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# Reconstructive REVIEW

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# Reconstructive Review

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**President of ICJR**

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

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### 3] META-ANALYSIS OF NAVIGATION VS CONVENTIONAL TOTAL KNEE ARTHROPLASTY

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Moin Khan (McMaster University), Bandar Hetaimish (McMaster University), Nicole Simunovic (McMaster University), Hatem Alharbi (Riyadh Military Hospital), Mohit Bhandari (McMaster University), Paul Zalzal (McMaster University)

*Background & Objective:* Navigated total knee arthroplasty (TKA) has been advocated as a means to improve limb and prosthesis alignment. The aim of this study was to perform a systematic review and meta-analysis for all randomized controlled trials (RCTs) in the literature comparing the mechanical alignment between navigated and conventional TKA.

*Methods:* An extensive search of the literature from 1986-2009 was performed including the following database: Pubmed, Cochrane, Medline and EMBASE as well as major medical and publisher databases exclusively for RCT studies comparing navigated and conventional arthroplasty. A search of the references of recent meta-analyses on this topic was also completed. No restrictions were made with regards to language. Two reviewers utilized the Detsky score to rate study methodological features independently. Alignment outcomes were pooled utilizing a random effects model and heterogeneity was explored.

*Results:* Twenty-three RCTs were identified comparing navigated vs. conventional total knee arthroplasty involving 2,541 patients. (1,374 Navigated TKA 1,302 Conventional TKR). Patients who underwent navigated TKA had a lower risk of implant malalignment at >3 degrees (Relative Risk: 0.37, Confidence interval, 95% 0.24-0.58) as well as >2 degrees. (Risk ratio: 0.54, Confidence interval, 95% 0.42-0.69). In addition the risk of malalignment was reduced with navigation for the coronal

plane femoral and tibial components as well as with regards to femoral and tibial slope at both >3 degrees and > 2 degrees.

*Conclusions:* This meta-analysis demonstrates that navigated TKA provides significant improvement in prosthesis alignment.

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### 4] A CLASSIFICATION SYSTEM FOR SHORT STEM UNCEMENTED THA:

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Timothy McTighe, (Joint Implant Surgery & Research Foundation, Chagrin Falls, Ohio) S. David Stulberg (Northwest Orthopaedic Institute), Louis Keppler (St. Vincent Charity Medical Center), John Keggi (Orthopaedics New England), Robert T. Kennon (Orthopaedics New England), Declan Brazil (Joint Implant Surgery & Research Foundation), Tony N. Aram (Advanced Orthopaedics & Sports Medicine Institute)

*Introduction:* The use of short stems is growing. The suggested advantages of these stems are: 1) elimination of femoral proximal-distal mismatch issues. 2) Improved positive proximal femoral remodeling; 3) Reduction in insertion instrumentation; and, 4) facilitation of less invasive surgical exposures. Initial 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. As a result, a very large number of short stem designs are available. However, there does not exist a classification system for uncemented short stem implants that would allow comparisons of clinical and radiographic results. The purpose of this presentation is to propose a classification system based upon the length of the stem and the method by which the stem seeks to achieve stability.

*Methods:* Femoral implants described as "short stems" were evaluated. The range of lengths for each stem type and the method of achieving





initial implant stability was determined. The optimum radiographic position of each of these implants and the proposed type of bone remodeling associated with this placement in the proximal femur was evaluated. Results: The proposed classification system addresses both the stem length and method of achieving stability. Stems were defined as “short” if the tip reached or was proximal to the metaphyseal-diaphyseal junction. This location on the proximal femur was defined as the place at which the medial-lateral metaphyseal flare became parallel. Stems were then classified as: 1) Metaphyseal Stabilized; 2) Neck-Sparing Stabilized; and 3) Head Stabilized. An analysis of radiographs with a minimum of 1-year follow-up suggested that the evolution of bone remodeling differed in relationship to the type of stabilization rather than stem length.

*Conclusions:* A classification of short-stemmed femoral components has been developed that makes it possible to evaluate and differentiate the different styles short stems on the market. Not all short stems generate the same radiographic findings and or clinical results. It is also important to appreciate the specific design and appropriate surgical technique for a given design. Not all short stems are created equal.

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## 5J RURAL VS. URBAN UTILIZATION OF TOTAL JOINT ARTHROPLASTY

Kenneth D. Illingworth, Devraj Banerjee (Southern Illinois University School of Medicine), Wendy M. Novicoff (University of Virginia), Steven L. Scaife (Southern Illinois University School of Medicine), Braden Jones (Southern Illinois University School of Medicine), Khaled J. Saleh (Southern Illinois University School of Medicine)

*Background:* Patients in rural areas are increasing their utilization of total joint

arthroplasty as speculated by an increased rural mobility and a changing healthcare environment. The purpose of this study was to determine the association between patient demographics, hospital demographics, and access to care on utilization of total joint arthroplasty in rural and urban populations.

*Study Design:* The 2008 National Inpatient Sample Database was used for analysis. Any patient that was discharged after a primary total hip or primary total knee arthroplasty was included in this study. Patients were grouped by whether they lived in urban or rural areas based on the National Center for Health Statistics Classification. Uni and multivariate analysis was done using payer type, gender, age, race, length of stay, Charlson co-morbidity index, hospital region, and hospital type.

*Results:* A total of 869,417 primary total knee and total hip arthroplasties discharges were identified. 179,462 (20.6%) total joint arthroplasties were performed on rural patients and 689,955 (79.4%) total joint arthroplasties were performed on urban patients. Rural patients living in Northeastern hospital region compared to West, less than 65 years of age, females, Blacks and Hispanics were less likely to undergo total joint arthroplasty compared to their urban counterparts.

*Conclusion:* Total joint arthroplasty utilization is lower among rural patients less than 65 years of age, rural females, and rural Blacks and Hispanic patients compared to their urban counterparts, which have already been shown to be underutilized when examining urban populations. These impactful findings suggest an even bigger gap of utilization among these rural patients suggesting the need for better access to total joint arthroplasty care.

## 6] INPATIENT MORTALITY AFTER PRIMARY TOTAL HIP ARTHROPLASTY: ANALYSIS FROM THE NATIONAL INPATIENT SAMPLE DATABASE

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 Kenneth D. Illingworth, Youssef el Bitar (Southern Illinois University School of Medicine), Devraj Banerjee (Southern Illinois University School of Medicine), Steven L. Scaife (Southern Illinois University School of Medicine), Wendy M. Novicoff (University of Virginia), Khaled J. Saleh (Southern Illinois University School of Medicine)

*Background:* Although inpatient mortality rates following total hip arthroplasty are low, understanding factors that influence inpatient mortality rates are critical. The purpose of this study was to assess factors that influence inpatient mortality rates after primary total hip arthroplasty in a large national database.

*Materials/Methods:* Discharge data from the 2007-2008 HCUP Nationwide Inpatient Sample database were used in this study. Patients were identified based on whether they were admitted for a primary total hip arthroplasty and grouped based on their mortality status. Mortality rates were explored using patient demographics, hospital demographics, inpatient complications, co-morbidities, elective vs. non-elective surgery, and weekend vs. weekday admissions. Univariate analyses and an adjusted logistic regression analysis revealed several relevant variables. A principal components analysis was used as a strategy to reduce the number of variables in the final logistic regression model.

*Results:* Weighted discharge data from 2007-2008 revealed 530,079 primary total hip arthroplasties with an inpatient mortality rate of 0.20%. Inpatient complications (2.05%), weekend admissions (1.33%), non elective surgery (0.97%) and patient age over 80 (0.77%) had the strongest association with an

increase in inpatient mortality rates. Using a principal components analysis, 5 factors were identified, including demographic, location, elective, co-morbidity, and inpatient complication, which were significantly related to mortality. A logistic regression analysis was run using the factor variables. The odds ratios for all 5 factors were statistically significant ( $p < 0.05$ ).

*Conclusion:* Mortality rates following total hip arthroplasty were significantly affected by multiple factors, with the most significant variables being inpatient complications, weekend admission, non-elective surgery and an increasing patient age.

## 9] USE OF SURGERY CENTRES FOR MAJOR JOINT ARTHROPLASTY

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 Roy Abraham (Miller Orthopaedic Affiliates), Clifford K. Boese (Miller Orthopaedic Affiliates), Carla Plantikov (Miller Orthopaedic Affiliates)

This study was conducted to determine the safety, efficacy, and cost implications of performing major joint replacements as an outpatient procedure.

Since January 2009 we have been performing unicompartmental knee arthroplasty (UKA) and partial femoral joint (PFJ) replacements as a same day procedure in our surgery centre. Any patient fit to undergo surgery as a daycase was selected. (BMI > 35, no major cardiac history) General anesthesia with or without nerve block was administered according to patient preferences. Subcutaneous infiltration of a local anesthetic cocktail consisting of 0.5% bupivacaine with adrenaline, methylprednisolone acetate, ketorolac. Methylprednisolone acetate was not used if the patient was diabetic or had immune deficiency. Enteric coated aspirin was given for



thromboprophylaxis for 1 month. Patients were seen by a visiting nurse at home on the evening of surgery and were helped with pain control if necessary. Oral narcotics and Cox-2 inhibitor were used for post operative pain control along with cryocuff for the first 48-72 hours.

62 patients underwent joint replacements (56 UKA and 6 PFJ replacements) at the day case surgery center. Mean age and BMI were 56 and 32 respectively. There were 36 females and 26 males and the average ASA score was 2.1. There were 4 readmissions to the hospital within 1 month following the procedure. Persistent high blood pressure (1), Shortness of breath (1), and inadequate pain control (1), and infection (1), were the reasons for readmission. The total cost of joint replacement is almost halved by doing the procedure on an outpatient basis. We also matched 34 patients in this cohort with 34 patients who underwent UKA or PFJ replacements as inpatients in a nearby hospital. There was no evidence of increased complications in the outpatient group.

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## 10] CADAVERIC ANALYSIS OF AN ACCELEROMETER BASED, PORTABLE NAVIGATION SYSTEM FOR DISTAL FEMORAL CUTTING BLOCK ALIGNMENT IN TOTAL KNEE ARTHROPLASTY

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Denis Nam, Seth A. Jerabek (Hospital for Special Surgery, New York, NY, USA), Michael B. Cross (Hospital for Special Surgery, New York, NY, USA), David J. Mayman (Hospital for Special Surgery, New York, NY, USA)

*Background:* Distal femoral cutting block alignment in TKA is typically performed using an intramedullary (IM) guide. However, this relies on assumptions regarding the difference between the femoral anatomic and mechanical axes, which can be highly variable. The KneeAlign® 2 is an accelerometer based,

portable navigation system for TKA, and does not require a large computer console.

*Objectives:* To validate the accuracy of the KneeAlign® 2 system in navigating distal femoral cutting block alignment in TKA.

*Methods:* 5 cadaveric specimens were included. The KneeAlign® 2 was used to set the femoral cutting block to a “target” alignment, specified prior to each specimen. The KneeAlign® 2 femoral jig is set at the most distal aspect of the femoral condyles, and the hip center of rotation is registered by maneuvering the femur in a circular motion. The cutting block is set to the desired alignment, as the display console (2x4x2 inches) provides real-time feedback of its orientation.

The Orthosoft CAS System is a large console, imageless navigation system. After registration, the Orthosoft CAS paddle was used to record the alignment of the cutting block previously set by the KneeAlign® 2.

6 trials were performed for each specimen. The mean absolute difference and standard deviation (+ s.d.) between the preoperative target alignment, and the alignment reported by the Orthosoft CAS system (cutting block set by the KneeAlign® 2) was calculated, along with 95% confidence intervals.

*Results:* For varus/valgus alignment, the mean absolute difference between the preoperative target and the cutting block’s alignment was  $0.83^\circ + 0.60^\circ$  (95%: CI  $0.61^\circ$  and  $1.04^\circ$ ). For flexion/extension alignment, the mean absolute difference was  $0.83^\circ + 0.60^\circ$  (95% CI:  $0.53^\circ$  and  $1.13^\circ$ ).

*Conclusions:* Portable, accelerometer based navigation can reliably be used for performing the distal femoral resection in TKA.

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## 11] AN ACCELEROMETER BASED, PORTABLE NAVIGATION SYSTEM: THE FUTURE OF COMPUTER NAVIGATION IN TOTAL KNEE ARTHROPLASTY?

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 Denis Nam (Hospital for Special Surgery, New York, NY, USA), Michael B. Cross (Hospital for Special Surgery, New York, NY, USA), David J. Mayman (Hospital for Special Surgery, New York, NY, USA)

*Background:* Numerous studies have demonstrated computer-assisted surgical (CAS) techniques to improve TKA alignment, but concerns regarding the cost and learning curve have limited its acceptance. The KneeAlign® 2 is an accelerometer based, portable navigation system for TKA. It does not require the use of a large computer console or navigation arrays as with most CAS systems.

*Objective:* To determine the accuracy of the KneeAlign® 2 system in obtaining a coronal tibial and femoral component alignment perpendicular to the mechanical axis, a tibial posterior slope of 3°, and an overall mechanical alignment within 3° of neutral to the mechanical axis.

*Methods:* 48 knees (mean age = 63.3 +/- 9.6 yrs; mean BMI = 30.2 +/- 6.2 kg/m<sup>2</sup>) received a TKA in which the KneeAlign® 2 was used to perform both the proximal tibial and distal femoral resections. The KneeAlign® 2 consists of a portable display console (2x4x2 inches) that, after registration, provides real-time feedback of the alignment of the proximal tibial and distal femoral cutting blocks relative to each, respective mechanical axis.

Standing AP hip-to-ankle radiographs and standing lateral knee-to-ankle radiographs were obtained for radiographic measurements. Negative values correspond with valgus alignment.

*Results:* The mean tibial component varus/valgus alignment was  $-0.2^\circ \pm 1.1^\circ$ , with 95.8% within 2° of perpendicular to the tibial mechanical axis. The mean tibial posterior slope was  $3.0^\circ \pm 1.1^\circ$ , with 95.8% within 3° +/- 2°. The mean femoral component varus/valgus alignment was  $-0.1^\circ \pm 1.1^\circ$ , with 95.8% within 2° of perpendicular to the femoral mechanical axis. The mean overall mechanical alignment was  $-0.4^\circ \pm 1.9^\circ$ , with 93.8% of the TKAs within 3° of neutral to the mechanical axis.

*Conclusion:* The KneeAlign® 2 system is a portable, accelerometer-based system that accurately aligns both the tibial and femoral components, and is a promising alternative to large console CAS systems in TKA.

## 12] CLINICAL OUTCOMES AND FAILURE MECHANISMS OF A CONSTRAINED KNEE WITHOUT STEM EXTENSIONS: A MID-TERM FOLLOW-UP

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 Denis Nam (Hospital for Special Surgery, New York, NY, USA), Ben-Paul N. Umunna (Hospital for Special Surgery, New York, NY, USA), Shivi Duggal (Hospital for Special Surgery, New York, NY, USA), Michael B. Cross (Hospital for Special Surgery, New York, NY, USA), Keith R. Reinhardt (Hospital for Special Surgery, New York, NY, USA), Charles N. Cornell (Hospital for Special Surgery, New York, NY, USA)

*Background:* In TKA, implants with increased articular constraint are often supplemented with stem extensions. However, disadvantages exist with their use, including cost, intramedullary invasion, diaphyseal pain, and increased bone loss.

*Objectives:* To compare the clinical results, and analyze the rate and mode of failure of a constrained condylar knee without stem





extensions versus a conventional, posterior-stabilized (PS) design.

*Methods:* 190 TKAs were implanted using a primary, nonmodular constrained (NMC) prosthesis without stem extensions, and were compared to 140 TKAs implanted over the same period using a standard, PS design. Clinical data included HSS, Knee Society, SF-12 scores, and reason for revision at the latest follow-up. Results were compared using a Student's two-tailed t test ( $p < 0.05$  = significant).

