear volume was consistent with other fixed bearing TKR couples made from CoCrMo and conventional non-irradiated polyethylene. Penetration was greater during the first half of the testing, likely due to creep.

SIGNIFICANCE: There was good agreement between wear volume estimated using micro-CT and gravimetric techniques. Micro-CT also enables analysis of the implant subsurface, and measurements of penetration and surface deformation, providing valuable data to researchers beyond what is achievable with conventional measurements. In addition, the 3D models from micro-CT could be used to validate computational wear models, increasing their predictive power and reducing the frequency in which expensive mechanical simulator trials need to be performed.

K727 Revision Surgery for Delayed Medial Instability After Total Knee Arthroplasty: A Report of Two Cases

Primary Author: Masanori Tsubosaka

Institution: Department of Orthopaedic Surgery, Kobe University Graduate School of Medicine

Coauthors: Tomoyuki Matsumoto (Department of Orthopaedic Surgery, Kobe University Graduate School of Medicine)

INTRODUCTION: It is reported that 10-year revision rate of total knee arthroplasty (TKA) is 6.2% [1]. Most common causes for revision surgeries are aseptic loosening, infection, pain and wear [2]. The delayed medial instability after TKA is relatively rare. We describe two cases of the delayed medial instability after TKA, which are required revision TKA.

CASE PRESENTATION: Case1: A 82-year old woman with osteoarthritis (OA) of the knee underwent TKA using a cruciate-retaining (CR) design. The delayed medial instability of the knee was developed one year after primary TKA. Hip-knee-ankle (HKA) angle was 134° and range of motion (ROM) was $-10-90^\circ$. The extensor mechanism was also injured by obsolete patellar fracture. In this case total hip arthroplasty (THA) at the contralateral side was performed due to hip severe OA and resolving long leg discrepancy in advance, then revision TKA with hinged prosthesis was performed due to fixed deformity and severe instability. The extensor mechanism was also repaired using artificial ligament augmentation with the partial patellectomy. Three months after the surgery, the patient got to walk with a walker. HKA angle improved to 175° and ROM was $-5-90^\circ$ (Fig.1). Case2: A 68-year-old woman with rheumatoid arthritis underwent TKA using a CR design. The delayed medial instability of the knee was developed slowly 12 years after primary TKA and 1 year after THA at the same side. HKA angle was 155° and range of motion was $0-110^\circ$. This case also required revision TKA with hinged prosthesis due to fixed deformity and severe medial instability. Three months after the surgery, the patient acquired walking ability without any support; HKA angle improved to 176° and ROM improved to $0-125^\circ$ (Fig.2).

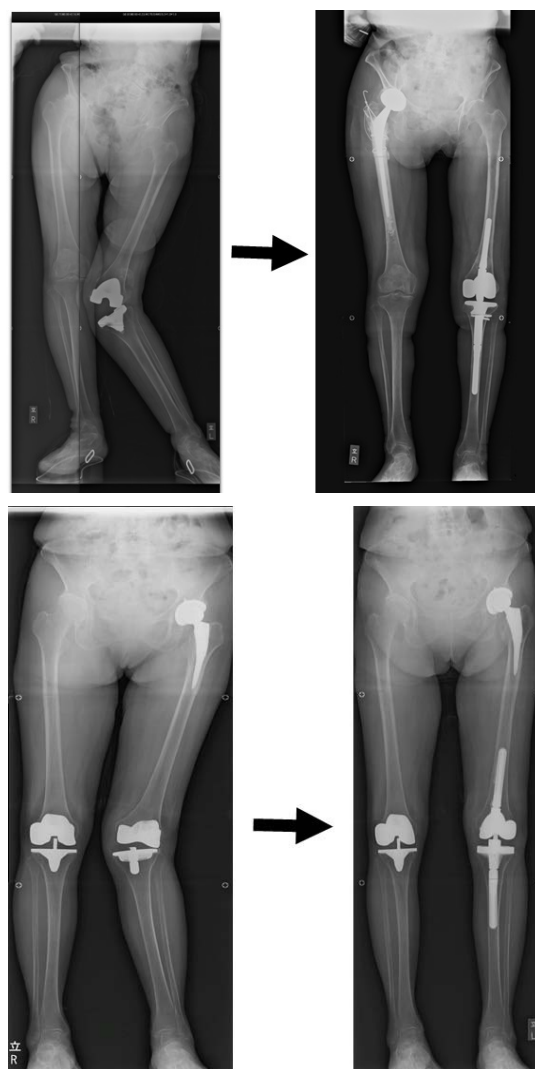
DISCUSSION: The delayed medial instability of the knee after primary TKA is relatively rare in the causes of revision TKA. In both of cases in this paper, the hip joint developed OA or RA changes prior to knee disorder. The coxitis knee and the long leg arthropathy were reported that hip joint OA lead to the secondly valgus knee deformity. The delayed medial instability after TKA in this study was partially due to the same mechanism as the long leg arthropathy or the coxitis knee caused by hip joint degenerative changes. Ligamentous reconstruction alone is reported to be inappropriate for the treatment of ligamentous instability after TKA [3]. In our two cases, we therefore performed revision TKA with hinged prosthesis due to fixed

deformity and severe medial instability, following total hip arthroplasty.

CONCLUSION: We experienced two cases of delayed medial instability after TKA due to prior hip disease. Constrained prostheses were applied and provided relative good results in the two cases.

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K728**Changes of Extension Gap and Flexion Gap Before and After Posterior Clearance in TKA***Primary Author: Yasunori Tsukimura**Institution: Kitasato Insutitute Hospital, Artificial Joint Center*

PURPOSE: We sometime have experienced cases extended extension gap sever after posterior clearance, although we used measured resection technique in TKA. Purpose of this study is to investigate changes of extension gap and flexion gap before and after posterior clearance in TKA.

CASES AND METHODS: 120 osteoarthritic varus knees with primary TKA were measured changes extension gap (EG) and flexion gap (FG) before and after posterior clearance (PC) in both 93 PS type TKA and 27 CR type TKA. Gap changes of both types each were compared in presence of femoral posterior condyle osteophyte. In PS, mean age was 77.3 years old, 78 females and 15 males, 56 left knees and 37 right knees. Mean pre-FTA was 186.3, mean pre- ROM was 100.6°. In CR, mean age was 73.8 years old, 22 females and 5 males, 12 left knees and 15 right knees. Mean pre-FTA was 183.4, mean pre- ROM was 101.4°. There was no significant difference in each factor between PS and CR. Operation was carried out using MIS-measured resection technique. 8-11cm medial longitudinal incision and sub-vastus or mini-vastus approach was used. The patella wasn't everted. Subsequently, medial site osteophyte of both medial femoral condyle and medial tibial condyle was removed. EG was measured after femoral distal cut first, and tibial articular cut secondly. Then, FG was measured after femoral anterior m posterior and chamfer cut. Finally, PC was carried out. Adhesive posterior capsule release remaining attachment of femoral posterior capsule, not only resected femoral condyle osteophytes, as PC. Both EG and FG was measured again after the PC. The correction value that attracted "femoral component thickness + tibia component thickness + minimum insert thickness" from raw value for examination of significant difference.

RESULTS: PC extended medial EG (mean 2.2mm) and lateral EG (mean 1.4mm), medial FG (mean 1.7mm) and lateral FG (mean 1.4mm), significantly in PS type. Extension of med EG with osteophyte (mean 3.1mm) was larger than that of med EG without osteophyte (mean 1.8mm) significantly. Another gap didn't extend significantly ac-

cording to presence of osteophytes. PC extended medial EG (mean 2.6 mm) and lateral EG (mean 2.7mm), medial FG (mean 1.4mm) and lateral FG (mean 0.9mm), significantly in CR type. But, there was no significant difference of each gap before and after PC according to presence of osteophytes.

CONCLUSIONS: We investigated changes of extension gap and flexion gap before and after posterior clearance in TKA. Posterior clearance extended medial extension gap, lateral extension gap, medial flexion gap and lateral flexion gap, significantly in both PS type and CR type. Extension of med extension gap with osteophyte (mean 3.1mm) was larger than that of med that without osteophyte (mean 1.8mm) significantly, although another gap didn't extend significantly according to presence of osteophytes. Adjustment of gap, especially extension gap before and after posterior clearance is needed scrupulous care in case of giant femoral posterior condyle osteophytes.

K729**Pre and Postoperative Subjective and Objective Clinical Assessment Using 2011 Knee Society Score in Total Knee Arthroplasty***Primary Author: Atsuo Uefuji**Institution: Department of Orthopaedic Surgery, Kobe University Graduate School of Medicine*

Coauthors: Tomoyuki Matsumoto (Department of Orthopaedic Surgery, Kobe University Graduate School of Medicine)

PURPOSE: With the use of traditional objective scoring system, total knee arthroplasty (TKA) has shown good clinical results in aspects of alignment, stability, pain relief and function. However, subjective assessment such as patient satisfaction in TKA should be investigated in more detail. In this study, the patient based scoring system, 2011 knee society score (2011 KSS), was compared between preoperatively and 6month postoperatively in TKA.

MATERIALS AND METHODS: We compared 49 knees of 47 patients undergoing TKA from May 2012 to June 2013 using 2011 KSS. There were 46 osteoarthritis knees and 3 rheumatic knees. The comparing aspects were objective knee indicators, satisfaction scores, expectation scores, and function scores. Then we evaluated the corre-

lations among the aspects.

RESULTS: Postoperative objective knee indicators, satisfaction score, and function score were significantly higher compared to preoperative scores, respectively. (objective knee indicators: 90.7 vs 53.6, satisfaction score 22.5 vs 14.5, function score 65.5 vs 44.5, post vs preoperative score, respectively, p Postoperative satisfaction scores and function scores had positive correlations with preoperative function scores ($p=0.029$, $p=0.002$, respectively). And postoperative objective knee indicators and expectation scores had no correlations with other aspects of preoperative scores. All scores of postoperative aspects had correlations with each other (objective knee indicator – satisfaction score, $p=0.002$. objective knee indicator expectation score.

DISCUSSION: Postoperative satisfaction scores had correlations with preoperative function scores, indicating that encouraging preoperative functional activities had the possibility to increase the postoperative satisfaction scores. Since each postoperative score of 2011KSS aspect had correlations with scores of the other aspects, the all evaluation aspects seem to influence each other. On the other hand, postoperative expectation score decreased compared with preoperative value in this short term (postoperative 6 month) study, we should check the scores in the long term study. Conclusion: The result of 2011KSS at 6 months after TKA comparing preoperative score indicated good outcome in objective knee indicators, satisfaction score, and function score. However, patient expectation score decreased compared to preoperative score, suggesting that more detailed informed consent explaining postoperative knee pain, condition, function, and activity et al. should be done in such an invasive surgery TKA.

Table. 1

N=49	Objective Knee Indicator	Satisfaction	Expectation	Function
Preoperative score	53.5±17.3	14.5±7.6	12.4±2.5	44.5±19.3
6M postoperative score	90.6±5.0	22.5±6.5	10.3±3.0	65.5±18.7
p	$p<0.001$	$p<0.001$	$p<0.05$	$p<0.001$

Comparison between preoperative and postoperative scores

Table.2

Correlation coefficient			Postope / Postope	R	p
Preope / Postope	R	p	Postope object/ Postope satisfaction	0.431	0.002
Preope function/ Postope satisfaction	0.344	0.029	Postope object/ Postope expectation	0.492	<0.001
Preope function / Postope function	0.466	0.002	Postope object/ Postope function	0.569	<0.001
			Postope satisfaction/ Postope expectation	0.572	<0.001
			Postope satisfaction/ Postope function	0.545	<0.001
			Postope expectation/ Postope function	0.607	<0.001

K730

Comparative Study of Innovative Wound Dressings After Total Knee Arthroplasty

Primary Author: Catherine Van Der Straeten

Institution: Ghent University Hospital, Belgium

Coauthors: Steven Smet (Ghent University Hospital, Belgium), Andreas Dobbelaere (Ghent University Hospital), Nika Schuermans (Ghent University Hospital), Jan Victor (Ghent University Hospital)

INTRODUCTION: Postoperative wound complications, including superficial infections, may cause important comorbidities. Moreover, wound complications substantially increase the total cost of the hospital stay. A good wound dressing enhances the patient's comfort and decreases the work load of the nurses. Recently, innovative wound dressings have been introduced. However, studies comparing the quality and effectiveness of wound dressings are scarce and often lack the power to come to relevant conclusions. Besides, the cost effectiveness of different wound dressings has not been investigated.

OBJECTIVES: The aims of this study were to compare the incidence of wound complications, the patients' comfort, the user friendliness and the cost of different innovative wound dressings.

METHODS: A randomized controlled trial was set-up to compare three innovative postoperative wound dressings to each other and to the standard postoperative wound dressing after Total Knee Arthroplasty (TKA) at our insti-

tution. One hundred eleven patients who received a TKA were randomized in 4 equal groups: 3 groups received a so-called innovative wound dressing (Aquacel Surgical, Opsite Postop Visible or Mepilex Border Postop) and the fourth group randomized to receive the standard wound procedure (Zetuvit and Cosmopor) was considered as control group. Follow-up evaluations were performed on the fifth postoperative day and included assessment of the wound itself, the status of the wound dressing and the patient's own assessment. The number of dressing changes was noted carefully. Cost per wound dressing was calculated via a formula taking into account the number of dressing changes, the nursing time and the individual cost of the dressings.

RESULTS: Clinically, Mepilex Border, a foam dressing with a silicone contact layer, proved to be the most skin-friendly dressing, with no incidences of blisters, maceration or allergic reactions. The glue used in the adhesive layer of the Aquacel Surgical and Opsite Visible dressings led to local irritation with blisters or maceration in a few cases. The mean number of dressing changes was 1.9 for the standard dressing (control group) which was significantly higher (p Pain upon withdrawal of the dressing was negligible with Mepilex Border (mean VAS 0.32) and most painful with Opsite Visible (mean VAS 1.87) ($p = 0.015$) Mepilex Border and Opsite Visible both scored best regarding freedom of movement and general comfort. The standard dressing was considered least comfortable and most bothersome with movements. Although Mepilex Border and with Opsite Visible are more expensive than the standard procedure, the mean cost of the dressings per patient including nursing care was considerably lower, because these dressings hardly had to be changed.

CONCLUSIONS: Mepilex Border and Opsite Visible had superior characteristics compared to the standard dressing (Cosmopor) and to Aquacel Surgical. Clinically Mepilex Border had the best results. Both patients and nurses had a clear preference for this wound dressing, which additionally is cheaper than the standard procedure. Opsite Visible was the cheapest dressing and also scored well clinically but Mepilex Border had the best cost-benefit evaluation and is advocated for use after TKA based on the results of this study

K731

Determinants for Patient Satisfaction in Total Knee Arthroplasty. Large-scale Trial

Primary Author: Catherine Van Der Straeten

Institution: Ghent University Hospital, Belgium

Coauthors: Stefaan Van Onsem (Ghent University Hospital, Belgium), Jan Victor (Ghent University Hospital)

INTRODUCTION: Total Knee Arthroplasty (TKA) is a proven successful and cost-effective method to relieve pain and improve joint function and quality of life in patients with advanced knee arthritis. However, after a TKA, only 75 to 89% of patients are satisfied. Since patient satisfaction is one of the main objectives of elective orthopaedic surgery, it is important to investigate the reasons for dissatisfaction and develop remedial strategies.

OBJECTIVES: The aims of the current project are to investigate patient satisfaction after TKA and establish physical, mental and social determinants of patient satisfaction and overall socio-economic costs associated with unsatisfactory outcome. The global objective is to identify patients most likely to benefit from primary TKA, establish optimal evidence-based indications and timing for TKA, and address the necessity to educate patients preoperatively towards realistic expectations or propose alternative therapies. Based on the results, a composite score for patient selection will be developed using objective and subjective parameters. Cut-off values for acceptable indications for TKA will be proposed.

METHODS: General determinants of patient satisfaction are first investigated in a retrospective and prospective survey of TKA. Expectations regarding the global benefit of TKA, postoperative pain and difficulties are evaluated. Psychological tests assessing the ability of patients to cope with pain are performed. Objective clinical and radiographic parameters, patient reported outcomes and satisfaction are compared between subgroups based on (1) patient intrinsic factors such as gender and age, BMI, co-morbidities, general physical and mental health, activity, level of education and socio-economic situation, (2) implant factors, (3) surgery and surgical experience related factors. Subsequently, a randomized controlled trial of 330 consecutive primary TKAs using 3 contemporary implants of different design concepts will be carried out.

Evaluation will be double-blinded (immediately preoperative randomisation, patient blinded, postoperative observer blinded). In addition, a surgeon's assessment of subjective technical difficulty will be performed. A university/teaching hospital setting will be compared with a private hospital and the influence of the surgeon on the level of patient satisfaction will be assessed.

RESULTS: Intermediate evaluation of the study revealed extensive logistic difficulties in setting up such a large scale trial and in motivating patients, nursing and medical staff to participate and sustain the necessary commitment and discipline to collect all necessary data at all follow-up intervals. Patients often felt overwhelmed by a multitude of clinical scores and technical assessments leading to a decrease in study compliance and rapid loss to follow-up. Motivation proved easier in a smaller private hospital environment. At the university hospital, patient involvement was enhanced by a personalized approach with information sessions in small groups. The introduction of a new software system with direct patient input via touch screens or remote online completion of scores reduced the data input burden. Scores are examined for simultaneous digital answering of overlapping questions.

CONCLUSIONS: A large scale trial to investigate longer term patient satisfaction after TKA and establish its determinants involves continuous motivation and sustained discipline of patients and staff. A personalized approach and digital patient reported outcomes prove to maximize data acquisition

K732

Management of Patella Femoral Joint with New TKA Design

Primary Author: Bruno Violante

Institution: Istituti Clinici Zucchi , Monza

The Presentation looks to the New opportunities given by New TKA Designs , The Author on the experience with the Attune System analyzes how can be treated the P/ F joint as a critical part of the Patient functional results. P/F Joint is very likely the Functional Core of the TKA for those Patients with medium High Activity request. The quad Level arm is linked to the design capability to create a distal anterior and posterior joint Line the closest possible to the native one. Analysis is Made on the limb alignment and

technique details. When and how we can leave unresurfaced the patella.

K733

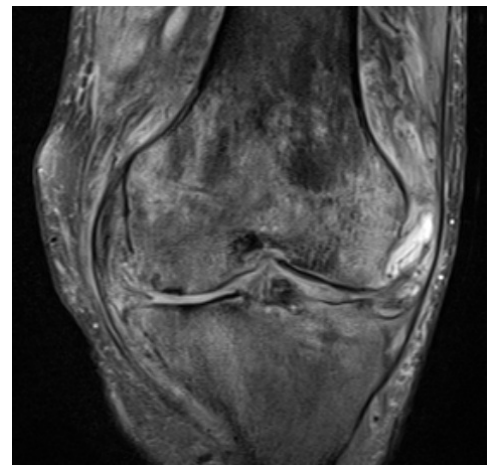
Primary Articulating Spacer for Treatment of MRSA Septic Arthritis After Knee Arthroscopy: A Case Report

Primary Author: Joel A. Virkler

Institution: Botsford Hospital affiliated with Michigan State University

Coauthor: Joseph C. Finch (Botsford Hospital affiliated with Michigan State University)

Infection is a rare, yet catastrophic complication of knee arthroscopy. In the case presented, the patient's early degenerative condition progressed to end-stage methicillin resistant staphylococcus aureus (MRSA) septic arthritis with subacute osteomyelitis (see Figure 1) after routine knee arthroscopy. Treatment was accomplished with a primary articulating antibiotic cement spacer (see Figure 2) and subsequent conversion to total knee arthroplasty. The treatment protocol was based on the authors experience in a small series of patients. A similar protocol was suggested in our literature review but there is currently limited guidance from large randomized trials looking at outcomes. Regardless, the consequences of MRSA infection progressing to periprosthetic infection are severe. Therefore, the purpose of this case presentation is to emphasize the importance of an aggressive treatment algorithm to prevent a prolonged treatment course and super-infection post-arthroplasty.





K734

Is the “Japanese Seiza” Position Permitted After Oxford UKA?

Primary Author: Hiroki Watanabe

Institution: Hachiya Orthopaedic Hospital

Coauthors: Yudo Hachiya (Hachiya Orthopaedic Hospital), Koichi Muramatsu (Hachiya Orthopaedic Hospital), Syoichi Taniguchi, Kenichiro Tanaka (Hachiya Orthopaedic Hospital)

INTRODUCTION: There are some patients who kneel in the “Japanese Seiza” position after Unilateral knee Arthroplasty (UKA). We have had a case of bearing failure which was probably due to the patient sitting in Seiza on a daily basis after Oxford UKA. What we are concerned with here is whether kneeling in Seiza is safe after UKA especially Oxford Uni as the mobile type UKA. We verified the safety of kneeling in the Seiza position using lateral X-rays of knees in deep flexion.

MATERIALS AND METHODS: We had a case where a 70 y.o. female patient broke a bearing due to kneeling in the Seiza position on a daily basis. She suddenly felt severe pain in her knee which then locked up and she could not walk at all. This incident occurred 10 years after surgery. The bearing breakage was diagnosed by X-ray and we then performed revision surgery as TKA. We postulated that the bearing was being overloaded by the posterior edge of the femoral component. We followed up by investigating 89 cases where we took lateral X-rays of the patients kneeling in the Seiza position. In the cases where kneeling in the Seiza position was possible, we measured the flexion angle between femur and tibia, the femoral component flex-

ion angle, the tibial component posterior tilting angle and the position of the femoral posterior edge to the bearing using a lateral X-ray while the patient was kneeling in the Seiza position.

RESULTS: In the woman’s case presented, bearing breakage was caused by the so-called fretting fatigue phenomenon which was generated by repeated collision. This was observed using a microscope and scanning electron microscopy. Based on analysis using lateral X-ray in Seiza position, the average flexion angle between femur and tibia was 156 degrees (146-168 degrees). The femoral component flexion angle was 12.5 degrees in the standard component and 21.7 degrees in the High-flex implant, respectively. The posterior tilting angle of the tibial component was 11.6 degrees. The posterior edge of the femoral component was expected to be located at an average of 67% from the anterior edge of bearing.

DISCUSSION: The cases that could kneel in the Seiza position after Oxford UKA achieved an average of 156 degrees of knee flexion. In this situation, the posterior edge of the femoral component should be located at approximately 60% from the anterior edge of the bearing if we take the femoral flexion angle and tibial posterior tilting angle into consideration. However, in fact it was located more posteriorly. In other words, this means edge loading is occurring. In conclusion, we considered kneeling in Seiza to be safe as long as the bending angle is of no more than 150 degrees in cases with High-flex implants.

K736

Kinamatically Aligned TKR with Nonconventional Use of Conventional Instruments

Primary Author: Ye-yeon Won

Institution: Dept. of Orthopaedic Surgery, Ajou University Hospital

Coauthors: Chang-dong Han (Yon-sei University Hospital), Hyung-min Ji (Dept. of Orthopaedic Surgery, Ajou University Hospital), Jun Han (Dept. of Orthopaedic Surgery, Ajou University Hospital), Don-san Kim (Dept. of Orthopaedic Surgery, Ajou University Hospital)

INTRODUCTION: Kinamatically aligned TKR(KA-TKA) has been performed with PSI or nonconvention-

al use of conventional instruments in which preoperative MRI is a basic requirement for prediction of pre-arthritis articular surface dimensions. In addition to extra cost, however it seems to give no more accurate estimation of cartilage and bony defect than intra-operative direct estimation and measurements.

MATERIALS AND METHODS: The authors tried to do KA-TKA based on intraoperative cartilage thickness measurements without any assistance of pre-operative MRI measurements. We used calibrated spinal needle(image#1) for intraoperative direct measurements of remained articulate cartilages around femoral and tibial condyles: distal femoral condyles(5 points for each condyle), posterior femoral condyles(3 points for each condyle), proximal tibial condyles(5 points for each condyle). The measurements were averaged for the selection of appropriate shim which was attached to the conventional femoral cutting guides and tibial articular surfaces(image #2).

RESULTS: 20 CR-TKA(average age=70 years old, M:F=2:18, single radius design, all cemented) were done using this methods. Average pre and postoperative mechanical axis deviations were 5.8° varus(range, 13° varus~ 5° valgus) and 1.7° varus(range, 8° varus~ 3° valgus). Average postoperative tibiofemoral anatomic axis was 5.4° valgus(0° ~ 9° valgus). Average postoperative joint line obliquity was 3.1° (range, 0.5° varus~ 5.3° varus). Average postoperative alpha, beta, gamma and delta angle was 100° , 94° , 3.8° (flexion) and 85° . The patients were followed at least postoperative 4 months for clinical and functional knee scores.

DISCUSSIONS AND CONCLUSIONS: KA-TKA is one of the emerging concepts in patient specific knee replacement. The critical requirement is accurate estimations of pre-arthritis status of articular surface of patient's own. We introduce the surgical technique of KA-TKA in which intra-operative direct measurements of articular surface defects could contribute the exact evaluation of cartilage and bone defects and a positive cost benefit point of view. However further evaluation and follow-up results should be coming out for more general use.



