

# Reconstructive REVIEW

## ABSTRACT SUPPLEMENT:

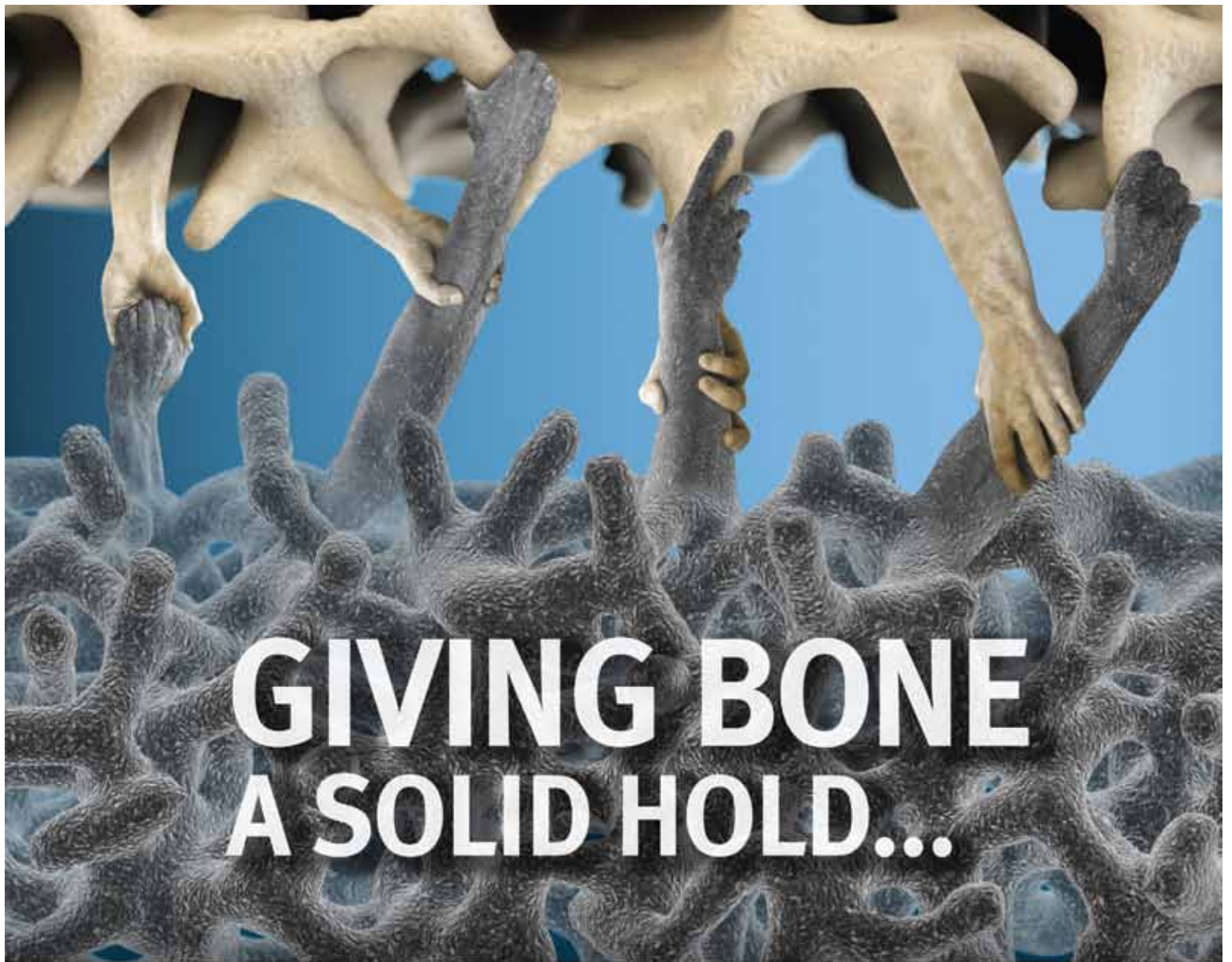
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# Reconstructive Review

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- Importance of topic/originality
- Purpose clearly stated
- Methods defined
- Results adequately described
- Conclusion supports results



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Research grants, charitable contributions and revenue from our general fund support the IRB's work.