*Results:* The mean age was  $72.3 \pm 10.2$  yrs and mean follow-up was  $7.3 \pm 2.1$  yrs for the NMC group, versus  $67.1 \pm 8.7$  yrs and  $6.1 \pm 2.2$  yrs for the PS group. The mean HSS score was  $87.7 \pm 9.7$ , KSS score was  $87.7 \pm 14.5$ , SF-12 mental score was  $51.3 \pm 9.9$ , and SF-12 physical score was  $41.4 \pm 10.5$ , in the NMC group. There was no statistically significant difference compared to the PS group for these measures ( $p=0.19$ ,  $p=0.07$ ,  $p=0.93$ ,  $p=0.11$ , respectively). The revision rate in the NMC cohort was 4.2%, compared to 4.3% for the PS cohort. Femoral component loosening was the most common cause of failure in the NMC cohort, all of which occurred when Palacos cement was used for fixation. 55.6% of NMC components implanted with Palacos cement failed due to femoral component loosening. All PS components requiring revision were revised for instability.

*Conclusion:* At mid-term follow-up, NMC prostheses without stem extensions have excellent clinical results. Palacos cement in this setting was associated with a high rate of femoral component loosening, possibly due to the decreased intrusion depth of Palacos when compared to Simplex.

### 13] RECUTTING THE DISTAL FEMUR TO INCREASE MAXIMAL KNEE EXTENSION DURING TKA CAUSES CORONAL PLANE LAXITY IN MID-FLEXION

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Michael B. Cross (Institution: Hospital For Special Surgery), Michael B. Cross (Hospital for Special Surgery), Denis Nam (Hospital For Special Surgery), Christopher Plaskos (Hospital For Special Surgery), Seth Sherman (Hospital For Special Surgery) Stephen Lyman (Hospital For Special Surgery), Andrew Pearle (Hospital For Special Surgery), David J. Mayman (Hospital For Special Surgery)

*Background:* Proximalization of the femoral component is often required in total knee arthroplasty (TKA) in the presence of a flexion contracture and/or a tight extension space.

*Objectives:* The aim of this study was to quantify the effects of distal femoral cut height on maximal knee extension and coronal plane knee laxity.

*Methods:* Seven fresh-frozen cadaver legs from hip-to-toe underwent a posterior stabilized TKA using a measured resection technique with a computer navigation system equipped with a robotic cutting-guide. After the initial femoral resections were performed, the posterior joint capsule was sutured until a  $10^\circ$  flexion contracture was obtained with the trial components in place. Two distal femoral recuts of +2mm each were then subsequently made and the trials were reinserted. The navigation system was used to measure the maximum extension angle achieved and overall coronal plane laxity [in degrees] at maximum extension,  $30^\circ$ ,  $60^\circ$  and  $90^\circ$  of flexion, when applying a standardized varus/valgus load of 9.8 [Nm] across the knee.

*Results:* For a 10 degree flexion contracture, performing the first distal recut of +2mm increased overall coronal plane laxity by



approximately 4.0° at 30° of flexion ( $p=0.002$ ) and 2.0° at 60° of flexion ( $p=0.125$ ). Performing the second +2mm recut of the distal femur increased mid-flexion laxity by  $6.4^\circ \pm 1.8^\circ$  ( $p < 0.0001$ ) at 30° and  $4.0^\circ \pm 2.9^\circ$  at 60° of flexion ( $p=0.01$ ) compared the 9mm baseline resection (control). Maximum extension increased from 10° of flexion to  $6.4^\circ (\pm 2.5^\circ \text{ SD}, p < 0.005)$  and to  $1.4^\circ (\pm 1.8^\circ \text{ SD}, p < 0.001)$  of flexion with each 2mm recut of the distal femur.

*Conclusions:* In this cadaveric study, we have shown that proximalization of the femoral implant in the case of a 10 degree flexion contracture increases the maximum extension angle achieved but also decreases the coronal plane stability in mid-flexion (i.e. at 30° and 60°).

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#### **14] THE INTEGRITY OF THE POSTERIOR SOFT TISSUE REPAIR FOLLOWING THA AT AN AVERAGE OF FOUR YEARS: AN MRI ASSESSMENT**

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Michael B. Cross (Institution: Hospital For Special Surgery), Paul Pellicci (Hospital For Special Surgery), Hollis Potter (Hospital For Special Surgery), Li Foong Foo (Hospital For Special Surgery), Marschall Berkes (Hospital For Special Surgery), Freidrich Boettner (Hospital For Special Surgery)

*Background:* The complete posterior soft tissue repair has reduced the incidence of dislocation following primary total hip arthroplasty performed through the posterolateral approach.

*Objectives:* The aim of this prospective study was to evaluate the integrity of the posterior repair at longer-term followup, using (MRI).

*Methods:* Of the 36 patients who were prospectively enrolled in our initial study, 23 (64%) (14 males, 9 females) were available to

undergo a longer term MRI. Each patient underwent MRI using an established and standardized 1.5T protocol that reduces artifact generated by the metallic components to evaluate the integrity of the posterior soft tissues following primary total hip arthroplasty. The piriformis and conjoined tendons, and the posterior capsule, were repaired as a separate layer using nonabsorbable sutures through two drill holes in the greater trochanter. The quadratus femoris was repaired as anatomically as possible. MRI results were compared to prior MRIs obtained immediately and at three months postoperatively. In addition, all patients were given a self-reported modified Harris Hip Score (HHS) at the time of MRI (maximum possible score=81).

*Results:* At a mean follow-up of 51 months, 21 of 23 (91%) patients had an intact quadratus femoris, and 21 of 23 (91%) had an intact posterior capsule. In addition, 22 of 23 patients (96%) had soft tissue or scar from the piriformis and conjoined tendons in contact with bone; further, "gaps" between the tendon and bone seen immediately and at 3 months postoperatively were often filled with scar with low signal intensity similar to that of tendon. The average modified Harris Hip Score in the cohort was  $78.2 \pm 6.1$ .

*Conclusions:* The posterior soft tissue repair remained intact at longer-term follow up in the majority of patients. Over this time frame, we observed maturation of scar tissue in such a way to achieve the orientation and low signal intensity resembling native tendon.

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### 15] KINEMATICS AND CORONAL PLANE STABILITY BETWEEN A POSTERIOR STABILIZED VS BICRUCIATE STABILIZED VS ULTRACONGRUE TOTAL KNEE ARTHROPLASTY

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Michael B. Cross (Institution: Hospital For Special Surgery), Christopher Plaskos (Hospital For Special Surgery), Denis Nam (Hospital For Special Surgery), Claus Egidy (Hospital For Special Surgery), Joseph Nguyen (Hospital For Special Surgery), Angela X. Li (Hospital For Special Surgery), Stephen Lyman (Hospital For Special Surgery), Andrew D. Pearle (Hospital For Special Surgery), David J. Mayman (Hospital For Special Surgery)

*Background:* Modifications are continuously being made to total knee implant designs in order to recreate the native knee kinematics.

*Objectives:* Our aim was to compare the passive kinematics and coronal plane stability throughout flexion in the native and the replaced knee, using three different TKA designs: posterior stabilized (PS), bi-cruciate stabilized (BCS), and ultra congruent (UC).

*Methods:* Five hip-to-toe cadaveric specimens then underwent TKA using an anatomic measured resection technique with a computer-navigated robotic femoral cutting-guide. The

Surgery), Edwin P. Su (Hospital For Special Surgery)

*Background:* Although hip resurfacing arthroplasty (HRA) preserves more femoral bone than total hip arthroplasty (THA), it is debated whether more bone is removed during acetabular preparation in HRA.

*Objectives:* The aim of our study was to compare the amount of acetabular bone removed during HRA and THA, controlling for the patient's native femoral head diameter (NFHD).

*Methods:* Based on pre-hoc sample size determination to achieve 80% power, 64 consecutive patients (68 hips) undergoing THA or HRA were prospectively enrolled in this comparative study (n=34 hips/group). Data recorded intraoperatively included: NFHD, the largest reamer used during acetabular preparation, final acetabular implant size, prosthetic femoral head size, and whether a decision was made to increase the cup size in order to use a larger prosthetic femoral head. The primary outcome was the acetabular cup size to NFHD ratio, which was calculated for each patient. Results were compared using two-sided, independent samples student's t-tests, and significance was set at p<0.05.

*Results:* A significant difference existed in the mean ratio of acetabular cup size to NFHD (THA:  $1.09 \pm 0.05$ , HRA:  $1.05 \pm 0.04$ ; p<0.001) and largest acetabular reamer used to NFHD (THA:  $1.09 \pm 0.05$ , HRA:  $1.03 \pm 0.04$ ; p<0.001). The ratios varied minimally when the groups were subdivided by gender, age, and obesity. The decision to upsize the cup to accommodate a larger femoral head was made more often in the THA group (27% vs. 9%). There was also a statistically significant difference (p<0.05) in NFHD, acetabular cup size, largest acetabular reamer used, and

### 16] ACETABULAR BONE REMOVAL IN HIP RESURFACING ARTHROPLASTY VS TOTAL HIP ARTHROPLASTY: A COMPARISON USING THE ACETABULAR CUP TO NATIVE FEMORAL HEAD DIAMETER RATIO

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Michael B. Cross (Hospital For Special Surgery), Mark M. Dolan (Hospital For Special Surgery), Gursukhman Sidhu (Hospital For Special Surgery), Joseph Nguyen (Hospital For Special Surgery), David Mayman (Hospital For Special





prosthetic head size, all of which were larger in the HRA group.

*Conclusion:* Despite the emphasis upon avoiding damage to the femoral neck in HRA, the cup size to NFHD ratio was larger in THA than HRA, potentially because the acetabular component was enlarged more often in THA.

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### **17] A NOVEL ASEPTIC PROTOCOL DECREASES SURGICAL SITE INFECTIONS AFTER TOTAL AND REVISION HIP ARTHROPLASTY**

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Gaurav Luther (University of Chicago), Melinda Stack (University of Chicago), David Manning, MD (University of Chicago)

*Background:* Surgical site infections (SSI) are devastating complications of total and revision hip arthroplasty. Previous studies have shown the following risk factors contribute to higher incidence of SSI; (1) ASA class > 3, (2) BMI > 30, (3) revision arthroplasty, (4) renal insufficiency, and (5) immunodeficiency. In a high risk patient population, we predicted that a novel aseptic protocol, which involves a 3 phase antiseptic scrub (4% chlorhexidine-gluconate, 70% isopropyl alcohol, 10% topical povidone iodine) and pre-operative treatment with vancomycin and cefazolin, would significantly lower the risk of SSI.

*Methods:* A single surgeon case series for patients who underwent hip arthroplasty from 2005 to 2010. We documented all pre-operative infectious risk factors as mentioned above. All patients received the three phase antiseptic scrub and peri-operative vancomycin and cefazolin, and had one year minimum follow-up. SSI was defined by return to the OR and positive culture within 90 days. All patient information was blinded and three independent reviewers recorded data.

*Results:* We found our patient population to be significantly higher risk than populations in previously published studies ( $p < 0.04$ ). 70% of patients were ASA Class > 3, 45% had a BMI > 30, and 50% had at least three independent risk factors for infection. We found a 0.4% (2 / 467 patients) SSI rate using our aseptic protocol, which is among the lowest in current literature ( $p < 0.05$ ). Infections in the two patients occurred with atypical, non-skin flora organisms (*Pseudomonas* and *Enterobacter*), and both patients demonstrated successful retention of the implant with osseous integration of femoral and acetabular components at greater than two years follow-up. No patients were lost to follow up.

*Conclusion:* In a high risk patient population, our novel aseptic protocol results in a 0.4% SSI rate in total and revision hip arthroplasty, which is amongst the lowest in reported literature.

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### **18] IMPROVED WEAR RESPONSE CERAMIC MG-STABILIZED ZRO2/MOLDED UHMWPE IN KNEE JOINT SIMULATOR**

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Riichiro Tsukamoto (Shonan Kamakura Joint Reconstruction Center), Ian C. Clarke (Loma Linda University), Koji Tsuji (Shonan Kamakura Joint Reconstruction Center), Akira Saito (Shonan Kamakura Joint Reconstruction Center), Satoshi Takayanagi (Shonan Kamakura Joint Reconstruction Center), Miho Iwase (Shonan Kamakura Joint Reconstruction Center), Kazuo Hirakawa (Shonan Kamakura Joint Reconstruction Center)

*Background:* Suggested improvements for TKR bearings have included both crosslinked polyethylene tibial inserts and either alumina or zirconia ceramic for femoral components. Zirconia was introduced as high-strength and high toughness ceramic in alternative to alumina ceramic. Zirconia has two types that

one is  $\gamma$ -ZrO<sub>2</sub>, another is Mg-ZrO<sub>2</sub>. In Japan, such zirconia ( $\gamma$ -ZrO<sub>2</sub>) femoral condyles have been used clinically since 1989.

Therefore the aim of this study was to compare the wear of molded UHMWPE run against zirconia (Mg-ZrO<sub>2</sub>) and CoCr femoral implants.

*Method:* Mg-ZrO<sub>2</sub> and CoCr femoral condyles were compared in the Vanguard™ knee configuration. The Molded tibial inserts were gamma-irradiation sterilization to 3.2-Mrad in Argon. Knee simulation was conducted on a 6 station simulator. All knee components were subjected to 6 million cycles of normal walking. Wear was measured gravimetrically.

*Results:* The control implants (CoCr / 3.2-Mrad) showed excellent linear trending ( $r > 0.99$ ) of weight-loss with respect to test duration. The wear rate averaged 6.3 mm<sup>3</sup>/Mc and the set showed good control of experimental variance ( $< 10\%$ ). The ZrO<sub>2</sub> / 3.2-Mrad combination also showed fair linear trending ( $r > 0.86$ ). The wear rate averaged 0.8 mm<sup>3</sup>/Mc and the set showed good control of experimental variance ( $< 15\%$ ).

*Discussion:* This appears to be the first wear description for molded UHMWPE inserts run with zirconia femoral condyles. The remarkable finding was very small wear 0.8 mm<sup>3</sup>/Mc at 6-Mc duration. The most significant finding was that the Mg-zirconia/molded PE reduced wear by 8-fold compared to control. There was a clearly a beneficial effect of zirconia for knees. The clinical use of the ceramic Bi-Surface™ knee joints has appeared satisfactory with up to 9 years follow up using both  $\gamma$ -TZP doped zirconia. Thus zirconia implants may prove excellent for active patients who may otherwise risk high wear rates over many years of use.

## 19] THE CORTICAL COVERAGE OF THE TIBIA IN ASYMMETRIC COMPONENT OF TOTAL KNEE ARTHROPLASTY IS SIGNIFICANTLY HIGHER THAN THAT OF THE SYMMETRIC ONE.

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Nariaki Nakura (University of Occupational Health and Environmental Health, JAPAN), Daisuke Ikei (University of Occupational Health and Environmental Health, JAPAN), Hideo Ohnishi (University of Occupational Health and Environmental Health, JAPAN), Toshiharu Mori (University of Occupational Health and Environmental Health, JAPAN), Toshitaka . Nakamura (University of Occupational Health and Environmental Health, JAPAN)

*Background:* The tibial coverage of Total Knee Arthroplasty (TKA) is associated with the equal load transfer and fixation to the tibia. There is no reports of the differences of the cortical coverage of the Tibia in TKA using the CT based preoperative planning software.

*Objectives:* The objectives of this study is to clarify the differences of the tibial cortical coverage and the tibial coverage area in TKA between symmetric component and asymmetric one.

*Methods:* In 62 Osteoarthritis cases of TKA were digitally templated preoperatively with the preoperative planning software. The coverage of the tibia was measured in the axial plane of CT at 10mm from lateral joint line using "Image J" (Wayne Rasband/NIH). The coverage rate were calculated in covering area and the cortex margin of the cutting surface of tibia. Both the symmetric design of tibial component and the asymmetric design of tibial component were analyzed to the same patient preoperatively.