K737

Radiographic Assessment of Total Knee Arthroplasty Using Conventional Instrumentation

Primary Author: Wendy W. Wong

Institution: Loma Linda University Medical Center & Donaldson Arthritis Research Foundation

Coauthors: Travis Scudday (Loma Linda University Medical Center), Halsie Donaldson (Donaldson Arthritis Research Foundation), Thomas K. Donaldson (Donaldson Arthritis Research Foundation)

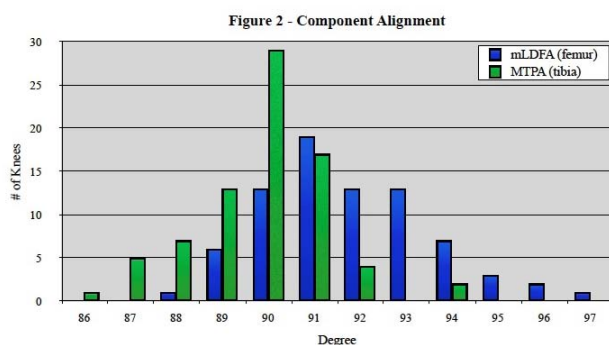
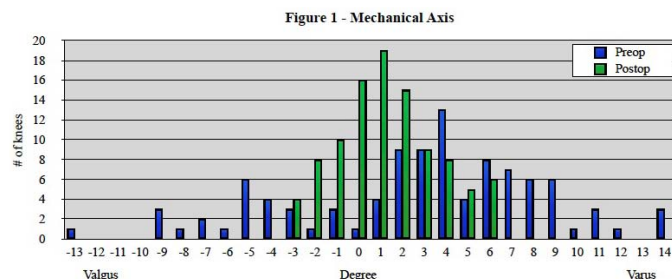
INTRODUCTION: Conventional total knee instrumentation is used for most total knee replacements. Computer-assisted total knee arthroplasty (CA-TKA) including custom guides has gained popularity due to its reported accuracy in restoring optimal alignment. CA-TKA has demonstrated increased surgical time and cost, with known risks of pin-site infection and fracture. We assessed the radiographic alignment of conventional TKA by one surgeon and determined whether preoperative alignment has an effect on postoperative alignment.

METHODS: A prospective series of 100 primary total knee arthroplasties (in 95 patients) from 1/2012-3/2013 were performed by the senior author, using a single con-

ventional instrument system and a consistent methodology of 5° valgus distal femoral cut, intramedullary femoral entry-point, and minor cement balancing. Mechanical axis and component alignment were measured digitally on pre-operative and postoperative lower extremity scanograms. Target alignment was set at neutral \pm 3°. Knees with preoperative deformity within 0 \pm 5° (non-deformed group) and those with >5° varus/valgus (deformed group) were compared using chi-square test.

RESULTS: Target mechanical axis alignment (0 \pm 3°) was achieved in 79% cases, while 21% remained in varus alignment (Fig1). The non-deformed group achieved target alignment in 93.2% cases versus 62.2% in the deformed group ($p=0.0006$). The femoral component fell within target alignment (90 \pm 3°) 80% of the time and most often was in 1° of varus. The tibial component achieved target alignment (90 \pm 3°) 96% cases and was most often in neutral (Fig2).

CONCLUSION: Our results were consistent with those reported in the literature for conventional TKA, with a trend towards under-correction of varus deformity. The majority of the variability stemmed from the femoral component position and careful adjustments should be made to accommodate the individual differences of each patient. Given the significant difference in achieving target alignment between the deformed and non-deformed groups, perhaps CA-TKA could be useful in patients with preoperative deformity > \pm 5°.



K738

The Effect of Patella Medialization During TKR

Primary Author: Abraham P. Wright

Institution: DePuySynthes

Coauthors: Chadd W. Clary (DePuySynthes), Komosa Mark (University of Kansas), Lorin Maletsky (University of Kansas)

INTRODUCTION: Lateral patellofemoral ligament (LPFL) release to remedy patellar mal-tracking during total knee replacement (TKR) remains a common occurrence [Ballantyne, 2003], potentially restricting blood supply to the patella and increasing the risk of patella fracture [Ritter, 1999]. Recent research indicates that patella component medialization potentially reduces strain in the LPFL, improving patellar tracking and reducing the risk of lateral release [Anglin, 2008]. The purpose of the current study was to measure the effect of patella medialization during TKR on patellar motion.

METHODS: Seventeen cadaveric knees were dissected and mounted into the Kansas knee simulator [Maletsky, 2005]. A deep knee bend was performed with the flexion angle controlled by a force applied to the quad tendon. The medial-lateral translation and all rotations at the ankle were unconstrained. After the natural evaluation, each knee received a posterior stabilized TKR with either a centralized patella (PFC Sigma™, DePuy) (n=7) or a medialized patella (Attune™, DePuy) (n=10). Both patellae had identical outer profiles, but the articular peak of the medialized patella was offset 2-3 mm medially. Both femoral components had equivalent trochlear angles. A point at the center of the patella implant was tracked through flexion in both the natural and implanted conditions using an Optotrak 3020 (NDI, Waterloo, Canada). The linear distance from the lateral border of the patella to the lateral epicondyle was calculated to quantify strain in the LPFL.

RESULTS: Tracking of the natural patella started centrally and moved slightly lateral in flexion, consistent with previous descriptions [Iranpour, 2009]. Following TKR, both the centralized and medialized patella groups moved medially with flexion, but the medialized patella group consistently tracked 2-3 mm lateral of the centralized patella group, resulting in a position more similar to the natural patella at 90° flexion (Fig. 1). Medialization of the patella

component reduced the length of the LPFL, particularly from 15° to 35° knee flexion (Fig. 2).

DISCUSSION: The LPFL is the primary restraint of medial patella translation near extension [Merican, 2009]. Patella medialization led to a reduction in the LPFL length through 45° flexion. These results are consistent with surgical techniques which release the LPFL to address lateral patella tracking [Strachan, 2009] and suggest that medialization of the patella may reduce lateral release rates during TKR.

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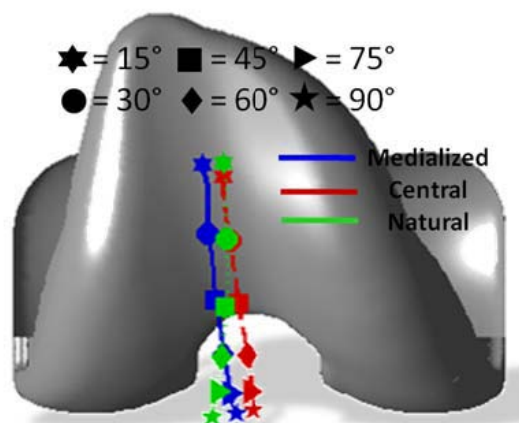


Figure 1. Patella motion with natural (green), central (red), and medialized (blue) patellae.

K739

Do We Need Routine Use of Suction Drain After Total Knee Arthroplasty: A Clinical Study

Primary Author: Chandra Shekhar Yadav

Institution: All India Institute of Medical Sciences, New Delhi

Coauthors: Nishikant Kumar (All India Institute of Medical Sciences, New Delhi), Sanjay Yadav (All India Institute of Medical Sciences, New Delhi), Samarth Mittal (All In-

dia Institute of Medical Sciences, New Delhi), Prashant (All India Institute of Medical Sciences, New Delhi)

BACKGROUND: Is routine use of suction drain after joint replacement justified.

MATERIAL & METHODS: Prospective evaluation was done to compare the effects of postoperative suction drain in 56 patients with no postoperative drain, undergoing total knee arthroplasty at our institute. Patients having severe systemic diseases, disturbed liver function, obesity, unstable diabetes and coagulation disorders were excluded from the study. Comparative evaluation was done for the blood loss, no of units of blood transfusion, wound hematoma, wound healing, duration of hospital stay, pain and range of motions.

RESULTS: All the patients were operated by one surgeon by using midline skin incision, midvastus approach and same method of wound closure. Sex distribution was same and no patient received anticoagulant chemoprophylaxis. Average fall in postoperative hemoglobin was 3.1 gm/dl in the drain group and 2.2 gm/dl in the non drain group. Drains were removed at 48 hrs or at 24 hr when drainage was less than 50 ml. Statistically comparative results were seen in both groups in regard of wound hematoma, wound healing, duration of hospital stay, pain and range of motions. But blood loss, fall of hemoglobin and no of units of blood transfusion was more in drain group.

CONCLUSION: Routine use of suction drainage do not offer any advantages and it should be used in patients with coagulation defects, on heparins, unstable diabetes or other risk factor for postoperative infection and hematoma formation.

K740

Role of Intra-articular Tranexamic Acid in Total Knee Replacement Arthroplasty

Primary Author: Chandra Shekhar Yadav

Institution: All India Institute of Medical Sciences, New Delhi

Coauthors: Prashant (All India Institute of Medical Sciences, New Delhi), Nishikant Kumar (All India Institute of Medical Sciences, New Delhi), Samarth Mittal (All India Institute of Medical Sciences, New Delhi), Sanjay Yadav

(All India Institute of Medical Sciences, New Delhi)

BACKGROUND: Role of intra-articular Tranexamic acid in total knee replacement arthroplasty

MATERIALS AND METHODS: Prospective evaluation was done to see the effect of intra-articular Tranexamic acid on blood loss in 60 patients (120 knees) undergoing total knee arthroplasty. All the patients were operated by one surgeon with same technique by using same implants. Patients were randomly injected 1500 mg/20 ml of Tranexamic acid on one side of the knee only. Nothing was injected on the contra lateral knee. Evaluation was done for swelling and the amount of blood loss in the drain.

RESULTS: Average blood loss in the drain on Tranexamic side was 140 ml and the opposite side was 390 ml. Swelling was more observed on the non Tranexamic side. Average time for drain removal on Tranexamic side was 36 hours while it was 48 hours on non Tranexamic side. Early mobilization and weight bearing was less painful in Tranexamic side. No patient had systemic complications of Tranexamic acid. Conclusion: Intra-articular injection of Tranexamic acid reduces blood loss, swelling around the knee without systemic side effects and allows early weight bearing and mobilization of the joint.

K741

Is Every Knee Osteoarthritic? Spontaneous Avascular Necrosis of the Medial Tibial Condyle

Primary Author: chandrashekhar yadav

Institution: Aiims, New Delhi

Coauthors: Sanjay Yadav (Aiims, New Delhi), Nishikant Kumar (Aiims, New Delhi), Samarth Mittal (Aiims, New Delhi), Swapnil Singh (Aiims, New Delhi)

Avascular necrosis (AVN) of tibial condyles especially medial condyle is uncommon (2%). It may mimic osteoarthritis. Differentiation between spontaneous and secondary osteonecrosis is important for appropriate management. We present a case of spontaneous avascular necrosis of medial tibial condyle causing varus deformity and aim to recapitulate various types and currently available treatment options. It typically affects older patients (usually >50 years) with female predominance (3:1). Radiological

changes vary with stage and disease severity. Carpintero et al have described four stages based on plain radiographs. Size of the initial lesion is an important consideration. Various methods have been described for quantification of the lesion. Magnetic resonance imaging (MRI) is very sensitive and specific in diagnosing spontaneous osteonecrosis. Role of bone scan was variable in different studies. Bone scan was not done in our case as it would not have affected the further management. Lotke et al described three types of MRI patterns of osteonecrotic changes. Treatment options range from non-operative and joint preserving methods to knee replacement procedures. Non-operative treatment like protected weight bearing and sole wedges is applicable only to pre-collapse stage. Our patients rarely present so early. Surgical options include a spectrum from microfracture treatment, osteochondral defect repair, extra-articular core decompression, high tibial osteotomy, unicompartmental knee replacement to total knee replacement. Our patient was initially planned for high tibial osteotomy but due to severe varus collapse and associated degenerative changes, total knee replacement was done. Osteonecrosis may be associated with osteoporosis or osteopenia. This may result in insufficiency fractures without any traumatic event. Considering outcomes, some studies have shown less promising results following TKR in avascular necrosis. Use of cemented implants in present case may have contributed to good functional and radiological outcome. In the present case, there was sudden increase in pain during past one month; localization was to the medial tibial condyle near joint line with exacerbation on weight bearing. Though age was less than 50 years as compared to the description in literature, other findings and lack of any predisposing factors lead to the diagnosis of spontaneous avascular necrosis of medial tibial condyle. Considering advanced stage of AVN and associated degenerative changes, TKR was performed successfully with good outcomes.

K742

Short-Term Outcome of Total Knee Arthroplasty by Triathlon®

Primary Author: Makoto Yamanaka

Institution: Department of orthopedic surgery, Tokyo Rosai Hospital Japan Labour Health and Welfare Organization

Coauthors: Masashi Takemitsu (Tokyo Rosai Hospital), Hiroshi Fujii (Tokyo Rosai Hospital), Tokuro Narimiya

(Tokyo Rosai Hospital), Ryohei Matsuo (Tokyo Rosai Hospital), Yu Taniguchi (Tokyo Rosai Hospital), Yuta Asanuma (Tokyo Rosai Hospital)

INTRODUCTION: In the total knee arthroplasty, the range of motion is not necessarily involved in direct to patient satisfaction, but in Japanese, the deep flexion is required in daily life in many cases. Thus it appears that patient satisfaction is higher if deep flexion is obtained. We report on total knee arthroplasty that was performed to minimize the soft tissue release and bone resection.

MATERIAL AND METHOD: 85 total knee arthroplasty of 70 cases was performed in our hospital from July 2011 to December 2013. Until 2013.12. subjects were 35 knees of 30 cases that an author performed total knee arthroplasty using Triathlon as the performance of an operation or the first assistant by December, 2013 from July, 2011. We have investigated Kellgren-Lawrence grade, intraoperative femoral resection amount, the amount of tibial resection, range of motion before and after surgery. Surgical procedure The operation used midvastus approach by a midline incision at the beginning. The femoral externally rotation is three degree from posterior condyle axis, valgus five degree from longitudinal axis and the quantity of distal osteotomy assumed 8mm basics. Using the CR type if during surgery, PCL was judged as normal, using a CS-type if it is not normal. The tibia osteotomy assumed medial plateau 2mm basics not to hang to the head of fibula. I removed bone osteophyte such as the medial or posterior condyle enough when I finished osteotomy.

RESULT: Kergren-Lewrence4 type was 28 knees, Kergren-Lewrence3 type was 8 knees. CR type were 27 knees, CS type were 7 knees. Preoperative extension was Minus 12 degrees, preoperative flexion was 121°. Preoperative extension was minus three degrees, postoperative flexion was 129 degrees. Femoral resection amount is 8.2mm, the tibial resection amount was 1.5mm. Femoral osteotomy plane was all cases grand piano type. There were no cases admitted mid flexion instability after surgery.

DISCUSSION: It is believed facilities seeking to high-flexion TKA is increasing in recent years, it has been reported that there is no necessarily correlate high flexion and patient satisfaction. Think mid flexion instability is or not they relate to one of the causes performers, which set the goal of TKA with no slack in the varus-valgus without release the deep MCL as possible. In other words, var-

us-valgus balance, extension-flexion gap becomes better enough resection of osteophytes, I believe that post-condyle off-set can be sufficiently secured. It is possible to perform the TKA without having to release the deep MCL with sufficient dissection of osteophytes from the results of this excursion also shows a 17° improvement. It is believed to be able to perform A more satisfying by performing a TKA using the Triathlon® surgery method of author, colleague. However, it is necessary to repeat the study in a similar way in the future because of number of cases is small.

K743

Effect of Femoral Component Design on Patellar Crepitus Incidence Following TKA

Primary Author: Charlie C. Yang

Institution: Colorado Joint Replacement

Coauthors: Douglas A. Dennis (Colorado Joint Replacement), Raymond H. Kim (Colorado Joint Replacement), Peter J. Laz (Colorado Joint Replacement)

INTRODUCTION: Patellar crepitus occurs in up to 14% of cruciate-substituting (PS) total knee arthroplasty (TKA) patients resulting from synovial tissue impingement within the femoral component intercondylar box (IB). Femoral design features including the IB ratio and transition zone between the trochlea and IB are etiologic factors in developing patellar crepitus. A design change in a PS femoral component with a known incidence of patellar crepitus (PFC Sigma; Depuy; Warsaw, IN) resulting in a smoother transition zone was incorporated into the PFC Sigma-HP femoral component. We compare the incidence of patellar crepitus between patients implanted with the PFC-Sigma and the PFC Sigma-HP femoral components.

METHODS: A review of prospectively collected data was performed comparing the incidence of patellar crepitus in the initial 625 consecutive PFC Sigma-HP PS femoral components implanted to the previous 625 consecutive PFC-Sigma (non-HP) PS components implanted by two surgeons. The overall incidence of patellar crepitus, symptomatic crepitus (noted by the patient), and crepitus requiring surgical intervention was evaluated.

RESULTS: At minimum two year follow-up duration, 531 non-HP and 555 HP subjects have been evaluat-

ed. The overall incidence of patellar crepitus in the non-HP group (13.9%) was similar to that observed in the HP group (14.41 %) ($p=0.33$). There was a trend for symptomatic crepitus to occur more frequently in the non-HP group (5.08%) than the HP group (4.32%; $p = 0.06$). Those requiring surgical intervention for crepitus was greater in the non-HP (3.39%) than the HP cohort (1.26%; $p = 0.02$).

CONCLUSION: Current data demonstrates a similar incidence of overall patellar crepitus, while symptomatic crepitus, and crepitus requiring operative intervention occurred more frequently in the non-HP group. The geometry of the transition zone from the trochlea to the intercondylar region of PS femoral components is an important determinant in development of patellar crepitus. Smoothing the transition zone lessens quadriceps tendon irritation and the incidence of operative patellar crepitus.

K744

Comparing Three Different Femoral Fixation Techniques in Anterior Cruciate Ligament Reconstruction

Primary Author: Hamed Yazdanshenas

Institution: Charles R. Drew University of Medicine and Science

Coauthors: Firooz Madadi (SBMU), Firoozeh Madadi (SBMU)

BACKGROUND: The anterior cruciate ligament is the primary structure that controls anterior displacement in the unloaded knee. Anterior cruciate ligament reconstruction may return normal functions of the knee. The aim of the present study was to compare three different femoral fixation techniques in anterior cruciate ligament reconstruction.

METHODS: In a clinical trial study, 120 patients that were candidates for ACL reconstruction were randomly divided into 3 groups of 40 individuals. The femoral fixations were by the three methods of “Aperfix”, “Rigidfix” or “Endobutton”. The cases were re-examined 12 months after surgery and evaluated by Lysholm score as well as with KT-1000 machine. The results were compared together for the three above methods.

RESULTS: The Lysholm score showed improvement

from pre-operative values in all three techniques: From 63.21 ± 18.59 to 90.64 ± 9.47 in “Endobutton” group, from 65.72 ± 18.74 to 96.22 ± 5.35 in “Aperfix” and from 69.21 ± 17.45 to 90.64 ± 9.47 in the “Rigidfix” group. There were 6 failures in “Endobutton”, 4 in “Rigidfix” and one in “Aperfix” group. The anterior displacement tibia was 3.96 ± 1.58 millimeters in “Endobutton”, 4.28 ± 1.48 in “Rigidfix”, and 4.03 ± 1.79 millimeters in “Aperfix” group. There was no significant difference in the operating time in the 3 groups.

CONCLUSION: Regarding the instant stability of the graft, the “Aperfix” method seemed stranger. Further investigations with larger number of cases and longer duration of follow up are recommended.

KEYWORDS: Anterior cruciate ligament; Arthroscopy; Knee

K745

Prognostic Factors of the Arthroscopic Adhesiolysis in the Arthrofibrosis of the Knee

Primary Author: Kyu Woong Yeon

Institution: Chungnam National University Hospital

Coauthors: Young Mo Kim (Chungnam National University, school of medicine), Yong Bum Joo (Chungnam National University Hospital)

PURPOSE: To research the prognostic factors that affect the result of arthroscopic adhesiolysis and postoperative results on knee arthrofibrosis patients.

MATERIALS AND METHODS: Among the patients with arthrofibrosis after knee joint surgery, 68 cases that underwent arthroscopic adhesiolysis and were able to follow up for at least 1 year were compared using their Lysholm knee score, International Knee Documentation committee (IKDC) subjective knee score, patient satisfactory, causes, duration of arthrofibrosis, and knee range of motion (ROM) according to their age.

RESULTS: The 61 cases (89.7%) showed an average of 48.6° increase of ROM, however, the other 7 cases (10.3%) did not show any increase of their ROM on the final follow up. Lysholm knee score and IKDC subjective knee score increased significantly on the final follow up. Patient satis-

factory showed satisfied or very satisfied in 89.7% on the final follow up. All postoperative ROM was significantly increased regardless of the causes of the knee arthrofibrosis. The duration of arthrofibrosis was highly correlated to the postoperative recovery of the ROM. however, age was not related to the recovery.

CONCLUSIONS: Arthroscopic adhesiolysis for intraarticular arthrofibrosis is effective treatment, and especially, the shorter the duration of the disease, the better were the results.

K746

Influence of the Translation of Mobile Bearing on Range of Motion After Anterior-posterior Glide Total Knee Arthroplasty

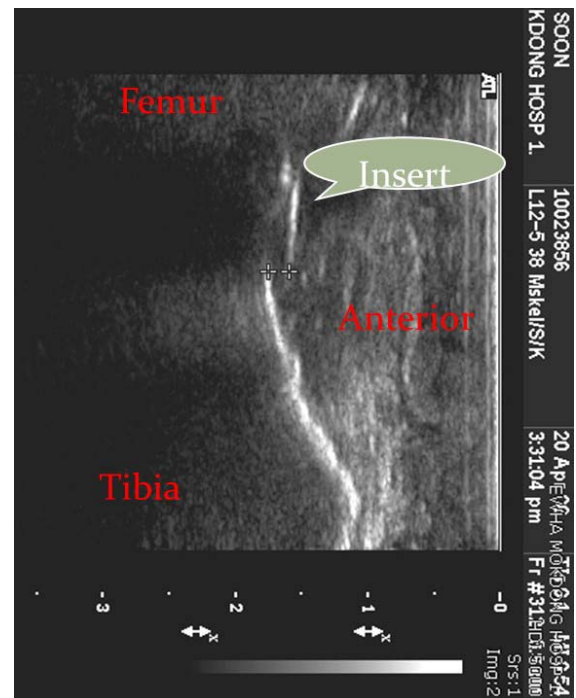
Primary Author: Jae Doo Yoo

Institution: Ewha Womans University, Mokdong Hospital

Coauthor: Yeong Won Koh (Ewha Womans University, Mokdong Hospital)

The anterior-posterior-glide Low Contact Stress (LCS APG) mobile-bearing knee prosthesis was designed to facilitates the femoral roll back and increase the range of motion rather than the rotating-platform Low Contact Stress mobile-bearing knee prosthesis does. We investigated the distance of bearing movement using the ultrasonography after surgery and the correlation between the distance of bearing movement and the postoperative knee range of motion. Fifty one knees were included in this study and the average duration of follow-up was 6.4 years. Measurement of intraoperative bearing movement was performed with ruler from the anterior edge of tibial plate to the anterior edge of the polyethylene bearing along the guide arm. Using the ultrasonography, the measurement of the bearing movement was performed in 0 degrees , 30 degrees , 60 degrees and 110 degrees flexion at postoperative 4 weeks 1 year after surgery. The final flexion angle was $122^{\circ} \pm 11.2^{\circ}$ (range , 100 ~ 145°). Intraoperative distance of bearing movement was average 4.8mm (range 0mm ~ 11mm) at 110 °flexion. The average moving distance of the bearings was 2.3 ± 2.5 mm to 4 weeks after surgery and at 1 year after surgery, it was 2.9 ± 3.5 mm. The distance of intraoperative bearing movement was not correlated with the postoperative 4 weeks knee flexion angle ($r^2 = 0.183$) and final flexion angle ($r^2 = 0.135$). There was no correlation

between the distance of intraoperative bearing movement and the followup bearing movement measured by ultrasonography ($r^2 = 0.053$). The distance of intraoperative rearward bearing movement was not correlated to the flexion angle after LCS APG total knee arthroplasty, and the intraoperative rearward bearing movement was not reproduced after surgery.



K747

Comparison of Radiographic Results of Total Knee Arthroplasty Using Robot-Assisted and Conventional Manual Method in Severe Varus Deformity

Primary Author: Sunghwan Yoon

Institution: Leechuntek Orthopedic Specialty Hospital

Coauthors: Chuntek Lee (Leechuntek Orthopedic Specialty Hospital) Ohmyung Kwon (Leechuntek Orthopedic Specialty Hospital) Hangjae Lee (Leechuntek Orthopedic Specialty Hospital) Junehyuck Hur (Leechuntek Orthopedic Specialty Hospital)

INTRODUCTION: The success of total knee arthroplasty depends on many factors, including the preoperative condition of the patient, the design and materials of the components and surgical techniques. It is important to

position the femoral and tibial components accurately and to balance the soft tissues. Malpositioning of the component can lead to failures due to aseptic loosening, instability, polyethylene wear and dislocation of the patella. In order to improve post-operative alignment, computer-aid systems have been developed for total knee arthroplasty. Many clinical and experimental studies of these systems have shown that the accuracy of implanted components can be improved in spite of the increase in costs and operating time. This may not, however, improve the outcome in the short-term. Restoration of the normal mechanical axis of the knee and balancing of the surrounding soft tissues have been shown to have an important bearing on the final outcome of knee replacement operations. In severely deformed knees, whether varus or valgus, these goals may be difficult to achieve. We compared the radiologic results of the mechanical axis and implant position of Total Knee Arthroplasty using a robot-assisted method with conventional manually implanted method in severe varus deformed knee.

MATERIALS AND METHODS: A data set of 50 consecutive cases that were performed from April 2007 to December 2010 using the robot assisted TKA(Group A) were compared with a data set of 50 consecutive cases from the same period that were done using conventional manual TKA(Group B). All cases had a preoperative mechanical varus deformity $>15^\circ$ and one brand of implant was used on all cases. The diagnosis was primary osteoarthritis in all knees. The operations were performed by one-senior author with the same robot system, ROBODOC (ISS Inc., CA, USA) along with the ORTHODOC (ISS Inc., CA, USA) planning computer. (See Figure 1.) The radiological evaluations included mechanical axis, implant position ($\alpha, \beta, \gamma, \delta$ angle) according to the system of American Knee Society.

RESULTS: There was a significant difference in the post-operative α, β, γ angle and mechanical axis between two group ($p < 0.05$). In group A, mechanical axis angle changed from preoperative varus $18.5 \pm 3.3^\circ$ to postoperative varus $0.6 \pm 1.5^\circ$ without outlier. In group B, mechanical axis angle changed from varus $19.4 \pm 4.2^\circ$ to varus $2.5 \pm 3.8^\circ$ with 8 outliers. In group A, the mean $\alpha, \beta, \gamma, \delta$ angle were $96.7^\circ, 90.1^\circ, 1.9^\circ, 86.8^\circ$ and $93.1^\circ, 88.3^\circ, 3.8^\circ, 85.9^\circ$ in group B. But we found no loosening and osteolysis at last follow up in both group.