## The 5-Year Results of Tantalum Cones for Severe Bone Loss in Revision Total Knee Arthroplasty

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We report the 5-year results of 26 porous tantalum cones (“Trabecular Metal Cone,” Zimmer Inc., Warsaw, IN) implanted for severe femoral and/or tibial bone loss in 18 patients (12 women and six men) during revision TKA. Patients had an average age of 73 years at the time of the procedure. In this series, patients had a mean of 2.5 prior total knee arthroplasties. According to the Anderson Orthopaedic Research Institute (AORI) bone defect classification, all femoral and tibial defects were rated 2B and 3. A femoral cone was inserted in six patients, a tibial cone was inserted in five, a double cone in five (femoral and tibial) (Fig.1), and a triple cone in one (one femoral and two tibial). Twenty-four cones were impacted and two were cemented. Five patients were



Fig.1

revised for aseptic loosening and 13 for infection. A two-stage procedure was used in all septic cases. A constrained condylar implant (LCKK, Zimmer, Warsaw) was inserted in six patients and a rotating hinge knee implants (RHK, Zimmer, Warsaw) in 12. The diaphysis was cemented in three cases and the metaphysis in 15. Offset stems were used in half of cases. The average preoperative Knee Society Score improved from 31 to 76 at 5 years follow-up. Radiological follow-up revealed no evidence of loosening and implant migration. All the radiographs showed good osteo-integration after 1 year. There were two cases of recurrent infection. In both cases, cones were noted to be well fixed to the bone at the time of explant. This study reveals a low infection rate (11%). Our excellent clinical and radiological results indicate that metaphyseal tantalum cones represent a valid option in revision total knee with severe bone defects.

## Is Knee Arthrodesis an Effective Treatment for a Failed Infected Revision TKA?

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**INTRODUCTION:** Infection after revision total knee arthroplasty (R-TKA) for previous septic TKA can be a challenging problem to treat due to loss of bone stock and soft tissue integrity. In these cases, arthrodesis is a well-recognized salvage procedure. The aim of this retrospective study was to compare the results of knee arthrodesis performed by using either an external fixator (EF) or an intramedullary (IM) nail.

**METHODS:** The study included 34 knee arthrodesis divided in two groups: First group included 12 patients treated with EF; second group of 22 patients

dealt with IM nail. Clinical and functional evaluation was performed using the Visual Analogue Scale (VAS) and the Lequesne Algofunctional Score (LAS). Full-length radiographs were used to verify limb-length discrepancy.

**RESULTS:** VAS and LAS results showed a substantial improvement relative to preoperative condition in both groups. However, the LAS was significantly better in the IM nail group. The mean leg-length discrepancy was significantly greater (4.5 cm) in the first group than in the second one (0.8 cm). No recurrence of infection was observed in the EF group, while there were three recurrent infections in the IM nail group.

**CONCLUSIONS:** Our study supported the existing literature and found that reinfection after R-TKA can be effectively treated with arthrodesis. In presence of massive bone loss, we recommend arthrodesis with IM nail used as endoprosthesis, without bone-on-bone fusion, to produce a stable and painless knee, while preserving the limb length. IM nail allowed us to get a better functional result than EF.

## The Adductor Tubercle is a Reliable Landmark to Determine Joint Line in Total Knee Arthroplasty

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**INTRODUCTION:** Joint line position in primary and revision total knee arthroplasty (TKA) is important to achieve stability, reduce anterior knee pain, and restore motion. The assessment of the femoro-tibial joint line is, both on the X-rays and intraoperatively, still controversial. The ratio of the distance between medial epicondyle or adductor tubercle and joint line to the transepicondylar width of the femur was proposed. The aim of our study was to confirm the linear correlation between the femoral width (FW) and the distance from the adductor tubercle to

the joint line (ATJL) and to prove the hypothesis that preoperative radiographic measurements can be reliably reproduced intraoperatively.

**MATERIAL & METHODS:** Standard anteroposterior knee radiographs of 40 patients who underwent TKA for knee osteoarthritis were included in the study.