*Results:* Tibial coverage of the area was 85.9% in asymmetric component and 89.5% in symmetric one. The symmetric component





covered significantly higher area than that of the asymmetric one. The tibial coverage of the cortex margin was 71% in asymmetric one and 62.8% in symmetric one. The asymmetric component covered significantly higher than that of the symmetric one in coverage of cortex margin. Although the underhang ratio at posteromedial area was the same level, 3.58% in asymmetric, 3.61% in symmetric, the underhang ratio at posteromedial cortex margin was 5.9% in asymmetric, 9.8% in symmetric. The tibial coverage of the posteromedial cortex margin in asymmetric component is significantly higher than that of symmetric one.

*Conclusions:* The symmetric tibial component of TKA covered significantly higher area than that of the asymmetric one and the cortical coverage of the tibia in the asymmetric component is significantly higher than that of the symmetric one.

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## **20] FAMILY HISTORY OF TOTAL JOINT ARTHROPLASTY AND TIBIOFEMORAL JOINT SPACE WIDTH ON PLAIN RADIOGRAPHS: DATA FROM THE OSTEOARTHRITIS INITIATIVE**

Kenneth D. Illingworth (Southern Illinois University School of Medicine), Jacob D. Sams (Southern Illinois University School of Medicine), Donald N. Sullivan (Southern Illinois University School of Medicine), John Horberg (Southern Illinois University School of Medicine), Steven L. Scaife (Southern Illinois University School of Medicine), Khaled J. Saleh (Southern Illinois University School of Medicine)

*Background:* Previous studies have shown a positive correlation between genetic factors and the predisposition for end stage osteoarthritis.

*Objective:* The purpose of this study was to determine whether a positive family history of total joint arthroplasty affects tibiofemoral joint space width on plain radiographs.

*Methods:* Data used in the preparation of this article were obtained from the Osteoarthritis Initiative public use data set (kXR\_QJSW\_Duryea16) which contains 1,805 individuals (3,257 knees) with quantified tibiofemoral joint space width on flexion-weight bearing radiographs. Two groups were defined; one with a positive family history of total joint arthroplasty and one with no family history. Individuals were separated into 3 age groups; 45-54, 55-64 and 65-74. All individuals had posterior to anterior 45° flexion weight bearing plain radiographs at baseline, 12, 24, 36 and 48 months. Mean medial and lateral joint space widths were analyzed at each time point. Independent T-tests were used for comparison between the two groups.

*Results:* There was a statistically significant difference in tibiofemoral joint space width in individuals with a positive family history of total joint arthroplasty when compared to no family history at all time points in individuals 65-74 years of age, both in the medial and lateral compartments ( $p < 0.05$ ). Rate of joint space loss was also significantly higher in the family history group of total joint arthroplasty than the no family history group in individuals 65-74 years of age ( $p < 0.05$ ).

*Conclusion:* Individuals between the ages of 65 – 74 with a positive family history of total joint arthroplasty have a significant increase in tibiofemoral joint space loss on plain radiographs as well as an increased rate of joint space loss compared to individuals with no family history.

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## 21] MEAN TEN-YEAR WEAR COMPARISON BETWEEN CONVENTIONAL AND HIGHLY CROSS-LINKED POLYETHYLENE AGAINST A ZIRCONIA HEAD

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 Kiyokazu Fukui (Kanazawa Medical University),  
 Ayumi Kaneuji (Kanazawa Medical University),  
 Tanzo Sugimori (Kanazawa Medical University),  
 Toru Ichiseki (Kanazawa Medical University),  
 Tadami Matsumoto (Kanazawa Medical University)

*Background:* The use of highly cross-linked polyethylene (HXLPE) is now commonplace in total hip arthroplasty. However, there has only been a few reports studying the mid to long-term results for in vivo HXLPE wear. We previously reported the minimum 5 year results associated with the 5-year in vivo wear of HXLPE, with that of conventional PE, using a zirconia femoral head. Objectives: The aim of this study was to investigate the mean ten-year update results for the 56 hips from the previous report.

*Methods:* Of the original cohort of 61 patients (65 hips), 52 patients (56 hips) available for the present study. Thirty-six hips with a Trilogy HXLPE (Zimmer; Longevity) were matched and compared to a control group of twenty conventional Trilogy PE (Zimmer) hips. The mean follow-up (f/u) duration was 10.5 years (range, 9-11 years). 26-mm zirconia femoral heads (NGK Spark Plug) were used for all patients. 2-dimensional linear wear and 3-dimensional volumetric wear were measured in the 1-year radiographs and the longest f/u radiographs using PolyWare software.

*Results:* There were no significant differences in demographic characteristics between the two groups. Both the mean steady-state linear and volumetric wear rates were significantly lower in the HXLPE group (0.045mm/y, 11.4mm<sup>3</sup>/y) compared with conventional PE group (0.08mm/y, 33.1mm<sup>3</sup>/y) between 1 and 10

years post operation. Incidence of osteolysis was 20% in the conventional PE group compared with no cases in the HXLPE group. No revisions were performed for polyethylene wear or liner fracture in each group. Statistical analysis revealed no influence of age, sex, BMI, f/u duration, the position of the center of prosthetic femoral head, femoral offset, abductor lever arm or inclination and anteversion of the cup on the steady-state wear rate.

*Conclusions:* The steady-state wear of HXLPE against a zirconia femoral head was significantly lower compared with that of conventional polyethylene even in a mean ten-year f/u.

## 22] USE OF A TWO-INCISION MINIMALLY INVASIVE TOTAL HIP ARTHROPLASTY TECHNIQUE REDUCES COSTS AND LENGTH OF STAY

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 Paul A. Manner (University of Washington),  
 Sean Amann (University of Washington), Amy Cizik (University of Washington), Seth Leopold (University of Washington)

*Introduction:* While anecdotal evidence suggests that length of stay (LOS) and hospital costs are reduced with minimally invasive techniques, few studies have been published. Frequent criticism of these studies centers on preferential selection of optimal patients, who would do well with any technique. We hypothesized that the apparent cost savings and reduced LOS, attributed to use of minimally invasive techniques, result purely from patient selection.

*Methods:* Medical records, hospital charges and costs for patients undergoing two-incision minimally invasive total hip arthroplasty (MIS) between September 2006 and September 2008



were obtained. Records and hospital charges and costs for patients undergoing THA via a standard approach (STD) in the same time period were reviewed to find patients who matched the two-incision patients for age, gender, BMI and medical comorbidity. Patients for whom a match could not be made were excluded.

*Results:* Mean LOS for MIS pts was 2.42 days compared to 3.64 days for STD. All MIS patients were discharged home; only 43 of 50 STD patients were discharged home.

Total, direct and indirect, OR, and therapy costs were all significantly lower for MIS than for STD approaches. For lab, materials management, and pharmacy, MIS and STD procedures had equal costs. The only cost center where STD procedures were less costly was imaging. Complication rates and component position were no different.

*Discussion/Conclusion:* Our initial hypothesis that matching of patients would eliminate any difference in cost and length of stay between patient groups was not proved. Instead, we found strong support for significant differences. LOS was shorter. In every instance, except imaging, costs associated with MIS procedures were equal or lower. Total costs were substantially lower. Not all patients qualify for MIS arthroplasty. However, hospital costs and length of stay can be significantly reduced in appropriately selected patients in the proper setting.

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### **23] IS WEAR DIFFERENT IN SMALL VERSUS LARGE DIAMETER MOM BEARINGS?**

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Ian C. Clarke (Dept Orthopedics Loma Linda University), Thomas K. Donaldson (Loma Linda University), Edward J. McPherson (Los Angeles

Orthopedic Institute), Christopher L. Peters (University of Utah)

*Introduction:* Large-diameter MOM (LDB) now produce concern due to high revision rates in total hips (THA). Major explant differences may relate to 'areas' of wear damage created during gait in different diameter THA. This study maps for the 1st time the surface-damage on MOM for insight as to how the patients actually functioned on their THA (28M vs. LDB).

*Methods:* LDB explants were selected from 3 vendors (30-60mm dia). Twenty of each brand were compared to 28M MOM. Areas of wear (MWZ: main-wear zone) were identified by interferometry, CMM and SEM. The MWZ were marked red for photography and algorithms calculated MWZ areas/ patient flexion ranges. Volumetric wear and taper damage were compared to MWZ charts.

*Results:* The MWZ on 28M bearings showed flexion arcs typically 30-35mm wide representing damaged areas of 900-1,000mm<sup>2</sup> (Fig. 1a) and occupying 60-70% of ball hemisphere. In contrast, LDB bearings revealed worn areas 1,900-5,000 mm<sup>2</sup>; occupying 70-100% hemisphere (Fig. 1b-d) with flexion arcs 50-90mm. LDB wear volumes (10 to 40 mm<sup>3</sup>/yr) appeared 2-6 times higher than 28M wear volumes (< 5 mm<sup>3</sup>/yr). Worn areas mostly appeared circular in shape (Fig. 1) similar to simulator studies but a few were elongated. The stripe-wear phenomenon was also clearly identified for the 1st time on MOM. Taper damage showed out of roundness typically 0.5 to 30um.

*Discussion:* In general, success appears to follow the 28mm diameter MOM over the first decade (28M: Park, 2010; Vendittoli, 2010; Vigler, 2010, Saito, 2011) and there appear to be very few reports on ARMD lesions. 28M explants showed smaller flexion arcs and they also showed the smallest areas of wear (x2-5

times smaller than LDB). These contrasting phenomena likely explain the continuing good clinical results of 28M. The wear-map data may also offer new insights into functional cup performance, wear concepts a

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#### **24] USE OF TRANSCRANIAL ELECTRICAL MOTOR EVOKED POTENTIALS TO MONITOR THE FEMORAL NERVE DURING MINIMALLY INVASIVE ANTERIOR APPROACH TOTAL HIP ARTHROPLASTY**

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 Craig R. Lareau (Brown University/Rhode Island Hospital), James C. Bolton (Brown University/Rhode Island Hospital), George M. Sachs (Brown University/Rhode Island Hospital), Joseph M. Caiati (Brown University/Rhode Island Hospital), Richard S. Limbird (Brown University/Rhode Island Hospital)

*Background:* Femoral nerve palsy is an uncommon but serious complication of total hip arthroplasty (THA). The anterior approach minimally invasive THA may put the femoral nerve at risk either due to improper retractor positioning or the extreme hip extension and external rotation required for femoral preparation. There are no prior studies that monitor the femoral nerve during anterior approach THA.

*Objectives:* The purpose of this study was to monitor the femoral nerve during single-incision minimally invasive anterior approach THA and to identify whether specific surgical maneuvers have a measurable effect on the nerve. In addition, our goal was to identify an anesthetic regimen that provides adequate muscle relaxation without compromising neuromonitoring accuracy. A common misconception is that paralysis by neuromuscular blocking agents is necessary to safely perform THA.

*Methods:* Intraoperative transcranial electrical motor evoked potentials (TCeMEP) were used to stimulate the vastus medialis muscle in a series of patients undergoing primary total hip arthroplasty. The contralateral extremity was used as a control. A neuromonitoring technician recorded stimulation thresholds throughout the surgical procedure, including during deep surgical dissection, dislocation, femoral preparation and reduction of the prosthesis.

*Results:* No clinically significant deteriorations in TCeMEP readings were observed in the operative extremity. This study illustrated that a regimen of propofol and 50% nitrous oxide can be used to achieve sufficient relaxation without impacting TCeMEP amplitudes.

*Conclusions:* This study failed to demonstrate any measurable effect on the femoral nerve at any point during anterior approach THA. We demonstrated that propofol and 50% nitrous oxide provide adequate anesthesia to safely perform THA without interfering with TCeMEP. Muscle paralysis is not necessary during THA as relaxation can be achieved through anesthetic depth.

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#### **28] PREFORMED ARTICULATING KNEE SPACERS IN TWO-STAGE REVISION ARTHROPLASTY: MINIMUM TWO-YEAR FOLLOW-UP**

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 Azim A. Karim (Methodist Hospital), Zhinian Wan (Methodist Hospital), Stephen Incavo (Methodist Hospital), Kenneth Mathis (Methodist Hospital)

*Background:* Two-stage revision arthroplasty remains the most successful management technique of deep infection following TKA with success rates averaging 92% from 37 published studies.





**Objectives:** Our purpose is to report results and technique of using a commercially available articulating cement spacer modified by the addition of stem extensions for the treatment of deep infection in primary and revision total knee arthroplasty. There is concern that articulating cement spacers may not be an optimal solution for several reasons including: the production of cement debris, loss of bony fixation, and unsuitability to cases involving bone loss.

**Methods:** IRB approval from our institution was obtained prior to the study. A total of 33 patients with infected primary or revision implants completed the two-stage reimplantation protocol from October 2005 to August 2009 at a single institution. The articulating spacer (InterSpace Knee©, Exactech, Gainesville, FL) was commercially available in 3 sizes and contained 1.2 g of gentamycin in each of the femoral and tibial components. In the majority of the cases a stem was added to each spacer component. A 6 mm metal rod of variable length was placed in a mold designed to uniformly coat the rod with antibiotic impregnated cement to produce a 13 mm diameter stem which was then minimally cemented to the preformed cement spacer. The minimum follow-up time was 24 months for inclusion. No cases of mortality occurred.

**Results:** After a minimum of a 24-month follow-up interval, the presenting infection was eradicated in 30 of 33 cases for a success rate of 91%.

**Conclusions:** We believe articulating cement spacers perform well in cases of deep infection. The addition of intramedullary stems delivers antibiotics into the medullary canals, facilitate balancing flexion and extension gaps, and provide additional stability to avoid spacer dislodgement.

### **30] POROUS TANTALUM BUTTRESS AUGMENTS FOR SEVERE ACETABULAR POSTERIOR COLUMN DEFICIENCY**

R. Michael Meneghini (Indiana University Health Physicians), Jason R. Hull (Virginia Commonwealth University), Glenn S. Russo (University of Connecticut Health Center), Lieberman R. Jay (University of Connecticut Health Center), William A. Jiranek (Virginia Commonwealth University)

**Introduction:** In revision total hip arthroplasty (THA), reconstruction of the most severe acetabular defects can be challenging and established consensus regarding the best method is lacking. Novel highly porous tantalum (TM) buttress augments were designed to provide structural support for the most severe posterior and/or superior acetabular bone defects. This study purpose was to report the clinical results of a consecutive series of complex acetabular reconstructions utilizing TM buttress augments.

**Methods:** A series of eight complex acetabular reconstructions utilizing a TM buttress augment for severe posterior column deficiency was performed at two centers. Seven patients were Paprosky 3A and one patient Paprosky 3B bone loss classification. Intraoperative findings at surgery revealed severe superior and posterior column acetabular defects where wedge shaped augments were insufficient for mechanical support. The acetabular cup sizes ranged from 64-78 and a buttress shim was used in 7 of 8 cases.

**Results:** Clinical and radiographic follow averaged 16.5 months (range, 10-28) and no cases were lost to follow-up. There were no cases of clinical or radiographic loosening and no case had required reoperation or revision. All patients except one were ambulating with either no assist device or a single cane at final follow-up. There was one complication of an



iliac wing fracture noted incidentally on postoperative xrays in the lone patient a buttress shim was not used.

*Conclusions:* At short-term follow-up, TM acetabular buttress augments appear to effectively substitute for the use of structural allografts or cages which would otherwise be used in this challenging setting. The potential for long-term biologic fixation is promising for the long-term durability of these reconstructions. Long-term comparison with alternative reconstructive techniques is required to evaluate the long-term effectiveness of this treatment approach.