CONCLUSION: On the basis of our results, patients with

severe varus knee ($>15^\circ$) tended to have more postoperative varus mechanical alignment in conventional manual TKA group than robot-assisted TKA group. We think that robot-assisted TKA is helpful in excessive varus knee in aspect of not only mechanical alignment and implant position but also long term clinical results and implant longevity. However, a long term followup evaluation will be necessary and complications in robot system.

K748

Microfracture and Platelet Rich Plasma (PRP) for the Treatment of Injuries Cartilage: Analysis of the Results

Primary Author: Pietro G. Zedde

Institution: Clinica Ortopedica Università degli Studi di Sassari

Coauthors: Federico Mela (Clinica Ortopedica Università degli Studi di Sassari), Fabio Del Prete (Clinica Ortopedica Università degli Studi di Sassari), Andrea F. Manunta (Clinica Ortopedica Università degli Studi di Sassari)

INTRODUCTION: In the last years different surgical techniques for the treatment of articular cartilage injuries have been proposed, which can be divided into two main groups according to their action mechanism: restorative techniques based on spinal cord stimulation including abrasion arthroplasty, subchondral, microfracture and nanofracture, and chondral restoration techniques such as autologous osteochondral grafts (OCT), autologous chondrocyte transplantation and the use of staminal cells or PRP associated to scaffolds. Among all these techniques microfracture are the most used by orthopedic surgeons as they are simple, they need no special instruments and have low costs. The results achieved are good even if the restoration tissue growing in the defects is made up of fibrocartilage, it contains a great amount of type I collagen and a low concentration of proteoglycans.

MATERIALS AND METHODS: In recent years we have chosen to treat selected cartilage injuries associating the microfracture with platelet concentrate infiltration, matching in this way a conventional and effective restorative technique with an innovative regenerative technique. For the study, 64 patients with III-IV chondral injuries have been selected, ICRS classification, located in the medial femoral condyle in load region and less than 2.5mm wide.

They all were single and not associated to meniscal or ligamentous injuries or particulate axial deviations. For 26 out of 64 patients microfractures were associated to PRP intra articular infiltrations once a week for 3 weeks.

RESULTS: For all the patients the treatment response was evaluated after 6, 12 and 24 months, both from a symptomatological and functional point of view, using VAS and IKDC subjective score. The post surgery clinical evaluations after 6 and 12 months have shown the best results in those patients treated associating the two methodologies compared with patients treated exclusively with microfractures. The evaluation with VAS scale shown at 6 and 12 months of follow up, respectively, a mean value of 3,6 and 4,5 in the group treated only with microfracture and a mean value of 1,8 and 2,5 in the group treated with both microfracture and PRP. Similarly, the evaluation with subjective IKDC scale at 6 and 12 months of follow-up shown, respectively, a mean value of 78 and 73 in the group treated only with microfracture and mean value of 87 and 82 in the group treated with both microfracture and PRP. After 24 months, however, the difference between the two groups decreased so that the patients reached substantially the same results, VAS scale 5 versus 4,3, IKDC score 63 versus 65.

CONCLUSION: On the basis of our data, we can state that the association of these two techniques for the treatment of cartilage injuries represents a valid methodology compared with the single microfracture in that it reduces the local inflammation, it improves the pain symptomatology and hastens the return to activities of daily living. Owing to the recent introduction of this methodology, however, clinical studies with long-term follow-up are necessary.

K749

Changes in Bone Mineral Density of Both Proximal Femurs after Total Knee Arthroplasty

Primary Author: Kwangkyoun Kim

Institution: Konyang University Hospital

BACKGROUND: This study investigated the effects of total knee arthroplasty (TKA) on bone mineral density (BMD) of the proximal femur in patients who underwent the procedure.

METHODS: Forty-eight patients scheduled to undergo unilateral TKA because of primary knee OA were included in this study, which was conducted at a medical center, between October 2006 and October 2009. In these 48 patients, 96 hips were evaluated. Measurement of BMD was performed preoperatively and one month, three months, six months, and one year after unilateral TKA.

Repeated measured ANOVA and paired t -tests for comparison of two repeated samples were used to compare differences between time points (preoperation, one, three, six, and 12 months) and between the operative and nonoperative sides.

RESULTS: Preoperatively, BMD of the femoral neck, trochanter, and total hip on the operative side were lower than on the nonoperative side; however, there was no statistical difference. BMD of both femoral neck areas was significantly lower than preoperative BMD at one month and three months after TKA. BMD of both trochanter areas was significantly lower than preoperative BMD at one month and three months after TKA. BMD of both total hips was significantly lower than preoperative BMD at three months after TKA. However, no statistical differences of changes in BMD were observed between the operative and nonoperative sides at each measurement time.

CONCLUSIONS: According to our results, TKA was found to affect both proximal femurs during the acute period. However, TKA did not affect a change in BMD of the proximal femur during one year postoperative.

Poster Session

Abstracts

– Shoulder –

S791

Reverse Shoulder Arthroplasty for Trauma in The Elderly: What Happened in the Long Term?

*Primary Author: Jean-Francois Cazeneuve
Institution: Centre hospitalier*

The aim of this retrospective and mono centric study is to present results and complications in trauma of the reverse concept without re-fixation of the tubercles because of major osteoporosis and poor quality of the cuff. We therefore ask whether clinically the patients recover a pre-broken state, what the radiologic follow-up reveals and whether the rate of complications is important.

Forty-six patients operated consecutively from 1993 to 2013 by the same surgeon were included in this study. The average follow-up time was 8.75 years. There were five men and forty-one women, mean age 74 (range, 48-92 years), with 31 complex four-part fractures and 15 fracture-dislocations.

Four complications occurred: 1 complex sympathetic dystrophy treated by medication, 1 early superior dislocation because of an impingement in adduction between the humeral stem and the remnants of the tubercles solved by their ablation without further problems, 1 deep infection solved by debridement and drainage for an early postoperative *Acinetobacter* infection without further problems and 1 aseptic loosening of the base-plate with a broken screw and no wear at 12-year follow-up leading to implant a classic base-plate because of a fair bone stock and efficient primary grip after impaction.

The mean Constant score was 53 points (20 to 84) at last revision representing 67% of the mean score of the injured side. Mean adjusted Constant score was 68. Forty percent of the patients were unsatisfied because of poor rotations avoiding nourishment with utensils, dressing and personal

hygiene. When the dominant arm was affected, the patients lost frequently their autonomy.

One patient with 42-mm glenospheres had a complete 2-mm radiolucent line at four-year follow-up. Inferior spurs were seen in 16 cases (34%). They were stable after emergence without functional impact or radiographic evolution. They appeared at a mean of 2.5 years (range, 1-6 years). Scapular notching was seen in 25 cases (54% of the patients), all appeared before two-year follow-up. Thirteen notches were stable with a sclerotic border and without critical humeral images. Twelve were progressive with a proximal humeral bone loss (n=7) or a radiolucent line (n=5). In these cases, there was a negative effect on the Constant score: 41 points instead of 53 for the global series.

Our experience reported in the present study shows (1) 40 % of the patients were unsatisfied because of poor rotations with a functional result never equal to the pre-injury state (2) 31% of the radiological images found were critical (3) 9% of the patients had a severe complication. For trauma in the elderly, such results allow us to implant a RSA only for selected cases. So nowadays, our elective indication is a woman for a non-dominant arm, over seventy years old with poor physiology and important osteoporosis.

S792

Clinical Results of Anatomic Total Shoulder Arthroplasty for Osteoarthritis and Rheumatoid Arthritis

*Primary Author: Ryoza Harada
Institution: Department of Orthopaedic Surgery, Okayama University Hospital*

Coauthors: Keiichiro Nishida (Department of Human Morphology, Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences), Kenzo Hashizume (Department of Orthopaedic Surgery, Okayama University Hospital), Ryuichi Nakahara (Department of Orthopaedic Surgery, Okayama University Hospital)

INTRODUCTION: Total shoulder arthroplasty (TSA) is successful in providing pain relief and functional improvements for patients with shoulder degenerations. We aimed to investigate the clinical and radiographic results of total shoulder arthroplasty (TSA) for damaged shoulder joints

with osteoarthritis (OA) and rheumatoid arthritis (RA).

PATIENTS AND METHODS: Between 1999 and 2013, we performed 20 total shoulder arthroplasties in 17 patients. Sixteen shoulders (6 OA and 11 RA) of 15 patients were available for more than a half-year follow-up study. In the RA patients, all shoulder were classified as grade 4 according to the modified Larsen's classification. All of the OA and RA patients were women, aged average 71.2 years old at the time of surgery, and average follow-up period was 42.8 months. Preoperative MRI scan showed supra-spinatus tendon was intact in the 6 shoulders (intact group), and torn or thin in the 11 shoulders (damaged group). According to the implants, we used the anatomic TSA for 5 Bio-modular®, 10 Bigliani-Flatow®, and 2 Global Advantage® in each shoulders. Clinical outcomes were assessed using the scoring system of the Japanese Orthopaedic Association shoulder scoring system (JOA scores, total 100 points, high score is excellent), the Disabilities of the Arm, Shoulder and Hand (DASH) score and the range of motion (ROM) of the shoulder. Radiographic loosening of the humeral stem and glenoid component was evaluated according to the criteria described by Stewart et al. Statistical analysis were done using the Wilcoxon signed-rank test and the Mann-Whitney U test.

RESULTS: The average JOA score improved from 40.3 ± 13.9 points preoperatively to 80.8 ± 11.6 points ($p < 0.01$) at the final follow-up. The average DASH score improved from 68.1 ± 16 points to 52.5 ± 31.5 points ($p < 0.01$). The mean pre- and postoperative range of active flexion was 69° , 104° ($p = 0.01$), the extension was 37° , 54° ($p = 0.01$), the abduction was 52° , 81° ($p = 0.03$), and the external rotation were, 14° , 39° ($p < 0.01$), respectively. Radiolucent line around the glenoid component was observed in 2 shoulders. There was one implant intraoperative fracture but was no other complications such as the aseptic loosening, the implant failure, the dislocation, the revision and the infections. Between the OA group and the RA group, there was no significant differences in the clinical outcomes. There was no statistically difference in the postoperative JOA score between the intact group (85.8 ± 9.8 points) and the damaged group (78.5 ± 12.1 points, $p = 0.24$), but the improvement in ROM (flexion, abduction and external rotation) was significantly greater in the intact group than in the damaged group. Postoperative JOA score showed the mild inverse correlation with preoperative DASH score ($r = -0.67$, $p = 0.04$).

DISCUSSIONS: The results of the current study showed satisfactory clinical outcomes of TSA for OA and RA, particularly with good pain relief. Clinical outcome might depend on preoperative status of rotator cuff and function of upper extremity.

S793

Functional Outcome of Comprehensive Reverse Shoulder System

Primary Author: Ali Abdullah. Mohammed

Institution: Royal Liverpool and Broadgreen University Hospitals NHS Trust

Coauthors: Alex Kyriakos (Royal Liverpool and Broadgreen University Hospitals NHS Trust), Simon P. Frostick (Royal Liverpool and Broadgreen University Hospitals NHS Trust)

INTRODUCTION: Reverse shoulder arthroplasty (RSA) is a recognized surgical intervention, which has been reported for different indications. The aim of this report is to present the functional outcome of forty-eight reverse shoulder replacements, over a mean follow up period of twenty-one months, following a standardized treatment protocol.

INDICATIONS: Rotator Cuff Tear Arthropathy (RCA), degenerative joint disease (DJD) with Cuff Tear, Rheumatoid Arthritis (RA) with Cuff Tear, massive irreparable rotator cuff tear (RCT) without Arthritis of the gleno-humeral joint, post traumatic arthritis with RCT, tumors, avascular necrosis, revision of failed Resurfacing, Hemi or Anatomic Total Shoulder Replacement due to irreparable RCT, instability with arthritis and rotator cuff pathology, and fracture.

FEATURES: Medialized or lateralized center of rotation with 0.5 - 4.5 mm offset in any direction. Inferior inclination up to 10° . Base plate central boss and modular 6.5 mm central screw. Utilize the same Comprehensive® platform stems. Can be used as primary reverse or revision, un-cemented or cemented. Exclusive RingLoc® technology. Tray available in standard, +5 mm and +10 mm. Polyethylene bearing options available in standard, +3 mm and +3 mm retentive, includes 12° angle, making the neck-shaft angle $33^\circ/147^\circ$. $45^\circ/135^\circ$ neck-shaft angle 69 stem sizes available.

MATERIALS AND METHODS: From Sept 2010 – May 2012, out of 48 RSA performed, 46 patients were followed up, with mean follow up of 21 months. 32 female & 16 male patients, with mean age of 69.88 (min 48; max 87). 29 right-sided shoulders replacement, while 17 were left-sided. Only 3 patients were left-handed. 24 Primary (52.2%) (8 RCA, 6 OA, 6 RA, 2 Post traumatic OA, 2 RC massive tear, 6/24 RSA had previous RC Repair (1 patient twice). 22 Revisions (47.8%) from failed: 6 Copeland, 11 Hemi, 5 Previous total shoulder arthroplasty or failed other types RSA). 13 were 1st revisions (28.2%), 9 were 2nd revision or more (7 were 2nd revision, while 2 patients had more than 2 revisions). 2 in the revision group had the previous stem retained (Epoca, Hemi) and converted to reverse. 16 Patients had other Joints Replaced. X- Rays, CT were used as standard diagnostic tools.

FOLLOW UP PROTOCOL: 2Weeks – 6Weeks – 3Months – 6Months – 12Months – Annually thereafter.

PROCEDURE: All cases operated in beach chair position, through delto-pectoral approach, under general anesthesia plus regional block (Scalene block).

STEM RETROVERSION: 14 in 10°, 30 in 20°, and 2 in 30° (46 Stems) 13 Stems cemented, 33 non cemented (both retained stems were cemented). All had standard Base plates, 36 Glenospheres 0 – 10 ° inferior inclination, and “D” inferior Offset (3.5mm).

SCREWS IMPLANTATION: 5 /46 - Central Screws not implanted (No enough bone stock). 10% of base plates fixed with no anterior or posterior screws (Ant > Post). 1 Patient’s baseplate fixed without ant and posterior screws.

RESULTS:

GROUPS PRIMARY/ REVISION	PRIMARY 24 PATIENTS		REVISION 20 PATIENTS	
RESULTS (Mean)	PREOP	F/U	PREOP	F/U
Oxford Score	13.77	33.3	12.27	21.2
Constant Score	19.17	45.43	17.36	34.5
SF12 PCS (Physical)	25.7	31.7	25.5	27.6
SF12 MCS (Mental)	52.56	55.8	52.2	43.5
PAIN	7.9	3.2	7.8	5.3
STIFFNESS	8.1	3.6	7.8	6.1
SATISFACTION	-----	9.48	-----	6.47
ELEVATION	60	107	53	95
ABDUCTION	52	90	42	77

CONCLUSION: The results report a satisfactory outcome of the reverse shoulder arthroplasty as reflected in the as-

essment tools in both primary, and revision cases, with better outcome in primary replacements. Long-term follow up is in progress.

S794

The Effects of Glenosphere Tilting, Inferior Displacement, and Humeral Retroversion on The Range of Motion and Impingement After Reverse Shoulder Arthroplasty

Primary Author: Kyu Cheol Noh

Institution: Hallym Univ Medical Center, Kangnam Sacred Heart Hospital

Coauthors: Yon-Sik Yoo (Hallym Univ Medical Center, Dongtan Sacred Heart Hospital), Seong-Wook Jang (Korea University of Technology and Education)

Though lots of research is done about the clinical outcomes of RSA, those focused on the factors of ROM and impingement other than inferior notching is few. This study further investigates the effects of glenosphere tilting, inferior displacement, and humeral retroversion(HRV), on the ROM and impingement after RSA.

3-D shoulder models were reconstructed based the outlines of the 2-D preoperative images of the scapula and the humerus of patients who undergone RSA. 3-D model of the widely used Aequalis® Reversed Prosthesis (Tornier SA, Montbonnot, FR) was also generated from the CAD model as well. Multiple sessions of virtual surgery was done incorporating the selective reconstruction models of the scapula and the humerus, and the prosthesis model.

The final output after virtual surgery is the postoperative model in the neutral position. For this, the human skeleton model was processed through a visualization software (Amira®, VSG, USA), and virtual surgery was processed by a CAD software (Rapidform 2006, INUS Technology, South Korea).

To analyze the impingement of the bony structures, shoulder movement was defined as abduction(ABD), forward flexion(FF), internal rotation(IR), and external rotation(ER), and was hypothesized that the stem of the humerus and the curved surface of glenoid head are mutually fixed during motion. Impingement between the scapula and humerus was quantified using the “Collision detect”

function provided by the Rapidform software, analyzing the impact of the inferior glenoid, superior glenoid, coracoids, and the acromion as the arm is abducted during scapular plane elevation (“Scaption”). After setting the position of the glenosphere to 0, 10 degrees inferior tilting, 0, 3mm inferior displacement, and 0, 10, 20 degrees of HRV, ROM was compared within combinations (T0, T0-tilt, T3, T3-tilt; HRV 0, 10, 20).

Impingement between inferior glenoid of the scapula and humerus was at its maximum at 20 degrees HRV and the least at neutral position. Group with 3mm inferior displacement of the glenosphere (T3, T3-tilt) also had low rates of inferior impingement.

However, in regards of the superior glenoid, neutral HRV had more impingement while 20 degrees HRV shows lesser impingement. Impingement was at its lowest in the group with only 3mm inferior displacement without tilting (T3).

The range of IR was superior at 3mm inferior displacement group(T3, T3-tilt), while 20 degrees HRV showed less ROM than neutral. The range of ER was superior at 3mm inferior displacement group(T3, T3-tilt), while 20 degrees HRV showed more ROM than neutral.

Position of the glenosphere and the degree of HRV is a factor determining the ROM of the shoulder joint after RSA, and impingement between bony structures and other internal structures as well. To minimize inferior notching, 3mm inferior displacement of the glenosphere was most effective. In all range of motion except FF, 3mm inferior displacement of the glenosphere was superior than all other combinations. 20 degrees HRV showed better ROM than neutral position during abduction and ER only.

S795

Glenohumeral Mismatch Affects Micromotion of Cemented Glenoid Components in Total Shoulder Arthroplasty

Primary Author: Vani Sabesan

Institution: Orthopedic Surgery Western Michigan University School of Medicine

Coauthors: Jeffrey Ackerman (Department of Orthopaedic Surgery, Beaumont Health System), Kevin C. Baker (Department of Orthopaedic Surgery, Beaumont Health

System), Michael D. Kurdziel (Department of Orthopaedic Surgery, Beaumont Health System), J. Michael Wiater (Department of Orthopaedic Surgery, Beaumont Health System)

BACKGROUND: The optimal degree of conformity between the glenoid and humeral components in cemented total shoulder arthroplasty (TSA) has not been established. Glenoid component stability is thought to be at risk due to the “rocking-horse” phenomenon, which, can lead to increased micromotion and loosening in response to humeral head edge loading. The goal of this biomechanical study was to investigate the influence of glenohumeral mismatch on bone-implant interface micromotion in a cemented glenoid implant model.

METHODS: Twenty-five cemented glenoids were implanted in polyurethane foam biomechanics testing blocks. Five glenoid sizes, 40mm, 44mm, 48mm, 52mm, and 55mm (n=5 per size), were cyclically tested according to ASTM Standard F2028-08 at a frequency of 2 Hz to a mismatch-dependent edge displacement representing an edge loading phenomenon for 50,000 cycles. Additional glenoids (n=3 per size) were cyclically tested to their same edge displacements at a constant humeral head rate of 4.4 mm/s for 50,000 cycles. Glenoid component compression, distraction, and superior-inferior glenoid translation were measured throughout testing via two differential variable reluctance transducers.

RESULTS: Humeral head translation distances were identified as 0.55mm, 1.09mm, 2.32mm, 3.82mm, and 4.73mm for each glenoid size, respectively. No significant differences in glenoid component micromotion were noted for smaller glenoid sizes of 40mm, 44mm, and 48mm, representing -1mm, +3mm, and +6mm of radial mismatch, respectively. However, significant glenoid distraction and translation was noted for mismatches greater than +6mm during constant rate cyclic testing.

CONCLUSIONS: Larger glenohumeral mismatch results in larger humeral head translation to induce rim loading. While an optimal glenohumeral mismatch in cemented pegged glenoids has not been established; our data suggests a threshold of +6mm of radial mismatch exists between increasing humeral translation with increasing glenohumeral radial mismatch and the risk of increasing glenoid micromotion and loosening.

CLINICAL RELEVANCE: Larger glenohumeral mismatch in TSA may contribute to increased glenoid component loosening and earlier component failure.

S796

Cost-effectiveness of Hemiarthroplasty Versus Reverse Total Shoulder for Proximal Humerus Fracture

Primary Author: Shahin Sheibani-Rad

Institution: McLaren-Flint/Michigan State University

Coauthors: Asheesh Bedi (University of Michigan)

BACKGROUND: Fractures of the proximal humerus are associated with a profound temporary and sometimes permanent, impairment of function and quality of life. The treatment of comminuted fractures of the proximal humerus like selected three- or four-part fractures and split fractures of the humeral head is a demanding and unresolved problem, especially in the elderly. Reverse Total shoulder arthroplasty (RTSA) and hemiarthroplasty (HA) are two viable surgical treatment options for comminuted proximal humerus fractures. Recent systematic reviews and randomized trials suggest that RTSA, while more costly initially, may have superior outcomes with regard to pain, func-

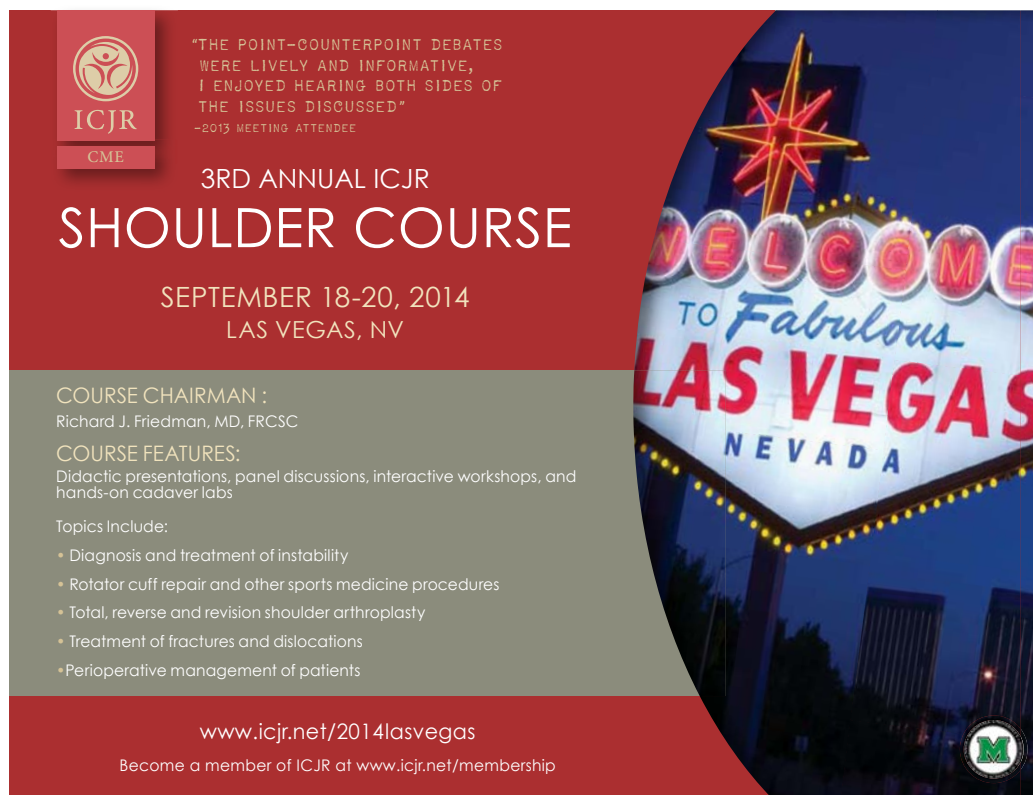
tion and quality of life with lower revision rates. This study compared the cost-effectiveness of RTSA with HA.

METHODS: A Markov decision model was constructed for a cost-utility analysis of TSA compared to HA in a cohort of 64-year-old patients. Outcome probabilities and effectiveness were derived from the literature. Costs were estimated from the societal perspective using the national average Medicare reimbursement for the procedures. Effectiveness was expressed in quality-adjusted life years (QALYs) gained. Principal outcome measures were average incremental costs, incremental effectiveness, incremental QALYs, and net health benefits.

RESULTS: In the base case, HA resulted in a lower number of average QALYs gained at a higher average cost to society and was, therefore, dominated by the TSA strategy for the treatment of comminuted proximal humerus fractures. The cost effectiveness ratio for RTSA and HA were \$957/QALY and \$1,194/QALY respectively. Sensitivity analysis revealed that if the utility of RTSA is equal to, or revision rate lower than HA, RTSA continues to be a dominant strategy.

CONCLUSION: Reverse Total shoulder arthroplasty is a cost-effective procedure, resulting in greater utility for the patient at a lower overall cost to the payer. These findings

suggest that RTSA is the preferred treatment for certain populations from both a patient and payer perspective. Currently available cost and outcome data show that RTSA could be a cost-effective alternative to HA for comminuted proximal humerus fractures. The cost-effectiveness of RSA depends most on the health utility gained from the operation, the utility lost due to complications from the operation, and the cost of the implant.