FW and the distance of ATJL were measured on preoperative X-rays by three surgeons and intraoperatively by two surgeons. Correlation between FW and this measurement was evaluated. The ratio between FW and ATJL was calculated using linear regression analysis. Intratester and intertester reliability was assessed.

**RESULTS:** Linear correlation between FW and ATJL ( $r=0.8$ ) was found. Interobserver and intraobserver reliability for ATJL were 0.8 and 0.9, respectively. The ratio between FW and ATJL was 0.54.

**CONCLUSION:** We conclude that adductor tubercle can be used as a morphologic landmark to determine the knee joint line position. Repeatability is good; because a linear correlation between FW and the distance of ATJL was found, the ratio can be useful to calculate the joint line level from femoral width before R-TKA.

## Morphometric Measurements of Resected Femur and Tibia in Indian Knees: Correlation to Current Knee Arthroplasty Systems

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**BACKGROUND:** Maximum implant coverage of the resected bone surfaces is highly desirable for long-term survivorship of total knee arthroplasty (TKA). Clinical data suggests that the anatomical profiles of Asian knees are smaller than Caucasian population. The paucity of anthropometric data concerning the morphological dimensions of distal end of femur and proximal part of tibia in Indian subjects undergoing TKA is the single most prominent deter-

rent to development of an implant system best suited to this group of world population. The objective of this study was to collect anthropometric measurements of Indian knees and to correlate these dimensions with the current prosthesis systems.

**METHODS:** Anthropometric data on the distal part of femur and proximal tibia was collected from 100 Indian knees. The study included 72 women and 28 men of mean age 59.3 years. Anteroposterior and mediolateral dimensions of femur and tibia were measured, and characterization of the aspect ratio (medio-lateral to Antero-posterior dimensions) was made. The available data from four knee arthroplasty systems was compared.

**RESULTS:** The aspect ratio of the femoral component among the compared systems shows wide variation. While the components available show little change in the aspect ratio, the morphometric data shows an inverse relation between the aspect ratio and the anteroposterior size of the knee. The female

Indian knees being smaller pose a greater problem of mediolateral overhang with the currently available knee systems. The tibial morphometry also demonstrated a similar correlation as on the femoral side. None of the compared systems could satisfactorily replicate the actual dimensions.

**CONCLUSION:** Our results will allow the development of knee replacement implants better suited to the Indian population.

## Comparison of Minimally Invasive Direct Anterior Versus Posterior Total Hip Arthroplasty Based on Inflammation and Muscle Damage Markers

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**BACKGROUND:** A number of surgical approaches are utilized in total hip arthroplasty. It has been hypothesized that the anterior approach results in less muscle damage than the posterior approach. We prospectively analyzed biochemical markers of muscle damage and inflammation in patients treated with minimally invasive total hip arthroplasty with an anterior or posterior approach to provide objective evidence of the local soft-tissue injury at the time of arthroplasty.

**METHODS:** Twenty-nine patients treated with minimally invasive total hip arthroplasty through a direct anterior approach and 28 patients treated with the same procedure through a posterior approach were prospectively analyzed. Perioperative and radiographic data were collected to ensure cohorts with similar characteristics. Serum creatine kinase (CK), C-reactive protein (CRP), interleukin-6 (IL-6), interleukin-1 beta (IL-1b), and tumor necrosis factor-alpha (TNF-a) levels were measured preoperatively, in the post-anesthesia-care unit (except for the CRP level), and on postoperative days 1 and 2. The Student t test and Fisher exact test were used to make comparisons between the two groups. Independent predictors of elevation in levels of markers of inflammation and muscle damage were determined with use of multivariate logistic regression analysis.