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### **31] REPAIR OF MEDIAL PATELLOFEMORAL LIGAMENT IMPROVES PATELLAR TRACKING IN TOTAL KNEE REPLACEMENT**

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R. Michael Meneghini (Indiana University Health Physicians), Shelly A. Smits (Indiana University Health Physicians), Mary Ziemba-Davis (St. Vincent Hospital), James Bicos (St. Vincent Orthopaedics)

*Introduction:* Patella tracking is critical to clinical success and durability in total knee replacement (TKR). The medial patellofemoral ligament (MPFL) is recognized as an important static stabilizer of the patella; however, this critical structure has not been addressed in TKR. The purpose of this pilot study was to determine whether patella stability is improved by repairing the MPFL prior to arthrotomy closure in TKR.

*Methods:* A review of 46 TKRs in 40 patients was performed. TKR was performed through a median parapatellar approach without lateral release. The patella was resurfaced in all cases. Standard closure was performed in 29 procedures. In 17 procedures, the MPFL was isolated and anatomically repaired at 30

degrees of flexion. Blinded radiographic evaluation was performed preoperatively and 4 months postoperatively.

*Results:* The MPFL repair group demonstrated a mean correction in patellar tilt of 4.8° after surgery, compared to only 0.1° average improvement in the standard closure group ( $p = 0.019$ ). Despite essentially equal preoperative mean subluxation in both groups (14.1 mm and 14.6 mm;  $p = 0.93$ ), postoperative patellar subluxation corrected to a mean of 1.3 mm medially in the MPFL repair group compared to a mean residual 6.4 mm lateral subluxation in the standard group ( $p = 0.008$ ).

*Conclusion:* Despite a trend for greater preoperative tilt, patients undergoing TKR with reconstitution of the MPFL prior to arthrotomy closure demonstrated a greater correction of tilt postoperatively as well as more optimal tracking centrally in the femoral trochlea. This simple step at arthrotomy closure appears to optimize patella tracking and may improve long term outcomes through minimization of patellar complications and wear. Further research in this area is warranted and necessary to elucidate the importance of the MPFL in TKR.

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### **32] STRAIN CHARACTERISTICS, INITIAL STABILITY AND FRACTURE PATTERNS DURING CEMENTLESS FEMORAL STEM INSERTION WITH TWO DIFFERENT STEM DESIGNS**

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R. Michael Meneghini (Indiana University Health Physicians), Lindsey Sturgis (University of Connecticut Health Center), Jay R. Lieberman (University of Connecticut Health Center)

*Introduction:* Periprosthetic femur fractures can result from excessive hoop stresses during cementless stem insertion. It has not been



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determined whether certain stem designs have greater propensity for fracture during implantation. The goal of this study is to determine the characteristic strain patterns, initial implant stability and resultant fracture patterns of two different femoral stem designs.

*Methods:* Cementless stem insertion was performed via both surgeon and drop-tower impaction in sawbone specimens with two different designs (a double taper “fit and fill” and a tapered “blade or wedge” design) and taken to fracture. 15 of each stem design were inserted and specimens biomechanically tested axially and rotationally. Force-displacement data were recorded, while rosette strain gages recorded cortical strain and fractures were documented photographically. Statistical analysis compared maximum principal strains, change in seating height and interface stiffness between the different implants with a p-value of 0.05 considered statistically significant.

*Results:* The highest strains for the blade-type stem were observed on the medial cortex compared to the anterior and lateral cortices for the double taper design. The blade stem strains were smaller than those for the fit-and-fill stems. There was no difference between stems in torsional stability ( $p = 0.53$ ); whereas the blade-type stem demonstrated greater axial interface stiffness over the double-taper stem ( $p = 0.038$ ). The blade stems produced a single medial or anterior fracture pattern, while the double taper stems characteristically produced two fractures medially.

*Discussion:* In this model, the data suggests the blade stem is more axially stable than the fit-and-fit stem. In addition, the two stem designs exhibit characteristic and different fracture and strain patterns with the blade-type stem demonstrating a more manageable single fracture and less overall peri-prosthetic cortical strain values

### 33] THE INFLUENCE OF INFRAPATELLAR FAT PAD RESECTION ON OUTCOMES FOLLOWING TOTAL KNEE ARTHROPLASTY

Hee-Soo Seo (Himchan Hospital), Su-Chan Lee (Himchan Hospital)

*Background:* Although resection of the infrapatellar fat pad produces significant changes in patellar biomechanics and knee kinematics, the influence of infrapatellar fat pad resection on outcomes following total knee arthroplasty has not yet been clearly reported.

*Objectives:* The purpose of the present study was to compare the patellar tendon length and clinical outcomes in knees receiving either fat pad resection or fat pad retention during total knee arthroplasty.

*Methods:* One hundred and twenty patients (mean age, 70.2 years) undergoing bilateral total knee arthroplasty were randomized to have infrapatellar fat pad resected in one knee and preserved in the contralateral knee. Seven patients were men, and 113 were women. At a mean of 2.2 years postoperatively, the patients were evaluated clinically with the knee-rating systems of the Knee Society and the Hospital for Special Surgery and with the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score. In addition, patellar tendon length was measured radiographically and compared between the two groups.

*Results:* The mean postoperative Knee Society knee scores were 91 and 93 points and the mean postoperative Hospital for Special Surgery knee scores were 88 and 90 points in the fat pad resection group and the fat pad retention group, respectively. The average postoperative WOMAC score was 24.4 points. With regard to the patellar tendon length, range of motion, global and anterior knee pain and patient



preference, no significant differences were identified at the latest follow-up.

*Conclusions:* After a minimum duration of follow-up of two years, we found no significant differences between the two groups (fat pad resection compared with fat pad retention). We concluded that infrapatellar fat pad resection appears to have no adverse effects on clinical and radiographic results after total knee arthroplasty.

*Level of Evidence:* Therapeutic Level I.

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### **35] COMPARISON OF SHORT-TERM OUTCOMES OF DIRECT ANTERIOR AND POSTERIOR APPROACHES IN MINIMALLY INVASIVE TOTAL HIP ARTHROPLASTY**

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*Purpose:* This study compared short-term outcomes of direct anterior approach (DAA) in minimally invasive hip replacement surgery (MIS-THA) with those of a small-incision posterior approach to determine the advantages and issues associated with DAA.

*Study Design:* This study reviewed the cases of 149 joints (135 patients) at 1 year after MIS-THA with DAA or the posterior approach.

*Patient Samples:* Between January 2008 and May 2010, DAA was performed on 101 joints (91 patients; age 44–84 years; mean BMI 22.5 kg/m<sup>2</sup>, range 16.8–34.7; group D). Between January and December 2010, posterior

approach was performed on 48 joints (44 patients; age 37–78 years; BMI 22.7 kg/m<sup>2</sup>, range 13.8–31.3; group P).

*Outcome Measures:* Mean operative time, blood loss, time to straight-leg-raising (SLR), time to discharge, preoperative and postoperative Japanese Orthopaedic Association (JOA) scores and improvement rate, stem alignment, and surgical complications were compared between the two groups. The Mann-Whitney U-test was used for comparisons, with significance set at  $p < 0.05$ .

*Results:* Mean pre- and postoperative JOA scores were 53.8 (19–99) and 96.0 (69–100) in group D and 52.1 (24–87) and (81–100) in group P, for improvement rates of 90.4% (28.1–100%) and 89.4% (36.7–100%), respectively. Operative time, SLR time, and stem alignment on sagittal images differed significantly between the two groups ( $p < 0.05$ ). Group D had no dislocation but 2 cases of greater trochanteric fracture, which were treated conservatively and did not affect JOA score at postoperative week 48. Group P had one case of dislocation.

*Conclusion:* DAA and the small-incision posterior approach had similar perioperative results, indicating that DAA is also an excellent surgical approach. Although DAA had no dislocation complications, because greater trochanteric fracture is a specific complication of DAA, the femur should be raised sufficiently when separating the rectus femoris muscle and articular capsule.

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### **36] PROSPECTIVE RANDOMIZED EVALUATION OF WOUND HEALING AFTER DIRECT ANTERIOR TOTAL HIP ARTHROPLASTY WITH USE OF A NOVEL RETRACTION DEVICE**

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 Juan C. Suarez (Cleveland Clinic Florida),  
 Megan Jack (Cleveland Clinic Florida), David  
 Friedman (Cleveland Clinic Florida), Wael K.  
 Barsoum (Cleveland Clinic Foundation),  
 Preetesh Patel (Cleveland Clinic Florida)

*Background:* Trauma from vigorous retraction needed for adequate visualization in direct anterior total hip arthroplasty may impair proper wound healing, offsetting the benefit of a smaller incision and potentially resulting in poorer overall wound cosmesis.

*Objective:* To prospectively investigate the efficacy of a specialized ring retractor in minimizing wound-edge trauma as reflected by improved scar cosmesis.

*Methods:* We enrolled 50 patients undergoing direct anterior total hip arthroplasty in this prospective, randomized, double-blinded study. Patients were randomized to surgery with or without the ring retractor. Incisional photographs were taken 2, 6, and 12 weeks after surgery and graded by two blinded plastic surgeons. Patient satisfaction questionnaires were also obtained. Primary outcome measures were Stony Brook Scar Evaluation Scale (SBSES) and Manchester Scar Scale (MSS) scores and patient satisfaction. Secondary measures included wound complications, nutritional markers, postoperative pain scores, and postoperative function represented by Harris hip and Short Form-12 scores.

*Results:* Average SBSES and MSS scores were similar for both groups at 6 and 12 weeks. Treatment group scores were better only by the MSS at two weeks ( $p = 0.028$ ). There were no differences in patient satisfaction between groups. Age  $>65$  years was a significant though small predictor of worse scores for both systems. Pre-albumin  $<20$  mg/L was a strong independent predictor of poorer SBSES scores for one scorer.

*Conclusions:* Our results suggest no lasting improvements in wound cosmesis with use of the ring retractor in our study population.

### 37] TOTAL ELBOW JOINT REPLACEMENT: BAKSI SLOPPY HINGE JOINT

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*Introduction:* Total elbow joint replacement is not a common surgery as is hip or knee replacement. Better & permanent options are available in younger patients viz. interposition arthroplasty & arthrodesis. Bakshi sloppy hinge elbow is a better & cheaper alternative in selected elderly patients.

*Method:* Twenty three cases of elbow joint replacement have been performed. Age ranged from 55 to 75 years with an average of 61.5 years. Eight females & seven males had rheumatoid synovitis with arthritis, three female having post traumatic arthritis & three males having osteoarthritis, two females having ununited fracture lower end of humerus. All had moderate to severe pain & stiffness of joint restricting activities of daily living. All cases were operated under regional block anesthesia & tourniquet control by postero medial Mayo's approach taking care of ulnar nerve. After trial reduction, final cementing of components done in single stage. Reduction, alignment of both components using lag screw & locking screw done Graduated course of mobilization exercises continued after operation.

*Results:* All patient followed up from 2.5 years to maximum 4.5 years follow up. All twenty three patients had no complaint about pain or stiffness. Full range of flexion & extension



achieved, rotation about 160 degrees in all cases in 8 to 10 weeks.

*Conclusion:* This is series of twenty three cases with follow up of 2.5 years average duration but without any complications and good early result. Bakshi sloppy hinge replacement is better, cheaper, easy to perform & require minimal instrumentation.

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### **38] IS MINIMALLY INVASIVE HIP ARTHROPLASTY MORE THAN JUST A NEAT SCAR? A SINGLE CENTRE, SINGLE SURGEON STUDY**

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Aria Daneshfar (The University Hospital Lewisham), Iheanyi C. Nwachuku (University Hospital Lewisham), Laurence Glancz (University Hospital Lewisham), Shivan Jassim (University Hospital Lewisham)

*Background:* With increasing pressure to improve waiting list times and to reduce length of stay within the National health service (NHS) the use of mini invasive surgery (MIS) may have an important role to play in the UK health care system

*Objectives:* This study is designed to examine the differences between Minimal access surgery incision length 5-10cm and the standard incision surgery incision length 15-25cm, all were performed by the senior author (AD) at the university hospital Lewisham London.

*Methods:* Two non-randomised patient groups were generated; "MIS" versus "Standard" surgery. This is a retrospective study looking at the hospital records of the senior author's total hip replacement surgery, encompassing 50 consecutive posterior approach MIS cases and 51 Standard Total Hip Replacements.

*Results:* There was a statistically significant difference in the average number of days to discharge for the MIS group, 3 days (IQR 2-3), compared with standard incision group at 7 days (IQR 4-10)  $p = 0.0001$ . There was also a large difference in the number of patients who received blood transfusion (MIS= 12%, Standard= 27.5%). We also record a statistically significant difference between the average days to mobility, the MIS group mobilised on the first day whereas the standard group took 2 days  $p = 0.0001$ . The MIS group reports no wound infections compared with 1 superficial infection seen in the standard incision patient group. However there appears to be a significantly higher though minor leg length discrepancy in the MIS Group at 18%, compared with 6% recorded for the standard group.

*Conclusion:* We learn from these results that the benefits of using the minimally invasive procedure may be reduced length of stay, reduced need for blood transfusion and Increased patient satisfaction with shorter scars.

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### **39] THROMBOSIS PREVENTION USING A PORTABLE COMPRESSION DEVICE AS MONOTHERAPY IN HIP AND KNEE ARTHROPLASTY**

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Center for Orthopaedic Research and Education at Scripps Clinic, La Jolla, CA), C. Lowery Barnes (Arkansas Specialty Orthopaedics, Little Rock, AK), Michael A. Mont (Rubin Institute for Advanced Orthopedics, Baltimore, MD), Douglas E. Padgett (Hospital for Special Surgery, NY, NY)

*Background:* Thromboembolic event is a common complication in patients undergoing total knee arthroplasty (TKA) or total hip arthroplasty (THA). The purpose of this study was to evaluate the effectiveness of a portable compression device with or without ASA as the sole means of venous thromboembolism (VTE) prophylaxis, including both deep vein thrombosis (DVT) and/or pulmonary embolism (PE) in patients undergoing primary total joint arthroplasty.

*Methods:* A multicenter registry was established to capture the rate of VTE occurring following elective primary unilateral lower extremity arthroplasty; 3060 patients from ten sites were included in the registry after undergoing primary TKA (1551) or THA (1509). All patients were older than 18 years without known history of prior VTE, coagulation disorder, or major operation in the previous three months. Use of the compression device began intraoperatively and continued a minimum of 10 days. Patients with clinical suspicion of DVT underwent duplex ultrasonography of both legs. Patients with clinical suspicion of PE were evaluated with spiral CT of the lungs. All patients were clinically evaluated three months after surgery documenting whether any evidence that a DVT or PE event had occurred postoperatively.

*Results:* Of 3060 patients, 24 (1%) had VTE (17 distal DVT, 3 proximal DVT, and 4 PE). Of 1551 TKA patients, 19 (1.4%) had VTE (12 distal DVT, 4 proximal DVT and 3 PE). Of 1509 THA patients, 5 (0.4%) had VTE (3 distal DVT, 1 proximal DVT and 1 PE).

*Conclusion:* When compared to current pharmacologic protocols, the use of a portable compression device as monotherapy for patients undergoing primary total joint arthroplasty provides a non-inferior risk for developing VTE without the risk of bleeding.

#### **40] MINIMUM FOURTEEN-YEAR FOLLOW-UP OF TOTAL KNEE ARTHROPLASTY USING THE PRESS-FIT CONDYLAR SIGMA DESIGN**

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*Introduction:* Many conflicting studies on long-term success of the original PFC knee are reported, but only short- to intermediate-term results are available on the PFC Sigma knee. This study represents a long-term clinical follow-up of 14 years or more in patients who had a primary cemented posterior cruciate-retaining total knee arthroplasty (TKA) utilizing the PFC Sigma implant.

*Methods:* Clinical outcomes of 80 consecutive PFC Sigma primary TKA in 78 patients were assessed. Thirty-seven patients (37 knees) had died and 3 patients (3 knees) resided out of the country and could not be contacted. The remaining 38 patients (40 knees) were included in the present analysis. Clinical outcomes included range of motion, Knee Society Rating System (KSRS) function and knee scores, and revision status. Patients were clinically evaluated; non-local or non-ambulatory patients were contacted by telephone. Radiographic outcomes (presence of



radiolucent lines and osteolysis) were evaluated for 34 living patients (35 knees).