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Poster Session

Abstracts

– Other –

O749

Elbow Arthroplasty Using Inter-Positional JK Membrane in the Era of Biologics

Primary Author: Weijia Chen

Institution: Sugioka Memorial Hospital

Coauthors: Ryuji Nagamine (Sugioka Memorial Hospital), Keiichi Kondo (Sugioka Memorial Hospital)

OBJECTIVE: In younger RA cases, even though elbow joints are destroyed, total replacement arthroplasty cannot be done due to the limited longevity. The other option is the inter-positional membrane. However, clinical results of arthroplasty using inter-positional membrane were not good because RA activity could not be controlled. Today, RA activity can be controlled by means of biologics; therefore, the usefulness of inter-positional membrane was re-evaluated.

METHODS: So called JK membrane was made. A sheet of fascia, 8 X 6 cm, was detached from the tensor fascia lata muscle of the patient. The fascia was stretched on a frame and kept in a 2% chromic acid potassium solution for 24 hours. Then, the fascia was exposed to direct sunlight in order to reduce the dichromic acid. The fascia was washed out in running water for 24 hours. Afterward, it was stored in phenol with the addition of 70% alcohol. Elbow arthroplasties were performed in 3 elbow joints in two young female patients. Case 1 had severely destroyed right elbow joint with severe dysfunction. An arthroplasty with JK membrane was done in 2003 when she was 34 years old. After the operation, infliximab and tocilizumab have been administrated with methotrexate in order to control RA activity. Case 2 had bilateral ankylosed elbows due to juvenile idiopathic arthritis. Bilateral arthroplasties with JK membrane were performed in 2010 when she was 32 years old. After the arthroplasties, several operative and manual manipulations were necessary in order to increase range of motion. Etanercept and tocilizumab have been ad-

ministrated with cyclosporine.

RESULTS: After the arthroplasties, joint function has been significantly improved in all 3 joints without pain. Range of motion was more than 120 degrees in all joints and RA has been well controlled.

CONCLUSION: If RA activity is controlled with biologics, elbow arthroplasty using inter-positional membrane is thought to be useful in young patient.

O750

Innovative Non-Invasive Method of Diagnosing Knee Pathologies with Vibration Analysis

Primary Author: Mathew Anderle

Institution: University of Tennessee

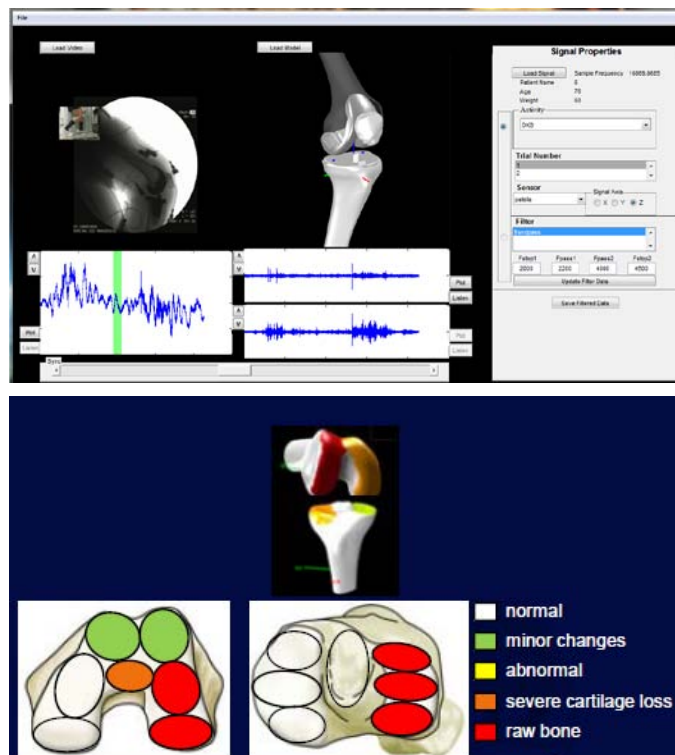
Coauthors: Mohamed R. Mahfouz (University of Tennessee), Ray C. Wasielewski (Minimally Invasive Orthopedics), Richard D. Komistek (University of Tennessee)

INTRODUCTION: Current clinical methods for diagnosing knees is mainly done through visual techniques, which can become costly, and utilize radiation, which induces a risk to the patient. More recently, research is being done on vibroarthrography, the study of joint vibrations, to come up with an additional tool to diagnose knee joint pathologies which will be non-invasive and at much lower cost. The objective of this study is to determine the feasibility of using vibroarthrographic signals as a tool to analyze knee joint conditions.

METHODS: Small sensitive accelerometers are strategically placed around the knee joint at bony landmarks including the patella, tibial tuberosity, and femoral condyles. These sensors can detect and measure the vibrations of the joint during weight-bearing activities. This method can be used on both implanted and non-implanted joints. Subjects have been analyzed that were previously diagnosed as arthritic or healthy. Knees have also been analyzed pre- and post-viscous supplementation. In vivo kinematics have also been synchronized and correlated to certain key traits including cam-post interactions. Pattern recognition approaches are used to develop a predictive model to distinguish healthy from arthritic knees based on vibroarthrographic signals alone.

RESULTS: Minimum-error-rate Bayesian analysis with multi-variate distribution on a subset of patients has yielded >95% accuracy. Support vector machines were also utilized and yielded a significant >95% accuracy. Using new comprehensive software, vibrations have been correlated to cam-post interactions and lift-off in implanted knees. Differences have also been found in the vibrations of knees pre- and post-viscous supplementation. Also, during the analyses of the frequencies, sounds have been detected for the patellofemoral interaction, and femoral condyle motion on the tibial insert.

DISCUSSION: Current diagnostic methods for the knee joint can become very expensive, time consuming, and pose health risks, but a new method of vibroarthrography may soon add a new tool right in the physician's office. A comprehensive software package is currently in development (Figure 1) to create an easy-to-use tool for analyzing knee joint vibrations, and predictive models are being further tuned to diagnose the signals. An ideal package will include easy to place sensors hooked up to a small interface that records and analyzes real-time signals and can give a physician instant feedback on the subjects' knee conditions (Figure 2).



O751

Assessment of Time-Dependent Coronal Laxity in Deep Flexion After Posterior-Stabilized Total Knee Arthroplasty

Primary Author: Kosuke Ebina

Institution: Department of Orthopedic Surgery, Osaka University, Graduate School of Medicine

Coauthors: Takaharu Yamazaki (Center for Advanced Medical Engineering and Informatics, Osaka University), Tetsuya Tomita (Department of Orthopedic Biomaterial Science, Osaka University Graduate School of Medicine), Takaaki Noguchi (Department of Orthopedic Surgery, Osaka University, Graduate School of Medicine)

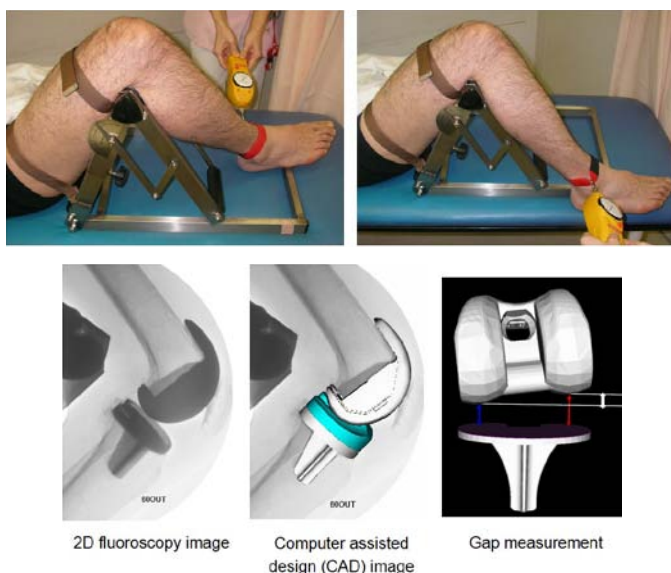
OBJECTIVES: It has been reported that obtaining adequate coronal laxity is one of the important factors in successful total knee arthroplasty (TKA). However, it is unknown whether the intra-operative coronal balance, especially in deep knee flexion, is maintained with time, because of its difficulty in existing radiological assessment. The aim of this study is to investigate the change of coronal laxity over time, especially in deep knee flexion, by using navigation and 2- to 3-dimensional registration system after total knee arthroplasty (TKA).

METHODS: We prospectively investigated 21 varus osteoarthritis knees (3 male and 17 female patients, mean age 77.3 years, mean body mass index 25.1kg/m²) implanted with primary posterior-stabilized (PS)-TKA with independent cut methods, using computed tomography (CT)-free navigation system intra-operatively, and using 2D-3D registration techniques at 3 weeks, 3 months, 6 months, and 24 months post-operatively. Valgus or varus forces of 40 N to the knees were applied at each angle of knee flexion, then lateral and medial laxities were evaluated.

RESULTS: The mean KSS knee score improved from 48 (pre-operation) to 86 (post-operation 24 months) and the mean mechanical axis improved from 5.4° varus (pre-operation) to 4.9° valgus (post-operation 24 months). The change of lateral laxity with time (intra-operative, 3 weeks, 3 months, 6 months, 24 months) in each flexion angle was 0° (3.3, 3.1, 3.6, 4.0, 4.1mm) / 30° (5.0, 3.0, 2.8, 3.5, 3.9mm) / 60° (5.1, 2.7, 3.7, 3.4, 4.0mm) / 90° (5.0, 2.5, 4.5, 5.2, 4.9mm) / 120° (4.8, 3.4, 5.0, 5.7, 4.8mm), and the change of medial laxity was 0° (1.4, 1.7, 2.1, 2.3, 2.5mm) / 30° (2.2, 2.0, 2.3, 2.7, 2.9mm) / 60° (2.5, 1.0,

1.9, 2.5, 2.3mm) / 90° (2.5, 0.7, 2.3, 2.4, 1.3mm) / 120° (2.1, 0.6, 1.3, 1.4, 0.5mm), respectively. Taken together, mean lateral laxity (4.0mm) was larger than mean medial laxity (1.9mm) at every time points and flexion angle. Lateral laxity increased with knee flexion, and was temporarily decreased at 3 weeks post-operatively, and then normalized to intra-operative levels after 3-24 months. Medial ligamentous laxity decreased with knee flexion, and was temporarily decreased at 3 weeks post-operatively, then improved to intra-operative levels after 3-6 months, but markedly decreased more than 90° of flexion at 24 months.

CONCLUSIONS: This study highlights that in PS-TKA of varus osteoarthritis knees with independent cut methods, obtaining sufficient medial laxity at more than 90° of flexion intra-operatively may be required to maintain proper coronal valance in long-term.



0752

Revision Total Elbow Arthroplasty: What Have We Learnt

Primary Author: Bhavuk Garg

Institution: All India Institute of Medical Sciences

Coauthor: Vijay Kumar (All India Institute of Medical Sciences)

BACKGROUND: Total elbow arthroplasty (TEA) is commonly gaining momentum, however not as fast as knee and hip arthroplasty. As the number of patients undergoing TEA is increasing, patients are also presenting us with dif-

ferent complications of TEA requiring revision.

MATERIAL AND METHODS: All patients undergoing revision total elbow arthroplasty were analyzed. All patients were operated through posterior approach and revision system of Conrad-Morrey system was used in each patient. Various intraoperative findings as well as their indications for revision were analyzed. Their postoperative radiological outcome as well as functional outcome was analyzed and compared with primary total elbow arthroplasty.

RESULTS: Aseptic loosening was found the most common cause for revision, which was found to be more common in young patients, especially, in which the indication for primary TEA was trauma. Other causes were fractured ulna, fractured arthroplasty components, infection, triceps tendon rupture, heterotopic ossification etc. Immediate postoperative radiological outcome in most of the patients was almost similar to that of primary TEA at the end of 2 years of follow-up, however functional outcome was inferior.

CONCLUSION: Revision elbow arthroplasty is a viable solution for failed total elbow arthroplasty, however the indication of revision warrants specific precautions and specialized revision components.

0753

Improving Confidence in Learning and Applying Orthopaedics in the Undergraduate Setting

Primary Author: Vivek Gulati

Institution: Imperial NHS Trust

Coauthors: Pooja Gulati (Imperial NHS Trust), Nia Williams (Imperial NHS Trust), Suveer Singh (Imperial NHS Trust)

AIMS: Orthopaedics appears to be one of the main surgical specialties that undergraduate medical students lack confidence in. Detailed feedback from two cohorts of 5th Year medical students on an orthopaedic rotation at a London teaching hospital highlighted a need for specific learning objectives, better firm structure, up-to-date teaching timetables, and one-on-one teaching on clinical examinations with a senior doctor in outpatient clinic. This led us

to develop an orthopaedic handbook tailored to their needs as well as structured one-on-one teaching on clinical examinations in an outpatient fracture clinic with an orthopaedic surgeon.

METHOD: Retrospective analysis of feedback from two control student cohorts (groups who did not receive the handbook or attend an outpatient clinic, $n = 20$), enabled us to identify potential reasons for student's lack of confidence. Subsequently the content of the handbook was tailored to their needs with emphasis on performing clinical examinations, interpreting radiographs, clear defined learning objectives and an up-to-date teaching timetable. Students outlined that they lacked confidence in performing clinical examinations and hence one-on-one teaching on clinical examinations in an outpatient fracture clinic with an orthopaedic surgeon was also established. We piloted the use of the orthopaedic student handbook and interactive outpatient clinics with a test cohort of students ($n=10$) and analyzed their feedback.

RESULTS: 80% of student agreed that teaching and learning opportunities for the orthopaedic placement were suitable in the test cohort compared to 30% in the control cohort. 80% of students in the test cohort also agreed that they received sufficient guidance and feedback on their placement compared to 20% in the control cohort. The latter difference was felt to be due to the one-on-one teaching and guidance that these students received in fracture clinic.

DISCUSSION: We have highlighted the use of an orthopaedic handbook and interactive outpatient fracture clinic to improve teaching, learning opportunities and confidence in orthopaedics. There are also a number of ways to enable that this orthopaedic handbook is accessible to students with the use of modern technology.

O754

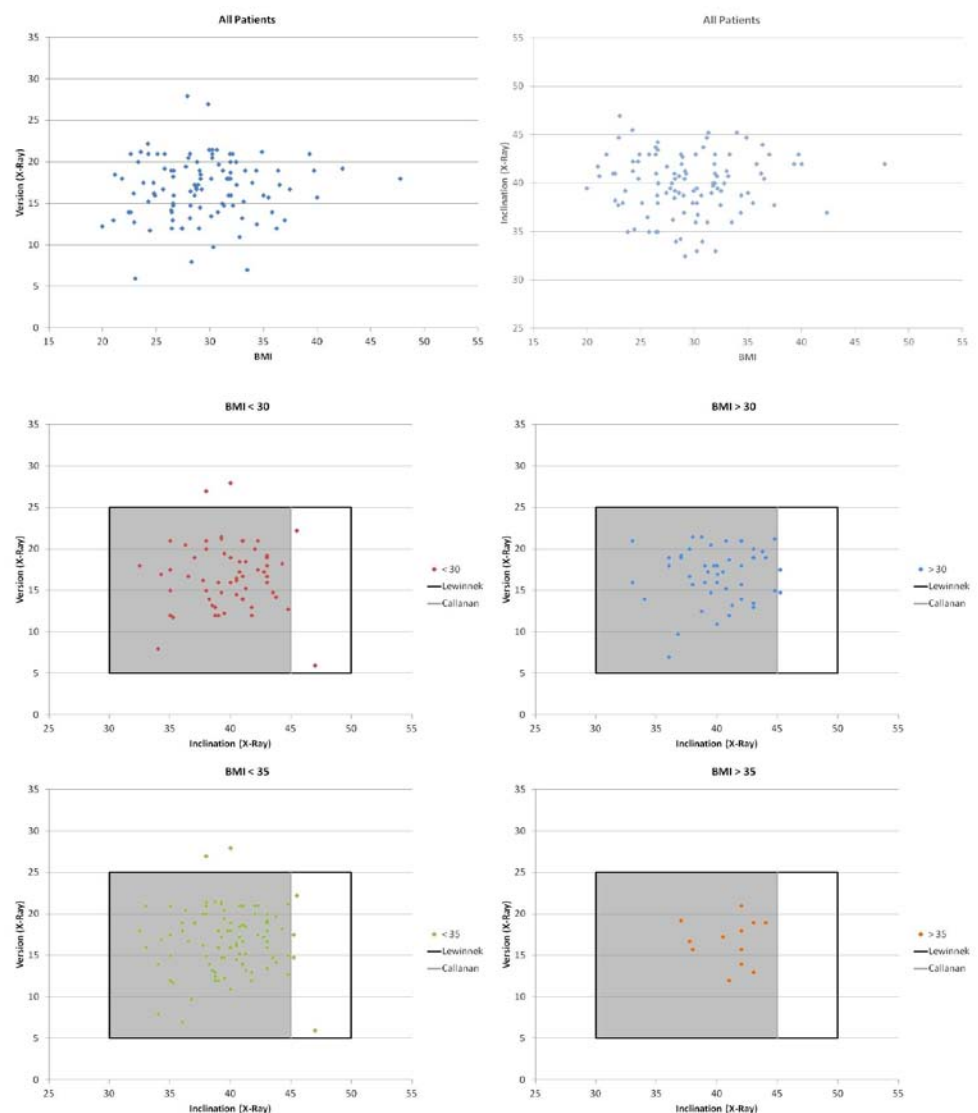
The Effect of Robotic-Assisted Computer Navigation on Acetabular Component Positioning in the Obese Patient

Primary Author: Asheesh Gupta

Institution: American Hip Institute

Coauthors: Benjamin G. Domb (American Hip Institute), John M. Redmond (American Hip Institute), Jon E. Hammarstedt (American Hip Institute), Christine E. Stake (American Hip Institute), Alexandra E. Petrakos (American Hip Institute)

BACKGROUND: Numerous studies have shown that the accuracy of acetabular cup placement in the obese population can be challenging. Robotic-assisted computer-navigation has the potential to be accurate and consistently



reproducible in providing cup placement within the commonly accepted safe zones for inclination and version. To our knowledge, there are no reports on the evaluation of robotic-assisted computer-navigation for acetabular cup placement in the obese population.

PURPOSE: The purpose of this study is to examine the accuracy of acetabular cup position with regards to inclination and version in the obese patient during total hip arthroplasty with robotic-assisted computer-navigation.

METHODS: A total of 105 patients underwent robotic-assisted computer-navigation total hip arthroplasty with a posterior approach (Figure 1). 59 patients with BMI<30 and 46 patients with BMI≥30 were compared. The study population was then stratified by class II obesity with 93 patients with BMI<35 and 12 patients with BMI≥35. Acetabular component position was analyzed with respect to abduction and version.

RESULTS: The BMI<30 group had a mean acetabular cup inclination of 39.86 degrees and version of 16.78 degrees (Figure 2). The BMI≥30 group had a mean acetabular cup inclination of 40.04 degrees ($p=0.77$) and version of 16.95 degrees ($p=0.82$). When stratifying by class II obesity, the BMI<35 group had a mean acetabular cup inclination of 39.80 degrees and version of 16.87 degrees. The BMI≥35 group had a mean acetabular cup inclination of 41.02 degrees ($p=.195$) and version of 16.73 degrees ($p=.905$).

CONCLUSION: Robotic-assisted computer navigation provides accurate and reproducible placement of the acetabular cup with respect to safe zones for inclination and version in the obese patient.

O755

OsseoTi™ Porous Titanium Alloy Facilitates Bone Integration in Sheep Model

Primary Author: Gautam Gupta

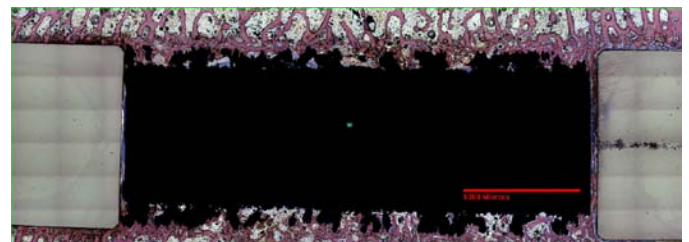
Institution: Biomet, Inc

Porous metal structures have historically been used to improve fixation of orthopedic devices to the host bone. [1] Biomet has developed OsseoTi™ - a porous Ti6Al4V structure with physical properties designed to enhance bone integration. [2] OsseoTi™ is an implantable biomi-

metic representation of human cancellous bone structure. In this study, the interaction between bone and OsseoTi™ was analyzed in a sheep model.

Cylindrical samples (20 mm long, 8 mm in diameter) with a 750 microns thick OsseoTi™ surface layer were implanted bilaterally in a line-to-line manner into cylindrical defects created in the distal femur and proximal tibia of sheep. The animals were sacrificed after 4 and 12 weeks. The explants harvested and processed for biomechanical push out testing ($N=9$) and histological evaluation ($N=3$) at each time point. For the biomechanical push-out testing, the specimens were mounted in custom fixtures and were subjected to compressive loading in the medial-lateral direction to quantify the ultimate shear push-out strength. For histological evaluation, the specimens were processed for undecalcified PMMA embedding. Longitudinal sections of the specimen were ground and stained with Sanderson's rapid bone stain.

The biomechanical evaluation showed excellent integration between OsseoTi™ and host bone as early as 4 weeks post implantation. The average (\pm std. dev.) push-out strengths obtained after 4 and 8 weeks were 4273 N (\pm 1018 N) and 5581 N (\pm 1074 N). In addition, the histological analysis showed that even after 4 weeks, there was significant new bone ingrowth in the OsseoTi™ porous volume (Figure 1). Though not a one-to-one comparison, in a push-out study reported by Bobyn [3], Trabecular Metal demonstrated a shear push out of 18.5 MPa that translates to 2905 N. The results from this animal study indicate that the interconnected porous architecture of OsseoTi™ has considerable potential to provide an optimal environment for bone ingrowth.



References:

1. Levine, B. A new era in porous metals: Applications in orthopedics. (2008) J Knee Surgery. 20(3): 185-194.
2. Gautam Gupta. OsseoTi™ - Porous Titanium Alloy For Enhanced Bone Integration. Society for Biomaterials. 2014. Submitted.

3. Bobyn et al. J Bone Joint Surg. 1999; 81-B: 907-14.
Disclaimer: Animal studies are not necessarily indicative of clinical results.

0756

Short-term Results of the New Linked Elbow Prosthesis (PROSNAP)

Primary Author: Kenzo Hashizume

Institution: Okayama University Hospital

Coauthors: Keiichiro Nishida (Okayama University Hospital), Nakahara Ryuichi (Okayama University Hospital), Masatsugu Ozawa (Okayama University Hospital), Ryoza Harada (Okayama University Hospital), Takahiro Machida (Okayama University Hospital)

INTRODUCTION: We have recently applied the newly developed linked elbow prosthesis (PROSNAP) to the clinical use from November 2007. Bone grafting between anterior flange and humerus is not necessary by selecting the proper size of separated modular flange. The shaft at joint portion of humeral component is connected with a snap-in mechanism into the polyethylene sleeve of the ulnar component after cement fixation of each component. In the current study, we aimed to evaluate the short-term clinical results of total elbow arthroplasty (TEA) for the reconstruction of severely damaged elbow joints by the PROSNAP® elbow prosthesis.

PATIENTS AND METHODS: Between 2007 and 2013, thirty elbows of 26 RA patients were replaced by PROSNAP® elbow with cement fixation. They were 3 men and 23 women, aged 64.1 (range 52-83) years at the surgery. The pre-operative conditions of the elbows were rheumatoid arthritis with massive instability (n=17), ankylosed (n=2) or stiff elbow with a preoperative range of motion of 45 degrees or less (n=3), loosening of primary TEA (n=5), and distal humeral fracture (n=3). Mean follow-up period was 26.3 (4-61) months. The clinical outcome of the elbows before and after the operation was evaluated by both Mayo Elbow Performance Score (MEPS, up-to 100 points), and the scoring system of Japanese Orthopaedic Association elbow scoring system (JOA score, up to 100 points), made up of scores of pain, function (activity of daily life and muscle strength), range of motion, instability, and deformity of the joint.

RESULTS: The mean range of motion (ROM) of extension / flexion was -31/115 degrees before the surgery, and was -30/146 degrees at the final follow-up. The mean ROM of pronation/supination was 56/55 before surgery, and was 80/77 degrees at the final follow-up. Average MEPS improved from 52.0 to 95.3 points, with marked pain relief. Average JOA score similarly improved from 49.7 to 88.6. Of the 30 elbows, 2 elbows were judged as good, 10 elbows as fair, and 15 elbows as poor preoperatively (3 elbows of distal humeral fracture have no preoperative clinical data), and all elbows were judged to have excellent (n=27) or good results (n=3) at the final follow-up. Complications noted in three elbows (10%), including intraoperative fracture, post-operative fracture, and disruption of triceps tendon.

CONCLUSIONS: Our new prosthesis can be correctly implanted with a relatively easy procedure, and showed a satisfactory short-term clinical outcome for the reconstruction of severely damaged elbows.

0757

Inter-State Variation in Hospital Costs for Common Orthopaedic Procedures

Primary Author: Nathanael D. Heckmann

Institution: University of Southern California

Coauthors: Lawrence Wang (Western University of Health Sciences), Liam Harris (University of Southern California), Brock Foster (University of Southern California), Reza Omid (University of Southern California)

SUMMARY: Hospital costs in the United States for the most common orthopedic procedures can exhibit a fivefold variation in price, reflecting variability that cannot be explained by wage differences alone.

INTRODUCTION: Rapidly escalating costs in health care have made the cost analysis of orthopaedic procedures an increasingly pressing issue. The introduction of the Affordable Care Act and, specifically, newly released Medicare data, has allowed for an unprecedented investigation into the variability in costs for numerous orthopedic procedures across various states.