**RESULTS:** The levels of the markers of inflammation were slightly decreased in the direct-anterior-ap-

INTRAOPERATIVE DATA FORM			
DATE _____	SURGEON _____	CASE REF _____	
LEFT KNEE <input type="checkbox"/>	RIGHT KNEE <input type="checkbox"/>	MALE <input type="checkbox"/>	FEMALE <input type="checkbox"/>
AGE _____			
<b>DISTAL FEMUR – RESECTION DIMENSIONS:</b> (Measure after appropriate bone cuts are made)			
FEMORAL EXTERNAL ROTATION: _____ degrees		DISTAL RESECTION: <input type="checkbox"/> 8mm	
FEMORAL VALGUS ANGLE: _____ ° Actual AP size _____		<input type="checkbox"/> 10mm	
		<input type="checkbox"/> 12mm	
<b>PROXIMAL TIBIA – RESECTION DIMENSIONS:</b> (Measure after bone cut is made)			
Tibial comp. _____		Tibial Insert _____	
TIBIAL VARUS/VALGUS ANGLE: <input type="checkbox"/> NEUTRAL <input type="checkbox"/> OTHER _____			
PROXIMAL RESECTION: <input type="checkbox"/> 2mm (Low side)		POSTERIOR SLOPE: <input type="checkbox"/> 3 degrees (std)	
<input type="checkbox"/> 8mm (High side)		<input type="checkbox"/> other _____	

proach group as compared with those in the posterior-approach group. The rise in the CK level in the posterior-approach group was 5.5 times higher than that in the anterior-approach group in the post-anesthesia-care unit (mean difference, 150.3 units/L [95% CI, 70.4 to 230.2];  $p < 0.05$ ) and nearly twice as high cumulatively (mean difference, 305.0 units/L [95% CI, 246.7 to 656.8];  $p < 0.05$ ).

**CONCLUSIONS:** We believe that the anterior total hip arthroplasty approach used in this study caused significantly less muscle damage than did the posterior surgical approach, as indicated by serum CK levels. The clinical importance of the rise in the CK level needs to be delineated by additional clinical studies. The overall physiologic burden, as demonstrated by measurement of inflammation marker levels, appears to be similar between the anterior and posterior approaches. Objective measurement of muscle damage and inflammation markers provides an unbiased way of determining the immediate effects of surgical intervention in patients treated with total hip arthroplasty.

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

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

**PURPOSE:** This retrospective, matched-pair study evaluates manipulation under anesthesia (MUA) rates in cemented patient-specific cruciate-retaining (PSCR) TKA compared to that in both cemented posterior-stabilized (PS) and non-cemented cruciate-retaining rotating-platform (NC CR RP) TKA.

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

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

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

**LEVEL OF EVIDENCE:** Level III, Retrospective comparative study

**KEYWORDS:** Patient-specific total knee, Manipulation, TKA

## Two-Year Survivorship of Robotically Guided Unicompartmental Knee Arthroplasty

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**INTRODUCTION:** Successful clinical outcomes following unicompartmental knee arthroplasty (UKA) depend on component positioning, soft tissue balance and overall limb alignment, which can be difficult to achieve using manual instrumentation. Recently, robotically guided technology has been used to improve postoperative implant positioning and limb alignment in UKA with the expectation that this will result in greater implant longevity. This multicenter study examines the survivorship of this robotically guided procedure coupled with a novel, anatomically designed UKA implant at 2 years follow-up.

**OBJECTIVES:** This study examines the 2-year survivorship and patient satisfaction of an anatomically designed UKA implant using a new robotically guided technology that has been shown to improve implant positioning and alignment.

**METHODS:** 788 patients (890 knees) from six surgeons underwent robotically guided unicompartmental arthroplasty surgery and reached a minimum 2-year follow-up. The tibial component was a fixed bearing, metal backed onlay design. Patients were consecutive for each respective surgeon and were also each surgeon's first series of patients for that implant system. As part of an Institution Review Board (IRB)-approved study, every patient was contacted and asked a series of five questions to determine implant survivorship and patient satisfaction at a 2-year follow-up. Six hundred and twenty patients (701 knees) enrolled in the study; the overall enrollment rate was 79%. There were 352 males and 266 females; the average age was  $70 \pm 9.23$  years (range

39-93) and the average body mass index (BMI) was  $29.35 \pm 4.59$  (range 18.97-47.77). The average follow up at the time the patients were contacted was  $30 \pm 5.53$  months (range 22-42).

**RESULTS:** Eight knees were reported as revised within 24 months after the index procedure, yielding a 2-year revision rate of 1.1%. The average time to revision was 11 months. Five patients returned to their same surgeon for the revision procedure. Seven knees were revised to a total knee arthroplasty; one knee was revised to another UKA. 71% of patients reported feeling "Very Satisfied" with their overall knee function. 22% of patients reported feeling "Satisfied"; 3% of patients reported feeling "Neutral"; 3% of patients reported feeling "Dissatisfied"; and 1% of patients reported feeling "Very Dissatisfied."