*Results:* Average age was 65 years and 54% were male. The mean follow-up was 14.3 years (range, 14.0-14.8 years). Average postoperative flexion was 114° (range, 65°-140°). Clinically, KSRS function scores improved from 49.1 preoperatively to 86.7 currently; KSRS knee scores improved from 46.4 to 85.8. An average of 10.1 years follow-up, radiographic analysis revealed radiolucent lines in 22.8 % of knees with minor osteolysis in 5.7% of knees. Two revisions occurred: 1 for instability/nickel allergy at 4 years postoperatively and 1 for polyethylene wear at 10 years postoperatively. Overall survivorship with revision for any reason was 95%. Using aseptic loosening as an endpoint, the survivorship was 100%.

*Conclusion:* This study demonstrated excellent long-term results with the PFC Sigma knee with an overall 95% survivorship.

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#### **41] HIGH FLEXION KNEES – ARE WE GETTING WHAT WE ARE PAYING FOR?**

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*Objectives:* Range of motion (ROM) following total knee arthroplasty (TKA) remains one of the most important factors in patient satisfaction following this surgical procedure. Because of relatively poor improvement in this measure with early design, newer high flexion designs by multiple manufacturers have been marketed.

The purpose of our study was to compare ROM of the newer designs with previous designs.

*Methods:* Clinical measurement with goniometer and radiographic measurement were obtained by 3 independent orthopedists. Gravity-assisted ROM, where patients maximally bend their own knees and active-assist ROM, where patients' knees are bent by the surgeon maximally until stopped by anterior knee discomfort or inhibited by posterior soft tissue impingement were recorded and compared with the measurement from lateral radiographs obtained with knees in the same 2 positions.

*Results:* One hundred and forty-four patients were included in the study, with a mean gravity-assisted ROM preoperatively of 110 degrees and postoperatively of 113 degrees clinically and 112 degrees radiographically. Postoperative active-assist ROM were 117 degrees clinically and 121 degrees radiographically. Preoperative Knee Society function and score were 52 and 55, respectively, and improved to 78 and 90, respectively, after surgery. Measurements obtained by 3 examiners were highly correlated, especially when radiographs were used for measurement. Three of the 5 prostheses were designed with high-flexion features; however, no difference in ROM was found between the previous designs and the high flexion designs.

*Conclusion:* Although the newer designs allow for greater flexion, the actual flexion falls far short of the claim of the manufacturers. In addition, the ROM reported can depend significantly on the method of measurement used. Preoperative ROM remains the common denominator of postoperative ROM in all designs.

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#### **42] A PRECISE GAP CONTROL SYSTEM IN TOTAL KNEE ARTHROPLASTY: ESTIMATION OF THE COMPONENT GAP BEFORE FINAL BONE RESECTION OF THE FEMUR**

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Ryutaku Kaneyama (Funabashi Orthopedic Hospital), Hideaki Shiratsuchi (Funabashi Orthopedic Hospital), Kazuhiro Oinuma (Funabashi Orthopedic Hospital), Yoko Miura

*Background:* The component gaps can only be checked after completing the bone resection and setting the trial component in total knee arthroplasty (TKA).

*Objectives:* The purpose of this study is to establish a precise gap control system which can check the component gap before the final bone resection of the femur.

*Methods:* A “pre-cut trial component” for use in a pre-cut technique for the femoral posterior condyle was developed. The pre-cut trial component is composed of an 8-mm-thick usual distal part and a 4-mm-thick posterior part and lacks an anterior part of the femoral component. The extension gap (EG) is created with a standard femoral distal cut and tibial cut. A 4 mm pre-cut of the femoral posterior condyle from the posterior condylar line is performed. Once all of the osteophytes are removed and the bone gaps are checked, the pre-cut trial component is attached to the femur and the component gaps are estimated with the patella reduction. These gaps were the same as the component gaps via the measured resection technique. Finally, the femur is completely resected according to the measurements of the component gaps. In this study, 136 knees were implanted by this system. Bone gaps and component gaps with the pre-cut trial component were investigated.

*Results:* The bone gaps were  $17.7 \pm 2.9$  mm in extension and  $15.4 \pm 2.8$  mm in flexion. From these results, the expected component gaps

were  $9.7 \pm 2.9$  (bone gap – 8) mm in extension and  $11.4 \pm 2.8$  (bone gap – 4) mm in flexion. After the pre-cut trial component was set, the measured component gaps were  $9.5 \pm 2.8$  mm in extension and  $12.7 \pm 2.8$  mm in flexion. The EG became  $1.5 \pm 1.0$  mm smaller than expected, and the change of FG was  $0.2 \pm 0.5$  mm. While no large decrease of EG was noted, the variation was not insubstantial (0~5 mm). Finally, femoral bone resection was completed according to the measurement results.

*Conclusions:* With the technique we present here, the component gaps can be checked before final bone resection.

#### **43] INCIDENCE OF HETEROTOPIC OSSIFICATION IN DIRECT ANTERIOR TOTAL HIP ARTHROPLASTY: A RETROSPECTIVE RADIOGRAPHIC REVIEW**

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Duane Tippets (Cleveland Clinic Florida), Anton Zaryanov (Broward General Medical Center), Erin E. Ely (Cleveland Clinic Florida), Nathania M. Figuera Guilliani (Cleveland Clinic Florida), Vince Burke (Broward General Medical Center), Preetesh D. Patel (Cleveland Clinic Florida), Juan C. Suarez (Cleveland Clinic Florida)

*Background:* The direct anterior approach (DAA) has become a popular approach for total hip arthroplasty (THA) in recent years and has shown decreased soft tissue trauma, early recovery of hip function and gait mechanics, decreased postoperative dislocation rates, and promising short-term outcomes. Heterotopic ossification (HO) is a known complication following THA using traditional approaches, and is associated with decreased range of motion and patient satisfaction. While the pathophysiology of HO is not well understood, several risk factors predispose patients to development. Currently, there is no data regarding the development of HO in patients



who have undergone a DAA THA and it is unclear whether HO will continue to be a cause of postoperative morbidity with the use of the DAA. The purpose of this study is to determine the incidence of HO in patients who have undergone a DAA THA.

*Methods:* This is a retrospective radiographic review of patients who have undergone a DAA THA at two institutions. Target population is 250 patients, 125 from each institution, who have at least 6 months of follow-up from index operation. Two physicians will independently review all radiographs and will determine the presence of HO based on the Brooker classification.

*Results:* The Wilcoxon rank sum test will be used to delineate differences in distribution of demographics and clinical data. Inter-observer reliability will be calculated with correlation coefficients. Calculations will be performed using Microsoft Excel and SPSS.

*Conclusions:* The DAA THA has emerged as a popular approach due to its advantages of decreased soft tissue damage and postoperative dislocation rates, as well as improved early patient outcomes. HO is a known complication of THA that compromises patient outcomes. We hypothesize that the incidence of HO in patients who have undergone the DAA THA will be decreased when compared to traditional approaches.

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#### **45] EFFECT OF PRE- AND PERIOPERATIVE FACTOR FOR ABDUCTOR MUSCLE POWER SIX MONTHS AFTER PRIMARY TOTAL HIP ARTHROPLASTY**

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Satoshi Takayanagi (Shonan Kamakura Joint Reconstruction Center), Kazuo Hirakawa (Shonan Kamakura Joint Reconstruction Center), Riichiro Tsukamoto (Shonan Kamakura

Joint Reconstruction Center), Koji Tsuji (Shonan Kamakura Joint Reconstruction Center), Akira Saito (Shonan Kamakura Joint Reconstruction Center), Miho Iwase (Shonan Kamakura Joint Reconstruction Center)

*Background:* Hip abductor muscles are generally considered the most important muscles surrounding hip joint because of their function as pelvic stabilizers, especially during single-limb stance. A decrease in hip abductor muscle power (AMP) may be responsible for trunk compensation and abnormal gait pattern after total hip arthroplasty (THA).

*Objectives:* To assess the relationship between pre- and perioperative factors and hip AMP six months after primary THA.

*Methods:* A total of 52 patients who operated primary THA participated in this study. All the procedures were performed with mini- anterolateral approach and using Kinectiv®, neck changeable stem. The AMP was measured with MICRO FET 2® and measured AMP (N) was divided by the patient's weight (N/Kg) with which analysis was done. Stepwise regression analysis was performed with AMP per weight six months after primary THA as dependent variable. Independent variables included age, height (m), weight (Kg) and body mass index (Kg/m<sup>2</sup>) of the patient at surgery, AMP per weight before surgery (N/Kg), pre- and postoperative hip offset (mm), postoperative change of hip offset (mm) and contralateral hip offset (mm).

*Results:* Multivariable stepwise regression analysis showed that hip AMP per weight before surgery (regression coefficient = .670), height (regression coefficient = .214), weight (regression coefficient =  $-1.077 \times 10^{-4}$ ), change of offset (regression coefficient = .006) (listed by the order of forward selection) were the predictors of AMP per weight six months after primary THA ( $p < .0001$ ).

*Conclusions:* The findings of this study provided that the pre- and perioperative factors predicted the hip abductor muscle power six months after primary THA. These results implied the importance of preoperative muscle exercise and sufficient increase of hip offset at surgery.

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#### **46] IN VIVO WEAR PARTICLES ANALYSIS OF REMELTED HIGHLY CROSS-LINKED POLYETHYLENE IN TOTAL HIP ARTHROPLASTY**

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Hiroyoshi Iwaki (Orthopaedic Dept. Osaka City University Medical School), Yukihide Minoda (Orthopaedic Dept. Osaka City University Medical School), Mitsuhiko Ikebuchi (Orthopaedic Dept. Osaka City University Medical School), Taku Yoshida (Orthopaedic Dept. Osaka City University Medical School), Hiroaki Nakamura (Orthopaedic Dept. Osaka City University Medical School)

*Introduction:* To reduce wear generation and to achieve better long-term results of THA, highly cross-linked polyethylene (XLP) was introduced and coming into wide use. In this study, remelted XLP wear particles from THAs not only from revision surgery but well functioning patients were analyzed.

*Methods:* Peri-prosthetic tissues of two failed THAs 2.3yrs p.o. with Longevity liner were retrieved on the revision surgery. We also aspirate a joint fluid from 6 well-functioning hips with Longevity were analyzed 16 months in average (5-31 months) p.o. We extracted polyethylene particles by Cambell's method modified by us. Number, size and shape were determined by a image analyzer.

*Results:* Revision study; The mean number of particles was  $8.02 \times 10^7/g$ . Particle size (ECD; equivalent circle diameter) was  $0.62 \mu m$ . Particle shape (R; roundness and AS:aspect

ratio) was 1.45 and 1.41. Joint fluid study; The number of particles were  $2.95 \times 10^7/ml$ . ECD was  $0.72 \mu m \pm 0.26$ , R was  $1.54 \pm 0.21$  and AR was  $1.70 \pm 0.11$ .

*Discussion:* Simulator study showed that XLP generated less, smaller, and rounder particles. If XLP generates smaller particles in vivo, reduction of volumetric wear does not result in reduction of the number and the biological activity of wear particles. Therefore, in vivo XLP wear particle analysis is very important. Size and shape of particles from revision tissue and joint fluid were similar. The number was in revision tissue was much less than that of conventional polyethylene. Particle size of a remelted XLP in vivo was much larger than that in vitro, and was equivalent to that of conventional polyethylene in vivo. Particle shape of a remelted XLP in vivo was rounder than that that of conventional polyethylene in vivo. The current in vivo study supported the wear reduction and less biological activity of a remelted XLP.

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#### **48] ANATOMIC BOSS POSITION DECREASES THE NEED FOR OFFSET IN REVISION TOTAL KNEE ARTHROPLASTY**

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Yogesh Mittal (The Orthopaedic Center), Manoshi Bhowmik-Stoker (Stryker Orthopaedic), Michael S. Howard (Stryker Orthopaedic), Kirby Hitt (Scott & White Clinical), Richard D. Heekin (Heekin Orthopaedic Institute for Research, Inc.)

*Background:* Revision total knee arthroplasty (TKAR) is a complex procedure which requires a greater degree of accuracy and instrumentation in joint line reconstruction to achieve successful clinical results. As failure rates continue to be high in revisions due to insufficient gap balancing and tibial



malalignment, new revision devices are sought to improve patient outcomes.

*Objective:* The objective was to investigate a new revision system to determine if it could reduce instrumentation needed during surgery while delivering positive clinical results.

*Methods:* This data was collected as part of a prospective, post-market, multicenter study. Eighty-three cases, enrolled from 5 sites, underwent TKAR. Surgical details, KSS, KOOS, LEAS, and HSS Patella scores were collected. Radiographs were assessed by an independent reviewer for radiolucency, osteolysis, gap, and joint line position. Patients were stratified into two groups; femoral offset adapter group and non-femoral offset group. Early clinical results, radiographic findings, and operative data were used to compare groups.

*Results:* In this study, 90.4% of cases did not need a femoral offset. Similar demographic distribution was seen between offset and non-offset groups. At 6 weeks and 6 months improvements in function, range of motion, and quality of life, and a reduction in pain were noted in both groups, with higher mean values in the non-offset group. In both groups, the mean joint line was reconstructed to be 3mm when measured in extension and 2mm when measured in 90° of flexion.

*Conclusion:* Studies have reported the need for femoral offset adapters in 55.4% of cases to achieve optimal joint line reconstruction. The design of the new system inherently reduced the need for use of the offset adapter in the majority of cases due to the anatomic boss position. This study suggests single radius revision knee systems may address issues related to the complexity of TKAR while alleviating pain and improving function.

#### **49] THE EFFECT OF IMPLANT RECALLS, CLASS ACTION LAWSUITS, AND DIRECT TO CONSUMER MARKETING ON PATIENTS' PERCEPTIONS OF TOTAL JOINT ARTHROPLASTY**

Robert Moore (West Virginia School of Osteopathic Medicine), Daniel J. Del Gaizo (University of North Carolina Chapel Hill Department of Orthopaedic Surgery)

*Background:* Orthopedic implant recalls, class action lawsuits, and direct to consumer (DTC) marketing is affecting patients' perceptions of hip and knee arthroplasty in an unknown manner. Patients are often presented with conflicting information from physicians, implant manufacturers, the media and litigators.

*Objectives:* The aim of this study was to examine the impact implant recalls, class action lawsuits, and DTC marketing have had on total joint arthroplasty (TJA) patients.

*Methods:* A 16-item questionnaire was developed to assess patient awareness and perceptions on the topics of implant recalls, class action lawsuits, and DTC marketing. The questionnaire was distributed to 474 consecutive prospective and/or post-operative TJA patients. Demographic data was obtained from the patient's medical record and analyzed to examine correlations between age, sex, education, and income level.

*Results:* The response rate was 83.5% (396/474). 49.75% of the respondents indicated a specific awareness of the J&J Depuy ASR recall with 56.82% aware of class action lawsuits involving total joint arthroplasty implants. 59.5% of patients had been exposed to DTC marketing. The most commonly noted negative feeling toward TJA resulted from the J&J ASR recall (12.18% of respondents). Class action lawsuits (7.57%) and DTC marketing



(5.49%) also but to a lesser extent resulted in negative perceptions towards TJA.

*Conclusion:* A large percentage of the patients studied noted at least awareness of the aforementioned issues in TJA. These issues will shape (often negatively) patient perceptions of joint replacement surgery. TJA surgeons and their representative organizations should disseminate accurate information and clarify confusion on issues frequently being addressed by sources outside of medicine.