METHODS: Medicare data from over 3,000 hospitals in all 50 states and the District of Columbia were exam-

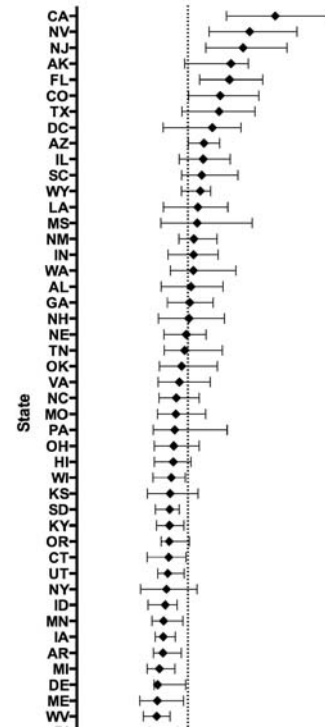
ined for the 5 most common orthopedic procedures as defined by Medicare's Diagnosis-Related Group (DRG) coding schema. Our study included the following procedure categories: cervical spinal fusion, non-cervical spinal fusion, hip and femur procedures (excluding major joints), hip and pelvis fractures, and lower extremity joint replacement. Over 500,000 discharges from 2011 were analyzed, looking at hospital cost and location. (Figure 1) A median state hospital cost and inter-quartile range was computed for each procedure in each state.

RESULTS: For cervical spinal fusion, the median hospital costs in the most expensive states (DC, CA, and CO) were 156%-185% of the national median and 364%-434% of the median in the least costly state (MD). For non-cervical spinal fusion, the median hospital costs in the most expensive states (CA, CO, and NV) were 146%-174% of the national median and 313%-374% of the median in the least costly state (MD). (Figure 3) For lower extremity joint replacement, the median hospital costs in the most expensive states (CA, NV, and NJ) were 150%-179% of the national median and 305%-364% of the median in the least costly state (MD). For hip and femur procedures, the median hospital costs in the most expensive states (NV, CA, and NJ) were 157%-198% of the national median and 383%-485% of the median in the least costly state (MD). (Figure 2) For hip and pelvis fractures, the median hospital costs in the most expensive states (NJ, CA, and NV) were 163%-210% of the national median and 378%-487% of the median in the least costly state (MD).

DISCUSSION AND CONCLUSION: Analysis of our results revealed variations in hospital costs between states that cannot be accounted for by wage variability and cost-of-living alone. These variations suggest that higher costs in several states are likely due to differences in hospital billing, surgical practice, and population health, among other factors. Understanding the causes of these variations will be critical to the long-term viability of the Affordable Care Act and, consequently, should be investigated further.

Diagnosis-Related Group (DRG)	DRG #	No. of Hospitals	No. of Discharges
Spinal Fusion	-	-	-
Cervical	473	840	23,834
Non-Cervical	460	1,319	65,997
Lower Extremity Joint Replacement/Reattachment	470	2,750	427,207
Hip & Femur Procedures Except Major Joint	482	1,040	20,739
Fractures of Hip & Pelvis	536	1,142	22,728

Lower Extremity Arthroplasty Median Cost by State



O758

Pre-designed Custom-Made Osteotomy Guide to Adjust Loading Axis of Whole Lower-Extremities in Total Ankle Arthroplasty

Primary Author: Makoto Hirao

Institution: National Hospital Organization, Osaka Minami Medical Center

Coauthors: Hideki Tsuboi (Osaka Minami Medical Center), Kosuke Ebina (Osaka University Hospital), Kenrin Shi (Osaka University Hospital), Yukihiro Saeki (Osaka Minami Medical Center), Tsuyoshi Murase (Osaka University Hospital), Hideki Yoshi

INTRODUCTION: Prosthesis edge loading after total ankle arthroplasty (TAA) is well known as a frequent complication in ankles with a preoperative coronal plane varus or valgus deformity. Complicated coronal plane deformity in ankle joint is often seen in rheumatoid arthritis (RA). Therefore, it is often required but difficult to produce a corrective and accurate tibia/talus bone osteotomy in RA cases. Although tibial osteotomy is instructed to be perpendicular to long axis of tibia, there is no established index for the talar bone corrective osteotomy. Then, we have been deciding the correction angle at the plan for adjust-

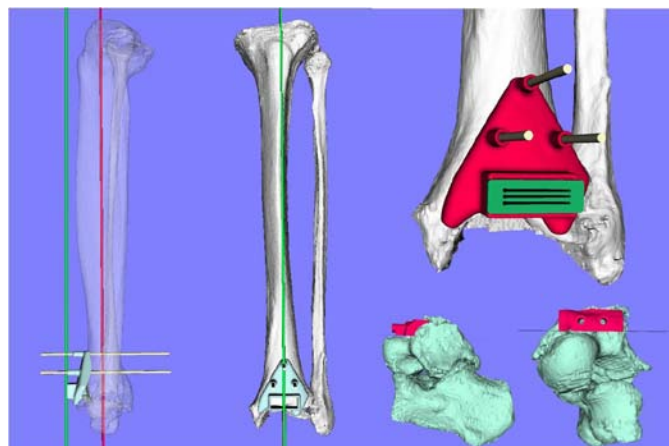
ment of the loading axis through whole lower extremities. Furthermore, information of the correction angle has been reflected to pre-designed custom-made guide [Hirao et al. Tech Orthop 2013 (in press)] to expect accurate bone cutting based on such preoperative planning.

METHODS: We studied 17 TAA cases with RA from 2011 to 2012. X-ray picture of hip to calcaneus view (hip joint to tip of the calcaneus) defined to show more approximated loading axis [Haraguchi et al. J. Jpn. Soc. Surg. Foot 2010] has been referred for the preoperative planning. Position of the calcaneal tip after adjustment of loading axis is different from preoperative state, thus the angle between the lines from ankle joint and old/new calcaneal tip was set to be corrected by osteotomy, and reflected to custom-made guide. The distance between the center of ankle joint and the axis (preD) was measured (mm) preoperatively, and the distance between the center of prosthesis and the axis (postD) was measured postoperatively. Next, the tilting angle between components (defined as the index of prosthesis edge loading) was measured with X-rays during standing at follow-up when weight-bearing was allowed. Tibio Calcaneal (TC) angle was also measured pre and postoperatively.

RESULT: Preoperative TC angle was $8.3 \pm 6.0^\circ$, and that was significantly improved to $3.5 \pm 3.6^\circ$ postoperatively ($P=0.028$). PreD was 12.9 ± 9.6 mm, and that was significantly improved to 4.8 ± 6.3 mm (postD) ($P=0.006$). Within 17 cases, 8 cases showed 0-1mm of postD, 4 cases showed 1-5mm of postD, remaining 5 cases concomitant subtalar fusion with severe valgus case (preD: 15.0, 25.3, 33.5mm) and severe varus with inverted and supinated cases (preD: 25.4, 23.2mm) showed over 8mm of postD. All 12 cases showing within 5mm of postD had within 13mm of preD. The tilting angle between components was $0.17 \pm 0.37^\circ$ postoperatively. Three cases with preoperative severe valgus deformity showed 1° of tilting, however remaining all cases showed 0° of tilting angle postoperatively.

DISCUSSION AND CONCLUSION: Although the number of cases is small, pre-designed corrective talar osteotomy based on preoperative planning using hip to calcaneus view X-ray picture was useful to adjust the mechanical axis for replaced ankle joint in RA cases. Furthermore, after surgery, the hip to calcaneus view was useful to evaluate post-operative mechanical axis of whole lower extremities. If preD showed within 13mm, adequate correction of mechanical axis was expectable. However, if subtalar joint

was destructed and fused, correction of the axis became difficult, and another optional procedures should be added.



O759

Three-dimensional Model-Based Navigation-assisted Contouring Arthroplasty of the Elbow for a Deformity of the Distal Humerus

Primary Author: Masayoshi Ikeda

Institution: Shonan Central Hospital

Coauthors: Ikuo Saito (Tokai University Hachioji Hospital), Yuka Kobayashi (Tokai University School of Medicine), Takayuki Ishii (Tokai University School of Medicine), Joji Mochida (Tokai University School of Medicine)

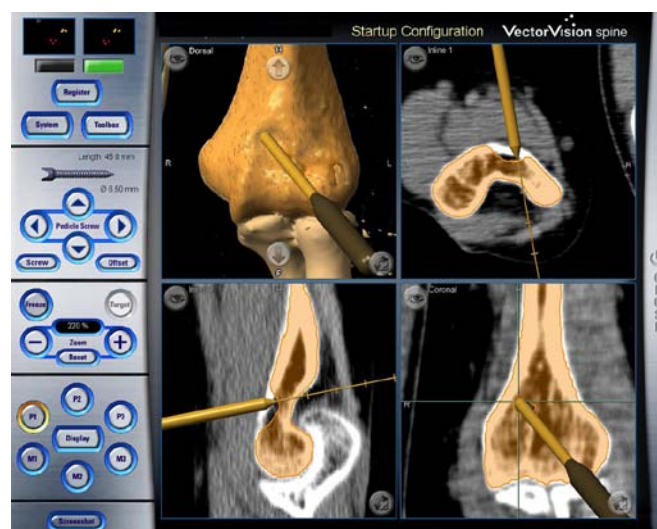
INTRODUCTION: We have reported satisfactory results in the clinical study on navigation-assisted debridement arthroplasty of the elbow. Then we have also reported navigation-assisted system to be accurate for the resection of osteophytes of the distal humerus. The purpose of this study was to report a technique of three-dimensional (3D) model-based navigation-assisted contouring arthroplasty for improving the flexion arc in a case of decreased elbow flexion caused by a deformity of the distal humerus.

CASE PRESENTATION: A 12-year-old boy was referred to our hospital with a complaint of decreased flexion of the left elbow. Elbow flexion was limited to about 70° without a loss of extension. Plain radiography and computed tomography (CT) showed extension deformity of the humeral condyle with a decreased humerocapitellar angle. The limited motion arc was characterized by condylar/trochlear extension deformity. The etiology was thought to be epiphyseal injury. The strategy for treatment in this case

was aimed at improving flexion, preserving trochlear congruity by contouring/milling of the anterior bony structures (coronoid and radial fossae as well as trochlea). A 3D model of the elbow was constructed and the distal portion of the humerus was milled so that the elbow could be flexed by more than 140° . Using the CT data derived from this reshaped model, navigation-assisted arthroplasty was performed. At final follow-up of the patient at the age of 18 years, the coronoid and radial fossae and trochlear curve had been reshaped, and the patient had an active elbow flexion of 125° .

DISCUSSION: Although there are previous reports on computer/navigation-assisted surgeries on the upper extremities, the technique described in this study has not been reported yet. Application of the technique is as follows. A 3D model was reconstructed with on the basis of CT of the actual bone, and the humerus in the model was reshaped to allow an improved range of elbow motion. Using the data from this reshaped model, navigation-assisted contouring arthroplasty was performed (Fig. 1). Navigation-assisted surgery facilitates appropriate burring out of the actual bone and offers real-time intraoperative feedback (Fig. 2).

CONCLUSION: We applied navigation-assisted contouring arthroplasty using a reshaped 3D model to a case of decreased elbow flexion caused by a deformity of the humeral condyle. This technique is a useful alternative when morphological management of the bone is required because the contralateral side does not always mirror the affected side. In future, this concept may have a significant role in the management of elbow deformity.



O760

Hand Joints Arthroplasty in Psoriatic Arthritis. Results and Rehabilitation

Primary Author: Viktor Kotyuk

Institution: SI "Institute of Traumatology and Orthopedics of the Academy of Medical Sciences of Ukraine"

Coauthors: Alexander Kostrub (SI "Institute of Traumatology and Orthopedics of the Academy of Medical Sciences of Ukraine"), Alexander Buryanov (National Medical University n.a. Bohomoletz A.A., Ukraine), Vladimir Kvasha (National Medical University n.a. Bohomoletz A.A., Ukraine), Viktor Kotiuk (SI "Institute of Traumatology and Orthopedics of the Academy of Medical Sciences of Ukraine"), Ivan Zasadnyuk (SI "Institute of Traumatology and Orthopedics of the Academy of Medical Sciences of Ukraine")

INTRODUCTION: Psoriatic arthritis is nonspecific inflammatory disease of the locomotor system with chronic progressive course and polymorphous clinical findings, which leads to severe joints deformities and longterm disability. Hand joints involvement keeps the leading position in psoriatic arthritis morbidity patterns and averages up to 78% among other localizations. Patients with psoriatic arthritis often need the replacement of the hand joints owing to the high prevalence of hand joints involvement and often severe their destruction and/or function loss. The results of silicon arthroplasty of the hand joints in psoriatic patients and their rehabilitation are poorly reported in the scientific literature.

OBJECTIVE: To evaluate prospectively the function of the hand and the rehabilitation program in psoriatic arthritis patients treated with silicon arthroplasty of the hand joints.

METHODS: We analyzed the results of hand joints replacements with silicon implants in psoriatic arthritis patients. Contraindications were malignant psoriatic arthritis, exacerbation of the disease, pustular psoriasis with skin lesion in the operative approach area, contractures of the joints in a functional position (particularly in distal interphalangeal joints).

RESULTS: The overall results of metacarpophalangeal joints arthroplasty in all the patients we consider as good. However, minor complications occurred. The choice of the implant, the possibility, causes and significance of the complications are justified. The rehabilitation program is discussed. The range of motions gradually decreased by the sixth month after the arthroplasty. The residual range of motions didn't decrease later and was functional in all the patients. Subjective patients' feeling of joints function improvement markedly outweighed improvement of objective results. This may be explained by significant decrease in the pain level and adequate use of the joint in functional range of motion.

CONCLUSION: Metacarpophalangeal joints silicon arthroplasty in psoriatic arthritis leads to improvement in hand function and quality of life though require special rehabilitation. Further more extensive research should focus on the best rehabilitation program and evaluation of contraindications.

0761 Reproducibility of the Attending Position for Repeated Assessment of the Position of the Lower Limbs: A New Approach by the EOS® Imaging System

*Primary Author: Jean Yves. Lazennec
Institution: Pitié-Salpêtrière Hospital*

*Coauthors: Aidin Eslam Pour (University of Michigan),
Adrien Brusson (Pitié-Salpêtrière Hospital), Marc-An-
toine Rousseau (Pitié-Salpêtrière Hospital), Folinais
Dominique (Pitié-Salpêtrière Hospital)*

INTRODUCTION The position and orientation of the lower extremities are fundamental for planning and follow up imaging after arthroplasty and lower extremity osteotomy. But no studies have reported the reproducibility of the measurements over time in the same patient and the our experience shows the variability of the results depending on the protocols for patient positioning. This study explores the reproducibility of the measurements in lower extremity with the patients in "comfortable standing position" by EOS® imaging system.

MATERIALS AND METHODS: Two whole body acquisitions were performed in 40 patients whom were evaluated for a spine pathology. The average interval between each acquisition was 15 months (4-35 months). Patients did not have severe spine pathology and did not undergo any surgery in between the 2 acquisitions. The "comfortable standing position" is achieved without imposing any specific position of the lower limbs and pelvis to the patients. All the measurements were performed and compared on both 2 and 3 dimensional images. Distances between the centers of the femoral heads, between the centers of the knee and ankle were measured from the front. The profile is shown by the flexion angle between the femur axis (center of the femoral head and the top of the line Blumensaat) and the axis of the tibia.

RESULTS: The average radiation dose was 0.80 mGy (0.5-1.1). For the first acquisition, the mean distance between the femoral heads was 17.9 cm (15.8-20.2), mean distance between the middle of the knee joints was 16.7 cm (11.2-23.1) and the mean distance between the medial malleolus was 13.1 cm (0 to 18). For the second acquisition, the mean distance between the femoral heads was 17.9 cm (14.9-21.5), mean distance between the middle of the knee joints was 16.9 cm (11.4-23.1) and the mean distance between the medial malleolus was 13.6 cm (0-19.4). For all comparisons no significant difference was demonstrated in related samples Wilcoxon rank test and paired student t test.

DISCUSSION: 2D and 3D data are not affected by repeated acquisitions even several months apart in "comfortable standing position." This work shows the reproducibility of the "comfortable standing position" for EOS imaging system. New prospects can be considered for combined measures face-profile position of each patient.

O762

Offset and Anteversion Reconstruction after Cemented and Uncemented Total Hip Arthroplasty: an Evaluation with the Low Dose EOS System Comparing Two and Three Dimensional Imaging

Primary Author: Jean Yves Lazennec

Institution: Pitié-Salpêtrière Hospital

Coauthors: Aidin Eslam Pour, MD (University of Michigan), Marc-Antoine Rousseau, MD, PhD (Pitié-Salpêtrière Hospital), Folinais Dominique, MD (Pitié-Salpêtrière Hospital), Adrien Brusson, MS (Pitié-Salpêtrière Hospital)

INTRODUCTION: Accurate evaluation of femoral offset is difficult with conventional AP X-rays. The EOS imaging system is a system that makes the acquisition of simultaneous and orthogonal AP and lateral images of the patient in standing position possible. These two dimensional (2D) images are equivalent to standard plane X-rays. Three-dimension (3D) reconstructions are obtained from these paired images according to a validated protocol. This prospective study explores the value of the EOS imaging system for comparing measurements of femoral offset from these 2D images and the 3D reconstructions. Material and

METHODS: We included 100 patients with unilateral THA. The 2D offset was measured on the AP view with the same protocol as for standard X-rays. The 3D offset was calculated from the reconstructions based on the orthogonal AP and lateral views. Reproducibility and repeatability studies were conducted for each measurement. We compared the 2D and 3D offset for both hips (with and without THA).

RESULTS: For the global series (100 hips with and 100 without THA), 2D offset was 40 mm (SD: 7.3; 7 to 57 mm). The standard deviation was 6.5 mm for repeatability and 7.5 mm for reproducibility. 3D offset was 43 mm (SD: 6.6; 22 to 62 mm), with a standard deviation of 4.6 for repeatability and 5.5 for reproducibility. 2D offset for the hips without THA was 40 mm (SD: 7.0; 26 to 56 mm), and 3D offset 43 mm (SD: 6.6; 28 to 62 mm). For THA side, 2D offset was 41 mm (SD 8.2; 7 to 57 mm) and 3D offset 45 mm (SD: 4.8; 22 to 61 mm). Comparison of the 2 protocols shows a significant difference between the 2D and 3D measurements, with the 3D offset having higher values. Comparison of the side with and without surgery for

each case showed a 5-mm deficit for the offset in 35% of the patients according to the 2D measurement but in only 26% according to the 3D calculation.

CONCLUSIONS: This study points out the limitations of 2D measurements of femoral offset on plane X-rays. The reliability of the EOS 3D models has been previously demonstrated with CT scan reconstructions as a reference. The EOS imaging system could be an option for obtaining accurate and reliable offset measurements while significantly limiting the patient's exposure to radiation.

O763

Results of Stemmed Almina Ceramic Total Elbow Arthroplasties with Cement Fixation for Patients with Rheumatoid Arthritis

Primary Author: Takahiro Machida

Institution: Department of Orthopaedic surgery, Okayama University Graduate School of Medicine)

Coauthors: Keiichiro Nishida (Department of Human Morphology, Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences), Kenzo Hashizume (Department of Orthopaedic surgery, Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences), Ryuichi Nakahara

BACKGROUND: Total elbow arthroplasty (TEA) is primarily indicated for damaged rheumatoid arthritis (RA) elbow with painful stiffness, painful instability, and ankylosis. In 1979 we developed an unlinked surface replacement prosthesis using polycrystalline alumina ceramic as a solid trochlea on high-density polyethylene (Kyocera type I ;KC-I), which was based on a measurement study involving Japanese cadaveric elbows, and used in the clinical setting. The initial design of the KC-I prosthesis did not possess the intra-medullary stem, and the results of a 3-year followup of prostheses implanted without bone cement in 21 RA elbows were disappointing, with loosening and subsidence of the humeral component caused by inadequate fixation. In 1986, the first model change was made to an unlinked stemmed type (Stemmed Kyocera type I ;SKC-I), and this was used in 15 RA elbows. The initial 8 elbows were implanted without cement fixation and early tilt or subsidence of the humeral component was noted; consequently we decided to use cement fixation in all cases from late 1987, resulting in stable clinical outcomes. In

this study, we aimed to determine the mid- to long-term results of TEA using unlinked elbow prostheses with SKC-I in patients with RA. Patients and

METHODS: Between 1987 and 1999, 105 TEA with cemented stems were performed in 83 RA patients. Fourteen patients (14 elbows) were lost to follow-up. Of the remaining 91 elbows in 69 patients, 54 elbows in 39 patients were available for detailed clinical and radiographic review over a 5+ year follow-up period. The mean follow-up period was 12.3 years (range, 5–22 years). The clinical condition before and after surgery was assessed using a modified version of the Mayo Elbow Performance Score (MEPS; 0–100 points) and a Japan Orthopaedic Association Elbow score (JOA score; 0–100 points). The radiographs were reviewed and loosening was defined as a progressive radiolucent line > 1 mm in width that was completely circumferential around the prosthesis. Clinical records of post-operative events of all 91 elbows were used for survival analysis of the prostheses using the Kaplan-Meier method.

RESULTS: The average modified MEPS and JOA scores improved significantly from 39.7 ± 14.3 and 44.7 ± 9.4 respectively, pre-operatively, to 90.4 ± 15.0 and 83.1 ± 12.8 respectively, post-operatively ($P < 0.0001$). The functional assessment score also improved from 4.9 ± 2.8 to 8.8 ± 3.1 points ($P < 0.0001$). Of the 54 elbows, 47 were judged to be good, 4 were fair, and 3 were poor results. With loosening and implant revision defined as the end point, the likelihood of survival of the prosthesis for up to 20 years was 90.8% (95% confidence interval (CI), 80.4–95.8), and 89.1% (95% CI, 75.1–95.5) respectively.

CONCLUSION: Satisfactory clinical results were obtained after TEA using SKC-I prostheses, which provided excellent pain relief and functional range of motion. The results of our study demonstrate high reliability of the cemented SKC-I prosthesis with an alumina ceramic component over a long period.

O764 Cost Effectiveness of Bariatric Surgery Prior to Total Knee Arthroplasty in the Morbidly Obese

Primary Author: Alexander S. McLawhorn
Institution: Hospital for Special Surgery

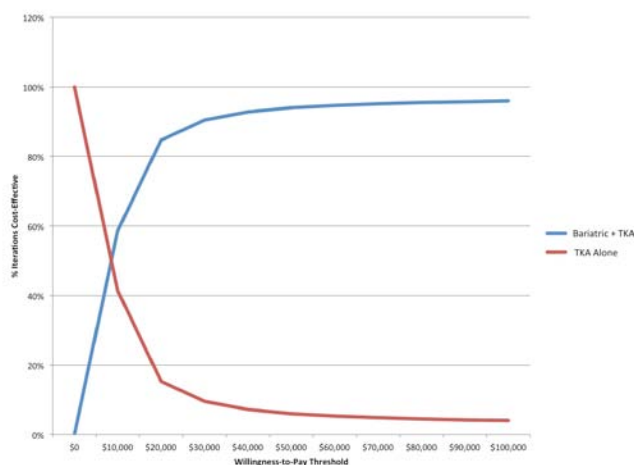
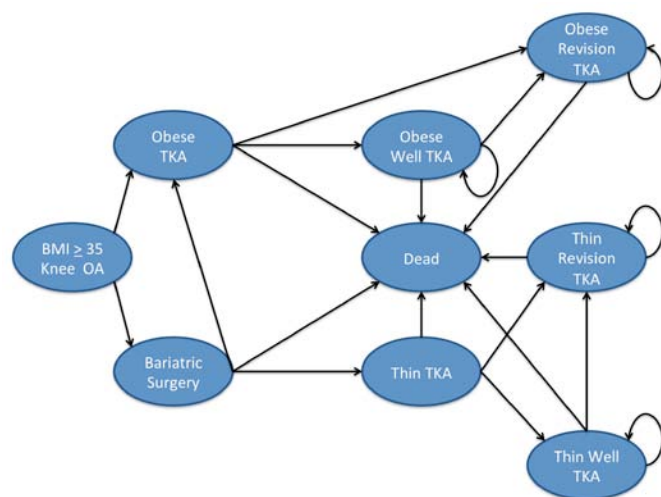
Coauthors: Daniel Southren (Columbia University College of Physicians & Surgeons), Y. Claire Wang (Columbia University Mailman School of Public Health), Robert G. Marx (Hospital for Special Surgery), Emily R. Dodwell (Hospital for Special Surgery)

BACKGROUND: Obesity is associated with adverse outcomes after TKA: superficial and deep infection, prosthetic loosening, perioperative morbidity, and poorer functional outcomes. Costs for TKA increase linearly with BMI. Bariatric surgery is a cost-effective treatment for obesity. The cost-effectiveness of bariatric surgery for weight loss prior to TKA is unknown. The purpose of this study was to determine the cost-effectiveness of bariatric surgery prior to TKA for patients failing medical management of obesity and knee OA using Markov decision analysis techniques.

METHODS: A Markov model was constructed to compare the cost-utility of two treatment modalities for patients with morbid obesity ($\text{BMI} \geq 35 \text{ kg/m}^2$ experiencing obesity-related health conditions) and end-stage knee OA: (1) immediate TKA, and (2) bariatric surgery prior to TKA [Fig. 1]. The probability of transition between each state and the utility of each state were derived from the literature. In rare cases in which utilities and probabilities were not available for a specific state, these were estimated from published data on similar states. Costs were estimated using Medicare reimbursement rates in 2012 US dollars. Costs and utilities were discounted at 3% per year, and utility was expressed in quality adjusted life years (QALYs). The principal outcome measure was the incremental cost-effectiveness ratio (ICER). One-way, two-way and probabilistic sensitivity analyses were performed, using the standard willingness-to-pay (WTP) of \$100,000/QALY as a threshold.

RESULTS: Obese patients undergoing TKA had lower QALYs gained than patients who received bariatric surgery with subsequent weight loss prior to TKA. With \$16,481 additional costs for patients undergoing bariatric surgery prior to TKA, the ICER between these two procedures was approximately \$10,366/QALY, well below the \$100,000/QALY WTP. Results were stable across broad value ranges for independent variables, except for the probability of weight loss after bariatric surgery and for TKA revision rates. Probabilistic sensitivity analysis demonstrated that there is greater than 95% chance that bariatric surgery prior to TKA is cost-effective [Fig. 2].