**CONCLUSION:** Excellent survival and satisfaction outcomes were noted in this subset of patients at 2 years postoperative. This robotically guided procedure shows promise of improved survivorship rates for UKA compared to what is currently reported in implant registries and comparative studies. These promising results indicate that improved implant placement accuracy achieved with robotic assistance leads to improved implant survivorship and patient outcomes.

## Robotic-Assisted Total Hip Arthroplasty Improves Accuracy and Clinical Outcome Compared with Manual Technique

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**INTRODUCTION:** Accurate implant placement affects outcome of total hip arthroplasty (THA). Component malposition contributes to edge loading, impingement, wear, dislocation, and leg-length discrepancy (LLD). Significant component malposition rates persist with manual THA (mTHA) even in the hands of experienced surgeons. Robotic-assisted THA (rTHA) utilizes computer-assisted haptically guided bone preparation and implant insertion to improve accuracy. The goal of this study is to review an 11-year experience comparing implant placement



and clinical outcome with primary mTHA and rTHA.

**METHODS:** Prospective analysis of primary THA performed by one fellowship trained surgeon at one academic center were recorded at several time points: The first 100 consecutive mTHAs in clinical practice (Group 1- year 2000), the last 100 consecutive mTHA before use of rTHA (Group 2- year 2010), and the first 100 consecutive rTHA (Group 3- year 2011). All mTHAs and rTHAs were performed using a posterior-lateral approach, cementless implants, and metal on cross-linked polyethylene bearings. Groups were compared regarding age, sex, body mass index (BMI), diagnosis, femoral head size, blood loss (EBL), operative time, early dislocation and infection rates (<6 months), LLD, and liner fracture rate. Implant positions were measured using validated software to determine acetabular abduction (AB), anteversion (AV), and LLD. The Lewinnek safe zone was used to define the target acetabular position (AB- 30°-50°, AV- 5°-25°).

**RESULTS:** No differences were noted between groups in age, sex, BMI, or diagnosis (Table 1). Average operative times improved in mTHA with clinical experience (Group 1 versus Group 2) ( $p<0.0001$ ) and were 14 minutes longer with rTHA compared

with Group 2 mTHA ( $p<0.0001$ ). Average EBL was less with rTHA than with mTHA (Group 1 or 2) ( $p<0.0001$ ). Implant head size was smaller in Group 1 compared with Group 2 and 3 ( $p<0.0001$ ) and slightly larger for Group 3 compared to Group 2 ( $p=0.037$ ) (Table 1). Significant improvement in acetabular AB occurred with 10 years of mTHA clinical experience (Group 1 versus Group 2) ( $p<0.0001$ ). Significant acetabular AV malposition remained in Group 2 mTHA that was reduced using rTHA (Group 2 versus Group 3- Table 1) ( $p<0.0001$ ). Improved implant position with rTHA correlated with lower dislocation rates compared with mTHA (Group 3 versus Group 1 and 2) ( $p<0.001$ ). Liner fractures occurred in 3% of cases in Group 1 and were associated with implant malposition ( $p=0.02$ ).

**DISCUSSION:** A decade of clinical experience improved acetabular component AB positioning with manual techniques, but significant outliers remained regarding acetabular AV. rTHA further improved acetabular component positioning and reduced early dislocation rates compared with mTHA ( $p<0.05$ ). Component malposition has been shown to correlate with liner fracture, LLD, and dislocation rates. Clinical experience, improved component positioning, and increased femoral head size with mTHA resulted in reduced rates of dislocation and LLD. Operating room times were 14 minutes longer for rTHA compared with mTHA, but this was not associated with increased EBL or infection rates. These encouraging early results with rTHA deserve further analysis at longer follow-up intervals to determine if improved component position will translate into cost-effective improvements in long-term clinical outcome.