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## 50] RAPID WEIGHT LOSS AFTER BARIATRIC SURGERY MAY INCREASE RISK FOR TOTAL JOINT ARTHROPLASTY

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Obesity is a well-known risk factor for the development of arthritis and increases the risk of needing a total joint arthroplasty (TJA). As such, weight loss has proven to be an effective means of reducing one's risk of TJA. The purpose of this study was to examine the rapid weight loss associated with bariatric surgery as a possible risk factor for TJA. The Body Mass Index (BMI) changes, rate of weight loss and percentage of excess body mass index loss (%EBMIL) were retrospectively assessed in 15 bariatric surgery patients who subsequently received a primary TJA and compared to matched bariatric controls. Controls were matched for age, sex, length of follow-up and underlying diagnosis of osteoarthritis at the time of bariatric surgery. Patients were subdivided into three groups according to the length of time between surgeries: 0-24 months (mo), 25-48 mo, and 49 mo and longer. Patients were also analyzed based on the type of TJA performed: total knee arthroplasty (TKA) or total

hip arthroplasty (THA). Bariatric patients who later required a TJA lost 27.9% more of their BMI compared to controls ( $p = 0.049$ ). Weight loss was particularly elevated in patients who underwent TJA 25-48 mo post bariatric surgery. These patients lost 78.2% more of their BMI versus controls at a significantly elevated rate ( $p < 0.001$ ). Patients who received a TKA lost 43.9% more of their BMI than controls ( $p = 0.02$ ), while the change in BMI associated with THA was not significant ( $p = 0.86$ ). The increased weight loss seen in bariatric patients who needed a TJA contradicts the tenant that weight loss is universally protective against arthritis. The timeframe of 25-48 mo post bariatric surgery may represent a period where bariatric patients are at increased risk for symptomatic osteoarthritic pain, particularly of the knee.

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## 51] REVISION HIP ARTHROPLASTY FOR TYPE IIIB FEMORAL DEFECTS USING A MODULAR, TAPERED FEMORAL COMPONENT

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Michael G. Ryan (Southern California Permanente Medical Group), James M. Fait (SCPMG), Glenn Barnes (SCPMG)

*Background/Objective:* In revision hip surgery, Type IIIB femurs have presented the greatest historical challenge to achieving stable fixation and osseous integration. This study evaluated the intermediate term outcome of a modular, tapered, distal fixation revision femoral component used in a consecutive revision hip series with special attention to its performance in the defective Type IIIB femur.

*Methods:* Between February 2002 and January 2005, 51 consecutive revision hip arthroplasties were performed using modular, tapered, distal fixation femoral components. The femoral defects at the time of revision surgery were classified using a system previously described by Paprosky. The most recent radiographs were



reviewed and clinic notes examined to assess femoral component stability.

*Results:* At a minimum of 4.2 years and a mean of 5.8 years follow-up, 2 patients were lost to follow-up. Revision cases classified by the Paprosky femoral defect classification system included 14 Type IIIB hips (28%). All hips reviewed (100%) had radiographic evidence of bony ingrowth. No stem migrated more than 2mm. There were no failures at the modular junction and no component disassociation.

*Conclusion:* A modular, tapered distal fixation femoral component had a 100% survival rate at mean 5.8 year follow-up after revision surgery. All femoral components showed successful osseous-integration. The ability with modularity to independently place the diaphyseal segment of a femoral component in the best remaining femoral host bone may have provided the greatest opportunity for osseous-integration. In this consecutive revision hip series there was no instance of modular junction fracture or component related failure in cases with minimal or no proximal bone support.

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## **52] ROLE OF INFLAMMATORY MARKERS PRIOR TO TOTAL HIP ARTHROPLASTY FOR FAILED INTERNAL FIXATION OF THE HIP**

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Jared Allred (Scott & White Hospital), Bryce Allen (Scott & White Hospital), Brett Trullender (Scott & White Hospital), Jessica Caroom (Scott & White Hospital)

*Background:* To date there is no literature to guide the clinician in regards to the preoperative role of inflammatory markers to diagnose an infection in patients with a previously failed internal fixation of the hip.

*Objectives:* The purpose of this study was to define the role of inflammatory markers in the

pre-operative work-up of patients with a previously failed internal fixation of the hip who presented for conversion to a THA.

*Methods:* 154 patients who underwent additional operative intervention following internal fixation of the acetabulum or proximal femur were retrospectively reviewed. CBC, ESR, and CRP values were collected and compared with hip aspiration and deep cultures obtained at the time of surgery. Sensitivity, specificity, negative predictive value, and positive predictive value for ESR and CRP using standard cut-points from the literature were determined. ROC curve analysis was used to determine the optimal cut-point values using ESR and CRP.

*Results:* 38 patients met our inclusion and exclusion criteria. Using previously defined threshold levels for evaluating infected total joint arthroplasties (CRP>10 or ESR>30), 18 had normal inflammatory markers and 20 had elevated inflammatory markers. Of the 6 patients that had infection, all had elevated inflammatory markers. The sensitivity of ESR and CRP with the predetermined threshold was 100% whereas the specificity was 59%. ROC curves demonstrated an optimal threshold for ESR and CRP of 44 and 18 respectively. Using the optimized threshold, the sensitivity was 100% and the specificity improved to 78%.

*Conclusions:* In patients who present for THA after failed internal fixation of the hip, the threshold levels for ESR and CRP often used for diagnosing periprosthetic infection are sensitive but not specific for diagnosing infection. Raising the threshold level of ESR and CRP may result in fewer false positive diagnoses of infection and improved preoperative decision making.

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### 53] INFLUENCE OF LOCALLY APPLIED CYR61 ON MUSCLE STRENGTH RECOVERY AFTER ACUTE COMPARTMENT SYNDROME TREATED BY LIMB SHORTENING AND DISTRACTION PROCEDURE IN RABBITS

Soenke Percy Frey (University of Wuerzburg, Dep of Trauma, Hand, Plastic and Reconstructiv Surgery), Sönke Frey (University of Wuerzburg)

Recently, we showed a significant deteriorating effect of soft tissue trauma injury in rabbit tibia and muscle in an acute limb shortening-distraction model. The aim of our study was to examine the influence of the human cysteine rich protein 61 (CYR61, CCN1) as a mediator in angiogenesis on muscle strength recovery.

The study was performed with 18 skeletally mature male New Zealand White rabbits (NZW) with an average weight of 3.8 kg (drop-out rate of 9%). The NZW rabbits were divided into two equal groups. In both groups an acute compartment syndrome was generated by 90 min. ischemia and 30 min. of muscle contusion with 100kPa (=10N/ 1cm<sup>2</sup>) and the limb was shortened by resection of a 10mm bone segment simulating the fracture site debridement. The contralateral leg functioned as the non operated control. In the test group a collagen matrix coated with 25µg CYR61 was locally applied circumferent the fracture. In both groups an external fixator was applied and the limb was shortened through resection of a 10mm segmental bone block. Distraction commenced 10 days postsurgery at a rate of 0.5 mm every 12 h using an external fixation device (Orthofix®). Compartment pressure was measured. Muscle strength was monitored bilaterally pre-trauma and every 5th days until 30 days posttrauma.

Muscle strength showed a continuous regeneration after a sharp decrease postoperatively until 30 days posttrauma. The average muscle strength recovery of the test

group was 87.77% of the contralateral side and 53.20% in the control (p=0.05). Histomorphometric analysis of the tibialis anterior muscle demonstrated a significant difference in fibrous degeneration in the control of 14.6% compared to 8,5% in the test group (p

### 54] ACCURACY OF ROBOTIC ARM ASSISTED ACETABULAR CUP IMPLANTATION

Michael A. Conditt (MAKO Surgical Corp.), Douglas E. Padgett (Hospital for Special Surgery), Jennifer A. Jones (MAKO Surgical Corp.), Sharon H. Branch (MAKO Surgical Corp.), Nicholas J. Dunbar (University of Florida), Scott A. Banks (University of Florida)

*Introduction:* Recent studies have revealed that ideal acetabular cup implantation during total hip arthroplasty (THA) is achieved less frequently than previously thought, 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.

*Objectives:* This study reports accuracy of a tactile robotic arm system to ream the acetabulum and impact an acetabular cup compared to manual instrumentation.

*Methods:* 12 fresh frozen cadaveric acetabula were pre-operatively CT scanned and 3D templates were used to plan the center of rotation, and anteversion and inclination of the cup. Each specimen received THA, six prepared manually and six prepared with robotic arm guidance. Tactile, visual, and auditory feedback were provided through the procedure. The robotic guidance constrained orientation of instruments during reaming and final cup impaction, thus constraining anteversion, inclination, and center of rotation for implant



placement. Post-op CT scans were taken to determine final cup placement for comparison to the pre-op plans.

*Results:* In all cases, robotic arm guidance resulted in  $\pm 4^\circ$  of anteversion and  $\pm 5^\circ$  of inclination each relative to the pre-op plan. Absolute RMS errors were  $2.16 \pm 1.35^\circ$  for anteversion and  $1.91 \pm 1.55^\circ$  for inclination. Cup placement with robotic guidance was significantly more accurate and precise than placement with manual instruments. With manual instrumentation the errors were, on average, 4.0 times higher in anteversion and 5.9 times higher in inclination compared to robotic instrumentation.

*Conclusion:* This tactile robotic system substantially improved the accuracy of acetabular reaming and placement of the final cup compared to traditional manual techniques. With greater knowledge of ideal acetabular cup position, highly accurate techniques may allow surgeons to decrease the risk of dislocation and promote durability.

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## 56] TACTILE-GUIDED UNICOMPARTMENTAL KNEE ARTHROPLASTY: CLINICAL ACCURACY

Michael A. Conditt (MAKO Surgical Corp.), Martin Roche (Holy Cross Hospital), Nicholas J. Dunbar (University of Florida), Brian Park (University of Florida), Sharon H. Branch (MAKO Surgical Corp.), Scott A. Banks (University of Florida)

*Introduction:* Unicompartmental knee arthroplasty (UKA) can achieve excellent clinical and functional results for patients suffering from single compartment osteoarthritis. UKA is considered to be more technically challenging to perform and malalignment of the implant components has

been shown to significantly contribute to UKA failures.

*Objectives:* The purpose of this study was to determine the clinical accuracy of UKA component placement using dynamically referenced tactile-robotics.

*Methods:* Pre-op CT, post-op CT, and surgical plan were available for 22 knees out of the first 45 procedures performed using a tactile-guided robotic system. All surgeries were performed by one surgeon (MR). 3D component placement accuracy was assessed by comparing the pre-op plan with the post-op implant placement. Bone and implant models were obtained from postop CT scans taken immediately following the surgery. A 3D to 3D iterative closest point registration procedure was performed and the measured implant position was directly compared to the preop plan. Errors were assessed as single axis root-mean-square (RMS) entities.

*Results:* Femoral component RMS placement errors averaged 1.4 mm/2.6° along any single axis. Tibial component RMS placement errors averaged 1.18 mm/2.14° along any single axis.

*Conclusion:* Using traditional manual instruments, Cobb et al. found average RMS errors of 2.20mm/5.48°. and 1.11 mm/2.5° using the robotic approach with bones fixed. This is directly comparable to our results with bones moving freely during surgery. Varus/valgus femoral component alignment and posterior tilt of the tibial component are within the accepted range to prevent excessive edge loading. Our results suggest excellent UKA implant placement accuracy can be achieved, comparable to that demonstrated for statically referenced tactile robotics.

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## 57] HOW MANY TKA PATIENTS COULD BE TREATED WITH EARLY INTERVENTION PROCEDURES?

Michael A. Conditt (MAKO Surgical Corp.), Stefan Kreuzer (Memorial Bone and Joint Research Foundation), Jess H. Lonner (Philadelphia Center for Minimally Invasive Knee Surgery), Kevin J. Leffers (Memorial Bone and Joint Research Foundation)

*Introduction:* The rationale behind bicompartamental (bicomp) arthroplasty is that many patients who undergo TKA have isolated bicomp arthritis involving only 2 compartments of the knee and have no significant deformity, excellent ROM, and intact cruciate ligaments. This study evaluates the radiographic and early clinical results of bicomp arthroplasty with modular components implanted with robotic-arm guidance. We also retrospectively reviewed TKA cases to examine the applicability procedure.

*Methods:* 30 consecutive modular bicomp knee arthroplasties were performed using robotic guidance. Clinical and functional data were collected pre-op and at 2, 6, 12 weeks and 1 year. We retrospectively reviewed intraop notes from 406 consecutive TKA patients from a single surgeon which included the integrity of the 3 compartments and ACL.

*Results:* At f/u, SF-12 PCS increased from 32.6 (preop) to 44.6 ( $p=0.05$ ); WOMAC pain, function, and total score decreased from 11.0 to 2.8 ( $p=0.0001$ ), 13.6 to 3.2 ( $p=0.0008$ ), and 24.6 to 6.0 ( $p=0.0001$ ) respectively; ROM increased from 122° to 138° ( $p=0.0001$ ); KS function and knee score increased from 55.9 to 78 ( $p=0.03$ ) and 40.1 to 92.4 ( $p=0.0001$ ) respectively. There was no radiographic evidence of loosening, polyethylene wear or progressive lateral compartment arthritis. There were no complications in the peri-op period. In the review of 406 TKA cases, the ACL was

intact in 66% of cases. 16% of these TKA patients were indicated for a unicompartmental arthroplasty and 31% were indicated for bicomp arthroplasty.

*Conclusion:* Modular bicomp arthroplasty is an effective method for treating OA of the knee restricted to the medial and PF compartments. Our data indicates that many TKA patients have healthy cruciates and disease in only 2 of 3 compartments, indicating that TKA is an overtreatment of earlier stage OA. Longer term studies will determine the clinical significance of preserving healthy cartilage and ligaments routinely removed with traditional TKA.

## 58] ERGONOMICS OF ROBOTIC ORTHOPEDIC SURGERY: A PROGRAM TO SIMULTANEOUSLY IMPROVE OPERATING ROOM EFFICIENCY AND QUALITY OF CARE

Michael A. Conditt (MAKO Surgical Corp.), Mike Ballash (MAKO Surgical Corp.), Sharon H. Branch (MAKO Surgical Corp.), Carinne Granchi (MAKO Surgical Corp.)

*Background:* Orthopedic surgery in the US is facing an imminent logjam due to the increasing divergence of the demand for services and the ability to supply those services. These factors may leave the system overtaxed and the patients suffering from either a lack of treatment, or treatment by less qualified providers. Enabling technologies must be introduced that can effectively increase the throughput while improving the quality of care. One such enabling technology is robotics, which has recently been introduced in orthopedic surgery. A surgeon interactive robotic arm has been developed for partial knee arthroplasty (PKA) and total hip arthroplasty (THA).



*Objectives:* The purpose of this study was to determine efficiency for a robotic-arm approach to PKA.

*Methods:* Data for operating room skin-to-skin time was recorded for 8,656 robotically guided PKA procedures spanning across 208 surgeons and 86 hospitals. The data was analyzed to produce a learning curve for each surgeon defined as the number of cases the surgeon performed before reaching a unique steady state time.

*Results:* The average skin-to-skin time across all cases was  $83 \pm 26$  minutes (range: 28 – 214 minutes). Across all surgeons, the average learning curve was 14 cases. Five sites were identified as the most efficient based on skin-to-skin time and average surgeon learning curve. These five sites exhibited an average skin-to-skin time of 68 minutes. The five lowest efficiency sites exhibited an average skin-to-skin time of 109 minutes.

*Conclusion:* Our data indicate that there are contributing factors to the efficiency of robotically guided PKA. Frequency of procedures, differences in workflow, and use of task overlap can all affect overall efficiency. By studying the most efficient sites we plan to extract generalizable concepts of efficiency that can be implemented at less efficient sites to measure their effectiveness at improving surgical efficiency over time.