CONCLUSIONS: In morbidly obese patients, bariatric surgery prior to TKA yielded greater utility than TKA alone. The addition of bariatric surgery prior to TKA results in a cost well below the standard WTP per QALY. Bariatric surgery prior to TKA is a cost-effective option for improving outcomes in morbidly obese patients with end-stage knee OA indicated for knee replacement.



O765 Bone Morphogenetic Protein and Cancer Correlation: An Analysis of 10,416 Patients from a Multi-Center Spine Registry

Primary Author: Lance K. Mitsunaga

Institution: Kaiser Permanente Northern California Regional Spine Center

Coauthors: Lance K. Mitsunaga (Kaiser Permanente Northern California Regional Spine Center), Ravi Bains (Kaiser Permanente Northern California Regional Spine Center), Yuexin Chen (Surgical Outcomes and Analysis, Kaiser Permanente), Kamran Majid (Kaiser Permanente Northern California Regional Spine Center)

BACKGROUND: Questions have been raised about the possible increased risk of cancer from the use of BMP-2 in spine fusion surgery. Existing literature on this topic is conflicting and relies on animal studies or human studies with limited sample sizes. The purpose of our study--one of the first independent, non-industry supported analyses--is to compare the risk of developing cancer in patients who underwent spine fusion with and without the use of BMP-2 using data from a large, multi-center spine registry.

METHODS: An integrated health system's spine registry was used to retrospectively identify patients who underwent spine fusion surgery between 1/09 and 6/12. Using this data, patient characteristics, BMP-2 dosage (if used), region of the spine fused, and number of levels fused were extracted. Data was also cross-matched with our institution's Cancer Registry to identify any de novo diagnoses of cancer in these patients. Using logistic regression analysis, the risk of malignancy following spine surgery with and without BMP-2 administration was determined.

RESULTS: In our cohort of 10,416 patients, 5,987 patients underwent a fusion procedure with BMP-2 while 4,429 patients underwent fusion without BMP-2. De novo cancer diagnoses were found in 73 patients in the BMP-2 group (1.2%), compared to 47 patients in the non-BMP group (1.1%, $p=0.454$). Average length of follow-up for patients in the BMP-2 group was 2.2 years, compared to 1.9 years for the non-BMP group. After adjusting for age, gender, BMI, ASA score, and smoking status, we did not identify a significant effect of BMP-2 on the development of cancer (OR 1.06, 95% CI 0.58-1.92).

CONCLUSIONS: In this retrospective analysis of data collected from a large spine registry over a 3.5-year period, we found no evidence that the use of BMP-2 (in dosages ranging from less than 1.05 mg to 12 mg) conferred an increased risk of developing cancer. This serves as a preliminary report. Longer follow-up is needed to conclusively determine that BMP-2 does not cause cancer.

O766

Does Chronic Kidney Disease Affect the Mortality Rate in Patients Undergoing Instrumented Spine Fusion?

Primary Author: Lance K. Mitsunaga

Institution: Kaiser Permanente Northern California Regional Spine Center

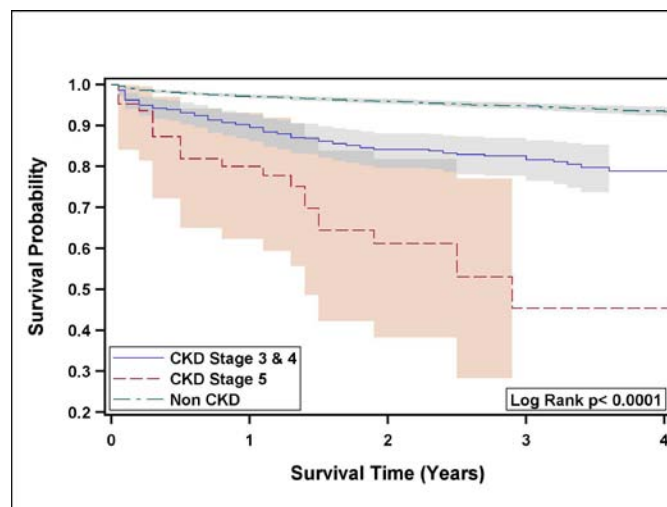
Coauthors: Lance K. Mitsunaga (Kaiser Permanente Northern California Regional Spine Center), Kamran Majid (Kaiser Permanente Northern California Regional Spine Center), Ravi Bains (Kaiser Permanente Northern California Regional Spine Center), Jessica Harris

SURGICAL OUTCOMES AND BACKGROUND: The number of patients with CKD requiring spine surgery is increasing. Data on the effect of CKD on overall clinical outcomes following spinal surgery is sparse, limited to small clinical series from single institutions reporting variable outcomes with limited follow-up. The purpose of this study was to investigate the long-term mortality rate in CKD patients who underwent instrumented spine fusion using a large, multi-center spine registry.

METHODS: An integrated health system's spine registry was used to identify 12,276 consecutive patients who underwent instrumented spine fusion procedures performed between 1/09 and 12/12. Data on CKD status and mortality were obtained using an integrated electronic medical records system. Patient characteristics, surgical factors, comorbidities, and complications were evaluated. Logistic regression and Kaplan-Meier analysis were used to evaluate risk of mortality following spine surgery.

RESULTS: The average age of the cohort was 59 (SD=13.4) and 53% were female. Patients who had stage 3, 4 or 5 CKD were older than the non-CKD patients, 71 (SD=9.2) vs. 59 (SD=13.3). After adjusting for age, gender, BMI, admitting diagnosis, use of BMP, smoking, diabetes, other comorbidities and complications, higher mortality rates were observed for patients who had stage 3 or 4 CKD (OR 1.78, 95% CI 1.3-2.45). Even higher mortality rates were noted for hemodialysis-dependent patients (stage 5 CKD), (OR 4.18, 95% CI 1.87-9.34). A Kaplan-Meier survival plot (with 95% confidence limits) for CKD and non-CKD patients following spine surgery is shown in Figure 1.

CONCLUSIONS: Spine surgery is associated with significantly higher mortality rates in patients with chronic kidney disease compared to patients with normal kidney function. Understanding the additional morbidity and mortality of spine surgery in this medically complicated group of patients is imperative for accurate preoperative risk assessment. Our findings from a large, multi-center spinal registry provide a starting point for future studies aimed at understanding the perioperative risk factors and clinical outcomes of spine surgery in the CKD patient population.



O767

Postoperative Spine Dressing Changes are Unnecessary: Our 15-Year Experience with an Institutional Dressing Change Protocol

Primary Author: Lance K. Mitsunaga

Institution: Kaiser Permanente Northern California Regional Spine Center

Coauthors: Lance K. Mitsunaga (Kaiser Permanente Northern California Regional Spine Center), Sukhraj Bains (Dept of Neuroscience, Univ of Southern California), Nirmal Singh (Kaiser Permanente Northern California Regional Spine Center), Kamran Majid (Kaiser Permanente Northern California Regional Spine Center)

BACKGROUND: There is minimal literature regarding when dressing changes should be performed. We present the dressing change protocol adopted by our institution. We previously reported our preliminary results with this dressing change protocol. In this prior study, we showed that our dressing change protocol did not increase surgical site infection (SSI rates) and, in fact, may even decrease

them. The purpose of this study was to provide an update of our experience with this dressing change protocol over a 15 year period.

METHODS: Effective January 2005, we implemented our universal protocol of no dressing changes for 5 days after surgery. All spine surgery cases involving instrumentation performed at our institution were captured by reviewing a health system administrative database. SSI cases--superficial, deep, and organ space--as defined by the CDC, were identified by reviewing an infection control database. Fischer's exact test was used to compare SSI rates in all instrumented cases from January 1999 to December 2004 (prior to implementation of the dressing change protocol) to those from January 2005 to December 2013 (after the protocol was initiated).

RESULTS: 8,631 instrumented spine fusions were performed by surgeons at a single institution from 1999 to 2013. Overall, after instituting our universal no-dressing change protocol, SSI rates for all cervical, thoracic, and lumbar instrumented cases combined decreased from 3.9% (97/2473) to 0.93% (57/6158) [$p<0.0001$]. The reduction in SSI rates was most significant for posterior cervical and posterior lumbar surgeries. After our dressing change protocol was implemented, we saw an improvement in SSI rates for posterior cervical instrumented cases from 3.2% (6/186) to 0.50% (4/815) [$p=.0041$]. Posterior lumbar instrumented fusion SSI rates dropped from 5.5% (65/1179) to 1.1% (32/2890) [$p<0.0001$].

CONCLUSIONS: Dressing changes in the immediate postoperative period are not necessary. Applying a sterile dressing in the operating room may serve as a barrier to nosocomial pathogens during hospitalization. Our data suggests this dressing change protocol may lead to reduced SSI risk. Leaving the original postoperative surgical dressing intact is safe, simple, and cost-effective.

O768

Functional Outcome of Liverpool Radial Head Replacement in Un- Reconstructable Radial Head Fractures

Primary Author: Ali Abdullah. Mohammed

Institution: Royal Liverpool and Broadgreen University Hospitals NHS Trust

Coauthors: Simon P. Frostick (RLBGUH NHS Trust), Omid Alizadehkhayat (RLBGUH NHS Trust)

BACKGROUND: Radial head fractures represent about one third of all adult elbow fractures. These injuries are commonly described as per Mason-Johnson classification (I - IV). Internal fixation should be reserved for minimally comminuted fractures, while un-reconstructable configurations could be treated with radial head replacement. This report presents the results of using Liverpool Radial Head (LRH) replacement for these fractures.

METHODS: Thirty-two patients (15 males and 17 females) were treated with metallic radial head (LRH) replacements. 29 cases were treated following primary post-traumatic un-reconstructable radial head fractures and 3 cases after failed open reduction and internal fixation (ORIF). Patients were followed up using Liverpool Elbow Score (LES) which is scored between 0-10, with 10 indicating the best functional outcome. The average follow-up period was 4.5 years (range: 2-7 years).

RESULTS: Average LES for the whole group was 8.0 while for those who were treated after failed ORIF was 7.9, and LES was significantly higher for radial head fractures classified pre-operatively as Type III compared to Type IV fractures ($p = 0.02$). Furthermore, replacements on the left side had a better outcome than those on the right side ($p = 0.003$). However, there was no significant difference in the outcome in terms of age or gender.

CONCLUSION: The results showed a good functional outcome for post-traumatic Liverpool Radial Head replacement as measured by the LES. Hence, this prosthesis provides an effective treatment for un-reconstructable radial head fractures.

O769

Sliding External Fixator "A Product Design"

Primary Author: Ali Abdullah. Mohammed

Institution: Royal Liverpool and Broadgreen University Hospitals NHS Trust

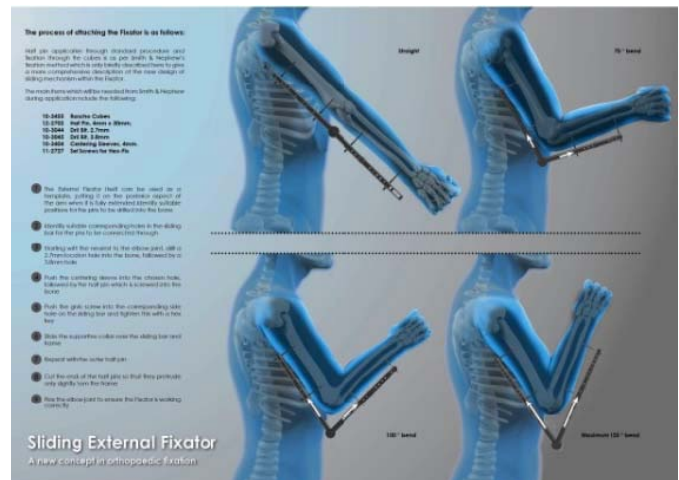
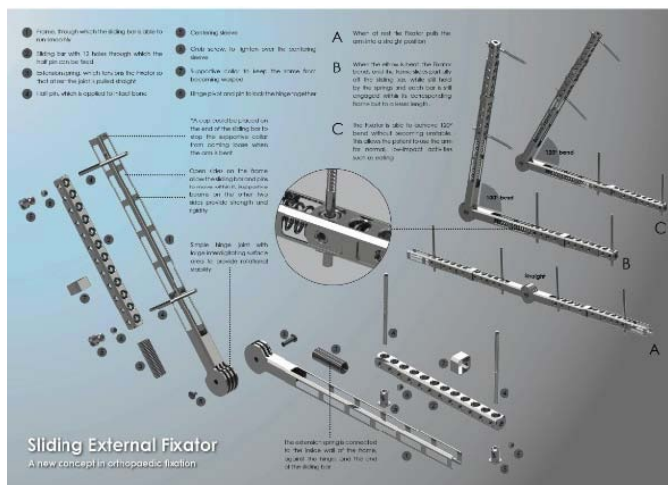
BACKGROUND: External fixation spanning a joint like the elbow, while maintaining joint mobility, is a well-established practice, and it could be done with a variety of external fixation systems. In general it is achieved by ap-

plying either a mono-lateral or a circular fixator.

CURRENT TREATMENT: Using systems like the galaxy fixation by Orthofix, correct identification of the elbow center of rotation under X-ray guidance with lateral views, is mandatory. If the center of rotation of the fixator is not aligned with that of the elbow joint, the assembly will not work, i.e. the elbow will be disrupted on trying to achieve flexion or extension movements.

NEW DESIGN: This idea aims to propagate the principle of sliding external fixation applied on the extensor side of a joint, with the limbs of the fixator being able to slide in and out during joint extension and flexion respectively, without hindering the joint movement. Taking the ulno-humeral joint as an example, it is enough to apply the sliding external fixator in line with the subcutaneous border of the ulna, and the pins in the sagittal plane, without the need to use x-ray guidance to identify the center of rotation, which simplifies the procedure, and makes it less technically demanding. The sliding external fixator over the elbow involves two bars which accommodate half pins fixation with headless grip screws to hold the pins, identical to the Rancho cubes technique by Smith & Nephew, these slide snugly into frames, while those frames are linked together through a hinge behind the elbow, and the bars are spring loaded to the hinge through the inside of the frames, which means they will slid into the frames in extension and out in flexion. Length of the frames should prevent the bars from dislodgement, and the cross section of both of these components has to correspond to each other in order to prevent rotational instability.

SUMMARY: Applying an external fixator on the extensor surface could simplify the procedure, the elbow is taken as an example, and other joints could also be addressed.



O770 Sliding External Fixator “Cadaveric Experiment”

Primary Author: Ali Abdullah Mohammed

Institution: Royal Liverpool and Broadgreen University hospitals NHS Trust

Coauthors: Simon P. Frostick (Royal Liverpool University)

OBJECTIVES:

1. To find out if external fixation applied on the extensor surface of the elbow can avoid the need to identify the center of rotation.
2. To find out if the joint stays congruent with this kind of fixation.

MATERIALS AND METHODS: A sliding external fixator (SEF) designed on the principle that it could be applied over the extensor surface of a joint, for that it has to be able to slide, hence a hinge lies behind the elbow and to extendable arm attach to bone proximal and distal to the joint, these arms slid out on joint extension and in on joint flexion. A spring-loaded mechanism helps recoils the construct into extension. A hand made SEF prototype from basic equipment's to simulate the sliding principle, it comprised of two sliding window glides, the bases of which linked with a door hinge, and on each sliding component two 4-5 holes blocks of Rancho cubes fixed with bolts and nuts. This prototype was applied on two cadaveric elbows on scapula to finger tip specimens. The experiment involved the following steps:

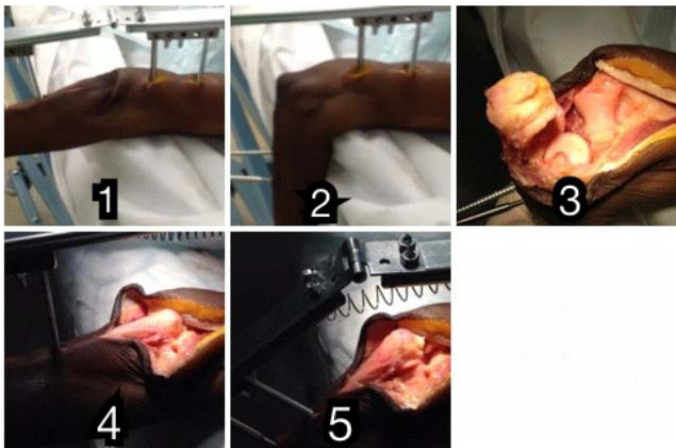
1. Applying two pins in the ulna and two pins in the humerus over the extensor surface, and per-

pendicularly over the subcutaneous border of the ulna.

2. Applying the SEF prototype on an intact elbow without identifying the center of rotation.
3. Moving the intact joint through an arc of movement, from full extension to ninety degrees of flexion to find out if the joint movement is impeded by the fixator or not.
4. Disconnecting the fixator, while keeping the pins.
5. Performing an open dislocation of the elbow (Picture 5), through the posterior approach, dividing the triceps tendon, medial collateral ligament, lateral collateral ligament, capsule, and brachialis insertion.
6. Re-applying the fixator.
7. Testing the joint congruency through the arc of movement to find out if the joint stays concentric or not.

RESULTS: Assembling the fixator over the intact elbows did not impede the joint movement. Furthermore, after surgical dislocation of the elbow the external fixator was able to keep the joint congruent, throughout the movement arc.

CONCLUSION: It is possible to apply a sliding external fixator on the extensor surface of a joint without identifying the center of rotation, and that does not seem to impede the joint movement, while can still keeps the dislocated joint congruent. A better-manufactured prototype would include a set of multidirectional pin clamps, would make the application easier. Furthermore, making the spring-loaded mechanism adjustable would prevent collapse in addition to recoiling from flexion to extension.



O771

The Development of Spinal Interbody Fusion Spacer Made of PEEK and PVF

Primary Author: Kazuma Nagamura

Institution: Kumamoto University

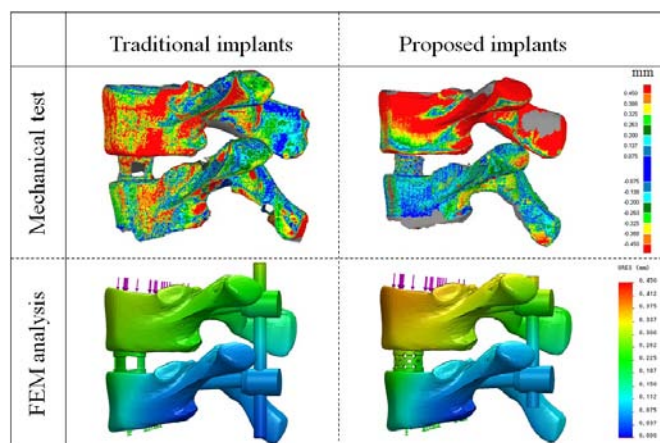
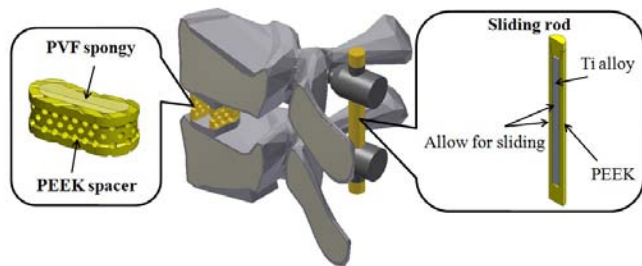
Coauthors: Akira Sei (Kumamoto University), Wakana Togami (Kumamoto University), Hiroshi Mizuta (Kumamoto University), Yukihide Iwamoto (Kyushu University), Hidehiko Higaki (Kyushu Sangyo University), Yoshitaka Nakanishi (Kumamoto University)

Spinal interbody fusion spacer used in posterior interbody fusion are made of titanium alloy which has a much higher elastic modulus than bone. Therefore, the induction of stress shielding may become a problem. Additionally there is a problem of the complications by autogenous bone harvest because it needs autogenous bone graft into spinal interbody fusion spacer. The implants that we proposed are shown in the figure 1. In an effort to increase mechanical stimulus to the lumbar spine we propose changing the material of the spinal interbody fusion spacer from a titanium alloy to plastic (PEEK - poly ether ether ketone), and to increase axial direction displacement we propose sliding rod too. Sliding rod consist of outer rod made of peek and inner rod made of Ti alloy these are allowed sliding. Furthermore in an effort to make it unnecessary to harvest autogenous bone we propose filling the PVF (poly vinyl formal) sponge that have potential for formation of bone cell. The bone formation into PVF sponge was ascertained at in vivo experiment. Biomechanical verification tests are often performed by both mechanical testing and FEM analysis. In the current study we conducted mechanical tests and FEM in an effort to develop the Spinal interbody fusion spacer.

First, CAD data of the lumbar spine (L4, L5) and traditional implants made of a titanium alloy, and the proposed implants were created. For mechanical testing, we made the L4 and L5 lumbar vertebrae from urethane by using 3D printer and casting technique, and the implants from titanium alloy and PEEK from CAD data. Compression tests were performed with a loads of 1000N and 3 dimensional displacement was recorded by 3D scanner. For FEM analyses, we made the FEM models from CAD data. FEM analyses were performed with the same component material properties and loads as used in mechanical tests.

The results are shown in the figure 2. In the Mechanical

tests and FEM analyses, the proposed implants showed an increase in the displacement of the L4 vertebra than traditional implants. The proposed implant is thought to increase mechanical stimulus to the lumbar spine. The spinal interbody fusion spacer is shown to be an interesting alternative to traditional inter body spacers. However, larger displacements were observed in the mechanical tests than in the FEM analyses, so it is necessary to improve the experiment conditions to conduct more detailed biomechanical verification tests.



0772 Development of Tablet Computer Based Clinical Score Input and Statistical Analysis System.

Primary Author: Ryuichi Nakahara

Institution: Okayama University Hospital, Orthopaedics Surgery

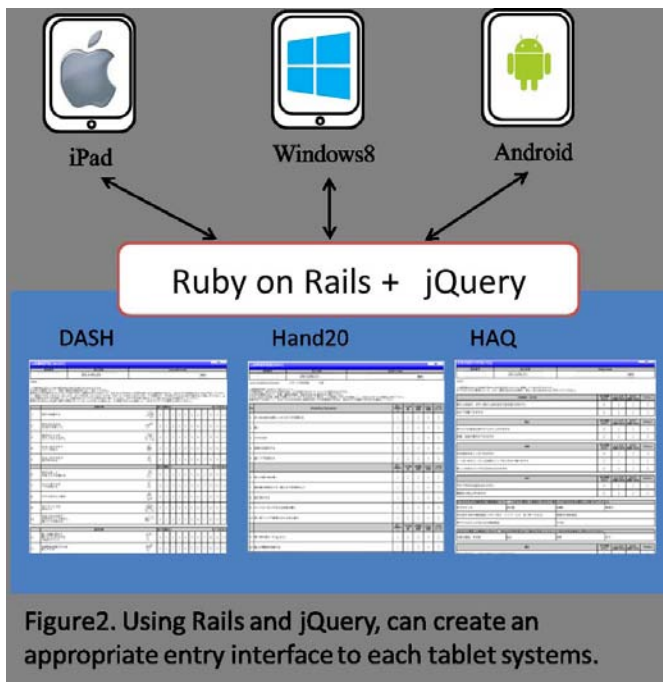
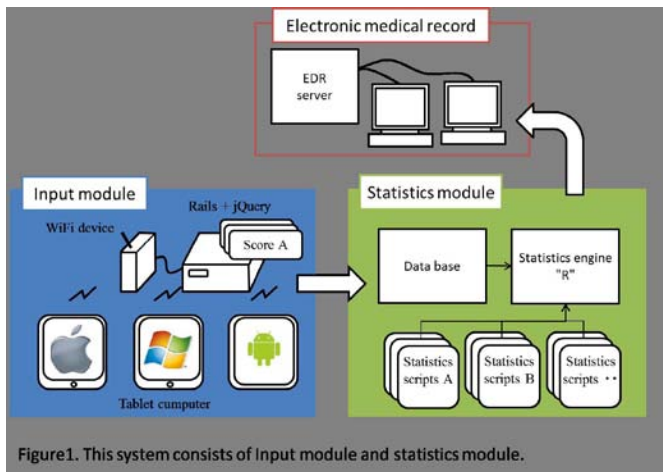
Coauthors: Keiichiro Nishida (Okayama University Hospital, Orthopaedics Surgery), Kenzo Hashizume (Okayama University Hospital, Orthopaedics Surgery), Masatsugu Ozawa (Okayama University Hospital, Orthopaedics Surgery), Harada Ryouzou (Okayama University Hospital, Orthopaedics Surgery)

OBJECTIVE: Clinical score, such as Health Assessment Questionnaire Disability Index (HAQ) is useful for the evaluation of joint replacement surgery and the treatment of rheumatoid arthritis (RA). For accurate and immediate evaluation, data input using tablet computer and statistical analysis on the electronic medical record is required. But electronic medical record system is different from each manufacturer, so development of each system is required. In order to reduce development costs, we selected the module development strategy. Firstly, we developed a separate module that specializes in score input and statistical analysis that is independent to the electronic medical record. And secondly, we build a connection module to each electronic medical record.

MATERIAL AND METHODS: For the input module development, we used jQuery and Rails, by which we can create an appropriate entry interface independent of tablet systems. For the statistic module, we took advantage of R, which enabled us to validate the statistic procedure and to generate various types of graphics. With combination of these modules, we can visualize the statistical results and graphics immediately after the data input. In order to verify the utility of this system, HAQ score input using tablet computer system was performed in 26 RA patients and 23 healthy controls. We recorded the score and time of entering data (input time), and examined the correlation between the score, input time, input experience and age. These statistics were performed immediately after the data input.