TABLE 1- Manual THA vs. Robotic Assisted THA

	Group 1: 1 <sup>st</sup> 100 mTHA (year 2000)	Group 2: last 100 mTHA before use of robot (year 2010)	Group 3: 1 <sup>st</sup> 100 rTHA (year 2011)
Age	62.5	60.8	62.3
Sex	M-42%, F-58%	M-50%, F-50%	M-51%, F49%
BMI	30.0	29.5	29.2
Dx:			
OA	81%	91%	95%
AVN	17%	8%	5%
RA/ infl. arthritis	2%	1%	0%
Average femoral head size	31.0mm	34.6mm	35.2mm
Early Dislocation rate	5%	3%	0%
LLD:			
average	6.6mm	4.4mm	3.4mm
≥16mm	9%	1%	1%
EBL	533cc	437cc	357cc
Early deep infection	0%	0%	0%
Average OR Time	160 minutes	129 minutes	143 minutes
Acetabular AB in target zone	66%	91%	98%
Acetabular AB >55 degrees	20%	0%	0%
Acetabular AV in target zone	40%	48%	76%
Acetabular AV and AB in target zone	31%	45%	75%
Acetabular liner fracture rate	4%	0%	0%

## Perioperative Outcomes in Patients with and without Workers' Compensation Claim Treated with Total Knee Arthroplasty

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**INTRODUCTION:** Workers' Compensation (WC) status has been shown to correlate with worse long-term outcomes after total knee arthroplasty (TKA) procedures. Perioperative results in WC population have not been well analyzed. The purpose of this study was to evaluate perioperative outcomes for WC and non-workers' compensation (NWC) patients, when matched for age.

**METHODS:** The National Hospital Discharge Survey (NHDS) database was searched using International Classification of Diseases - Ninth Revision (ICD-9) codes for patients admitted to U.S. hospitals for TKA between 2001 and 2010. ICD-9 codes were then used to analyze patient demographics, hospital length of stay (LOS), in-hospital adverse events (deep vein thrombosis [DVT], pulmonary embolus [PE], blood transfusion, mortality), and discharge disposition. Age was limited to patients between ages 49-55 in both groups. Trends were evaluated by linear regression with Pearson's correlation coefficient ( $r$ ), and statistical comparisons were made using Student's t-test and z-test for proportions with a significance level of 0.05.

**RESULTS:** One hundred and thirty WC TKA patients and 3,806 NWC TKA patients were identified. The WC group had a mean patient age of 52.2 years versus 52.5 years in the NWC group ( $p=0.12$ ). The average hospital LOS was significantly longer for WC (3.9 days versus 3.6 days,  $p=0.0222$ ). However, no significant difference was noted between WC and NWC in regards to rate of PE (0.77% versus 0.24%,  $p=0.49$ ), DVT (1.5% versus 0.39%,  $p=0.29$ ) or blood transfusion (12.3% versus 13.2%,  $p=0.76$ ). Mortality rate was insignificantly lower in the WC group (0.0% versus 0.05%,  $p=0.15$ ). The rate of discharge to home was insignificantly higher in the WC (83.0% versus 81.2%,  $p=0.59$ ). The rate of TKA for WC and NWC patients demonstrated positive correlation with time, however, there was a stronger correlation for the NWC group,  $r=0.938$  versus  $r=0.177$  respectively. WC accounted for 3.9% of the TKA performed between 2001 and 2005 and significantly decreased to 2.6% between 2006 and 2010 ( $p<0.001$ ).

**CONCLUSIONS:** Compared to NWC patients, WC patients have longer LOS but have similar rates of DVT, PE, blood transfusion, discharge to home, and

death while hospitalized. This study suggests that origin of inferior long-term results in WC patients after TKA is not related to the immediate postoperative period.

## **Patients with Knee Osteoarthritis Demonstrate Improved Gait Pattern and Reduced Pain Following a Noninvasive Biomechanical Therapy**

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**BACKGROUND:** Previous studies have shown the effect of a unique therapy with a noninvasive biomechanical foot-worn device (AposTherapy) on Caucasian western population suffering from knee osteoarthritis. The purpose of the current study to evaluate the effect of this therapy on the level of symptoms and gait patterns in a multiethnic Asian population suffering from knee osteoarthritis.