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## 59] HAPTIC ROBOTIC-ARM ASSISTED SURGERY SUBSTANTIALLY IMPROVES ACCURACY OF WIDE RESECTION OF BONE TUMORS

Michael A. Conditt (MAKO Surgical Corp.), Fazel A. Khan (Memorial Sloan Kettering Cancer Center), Andrew Pearle (Hospital for Special Surgery), Patrick Boland (Memorial

Sloan Kettering Cancer Center), Joseph Lipman (Hospital for Special Surgery), John Healey (Hospital for Special Surgery)

*Background:* Accurate reproduction of the pre-op plan is critically important during wide resection of primary bone tumors. Existing intraop strategies utilize rudimentary devices and imprecise techniques which can poorly reproduce a pre-op plan. As a result, tumor margins or healthy tissue may be compromised. We developed a novel technique of haptic robotic-arm assisted surgery to remove primary bone sarcomas, not approved by the FDA.

*Objectives:* We hypothesized this technique more accurately reproduces a pre-op resection plan than the standard, 'manual' technique.

*Methods:* A joint-sparing hemimetaphyseal resection was planned on 3D reconstructed images of 6 pairs of identical sawbone femurs. A tumor fellowship-trained surgeon performed the indicated resection using the standard manual technique on one specimen of each pair and using the robot-assisted technique on the other. Both techniques used a surgeon controlled oscillating saw to make the resections. The robotic technique utilizes a robotic-arm attached to the saw to prevent the surgeon from straying from the pre-defined planes of resection. A pre- and post-resection laser scan were performed on all specimens to determine the accuracy of the resections with respect to the preop plan.

*Results:* The robotic-arm assisted technique was significantly more accurate in terms of the maximum deviation from the pre-op plan for each specimen than the traditional manual technique ( $p=0.001$ ). The mean improvement in accuracy of the robotic technique over the manual technique for each specimen pair was 4.50 mm (range 1.4 to 10.6 mm). The percentage of times the maximum deviation was (i) greater than 3 mm and (ii) greater greater

than 5 mm was 100% and 40% for the manual group and 0.0% and 0.0% for the robotic group, respectively.

*Conclusion:* The findings indicate this technology has the potential to be of benefit in primary bone tumor resection. Further studies are warranted to evaluate this technology in patients.

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## 60] ACCURACY OF ROBOTIC ASSISTED FEMORAL OSTEOCHONDROPLASTY FOR TREATMENT OF FAI

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Michael A. Conditt (MAKO Surgical Corp.), Anil Ranawat (Hospital for Special Surgery), Hyosig Kang (MAKO Surgical Corp.), Snehal Kasodekar (MAKO Surgical Corp.), Scott Nortman (MAKO Surgical Corp.), Jennifer A. Jones (MAKO Surgical Corp.)

*Introduction:* Symptomatic hip disorders associated with cam deformities are routinely treated with surgical resection in an effort to restore joint ROM, reduce pain, and protect the joint from further DJD. This is a technically demanding procedure and the amount of correction is potentially critical to the success of the procedure: under-resection could lead to continued progression of the osteoarthritis (OA) disease process in the joint, while over-resection puts the joint at risk for fracture.

*Objectives:* This study compares the accuracy of a new robotic-arm assisted technique to a standard open technique.

*Methods:* 16 identical sawbone models with a cam type impingement deformity were resected by a single surgeon (AR) simulating an open procedure. An ideal final resected shape was the surgical goal in all cases. 8 procedures were performed manually using a free-hand technique and 8 were performed using robotic

assistance that created a 3D haptic volume defined by the desired post-op morphology. All 16 sawbones and an additional identical uncut sawbone were laser scanned. Post-resection measurements taken included arc of resection, volume of bone removed and resection depth and were compared to the pre-op plan.

*Results:* The desired arc of resection was  $117.7^\circ$  starting at  $-1.8^\circ$  and ending at  $115.9^\circ$ . Manual resection resulted in an average arc of resection error of  $42.0 \pm 8.5^\circ$  with an average start error of  $-18.1 \pm 5.6^\circ$  and end error of  $23.9 \pm 9.9^\circ$  compared to a robotic arc of resection error of  $1.2 \pm 0.7^\circ$  (p

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## 61] DEEP FLEXION KINEMATICS WITH ROBOTIC MODULAR KNEE ARTHROPLASTY

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Michael A. Conditt (MAKO Surgical Corp.), Toshifumi Watanabe (University of Florida), Stefan Kreuzer (Memorial Bone and Joint Research Foundation), Kevin Leffers (Memorial Bone and Joint Research Foundation), Jennifer A. Jones (MAKO Surgical Corp.), Scott A. Banks (University of Florida)

*Introduction:* In knee arthroplasty, several studies have shown that sparing soft tissue, particularly the ACL, will allow a patient to retain kinematic function that more closely relates to normal function versus those with cruciate substituting implants. Multi-compartment modular knee replacement has a long history of favorable outcomes.

*Objectives:* This study analyzed the kinematics of a series of patients that underwent robotic-arm guided knee arthroplasty with a modular implant system where both cruciate ligaments were preserved in a uni- or multi-compartment knee arthroplasty. No prior study has analyzed kinematics with modular knee arthroplasty.



*Methods:* We analyzed 15 osteoarthritic knees that underwent robotic-arm guided knee arthroplasty with modular implant components. All surgeries were performed by one surgeon (SWK). The average age of the patients at time of surgery was 62 years at a follow-up of  $13\pm 3$  months. Patients performed daily living activities (lunge and kneel) under fluoroscope. Three dimensional kinematics were assessed from single plane fluoroscopic images using a proven technique, Banks et al, 1996.

*Results:* The average maximum flexion angles observed during kneeling was  $123\pm 11$  degrees and  $115\pm 11$  during lunging. The mean tibial external rotation observed during kneeling was  $16\pm 8$  degrees and  $17\pm 7$  degrees during lunging. Mean lateral rollback, or posterior AP translation, observed during kneeling was  $18\pm 10$ mm and  $17\pm 10$ mm during lunging. The medial condyle remains relatively fixed during these motions with observed AP translations of  $2\pm 6$ mm in kneeling and  $0\pm 6$ mm in lunging. Patients showed improvement in average KSS knee and function scores:  $106\pm 27$  preop to  $170\pm 27$  postop.

*Conclusion:* The observed deep flexion kinematics related more closely to normal knee kinematics than previously published results for TKA. It was observed that robotic-arm assisted modular knee arthroplasty was indicated to replicate normal knee kinematics in deep flexion.

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### **63] CALCULATING THE POSITION OF THE JOINT LINE OF THE KNEE IN RELATIONSHIP TO ANATOMIC LANDMARKS**

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Derek Amanatullah (UC-Davis), Mike Alaia (NYU), Kenneth Montini (PENN), Matthew Lopez (UC-Davis), Paul Di Ceasre (UC-Davis), Gavin Pereira (UC-Davis)

*Background:* Restoration of the joint line of the knee during TKA is one of many critical steps that directly influence patient outcomes.

*Objective:* The purpose of this study was to determine a quantitative relationship between the joint line of the knee and several anatomic landmarks about the knee. These included the femoral epicondyles, femoral metaphyseal flares, proximal tibio-fibular joint (PTFJ), tibial tubercle, and medial and lateral malleoli.

*Methods:* Fifty MRI scans were analyzed to determine a quantitative relationship between the joint line of the knee and several bony landmarks of the knee joint especially looking at the relationship between the femoral and tibial dimensions. Absolute distances of these anatomic landmarks to the joint line of the knee were highly variable due to patient size and gender; hence, the ratios of these distances of the joint line of the knee were normalized to the respective bony diameters. The spatial relationship of the joint line of the knee to the femur and tibia was made by calculating ratios across the joint line.

*Results:* The distance of the lateral epicondyle to the joint line of the knee was about one-third the interepicondylar diameter and the distance of the lateral flare of the femur to the joint line of the knee was one-half the interflare 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 and the distance of the PTFJ to the joint line of the knee was one-third the diameter of the tibia in the coronal plane at the level of the PTFJ. The joint line of the knee was halfway between the lateral epicondyle and PTFJ in the coronal plane.

*Conclusions:* Results from this study validate previously quoted absolute distances and ratios while at the same time introduce anatomic ratios between femoral and tibial dimensions that will serve as valuable tools during TKA.



#### **64] IDENTIFICATION OF THE LANDMARK REGISTRATION SAFE ZONES DURING TOTAL KNEE ARTHROPLASTY USING AN IMAGELESS NAVIGATION SYSTEM**

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 Derek Amanatullah (UC-Davis), Paul Di Ceasre (UC-Davis), Patrick Meere (NYU), Gavin Periera (UC-Davis)

*Background:* Incorrect registration during computer assisted total knee arthroplasty (CA-TKA) leads to malposition of implants.

*Objective:* Our aim was to evaluate the tolerable error in anatomic landmark registration.

*Methods:* Each anatomic landmark on the tibia and femur were deliberately registered incorrectly, while keeping the remaining default landmarks correctly registered. Incorrect registration of each anatomic landmark was done at 2 mm intervals up to a total 16 mm in four directions (anterior, posterior, superior, and inferior for the malleoli or epicondyles; anterior, posterior, medial, and lateral for the tibial and femoral center). For each incorrectly registered point, the change in the varus/valgus angulation, flexion/extension, or rotation of the cutting block from the reference position was recorded.

*Results:* Incorrect registration of either the medial or lateral malleolus in the superior or inferior direction by up to 16 mm had no change in varus/valgus angulation but in the anterior or posterior direction 10 mm or more resulted in a 1° change in posterior tibial slope. Incorrect registration of the tibial center in the medial/lateral or superior/inferior direction by 6 mm or more resulted in a 1° change in varus/valgus or posterior tibial slope. Incorrect registration of either the medial or lateral epicondyles in the superior or inferior direction by up to 16 mm had no change in varus/valgus angulation but in the anterior or posterior

direction 2 mm or more resulted in a 1° change in internal/external rotation. Incorrect registration of the femoral center in the medial/lateral or superior/inferior direction by 6 mm or more resulted in a 1° change in varus/valgus or flexion/extension.

*Conclusions:* We found that the distal femoral epicondyles were the most sensitive anatomic landmarks to register. The other bony landmarks were more forgiving. Our observations may explain the inability of CA-TKA to improve upon the outcomes of conventional TKA.

#### **65] CLOUD BASED PREOPERATIVE PLANNING FOR TOTAL HIP ARTHROPLASTY: A STUDY OF ACCURACY, EFFICIENCY AND COMPLIANCE**

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 Joseph D. Maratt (University of Michigan Health System), Ramesh Srinivasan (University of Michigan Health System), William Dahl (University of Michigan Health System), Peter Schilling (University of Michigan Health System), Andrew G. Urquhart (University of Michigan Health System)

*Background:* Preoperative templating facilitates precise, efficient and reproducible total hip arthroplasty. Templating can help prevent the use of incorrect sized hip implants avoiding intraoperative and postoperative complications. Studies have established the utility of preoperative templating using an onlay technique with acetate x-rays. With the advent of digital x-rays, digital templating is now possible. Cloud computing is a new paradigm in web based software and storage that vastly improves access and availability of complex software.

*Objectives:* The purpose of our study was to evaluate the accuracy and efficiency of a cloud based digital templating system.



*Methods:* A retrospective review of 20 primary THAs performed under the direction of one surgeon was performed. Using a standard low-set AP view of the pelvis and templating technique, three surgeons templated cases with the cloud-based system and with acetate templates. Interrater reliability and accuracy of templating by both methods were recorded. The time required to template by both methods were also recorded and compared with pooled t-tests.

*Results:* Digital templating on average underestimated the acetabular component by 1.83 sizes ( $p < 0.0001$ ) and stem by 0.93 sizes ( $p < 0.0001$ ). Acetate templating on average underestimated the acetabular component by 2.57 sizes ( $p < 0.0001$ ) and the stem by 0.52 sizes ( $p < 0.0001$ ). Acetate templating on average took 2.04 times longer (mean = 140 seconds,  $p < 0.0001$ ) than digital templating.

*Conclusion:* Preoperative planning for THA with cloud-based digital templating is comparable to acetate templating in accuracy but offers the additional benefits of efficiency, cost savings, and workflow improvement. Cloud-based medical software can be safely implemented in compliance with federal privacy and security regulations. However, individual physicians and institutions should be judicious consumers of nascent technology with potential security and privacy pitfalls.

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## 66] ACCURACY OF A FIXED VERSUS ADJUSTABLE EXTRAMEDULLARY TIBIAL CUTTING GUIDE

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Asit K. Shah (Englewood Orthopedic Associates)

*Background:* In total knee arthroplasty, correct tibial alignment is critical to restoring normal function. It is generally accepted that in the

coronal plane, the implant should be aligned at  $90^\circ \pm 2^\circ$  varus/valgus to the mechanical axis of the tibia.

*Objective:* The purpose of this study was to compare resulting tibial component alignment and posterior slope using 2 different types of EM tibial guides for TKA: one guide with both ML and AP adjustability and a second fixed in both planes.

*Method:* We retrospectively reviewed 202 TKAs performed by a single surgeon. Each TKA was classified based on use of either an adjustable or fixed TCG. Using A/P and lateral x-rays, pre-op and post-op alignment was recorded. Each TKA was evaluated against optimal alignment of  $90^\circ$  to the tibial mechanical axis. The posterior slope was evaluated against an operative target of either  $3^\circ$  or  $6^\circ$ .

*Results:* There was no significant difference in the coronal alignment between the two groups. The mean alignment, using the fixed TCG, was closer to  $90^\circ$  ( $89.74^\circ$  vs.  $89.65^\circ$ ) and the standard deviation, lower ( $0.67$  vs.  $0.94$ ), suggesting the fixed TCG provided more consistent results. More important, 3 knees fell outside the optimal range of  $\pm 2^\circ$  using the adjustable TCG. The fixed TCG performed better for posterior slope. The standard deviation from the mean was lower for the fixed group and 95.05% of the knees fell within the target range of  $\pm 1^\circ$ , while only 84.16% of the adjustable group fell within the target range.

*Conclusion:* Proper alignment of the tibial component is critical in TKA. Numerous publications seek to compare the results of various methods of achieving optimal tibial alignment. While it is often presumed that making TCG's adjustable allows manipulation for higher levels of precision, our study suggests that the opposite may be true. The fixed position TCG provided better alignment results

than the adjustable guide, for similar patient populations operated by a single surgeon.

## 68] THE FIRST 1,000 SHORT CURVED NECK SPARING STEMS –CLINICAL SURGICAL OBSERVATIONS.

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 Timothy McTighe (Joint Implant Surgery & Research Foundation), Louis Keppler (St. Vincent Charity Medical Center), John Keggi (Orthopaedics New England), Tony Aram (Advanced Orthopaedics & Sports Medicine), Charles Bryant (Integrus Orthopaedics North), Corey Ponder (Oklahoma Sports Institute), Frank Schmidt (Northern Wyoming Surgical Center), Bradley K. Vaughn (Raleigh Orthopaedic Clinic) Ed McPherson, (Joint Implant Surgery & Research Foundation & L.A. Orthopaedic Institute) TSI™ Study Group (Joint Implant Surgery & Research Foundation)

*Introduction:* Architectural changes occurring in the proximal femur after THA continues to be a problem. Proximal stress shielding occurs regardless of fixation method. The resultant bone loss can lead to implant loosening and or breakage of the implant. We are seeing younger patients with higher levels of physical activity as compared to just a decade ago. A tissue sparing total hip stem provides for less tissue damage, a quicker rehab and leaves behind more infrastructure in case of future revision surgery.

Patients today demand more out of the hip reconstruction and their increase activity places a higher demand on the implant. A number of the current short stems introduced into the market are no more than standard stems cut short. There is concern with the increase in younger and more active patients that these modified short stems be adequate to resist the increased biomechanical loads placed on them?

The purpose of this paper is to review the first 1,000 implanted stems as to early clinical observations.

*Material:* There have been 1000 stems implanted with this novel neck sparing stem design since April 2010 to January 2012 with 700 from the primary surgical team. All seven were part of the initial surgical team to aid in designing and fine-tuning of surgical instruments. Typical patient profile showed two-thirds being female with an age range overall between 17 to early 90s. 90% were treated for OA. This stem has been used in all Dorr bone classifications (A, B, &C). Two surgical approaches were utilized the single anterior incision and standard posterior incision.