RESULTS: Input time was 170 +/- 83 seconds in RA patients and 88 +/- 38 seconds in healthy individuals. Age and input time has good correlation in healthy controls ($r=0.63$, $p=0.05$), but poor correlation in RA patients ($r=0.11$, $p=0.57$). HAQ and input time has good correlation in RA patients ($r=0.50$, $p=0.01$). Input time is shortened with an increase of the number of input experience. Real-time display of statistical results and graph drawing, and the connection to the electronic medical record was possible.

CONCLUSION: We developed score input and statistical analysis system, and performed clinical score input using tablet computer and real-time display of statistical results.



0773

Bioactive Titanium Applied for Implant Fixation and Bone Substitute

Primary Author: Takashi Nakamura

Institution: Kyoto Medical Center, National Hospital Organization

It is very important to fix implant to bone for bone substitute, joint replacement or spinal fusion in orthopedic surgery. Bioactive materials as hydroxyapatite have bonebonding ability. Hydroxyapatite-coating is a good procedure to fix metal to bone and applied to cementless THA or TKA. Plasma-splay coating is good method to coat metal with hydroxyapatite but the pore of the small

diameter is filled with hydroxyapatite and it is impossible to coat the deep layer of pores with plasma-spray method. To make its surface bioactive without changes of structure even in deep layer, new method alternative to plasma-splay coating should be developed.

Coworkers and I investigated bone-bonding mechanism of bioactive material and found that bone-like apatite formation plays key role for bonding. If the surface of metal is changed to form apatite on it in body, the inert metal changes into bone-bonding material. We developed alkaline and heat treatment of titanium to change titanium to bone-bonding material as follows. At first, titanium is dipped in 5N NaOH solution for 24 hours, at second the metal is washed in pure water and finally it is sintered in 500 degree C for 2 hours. The treated surface has bioactivity, bone bonding ability like hydroxyapatite. The advantage of this treatment over plasma spray coating is to treat the porous surface without any change of pore figures and make the surfaces of deep pores bioactive. We applied this alkaline and heat treatment to cementless THA. Ten years results of first 70 hips operated in Kyoto University and Kanazawa Medical University have been published and the survival rate of ten years with the end point of revision was reported 98% and only one revision was carried due to infection.

Porous titanium can be changed to bioactive material by alkaline and heat treatment. This bioactive porous titanium was found to have a property of material-induced osteoinduction, that is, the bone formation in pore of porous titanium implanted in canine back muscle. They can be used for bone substitute for big bone defect. We used two procedures to make porous titanium, sintering of titanium powder with spacer particle of ammonium sulfate and selective laser melting. The latter procedure can produce any type of pore structure of titanium. Selective laser melting was employed to fabricate porous Ti implants (diameter 3.3 mm, length 15 mm) with a channel structure comprising four longitudinal square channels, representing pores, of different diagonal widths, 500, 600, 900, and 1200 micrometer. These were then subjected to chemical and heat treatments to induce bioactivity. Significant osteoinduction was observed in widths 500 and 600 micrometer, with the highest observed osteoinduction occurring at 5 mm from the end of the implants. A distance of 5 mm probably provides a favorable balance between blood circulation and fluid movement. Recently we developed cage for spinal instrumentation using bioactive porous titanium. Preliminary clinical

test showed promising good results suggesting this porous metal also will be applied for the bone defect of the revision surgery of joint replacement.

O774 **Stress Distribution by the Finite Element Method in Kudo Total Elbow Arthroplasty**

Primary Author: Gaku Niistuma
Institution: Physician

Coauthors: Katsunori Inagaki (MD, Professor), Jun Ikeda (MD.), Hiroki Nishikawa (Physician), Yuuki Usui (Physician)

BACKGROUND: This study aimed to evaluate the biomechanical stress distribution within the bone tissue surrounding inserted total elbow prostheses, in resurfacing Kudo-type 5 total elbow arthroplasty.

METHODS: The elbow prosthesis was inserted and, while holding a 1-kg mass, scenarios in which the elbow joint angle (30°, 50°, 70°, 90°) was quasi-statically changed from an extended to a flexed position were generated on a computer. For each elbow angle, minimal muscle strength needed for maintaining the limb position was established. Biceps muscle was assumed to be the elbow flexor, and calculations were performed based on the presence or absence of triceps and brachioradialis. Furthermore, the reaction force on the frictional surface of the artificial joint was calculated. Using these results, a finite element model was created with 3D-FEM, and stress distributions of the humeral and ulnar bone tissues were assessed.

FINDINGS: Our results revealed that high stress occurs in the distal surrounding bone tissue of the ulnar component, regardless of the presence or absence of triceps or brachioradialis. Notably, the highest stress occurred in bone tissue surrounding the distal end of the ulnar component. The overall stress applied to the bone tissue surrounding the component increased when triceps muscle was used.

INTERPRETATION: A higher stress occurs in the distal surrounding bone tissue of the ulnar component, than humeral component, which is about one tenth in size. So ulnar component has a high load surrounding bone tissue in the Kudo TEA.

O775 **The Comparison of Concentration of Platelets and Growth Factors in PRP Generated Different Preparation System**

Primary Author: Kyu-Cheol Noh
Institution: Hallym Univ. Medical Center, Kangnam Sacred Heart Hospital

Coauthors: Kyung-Ok, Kim, Gacheon Univ. Medical Center, Yong-Tae, Kim, Hallym Univ. Medical Center

INTRODUCTION: The mechanism of action for PRP treatment could be from growth factors released from concentrated platelets. Platelet concentrations in the various PRP preparation techniques are dependent on amount of whole blood harvested, the platelet recovery efficiency and final plasma volume. A comparison study was performed on the buffy coat based Biomet GPS®III and the plasma based Arthrex ACP™ systems to assess the ability of each device to concentrate the platelets and growth factors.

METHODS: Fresh whole blood was extracted from 9 healthy human donors into 3 syringes containing anticoagulant (ACD-A). The first syringe was used as a baseline sample (1 ml ACD-A and 9 ml blood). The second syringe was loaded with 54 ml of blood and 6 ml ACD-A into the Biomet GPS®III device, and the third syringe was an Arthrex ACP™ double syringe (1.7 ml ACD-A and 15 ml blood). A 1-mL sample of each PRP preparation and each native blood specimen were analyzed by automated hematology analyser. Enzyme-linked immunosorbent assay (ELISA) were used to quantify the growth factor concentration of each PRP.

RESULTS: The average PRP output volume from the GPS®III concentrator was 6 ml and the average PRP output volume from the Arthrex™ system was 4ml. The average number of platelet from the GPS®III system demonstrated $618 \times 10^3/\mu\text{L}$. The average number of platelet from ACP™ system demonstrated $332 \times 10^3/\mu\text{L}$. The average number of WBC from the GPS®III system demonstrated $27 \times 10^3/\mu\text{L}$. The average number of WBC from ACP™ system demonstrated $3 \times 10^3/\mu\text{L}$. The buffy coat based Biomet GPS®III had a significantly higher concentration of the factors PDGF-AA, PDGF-AB/BB, TGF-B1, EGF and VEGF in comparison with the plasma based Arthrex ACP™ systems.

DISCUSSION AND CONCLUSION: A comparison study was performed on the GPS III and ACP systems to evaluate the ability to concentrate the platelets and growth factors. The buffy coat based GPSIII produces a high concentration of platelets, WBCs. and growth factors.

O776

Swanson Metacarpophalangeal(MP) Joint Arthroplasty in Severe Psoriatic Arthritis (PsA): A Case Report

Primary Author: Koei Oh

Institution: Department of Orthopaedics Showa University Yokohama Northern Hospital

Coauthors: Keikiti Kawasaki (), Akihiko Maeda (), Masanori Nakamura (), Katunori Inagaki ()

Swanson implants became available in the late 1960s and have been widely used in rheumatoid arthritis (RA), but few cases reported in PsA. We present the case of a 37-year-old man with severe PsA, who had undergone Swanson metacarpophalangeal (MP) joints arthroplasty and arthrodesis in proximal interphalangeal joints (PIP). He had psoriatic plaques over face, both of wrists, hands and onychodystrophy with nail pitting. The arc of motion were 90,85,85,90 degrees for PIP and -50,-45,-45,-50 degrees for MP at the 2nd through the 5th finger joints with severe contracture. He could not grasp at all. After he started TNFi therapy (Adalimumab) plus methotrexate, the arthrodesis in PIP joints was performed primary by interosseous wiring method. As the reason for every joints of PIP were ankylosing, we used CON-NEX® reamer (Wright medical technology) after wedge osteotomy. 3 months after the procedure, Swanson implant arthroplasties of the 2nd through 5th of the MP joints were performed secondly. The treated finger joints of the arc was 45,50,55,60 degrees for PIP and the range of motion for MP joints were from 0,5,5,10 degrees to 45,50,50,50degrees post-operatively. He can acquire ability of grasp and improve in hand function, grip strength and cosmesis. Swanson implant arthroplasty has got better hand function and aesthetics even in the case of severe PsA.



O777

Comparison of the Outcomes on Second-Look Arthroscopy after Anterior Cruciate Ligament Reconstruction Using a Hamstring Autograft or a Tibialis Anterior Allograft

Primary Author: Heegon Park

Institution: Dankook University Hospital

Coauthor: JooHong Lee ()

PURPOSE: We wanted to evaluate the status and changes of the reconstructed anterior cruciate ligament (ACL) graft by performing second-look arthroscopy after arthroscopic reconstruction of the ACL with a hamstring autograft or a tibialis allograft. Materials and

METHODS: From June 2003 to February 2007, second look arthroscopy was performed on 58 cases and a ham-

string autograft was used in 36 cases and a tibialis allograft was used in 22 cases. Second-look arthroscopy was conducted at an average of 19.1 (12~42) months after reconstruction. We measured the graft tension using displacement by probing and the synovial coverage by visual analysis at the time of second-look arthroscopy. The Lysholm score, the Lachman test and a KT-2000 arthrometer were used to evaluate the status of the reconstructed ACL.

RESULTS: The hamstring tendon autograft group showed normal tension in 25 cases, lax tension in 7 cases and partial tear in 4 cases. The tibialis anterior allograft group showed normal tension in 12 cases, lax tension in 5 cases and partial tear in 5 cases. In the hamstring tendon autograft group, the synovial coverage was good in 23 cases, there was half coverage in 8 cases and it was pale in 5 cases. In the tibialis anterior allograft group, the synovial coverage was good in 10 cases, there was half in 7 cases and it was pale in 5 cases. There were no significant differences between the two groups on the clinical examination, but on second look arthroscopy, the synovial coverage was better in the hamstring tendon autograft group than that for the tibialis anterior allograft group.

CONCLUSION: The hamstring autograft group had superior synovial coverage compared to that of the other group on second look arthroscopy. But there were no significant difference of the clinical outcomes between the groups.

O778 Design of Femoral IM Nail by Curvature Analysis for Korean Population

Primary Author: Heegon Park
Institution: Dankook University Hospital

Coauthors: YeonJun Kim (Dankook University Hospital)

PURPOSE: IM nail currently used in Korea was built with the physique of the western population in mind. As a result, procedural corrections for the structural angle can cause excessive distortion of the nail, which could lead to problems during the procedure and in long term maintenance. This study aims to measure the standard femur angle of the Korean population to improve the current IM nail situation.

MATERIALS AND METHODS: 183 patients who had femur imaging were studied. To assess the anterior & lateral bowing of the femur, X-ray imaging was used. After converting a curve connecting central points in 2.5mm intervals into a graph, the curve was assumed to be part of a circle whose radius is the curvature of the femur. This reflects the current industry practice of representing the curvature of IM nails by said radius. The curvature of the femur's cancellous portion was measured, and the radius was used to measure the lateral bowing of the IM nail.

RESULTS: The measurement of the femur's lateral bowing and intertrochanter yielded a disparity with the products currently used in clinical practice. Those products were developed with the femur of the western population in mind. While the radius of IM nails were between 2300 and 2600 millimeters, the average lateral curvature radius of 100 patients was 766.78mm. The lateral bowing of current products were 4.2 ± 2.1 while that of the patient group was 6.45.

CONCLUSION: In conclusion, in comparing the values of the IM nails and patient group, the femur length of the patient group was shorter, the lateral bowing angle larger, and the radius smaller.

O779 Patient Satisfaction Following Lower Limb Arthroplasty: A Supreme Goal

Primary Author: Kodali Siva Rama Prasad
Institution: Prince Charles Hospital, Merthyr Tydfil, United Kingdom

Coauthors: Altaf Hussain (Prince Charles Hospital, Merthyr Tydfil, United Kingdom), Anil Singhal (Prince Charles Hospital, Merthyr Tydfil, United Kingdom)

BACKGROUND: Patient satisfaction is an important outcome measure because there is a well-documented discrepancy between clinician and patient ratings of health status. Patient satisfaction data per se following total hip and total knee replacements in orthopaedic literature is limited. So we undertook a patient satisfaction survey to ascertain whether patients are satisfied with the information on consultation, consider the operation successful and have adequate support after the operation.

METHODS: We undertook a retrospective study of 143 patients, who underwent total hip replacements (73) and total knee replacements (68) between 1 January 2003 to 31 December 2005 by mailing patient satisfaction survey and Oxford Score questionnaires with responses from 100 (71%) – THR 49 (67%) and TKR 51 (75%).

RESULTS: Response rates between 67-75% for a Postal survey are comparable to current literature. 75% were very satisfied, 24% satisfied with consultation. 97% were satisfied with in-patient care, 1 unsure and 7 not documented. 97% expressed satisfaction with medical care and 95-97% with all personnel. 95% were satisfied with discharge and followup arrangements. Oxford scores for total hip replacements were n=48, range 12-47 and mean 27, median 27 and total knee replacements n=47, range 15-57, mean 32, median 34.

CONCLUSIONS: Our postal survey for total hip and total knee replacements generated good response rates for such a survey. 95-97% expressed satisfaction with the comprehensive care. Besides being a quality-of-care indicator, satisfaction with care with comprehensive care adds a new dimension to clinical practice, as a predictor of self-perceived outcome status after surgery.

O780

The Learning Curve Associated with Robotic-Assisted Total Hip Arthroplasty

Primary Author: John M. Redmond

Institution: American Hip Institute

Coauthors: Benjamin G. Domb (American Hip Institute), Asheesh Gupta (American Hip Institute), Jon E. Hammarstedt (American Hip Institute), Alexandra E. Petrakos (American Hip Institute), Christine E. Stake (American Hip Institute)

BACKGROUND: Several recent reports have documented a high frequency of malpositioned acetabular components, even amongst high volume arthroplasty surgeons. Robotic assisted total hip arthroplasty (THA) has the potential to improve component positioning; however, to our knowledge there are no reports examining the learning curve during the adoption of robotic assisted THA.

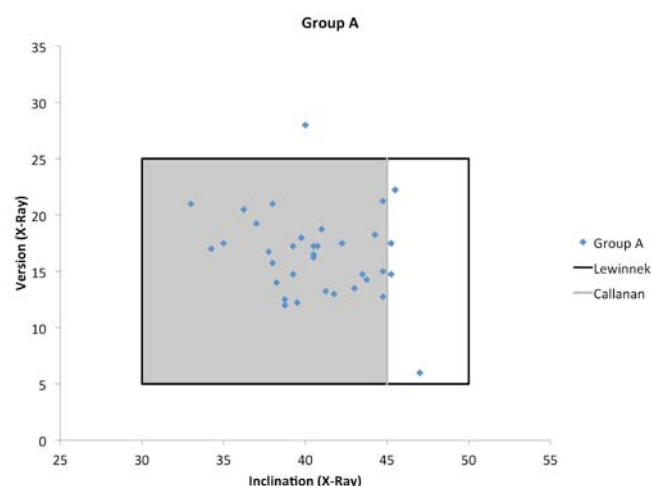
PURPOSE: The purpose of this study was to examine the

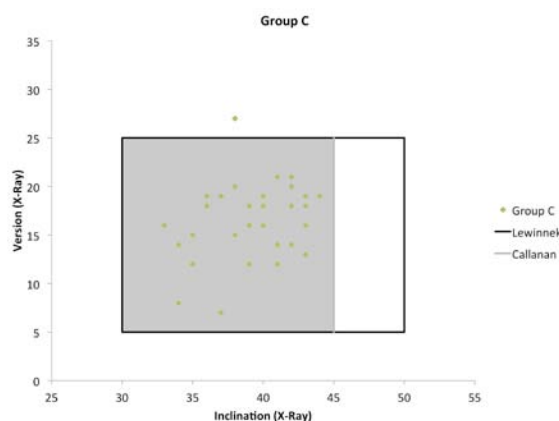
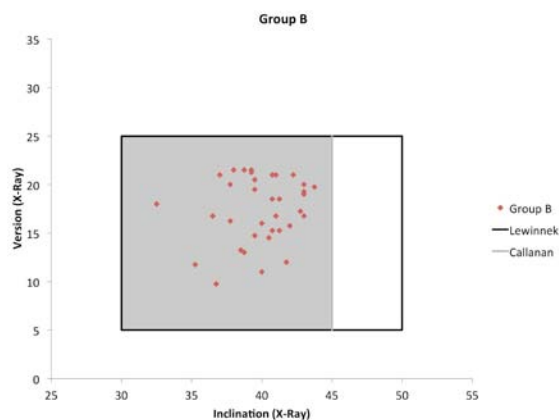
learning curve of robotic assisted THA as measured by component position, operative time, and intra-operative complications.

METHODS: The first 105 robotic-assisted THAs performed by a single surgeon through a posterior approach from June 2011 to August 2013 patients were divided into three groups based on the order of surgery. Component position, operative time, and intra-operative complications were recorded.

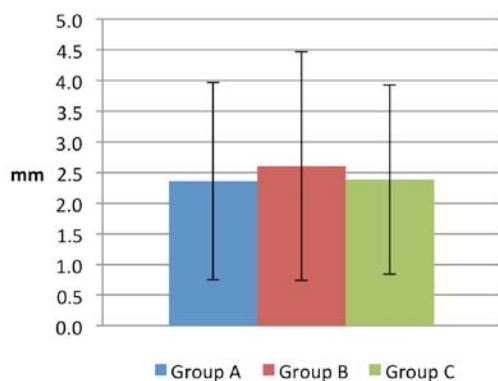
RESULTS: There was no difference in component position or rate of complications between the three groups ($p > 0.05$). There was no difference between groups for average acetabular component inclination or anteversion. There was a decreased risk of acetabular malpositioning with experience ($p < 0.05$). There was no difference between groups for average acetabular component inclination or anteversion. Operative time appeared to decrease with increasing surgical experience ($p < 0.05$). There were a total of eight robot associated technical problems, and one intra-operative complication during the study.

CONCLUSION: Excellent acetabular component positioning and leg length matching was found throughout the learning curve of robotic assisted total hip arthroplasty, with very few outliers in either category (Figure 1, Figure 2). However, a learning curve was found, as decreased incidence of acetabular component outliers and decreased operative time were noted with increased experience. Based on these findings, we conclude that there is a learning curve of approximately 35 cases in robotic-assisted total hip arthroplasty.

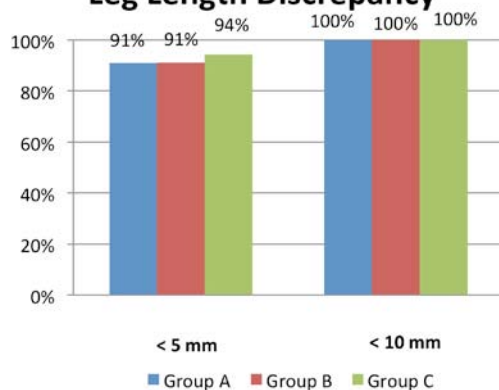




Leg Length Discrepancy



Leg Length Discrepancy



O781

The 3-stage Arificial Joint Arthroplasties for the Infectious Arthritis and the Prosthetic Joint Infections

Primary Author: Hirofumi Sakaeda

Institution: Gifu Red Cross Hospital

Coauthors: Atushi Kawaguchi (Gifu Red Cross Hospital), Takashi Mizoguchi (Gifu Red Cross Hospital), Osamu Yokota (Gifu Red Cross Hospital)

PURPOSE: We evaluated the results of 3-stage artificial joint implantation after the treatment for 7 patients who had had either an infected joint implants (5 patients) or infectious arthritis (2 patients).

METHODS: The surgical concepts is as follows. The first stage involves removal of the infected prosthesis, debridement of all infected devitalized tissue. The microbiological examination is made using the intraoperative specimens in aerobic and anaerobic bacterial cultivations. And an temporary antimicrobial-impregnated articulating spacers or beads chains are placed [Fig.1]. 6 weeks of systemic antimicrobial therapy is subsequently administered. The second stage procedure involves the exchange of the spacer or chains, and the taking of several cultures. When the cultures appear healthy, the new prosthesis can be implanted in the third stage [Fig.2]. Negative intraoperative cultures are essential for the reimplantaion. So if microbes are found, the second stage procedure must be repeated.

RESULTS: Bacteriological findings revealed that *Escherichia coli* were isolated in two cases, MRSE were in two cases, *Streptococcus* was in one case, and poly-microbial infection with MRSA, MRSE and *Pseudomonas aeruginosa* was in one case. Tibial and femoral bone loss were so large that constrained-type knee prostheses are selected in two cases, and rotating hinge knee prostheses were selected in two cases, and the full-length porous femoral long stem in one case. In all cases total arthroplastic implant were successfully placed. The interval between the resection and reimplantation typically is about 3 months. There have been no recurrences of bone infection except the one case with the soft tissue phlegmon attack after 1 year from the revision knee surgery. In the second stage of the 3 cases, microbes were identified in the cultures obtained from the unexpected lesions. It shows the importance of the appropriate microbiological diagnosis.

CONCLUSIONS: The factors associated with recurrent infection were retained microbes and either local postoperative or systemic potential immunocompromise. Our 3-stage treatment protocols, which were based on the clinical and bacteriological setting of infection, were successful for the infectious arthritis and the prosthetic sepsis.

O782

Operative Treatment for Interprosthetic Femoral Fractures

Primary Author: Naofumi Shiota

Institution: Okayama Medical Center

Coauthors: Toru Sato (Okayama Medical Center), Tomonori Tetsunaga (Okayama Medical Center)

INTRODUCTION: Total hip arthroplasty (THA) and total knee arthroplasty (TKA) are now common orthopaedic procedures. This, combined with an increase in the average life expectancy and functional requirements for the elderly, has led to a higher incidence of periprosthetic and interprosthetic fractures. Their treatment is not only technically demanding and challenging, but can also be associated with serious complications. I report of four cases of interprosthetic fractures treated in our hospital from 2007.

MATERIALS AND METHODS: 7.2 years average age, all four cases are female. Two cases of interprosthetic fractures are occurred between THA and TKA, two cases are between bipolar hip arthroplasty (BHP) and TKA. We investigate fracture type (Modified Vancouver classification), implant to fix these fractures, time to bone union.

RESULTS: All fracture types are type A (both stable). AO LCP-DF is used in all cases surgery. Re-operation recognize in one case because of pulled out of implant. These cases are considered to be clinically and radiographically healed average 8.9 months (5~15months).

CONCLUSION: Upon the surgery of interprosthetic fracture, plate position is limited, the allowable range is very narrow. Two directions X-ray check of temporarily fixed is very important. Another important point is that plate fixation, particularly at the proximal extremity, suitable length and with a sufficient number of screws and cerclage wires. In addition, these plates implanted with the MIPO technique, represent a solution that is more satisfying mechanically and biologically.



O783**Coronal Stabilization and Bracing of Displaced Capitellum Fractures: A Simple Kirchner Wire Stapling Technique***Primary Author: Sanjay Valmikrao. Sonanis**Institution: Bronglais Hospital & Hywel Dda Health Board**Coauthors: Sanjay Kumar (Bronglais Hospital), Nitin Deshmukh (Hywel Dda Health Board)*

A prospective study was done using Kirschner (K) wires to internally fix capitellum fractures and its results were analysed.

Since 1989, unstable displaced 17 capitellum fractures were anatomically reduced and internally fixed by inserting K wires in coronal plane from the capitellum into trochlea. The lateral end of wires were bent in form of a staple behind the fracture plane and anchored into the lateral humeral condyle with pre-drilled holes. Additional screws were used in 2 cases to stabilise the lateral pillar comminution. The capitellum was exposed with a limited lateral elbow approach between anconeus and extensor carpi ulnaris. The deeper dissection was limited anterior to lateral collateral ligament (LCL). The capitellum fragment was reposition under the radial head and anatomically reduced by full flexion of elbow and then internally fixed. Total 17 patients (7 males and 10 females) with average ages 34.8 years (14 to 75) had fractures, Type I: (Hans Steinthal #) 12, Type II: (Kocher Lorez #) 1, and Type III: (Broberg and Morrey #) 4. Post-operatively the patients were mobilised immediately.

Patients were assessed clinically and radiologically. Average followup was 31.7 (18-35) months. Capitellum fractures healed in all the patients. Mayo elbow score was excellent in 12, good in 4, and fair in 1 patient. Average elbow ROM was 5 to 132 degrees, pronation 84.5 (79-90) degrees and supination 88 (85-91) degrees. Complications seen were wire pain in 4 patients, loosening of wires in 2 which required early removal. We did not see any infection, non-union or avascular necrosis in the time scale we studied.

We found a simple manoeuvre of hyper-flexion of elbow reduced the capitellum anatomically, and K wires stapling technique to be very easy and stable. A limited exposure of capitellum helped to restore immediate stable elbow with good function.

O784**Evaluation of TKA Loosening and Polyethylene Wear Using Iterative Reconstruction Tomosynthesis - 2.5D Imaging***Primary Author: Kazutaka Sugimoto**Institution: Sonoda Joint Replacement Center Hospital**Coauthors: Yukihide Minoda (Osaka City University School of Medicine)*

Frontal and lateral plain radiographs are the first choice for follow-up observations of the osteotomy boundary that faces to the femoral and tibial components of the TKA. However, as plain radiographs provide no information in the image depth direction, it is difficult to determine the exact position of early stage bone radiolucent lines. A new tomosynthesis technique using both the iterative reconstruction and metal separation methods has recently attracted attention. We report that this technique provides multislice images of the boundary between metallic implant and osteotomy surface, which is difficult to observe by conventional multi-slice imaging methods such as CT and MRI, and permits semi-three-dimensional evaluations of polyethylene wear. and for our New technology We propose digital tomosynthesis with a new reconstruction method, a combination of iterative reconstruction (IR) with metal extraction, in order to reduce metal artifacts with compatibility of high spatial resolution for post-TKA followup examination. For comparison of metal artifact reduction efficiency, three images were respectively reconstructed by conventional FBP, FBP with modified kernel and proposed method. Proposed method provides higher resolution images with remarkably less metal artifacts than others, where we can observe the structure of trabecular bone in the region very close to a metal prosthesis. We demonstrate some clinical applications.