**METHODS:** Fifty-eight patients with bilateral medial compartment knee osteoarthritis participated in the study. All patients underwent a computerized gait test and completed two self-assessment questionnaires (WOMAC and SF-36). The biomechanical device was calibrated to each patient and therapy commenced. Changes in gait patterns and self-assessment questionnaires were reassessed after 3 and 6 months of therapy.

**RESULTS:** A significant improvement was seen in all of the gait parameters following 6 months of therapy. Specifically, gait velocity increased by 15.9%, step length increased by 10.3%, stance phase decreased by 5.9%, and single limb support phase increased by 2.7%. In addition, pain, stiffness, and functional limitation significantly decreased by 68.3%, 66.7%, and 75.6%, respectively. SF-36 physical score and mental score also increased significantly following 6

months of therapy (46.1% and 22.4%, respectively) ( $P < 0.05$  for all parameters).

**CONCLUSIONS:** The multiethnic Asian population with medial compartment knee osteoarthritis demonstrated improved gait patterns, reported alleviation in symptoms, and improved function and quality of life following 6 months of therapy with a unique biomechanical device.

## Enhanced Biomechanical Closed Kinetic Chain Therapy Intervention

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**INTRODUCTION:** Some patients after total hip arthroplasty (THA) may suffer from a limp and periarthral discomfort due to muscle weakness. Physiotherapy is important in restoring muscle strength. Evidence-based guidelines on rehabilitation after THA are scarce. We examined the immediate and longer-term effect of closed kinetic chain exercises (AposTherapy, Herzliya, Israel) causing controlled perturbations over gait parameters after THA.

**MATERIALS AND METHODS:** Thirty-three patients were prospectively followed during the study. Gait parameters were measured at initial evaluation, after 15 minutes of therapy, and after 3 months of treatment. SF-36 and WOMAC scores were filled by patients before treatment and after 3 months of treatment.

**RESULTS:** Gait velocity, single limb support (SLS) and step length of the operated leg significantly improved after a single 15-minute treatment (72.9 cm/s versus 87.6 cm/s, 33.3% versus 35.2 % of gait cycle and 45.8 cm versus 50.2 cm, respectively,  $p < 0.001$ ) and furthermore after 3 months of treatment (72.9 cm/s versus 108.5 cm/s, 33.3% versus 38.2 % of

gait cycle and 45.8 cm versus 56.7 cm, respectively,  $p < 0.001$ ). Forty three percent of patients had a normal gait velocity after 3 months of treatment SF-36 and WOMAC scores significantly improved after 3 months of treatment ( $p < 0.008$ ).

**DISCUSSION:** Using a closed kinetic chain exercise implemented by a foot-worn platform is useful for patients post-THA. Improvement in gait, limb functionality, stiffness, and pain may be seen after a single session and may be more noticeable after 3 months of treatment.

## A Noninvasive Foot-Worn Biomechanical Device for Patients with Hip Osteoarthritis

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**PURPOSE:** Physical therapy and biomechanical intervention for patients with hip osteoarthritis (OA) should aim to restore or maintain gait patterns close to normal. The purpose of this study was to evaluate the effect of a biomechanical therapy on the pain, function, quality of life, and spatiotemporal gait patterns of patients with hip OA.

**METHODS:** Sixty patients with hip OA were examined before and after 12 weeks of a personalized biomechanical therapy (AposTherapy). Patients were evaluated using the WOMAC questionnaire for pain and function and the SF-36 Health Survey for quality of life, and they underwent a computerized gait test.

**RESULTS:** After 12 weeks of treatment, a significant improvement was found in the patients' velocity, step length, and cadence ( $P \leq 0.001$ ). WOMAC-pain, WOMAC-stiffness, and WOMAC-function subscales were significantly improved compared to baseline ( $P \leq 0.001$ ). SF-36 physical score subscale

improved significantly ( $P=0.007$ ), whereas the SF-36 mental subscale improved but did not reach the statistical significance threshold.

**CONCLUSIONS:** Patients with bilateral hip OA treated with AposTherapy for 12 weeks showed statistically and clinically significant improvements in pain, function, and gait patterns. This therapy may be an additional useful tool for conservatively treating patients with hip OA. Further randomized controlled trial studies are needed the effect of this therapy on this population.