### *Results:* Anterior Approach

Dislocations = 2  
 Stem Revisions = 5  
 Aseptic Loosening = 2  
 Superficial Infection = 2  
 Septic Loosening = 1  
 Leg / Length Discrepancy +/- 7 mm = 9  
 Occult fracture distal end of stem = 1  
 Calcar Fractures wired = 2  
 Calcar Fractures not wired = 3  
 Hip pain = 2  
 Subsidence > 5mm = 5  
 Intra-op femoral perforation = 3  
 Intra-op calcar fractures resulting in stem bailout = 2  
 Posterior Approach  
 Dislocations = 2  
 Stem Revisions = 1  
 Aseptic Loosening = 0  
 Septic Loosening = 1  
 Superficial Infection = 0  
 Leg / length Discrepancy +/- 7 mm = 3  
 Fractures distal = 0  
 Calcar Cracks wired = 0  
 Calcar Cracks not wired = 3  
 Hip pain = 1 (process of being worked up/  
 potential spine problem)



Subsidence > 5mm = 0  
Intra-op calcar fractures resulting in stem  
bailout = 3

*Discussion:* There is a short learning curve for the surgeon (2-3 cases) and an easy transition for the O.R. surgical team with only one pan of instruments.

Six of the seven surgeons feel that these patients with this short curved neck-sparing stem have gotten back to full weight bearing and a full active life style quicker than their conventional cementless THA. One surgeon gauges them as equivalent to his conventional stems. All feel that there is less blood loss and operative times have been reduced.

The few explants have proven to be easily converted to a primary stem for revisions. Five intra-operative calcar fractures resulted in a bail out to a conventional primary cementless stem. The modular neck has proven to be beneficial in a couple of cases for access to the socket in revision situations. The modularity of the neck also helps reducing risk of mechanical impingement.

There have been minor incidence of over lengthening the leg (12) greater than 7 mm however; none have had to be revised. We are encouraged with our initial clinical / surgical observations (patients are happy) and believe the potential and real benefits warrant not only further evaluation but expanded evaluation of this tissue conserving approach to THA.

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## 69] ARTHROSCOPIC TREATMENT OF PATELLAR CREPITUS IN TOTAL KNEE ARTHROPLASTY

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Raymond H. Kim (Colorado Joint Replacement),  
Brian K. Daines (Colorado Joint Replacement)  
Steve Arbour (Colorado Joint Replacement)

Douglas A. Dennis (Colorado Joint Replacement)

*Introduction:* Post-operative peripatellar fibrous tissue scar formation has been reported in posterior stabilized total knee arthroplasties.<sup>1-5</sup> The purpose of this retrospective study is to provide an in-depth and consistent analysis of the effectiveness of arthroscopic synovectomy on the treatment of patellar crepitus in post-TKA patients.

*Methods:* This series is a 12 month minimum follow-up of a cohort of patients treated with arthroscopic synovectomy for symptomatic patellar crepitus at a single institution. Chart review identified 31 knees in 30 individuals with symptomatic patellar crepitus. Under direct visualization, the peripatellar hyperplastic synovium was removed using arthroscopic anterolateral and superolateral portals. Data collected included demographic information, date of operations and follow-up, pre- and post-operative range of motion, component information, radiographic measurements of variables deemed significant in the development of patellar crepitus<sup>2</sup>, and pre- and post-operative Knee Society and Function Scores.

*Results:* The average time to presentation post TKA was 9.53 months (range 3-26) and the average clinical follow up after the arthroscopic synovectomy was 24.07 months (range 0-103.1). Out of 31 cases, 26 (83.9%) reported complete resolution of symptoms. Three reported return of crepitus, which was painless and did not warrant further treatment. Two reported return of symptomatic crepitus. One patient developed recurrent painful crepitus, but did not desire further treatment. The other patient underwent a second synovectomy with complete resolution of symptoms. Defining failure as recurrence of painful crepitus after surgical treatment, arthroscopic synovectomy resulted in a 93.5% success rate.



*Discussion and Conclusion:* Arthroscopic synovectomy demonstrated a 93.5% success rate in the treatment of symptomatic patellar crepitus in TKA.

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## **70] EARLY CLINICAL RESULTS OF MOBILE-BEARING REVISION TOTAL KNEE ARTHROPLASTY**

Raymond H. Kim (Colorado Joint Replacement), Brian K. Daines (Colorado Joint Replacement), Charlie C. Yang (Colorado Joint Replacement), Douglas A. Dennis (Colorado Joint Replacement)

*Introduction:* Common failure modes of revision total knee arthroplasty (TKA) include aseptic component loosening and damage to constraining mechanisms which are often required in revision TKA. Mobile-bearing (MB) revision TKA components have been developed in hopes of lessening these failure mechanisms. Our objective was to evaluate the early clinical outcomes for the use of MB in revision TKA with a minimum 2-year follow-up and to evaluate bearing complications.

*Methods:* Retrospective clinical and radiographic evaluation of 84 MB revision TKAs with minimum 2-year follow-up was performed. Revision TKAs were performed using PFC Sigma and LCS revision rotating platform implants (Depuy, Warsaw, IN). Indications for revision include aseptic loosening (31 knees), instability (30 knees), failed unicompartmental knee replacement (8 knees), infection reimplantation (7 knees), arthrofibrosis (3 knees), chronic hemarthrosis (3 knees), failed patellofemoral replacements (1 knees), and nonunion of a supracondylar femur fracture (1 knee).

*Results:* At a mean follow-up of 3.7 years, the average Knee Society clinical and function

scores had increased from 50.3 points preoperatively to 89.1 points and from 49.3 points to 80.1 points, respectively. Average motion improved from 99.8° preoperatively to 116.5° postoperatively. Radiographic review demonstrated excellent fixation with no evidence of component loosening upon latest follow-up. No cases of bearing instability were observed.

*Conclusion:* This evaluation of 84 MB revision TKAs has demonstrated favorable early results at a mean follow-up of 3.7 years with no occurrence of bearing instability. Longer follow-up is required to evaluate for potential advantages of reducing polyethylene wear, lessening fixation stresses, and protection of constraining mechanisms.

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## **71] A NOVEL ASEPTIC PROTOCOL DECREASES SURGICAL SITE INFECTIONS AFTER TOTAL AND REVISION HIP ARTHROPLASTY**

Gaurav Luther (University of Chicago), Melinda Stack (University of Chicago), David Manning, MD (University of Chicago)

*Background:* Surgical site infections (SSI) are devastating complications of total and revision hip arthroplasty. Previous studies have shown the following risk factors contribute to higher incidence of SSI; (1) ASA class > 3, (2) BMI > 30, (3) revision arthroplasty, (4) renal insufficiency, and (5) immunodeficiency. In a high risk patient population, we predicted that a novel aseptic protocol, which involves a 3 phase antiseptic scrub (4% chlorhexidine-gluconate, 70% isopropyl alcohol, 10% topical povidone iodine) and pre-operative treatment with vancomycin and cefazolin, would significantly lower the risk of SSI.



*Methods:* A single surgeon case series for patients who underwent hip arthroplasty from 2005 to 2010. We documented all pre-operative infectious risk factors as mentioned above. All patients received the three phase antiseptic scrub and peri-operative vancomycin and cefazolin, and had one year minimum follow-up. SSI was defined by return to the OR and positive culture within 90 days. All patient information was blinded and three independent reviewers recorded data.

*Results:* We found our patient population to be significantly higher risk than populations in previously published studies ( $p < 0.04$ ). 70% of patients were ASA Class  $> 3$ , 45% had a BMI  $> 30$ , and 50% had at least three independent risk factors for infection. We found a 0.4% (2 / 467 patients) SSI rate using our aseptic protocol, which is among the lowest in current literature ( $p < 0.05$ ). Infections in the two patients occurred with atypical, non-skin flora organisms (*Pseudomonas* and *Enterobacter*), and both patients demonstrated successful retention of the implant with osseous integration of femoral and acetabular components at greater than two years follow-up. No patients were lost to follow up.

*Conclusion:* In a high risk patient population, our novel aseptic protocol results in a 0.4% SSI rate in total and revision hip arthroplasty, which is amongst the lowest in reported literature.

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## 71] PREDICTING ERRORS IN OFFSET TEMPLATING FOR TOTAL HIP ARTHROPLASTY

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H. Del Schutte (Medical University of South Carolina), William R. Barfield (Medical University of South Carolina), Jeffrey Conrad (The Orthopaedic Group, Mobile, AL), Neil Romero (Louisiana Orthopaedic Specialists, Lafayette, LA), Tomothy McTighe (Joint Implant

Surgery and Research Foundation, Chagrin Falls, OH)

*Background:* Numerous authors have attempted to assess femoral offset at the hip in vitro and in vivo with plane radiographs, special positioning devices, and modern imaging techniques including cross-sectional computed tomography. Each method demonstrated measurement error.

*Methods:* The goal of our study was to assess the role that rotation of the femur plays in changing the magnitude of femoral offset measured in a cadaver femur model. We hypothesized that traditional AP radiographs taken in neutral, 20 degrees of internal rotation, and 20 degrees of external rotation would alter femoral offset distance. Offset was measured as the horizontal distance between the center of the femoral head and the proximal border of the greater trochanter in millimeters by four senior level orthopaedic residents and three orthopaedic surgery faculty members.

*Results:* The general linear model results of our study supported our hypothesis with statistically significant differences among each position. Interaction was demonstrated between raters and femur positioning indicating there were differences between internal rotation and neutral positioning for some raters, but not for all when a comparison was made between internal rotation and neutral. External rotation was significantly different from internal rotation and neutral among all raters.

*Conclusions:* Findings from this study provides evidence that femoral rotation affects radiographic assessment of femoral offset. These findings may guide clinicians in preoperative planning.

*Level of Evidence:* Level II

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**72] DISSOLVABLE ANTIBIOTIC BEADS IN TREATMENT OF PERIPROSTHETIC JOINT INFECTION - THE USE OF COMMERCIALY PURE CALCIUM SULFATE (STIMULAN™) IMPREGNATED WITH VANCOMYCIN & TOBRAMYCIN**

Edward J. McPherson (LA Orthopedic Institute)

*Introduction:* Periprosthetic infection is a devastating problem that incurs a significant financial burden to health care systems. Treatment regimens to prevent and to treat periprosthetic infection focus to reduce morbidity and mortality associated with this problem.

*Purpose:* This study overviews the initial follow-up with the use of commercially pure dissolvable calcium sulfate antibiotic impregnated beads in its application in treating periprosthetic infection. We review outcomes and complications and compare our findings to historical controls with processed calcium sulfate derived from gypsum product.

*Methods:* From January 2010 to January 2012 a series of 562 total joint arthroplasty procedures were performed. In 183 cases, commercially pure dissolvable Calcium Sulfate beads impregnated with antibiotics (Stimulan Biocom UK) were employed. The application of dissolvable antibiotic beads was divided into 4 main categories:

Knee Arthroplasty

- Prophylactic Use in TKA in patients at risk for infection (MSIS - Musculoskeletal Infection Society - America Medical Grade B & C hosts)
- Therapeutic Treatment in DECRA (Debridement, Exchange, Component Retentive & Antibiotics) Procedures
- Therapeutic Treatment in Resection Arthroplasty

- Therapeutic Treatment in Reimplantation Arthroplasty

Hip Arthroplasty

- Prophylactic Use in THA in patients at risk for infection (MSIS - Musculoskeletal Infection Society - America Medical Grade B & C hosts)
- Therapeutic Treatment in DECRA (Debridement, Exchange, Component Retentive & Antibiotics) Procedures
- Therapeutic Treatment in Resection Arthroplasty
- Therapeutic Treatment in Reimplantation Arthroplasty

The dosage of antibiotics used in this series consisted of the following:

- 10cc of Calcium Sulfate
- 1gm of Vancomycin Powder
- 240mg of Tobramycin liquid (80mg/cc)

*Results:* The incidence of wound drainage in all groups was low. There were two knee cases requiring irrigation & debridement surgery in the perioperative period. There were two hip cases requiring irrigation & debridement surgery in the perioperative period. In three cases, heterotopic bone formation was noted (1 knee case, 2 hip cases). Heterotopic ossification was seen in cases where a large volume of Stimulan was used (≥ 40cc volume). The heterotopic bone was considered mild, being rated Brooker I-II class.

Data review indicated an overall complication rate of 11.6% and a failure rate of 2.8%. Of the 5 failures observed, 4 were as a result of infection.

*Summary:* The use of pure synthetic calcium sulfate (at physiologic pH 7.4) loaded with antibiotics is an adjuvant treatment tool for total joint infection that clinically has a low post



operative wound drainage rate, and a low rate of heterotopic bone formation. This synthetic crystal construct is hydrophilic, and slowly dissolves on radiographs after two to three weeks. In contrast, prior calcium sulfate products derived from processed gypsum have shown significant problems with wound healing and wound drainage<sup>1, 2</sup>. The Stimulan-antibiotic construct is adaptable, whereby various antibiotic formulas can be utilized (Cooper et al, OBIC 2012, Poster 0004). Furthermore, this localized antibiotic delivery method is relatively inexpensive and it obviates the need for a second surgery (i.e. removal of pmma antibiotic beads). Initial observations with Stimulan antibiotic beads are encouraging. The next two phases of research are to measure local antibiotic levels in-vivo and to treat periprosthetic infections with Stimulan antibiotic beads alone without intravenous antibiotic therapy.

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1. G. H. Lee, J. G. Khoury, J. E. Bell, and J. A. Buckwalter, 'Adverse Reactions to Osteoseal Bone Graft Substitute, the Incidence in a Consecutive Series', *Iowa Orthop J*, 22 (2002), 35-8.
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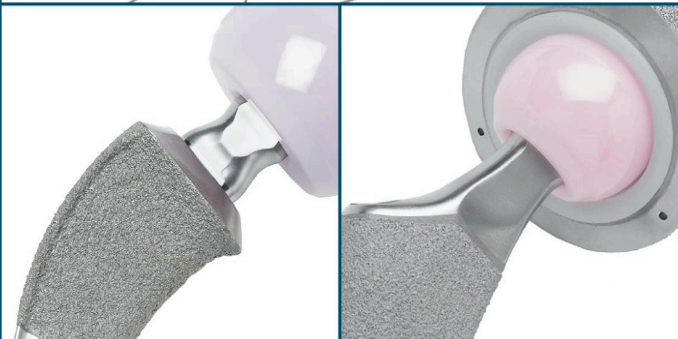
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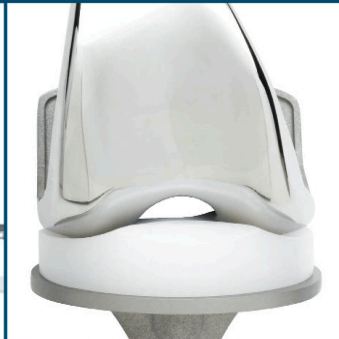
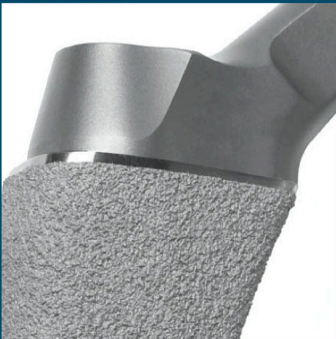
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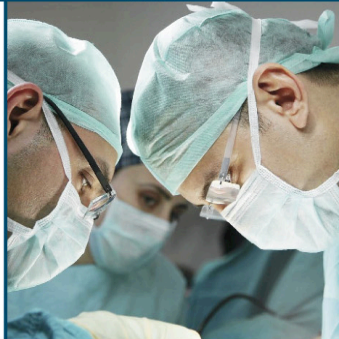
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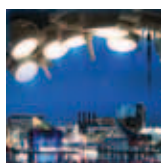
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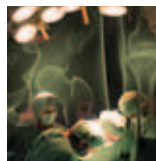
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