O785**Human Body Motion Tracking Using Inertial Tracking System with Hyper-dimensional Particle Filtering***Primary Author: Gary To**Institution: University of Tennessee**Coauthor: Mohamed Mahfouz (University of Tennessee)*

In recent years, there is an increasing amount of consumer electronics applications using inertial tracking system as a control interface for electronic system using simple body motion. These systems do not require an external observation unit such as the optical tracking system, and no additional setup. It has substantial potential in everyday clinic as a diagnostic tool and performance monitoring system during physical therapy. However, there is limited use of this technology for medical application due to inaccuracy and inconsistency.

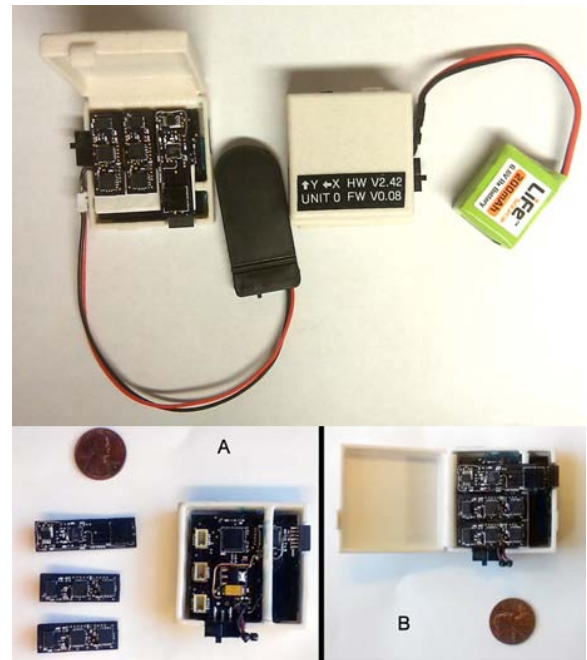
Off-the-shelf inertial trackers typically suffer from several drawbacks. First, the sensors are not optimized to monitor human motion. Many inertial tracker systems are designed for robotic or aeronautical applications, where the sensors have extremely high dynamic range. It is necessary to use sensors with high sensitive to accurately monitor the subtle motion from the human body. Second, the sensor fusion algorithm, which processes the signal from multiple sensors and determines the orientation of the object, is based on mathematical assumptions on the signal and error variances characteristics. These assumptions does not always hold true during human body motion. Lastly, since the estimation is temporal based, a delay in the data transmission can introduce significant amount of error for the estimation.

A high resolution modular wireless inertial tracking system that can accommodate to different tracking applications was developed as shown in figure 1. The system has three sensor ports where different sensor configurations can be used depending on the desired monitoring activity. Orientation representation resides on a hyper dimension manifold. Hence, all three dimensional representations has at least one singularity point. A novel algorithm using particle filters with hyper-dimensional statistical geometries was designed to provide stability and temporal disturbance recovery, while estimating the orientation of the unit. The final output is projected into Euler angles representation.

The performance of the system was verified and validated by multiple human body motion experiments. A total of 35 free hand motion activities were performed. The results are compared with optical tracking system. The root mean squared error (RMSE) is X: 0.45, Y: 0.53, Z 0.51 degrees. In the second experiment, the inertial trackers are attached to the thigh and shank of the test subject. Multiple deep knee bend and chair rise activities were performed and the result is compared with the optical tracking system. The RMSE for these activities are X: 0.29, Y: 0.49, Z: 0.41 de-

grees for thigh's tracker and X: 0.35, Y: 0.33, Z: 0.34 degrees for shank's tracker.

The current system shows highly accurate orientation tracking for dynamic activities in its optimal settings. For human motion tracking, the accuracy is generally acceptable as a biomechanics assessment or clinical diagnostic tool. Current effort has been focused on developing orthopedic assessment tool for the everyday clinic.



O786 Electromagnetic Stimulation of a Nanoparticle-Tissue

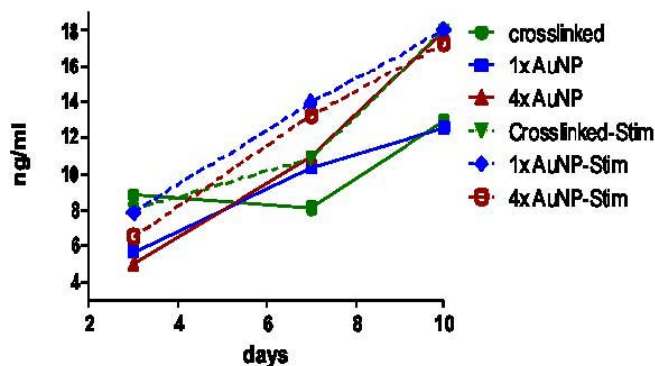
*Primary Author: Richard A. White
Institution: University of Missouri*

Coauthors: Daniel Grant (University of Missouri), Sheila Grant (University of Missouri)

The goal of this project was to investigate the effect of electromagnetic fields in promoting cellularity in nanoparticle-bioscaffolds which could be used to treat orthopaedic issues including ligament/tendon repairs. It was hypothesized that nanomaterial-bioscaffolds will allow for enhanced cellular in-growth and proliferation from cellular interactions with the nanoparticles and from the local fields generated around the nanoparticles by the extremely low frequency electromagnetic fields (ELF-EMF). Decellularized porcine diaphragm tendon was utilized as the tis-

sue scaffold. The scaffolds were assigned as crosslinked, crosslinked with 1X gold nanoparticles (AuNPs), or crosslinked with 4X AuNPs. A pair of Helmholtz coils generated a 12 Gauss, 60 Hz electromagnetic field. Cell culture was performed using L929 mouse fibroblast cells. Each scaffold was seeded with the same initial load of fibroblast cells. The bioscaffolds were exposed to the ELF-EMF for 2 hours each day for 3, 7, and 10 days. A Quant-iT™ PicoGreen double stranded DNA quantification assay was performed to measure the cellular proliferation. For the crosslinked samples at 7 and 10 days, the DNA concentration was significantly greater for the simulated group compared to the unstimulated group. There were no significant differences between the simulated and unstimulated groups at 7 or 10 days for the 1X AuNP or 4X AuNP samples. AuNP samples had greater DNA concentration at day 7 with or without stimulation compared to similar samples without AuNP. [Fig.1] Differential scanning calorimetry showed that the concentration of AuNPs on the scaffold does not adversely affect the thermal stability of the nanomaterial-bioscaffold.

This study highlighted the potential positive effects of ELF-EMF stimulation and the presence of AuNPs on bioscaffolds.



O787 Tibial Torsion Measurement by Computerized Tomography

Primary Author: Hamed Yazdanshenas

Institution: UCLA Charles R. Drew University of Medicine and Science

Coauthors: Firooz Madadi (SBMU), Firoozeh Madadi (SBMU)

BACKGROUND: Tibial torsion is a term used to describe the physiologic twist of the distal relative to the proximal articular axis of the tibial bone in the transverse plane around its longitudinal axis. This study focuses on a method of tibial torsion measurement with computerized tomography cuts.

METHODS: Sixty four volunteers aged over 16 years old had CT imaging of proximal and distal tibia in a teaching hospital in Tehran-Iran. The images were evaluated for leg rotation by four physicians using two different techniques in two different occasions, one month apart. In the first technique the middle of tibia and middle of fibula were used as reference points and in the second method the perpendicular axis to the line connecting the distal fibular notches on CT scans was used. The values were analyzed, and the intra and inter observer agreements for tibial torsions were assessed.

RESULT: The inter-observer agreement in tibial torsion was 0.861 and 0.863 in the first and second methods respectively. The intra-observer reliability in both measurements techniques were 0.868. The two techniques also had excellent agreement in tibial torsion measurements.

CONCLUSION: The second technique has high reliability and re-productivity in assessing tibial rotation in fibula deformity.

KEYWORDS: Tibia; Rotation; Tomography; Computed

O788 Tenorrhaphy Of The Achilles Tendon And Platelet Rich Plasma

Primary Author: Pietro G. Zedde

Institution: Clinica Ortopedica Università degli Studi di Sassari

Coauthors: Fabio Del Prete (Clinica Ortopedica Università degli Studi di Sassari), Federico Mela (Clinica Ortopedica Università degli Studi di Sassari), Andrea F. Manunta (Clinica Ortopedica Università degli Studi di Sassari)

INTRODUCTION: The rupturing of the Achilles tendon is today a pathology ever more frequently presented due to the rise in recent years of people participating in sporting

activities. Treatment goals for Achilles tendon ruptures include normalizing the muscle-tendon length and tension, and optimizing function and strength of the whole gastrocnemius soleus complex. However, studies available on this injury are not in agreement on the best way to achieve these goals.

OBJECTIVES: The treatment of Achilles tendon rupture must be based, regardless of the method chosen, on the knowledge and understanding of the biological repair processes that can be implemented by the use of Platelet Rich Plasma in patients treated surgically. This approach offers several advantages, enabling a faster recovery and reducing the chance of recurrence without any side effects.

METHODS: Between February 2008 and December 2011, 32 patients with Achilles tendon rupture were treated with non-absorbable end-to-end suture. In all patients, the time elapsed between rupture and surgery was two to four days. In 21 cases, PRP was used, and in one patient with a simultaneous bilateral rupture it was decided to apply the platelet gel only to the right limb for a comparative study. During the post-operative period, patients followed a standard rehabilitation protocol. In all patients, response to treatment was evaluated from both a symptomatologic (VAS scale) as well as a functional point of view, using the VISA-A scale (Victorian Institute of Sports Assessment-Achilles), a valid and reliable index for evaluating the clinical severity of Achilles tendinopathy through the analysis of pain, applicable to both normal daily activities and sports.

RESULTS: In all patients who underwent tenorrhaphy complete functional recovery was achieved. In cases where the PRP approach was used, the recovery process was quicker, as evidenced by the fact that these patients regained mobility and returned to their habitual sports activities more rapidly. In the patient with bilateral rupture, the wound healed earlier and with better restitutio ad integrum in the right limb compared to the left one, as demonstrated by the far superior results from isokinetic, stabilometric and functional tests. At a distance of 180 days from the surgery, the patients were assessed with the VISA-A questionnaire. All stages of the regeneration process can be enhanced and improved by the application of PRP. The application of PRP can therefore be used for modulation of cell activity in various stages of tissue regeneration.

CONCLUSIONS: In our opinion, the healing process

should be reinforced, more than accelerated. In fact, to complete the process of protein synthesis fibroblasts still need about three weeks, before the formation of collagen and other protein constituents of connective tissue can take place. When degenerate tissue and poor biological reaction prevail, the application of PRP at an intratendinous level, bringing to the lesion site the biological media needed for the normal regeneration process, can be extremely useful in patients who have specific functional demands. This approach can ensure a more rapid functional recovery and reduce risk of relapse in athletes with limited additional cost.

O789

X-ray Image Characteristics and Related Measurement in the Ankles of 118 Adult Kashin-Beck Disease Patients

Primary Author: Yi Zeng

Institution: Department of Orthopaedic Surgery, West China Hospital, West China Medical School, Sichuan University

Coauthors: Bin Shen (Department of Orthopaedic Surgery, West China Hospital, West China Medical School, Sichuan University), Jing Yang (Department of Orthopaedic Surgery, West China Hospital, West China Medical School, Sichuan University), Zongke Zhou (Department of Orthopaedic Surgery, West China Hospital, West China Medical School, Sichuan University)

BACKGROUND The purpose of this study was to show the radiographic characteristics in the ankles of adult Kashin-Beck disease (KBD) patients.

METHODS 118 KBD patients were examined with lateral radiographs of the right ankle. The morphological abnormalities in the talus, calcaneus, navicular, distal tibia and joint space were analysed and the calcaneus length, height, length/height ratio, tuber angle, front angle, plantar angle, and distal tibia anteroposterior (AP) length were also measured using Riepert's method.

RESULTS: 81 patients (68.6%) showed ankle radiographic abnormal, in which 72 (88.9%) patients had talus changes, 69 (85.2%) patients had had calcaneus changes, 28 (34.6%) patients had navicular changes and 48 (59.2%) patients had distal tibia changes. For 118 KBD patients, the average calcaneus length was 7.4cm, the height was

4.3cm, the length/height ratio was 1.7. The calcaneus tuber angle was 28.2° , front angle was 38.0° and plantar angle was 74.2° . The distal tibial anteroposterior length was 4.05cm. Compared with 50 normal adults as control group, significant differences were found at calcaneus length, calcaneus length/height ratio and distal tibial AP length.

CONCLUSIONS: KBD disease have characteristic abnormalities on ankle radiographs, in which the talus depression and deformity, the calcaneus shortening deformity and distal tibia deformity with AP length widening showed most typical changes.

O790

In-Patient Trends and Complications after Total Elbow Arthroplasty in the United States

Primary Author: Hanbing Zhou

Institution: University of Massachusetts

Coauthors: Joshua Shaw (University of Massachusetts), Mark Price (University of Massachusetts), Xinning Li (Boston University)

INTRODUCTION: Total elbow arthroplasty remains to be one of the few treatment methods for rheumatoid arthritis and post-traumatic arthritis. Few procedures are performed each year and they are mainly concentrated at select centers around the country. There are few large studies describe the long-term survival of the total elbow arthroplasty and associated cost and complications. To our knowledge, there is currently no data describing the national trends of total elbow arthroplasties in the United States. The purpose of our study is to evaluate the current practice trends and associated in-patient complications of total elbow arthroplasty at academic centers in the United States. Patients &

METHODS: We queried the University Healthsystems Consortium (UHC) administrative database from 2007 to 2011 for patients who underwent an elective total elbow arthroplasty, according to their ICD-9 procedure code 81.84. A descriptive analysis of demographics was performed which included patient age, sex, race, and insurance status. Next, a similar analysis of patient clinical benchmarks was performed, including hospital length of stay (LOS), hospital direct cost, in-hospital mortality, complications, and 30-day readmission rates.

RESULTS: Our cohort consisted of 3,146 adult patients who underwent a total elbow arthroplasty at 159 different academic medical centers across the country during the specified time period. The annual surgical volume for individual surgeons who performed this procedure was 7 ± 5 . The cohort was comprised of 36.5% male and 63.5% female patients. The majority of the cohort 2,334 (74%) was white, 285 (9%) were black, 236 (7.5%) were Hispanic, 16(0.5%) were Asian, 9% were other. The mean age of the cohort was 58 years old ± 17 . Overall, 51% of the cohort had private insurance, 41% had Medicare, and 8% had Medicaid. At least 70% of the cohort had one or more chronic medical conditions. The mean LOS for the cohort was 4.2 days ± 5 . The mean total direct cost for the hospital was \$16,300 $\pm 14,000$ per case. In hospital mortality was less than 1% for the cohort during their index hospitalization. Inpatient complication rate included: DVT 0.8%, re-operation 0.5%, and infection 0.4%. There was a readmission rate of 6.4% within the first 30 days from the time of discharge.

DISCUSSION/CONCLUSION: Total elbow arthroplasty is associated with low in-patient complications that include DVT (0.8%), re-operation (0.5%), and infection (0.4%). However, a significant number of patients were readmitted to the hospital within 30 days of the index procedure (6.4%). Majority of the patient population is female that had either private insurance or Medicare. Hospital stay average to 4 days with a cost of \$16,300 \pm \$14,000 per case.



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JISRF Creates Institutional Review Board

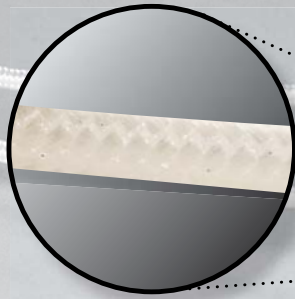
JISRF's Board of Directors have approved the formation of an Institutional Review Board (IRB).

JISRF has a long rich history of conducting clinical/surgical research projects. There has been considerable interest in JISRF establishing a formal IRB Committee. The specific purpose of this IRB Committee is to assure, both in advance and by periodic review, that appropriate steps are taken to protect the rights and welfare of humans participating as subjects in a research study. JISRF's IRB Committee will attempt to ensure protection of subjects by reviewing research protocols and related materials. IRB protocol review assesses the ethics of the research and its methods, promotes fully informed and voluntary participation by prospective subjects capable of making such choices and seeks to maximize the safety of subjects.

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SuperCable® Polymer Cerclage System

This unique polymer cable eliminates one possible source of metallic debris and metal ions in your patient's fracture or reconstructive procedure. Metal cables have been shown to suffer from significant rates of fatigue failure and to contribute to the generation of local and systemic metallic debris burden.^{1,2}

Laboratory testing demonstrates that the remarkably tough SuperCable withstands over one million load cycles while fully tensioned and abraded by a simulated bone plate, with negligible damage to the cable and metal plate.³

SuperCable has no sharp ends to irritate patient tissue, cut gloves, or create a "sharps injury" risk.

With over 30,000 cables used in cases worldwide since 2004, SuperCable has demonstrated its clinical effectiveness^{4,5} and offers significant benefit versus old technology metal cable and wire.

1. Callaghan et al (1997) Contribution of cable debris generation to accelerated polyethylene wear. *Clin Orthop* 344:20.
2. Jacobs et al (2004). Accumulation in liver and spleen of metal particles generated at nonbearing surfaces in hip arthroplasty. *J Arthroplasty* 19:94.
3. Sarin, Mattchen, Hack (2005) Novel iso-elastic cerclage cable for treatment of fractures. *ORS*. Washington, DC. 739.
4. Della Valle et al (2010) Early experience with a novel nonmetallic cable. *Clinical Orthop* 468:2382.
5. Edwards et al (2011) Utility of polymer cerclage cables in revision shoulder arthroplasty. *Orthopedics* 34:264.



0085



For additional information or to schedule a product evaluation, please give us a call at 800-827-5775. To view a video demonstration, visit us on the Web at: www.kinamed.com

SuperCable® U.S. Patent Nos. 6,589,246, and 7,207,090. Additional US & International Patents Pending. ©2014 Kinamed® Inc. B00138D



Proven Performance

- In clinical use since 2004
- Over 30,000 implantations



Locking or compression screw can be placed in any screw position



Curved and straight plate options



KINAMED®
INCORPORATED

Expect Innovation.

The Greenbrier Medical Institute

World Class Healthcare, Orthopaedics "Sports Medicine," Rehabilitation, Plastic Surgery, Research & Education



White Sulphur Springs, West Virginia

Future Site Selected For This Cutting-Edge Medical Initiative



Since 1948, the Greenbrier Clinic has been recognized as an industry leader in executive health and wellness through utilizing advanced diagnostics in the early diagnosis, prevention and treatment of disease. Building upon that history of medical excellence, Jim Justice, Chairman and owner of the Greenbrier Resort, has announced the creation of the Greenbrier Medical Institute. The institute's 1st phase is projected to cost about \$250 million, employ more than 500 people and include 3 buildings.

This phase will include an expansion of our world renowned executive health and wellness practice, The Greenbrier Clinic, which will be bolstered by a world-class sports medicine program, including an orthopedic surgery center and athletic performance/rehabilitation facility, all led by the Founder of the American Sports Medicine Institute, Dr. Jim Andrews and Chair of Cleveland Clinic Innovations, Thomas Graham. Rounding out the Institute's services will be a first-



in-class plastic and cosmetic surgery and Lifestyle Enhancement Academy, helping people look and feel their best. Physicians, universities, research foundations, medical journals and other healthcare industry leaders, all of whom are on the cutting edge of medical technology, research and care, have committed to join the project and establish an international research and education destination or "think tank" to stimulate research, drive innovation, force change and redefine how the world approaches health, wellness and longevity.

The Institute's facility, designed by Willie Stokes, will feature Georgian architecture similar to the resort's façade, a replica of the Springhouse, the site of the famous sulphur springs and special guests suites for patients and their families. Jack Diamond, President and CEO, and Mark Krohn, COO, are leading the development of this exciting project and are actively looking for other physicians and medical thought leaders to be involved.

For more information, please contact:

Mark E. Krohn, Chief Operating Officer
Greenbrier Medical Institute, 330-697-6581
mekrohn@bmdllc.com

Lighted Hip Retractors

Detachable
Clip-In Design
On All Lighted
Retractors!

NEW

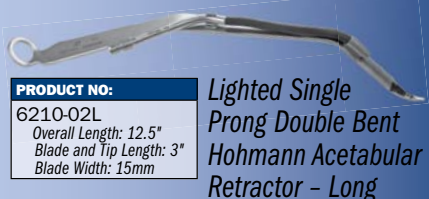
Lighting attachment for
enhanced visual exposure

Attaches to a fiber optic light cable with ACMI
(female) connector. Can be steam sterilized.

**PROUDLY
MADE
IN THE
USA**



Lighted Cobra
Retractors



Lighted Single
Prong Double Bent
Hohmann Acetabular
Retractor - Long



Lighted Inferior
Acetabular Retractor



Bozeman Cement Trimmer

Designed by Daniel M. Gannon, MD

Combines the two most
common cement trimming tools combined into one

The tool has a blunt blade tip on one end to help with separation of
the trimmed cement. The angled curette end helps gather the trimmed
cement. The thin shank and angled curette can reach into tight spaces
such as the back of the implants to remove excess cement. The ends are
titanium nitride coated to help eliminate metal transfer.

PRODUCT NO:
5245
Overall Length: 8.5"

**MADE EXCLUSIVELY
FOR INNOMED IN
GERMANY**

NEW



Extra Deep Hip Retractors

PRODUCT NO'S:

4535-01 [Extra Deep Modified Narrow Hohmann]
Overall Length: 11.625"
Blade Width: 16.4mm
4550-01 [Extra Deep Modified Blunt Hohmann]
Overall Length: 13.25"
Blade Width at End: 11mm
4558-01 [Extra Deep Hohmann]
Overall Length: 11.5"
Blade Width: 16.7mm
6450-01 [Extra Deep Single Prong Soft Tissue]
Overall Length: 13.75"
Blade Width: 22.3mm
6570-01 [Extra Deep Single Prong Acetabular]
Overall Length: 13.75"
Blade Width: 22.3mm
7115-03 [Extra Deep Bent Hohmann]
Overall Length: 12.125"
Handle Length: 9.75"
Depth from Bend: 6.25"
Blade Width: 19mm

Listed in order of appearance at left.

**PROUDLY
MADE
IN THE
USA**

For hip surgery with
large patients, and when
extra length instruments are
desired for increased depth
and leverage



Charnley/Sorrells Low-Profile Hip Arthroplasty Retractor System

Conforms to the thigh, providing low-profile self-
retaining exposure of the femur and acetabulum
in Total Hip Arthroplasty

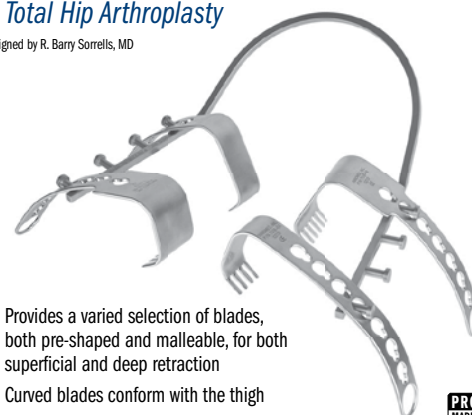
Designed by R. Barry Sorrells, MD

PRODUCT NO'S:

7318-00 [Complete System]
7318-01 [Frame]
Length: 14.5"
Maximum Width: 12"
7318-02 [Small Narrow Blade]
Blade Width: 1.25"
Blade Depth: 1.25"
Overall Length: 8.5"
7318-03 [Small Wide Blade]
Blade Width: 2"
Blade Depth: 1.25"
Overall Length: 8.5"
7318-04 [Medium Narrow Blade]
Blade Width: 1.25"
Blade Depth: 2.25"
Overall Length: 8.5"
7318-05 [Medium Wide Blade]
Blade Width: 2"
Blade Depth: 2.25"
Overall Length: 8.5"
7318-06 [Medium Malleable Blade]
Blade Width: 1.25"
Blade Depth: 2.25"
Overall Length: 8.5"
7318-07 [Large Narrow Blade]
Blade Width: 1.25"
Blade Depth: 3.25"
Overall Length: 8.5"
7318-08 [Large Wide Blade]
Blade Width: 2"
Blade Depth: 3.25"
Overall Length: 8.5"

- Provides a varied selection of blades,
both pre-shaped and malleable, for both
superficial and deep retraction
- Curved blades conform with the thigh
- Self-retaining and easily adjustable

**PROUDLY
MADE
IN THE
USA**



- (1) Low-Profile Frame
- (2) Small Retractors
 - (1) Narrow
 - (1) Wide
- (3) Medium Retractors
 - (1) Malleable Narrow
 - (1) Narrow
 - (1) Wide
- (2) Large Retractors
 - (1) Narrow
 - (1) Wide



COMPLETE SYSTEM

ISO 9001:2008 • ISO 13485:2003

FREE TRIAL ON MOST INSTRUMENTS

Scan to
Launch Our
Website



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103 Estus Drive, Savannah, GA 31404
www.innomed.net info@innomed.net

912.236.0000 Phone
912.236.7766 Fax

Innomed-Europe Tel. +41 41 740 67 74
Fax +41 41 740 67 71

1.800.548.2362

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Joint Implant Surgery and Research Foundation
46 Chagrin Shopping Plaza, #117
Chagrin Falls, Ohio 44022
www.jisrf.org