### Comparison Between Direct Anterior Approach and Mini-Posterior Total Hip Arthroplasty: 150 Consecutive Case Series

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This study evaluated the early postoperative results of primary total hip arthroplasty (THA) using the direct anterior approach versus the mini-incision posterior approach. One hundred and fifty consecutive cases were performed by a single surgeon with the only change being the surgical approach; the first 50 from mini-incision posterior approach, followed by 50 during the learning curve for the direct anterior approach, and 50 subsequent cases when the approach was routine. The anterior-approach groups had a significantly reduced hospital length of stay (2.9 and 2.7 days versus 3.9 days for the posterior group;  $p<.002$ ), and patients were more likely to be discharged home versus rehab (80% and 84% home in anterior groups, 56% home in posterior group;  $p=0.0028$ ). In the anterior groups, walker use was less at 2 weeks (20% and 12% versus 74%;  $p<.0001$ ) and cane use was less at 6 weeks (12% and 20% versus 49%;  $p<.0001$ ). VAS pain scores were significantly lower in the anterior groups at 2 weeks (2.7 and 2.2 versus 5.2;  $p<.0001$ ). Primary THA using the anterior approach allows for a more rapid recovery in a well-matched cohort of patients.



### Outcomes for Fixed - Versus Mobile-Bearing UKA: A Systematic Review and Meta-Analysis

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**PURPOSE:** Two design concepts are currently in use for unicondylar knee arthroplasty (UKA) prostheses: Fixed bearing (FB) and mobile bearing (MB). MB prostheses have become increasingly popular due to their theoretical advantages over the FB design, such as the congruent bearing, which reduces contact stresses and polyethylene wear rates, and the closer re-creation of native knee kinematics. However, it is not clear whether the MB design is indeed superior to that of FB prostheses for UKA. We conducted a systematic review to examine survivorship differences and differences in failure modes of between FB and MB designs.

**METHODS:** PubMed and Scirus were searched for randomized clinical studies, cohort studies, and case series reporting clinical outcomes for medial and/or lateral UKA. There were no language restrictions. A total of 44 studies involving 9,894 knees were eligible, including four randomized clinical trials and eight cohort studies. Methodological quality was assessed using a specific UKA survival assessment score. Outcomes studied included knee function, survivorship, and the reasons for, and incidence of, revision for FB and MB prostheses. Where available, cause-specific time to revision was extracted. The revision rate was expressed as number of revisions per 100 component years and compared between prosthesis designs.

**RESULTS:** Mean follow-up was 8.5 years for FB and 5.2 years for MB prostheses. There were no other relevant differences in baseline characteristics. The overall crude revision rate for FB and for MB prostheses was 1.01 and 1.24 per 100 component years, respectively. Cause-specific revision rates were not reported or were incomplete in 57% of studies. In the

remaining studies, aseptic loosening accounted for 0.27 and 0.40 revisions per 100 component years for FB and MB prostheses, respectively. The mean time to revision for aseptic loosening was 7.7 years in the FB group and 3.8 years in the MB group. In the MB group, insert dislocation accounted for 0.30 revisions per 100 component years, at a mean time to revision of 2.0 years.

Adjusting for follow-up time resulted in a comparable overall revision rate for FB and MB prostheses of 1.26 and 1.21 revisions per 100 component years, respectively. In the adjusted analysis, aseptic loosening accounted for 0.34 and 0.35 revisions per 100 component years, respectively. There was a large variation in methodological quality of the studies, but no apparent association between survival outcome and publication quality.

**CONCLUSION:** Crude analysis suggests survival advantages with FB UKA. However, adjusting for follow-up time confirms the equivalence of MB and FB UKA designs. The risk of loosening decreases over time. While insert dislocation is an additional cause of revision in MB knees, it does not increase the overall risk of failure. As our study is based on predominantly observational data, with large variations in reporting standards, inferences should be drawn with caution.



## Pulmonary Embolism After Total Knee Arthroplasty

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**INTRODUCTION:** Pulmonary embolism (PE) is a rare but potentially devastating complication of total knee arthroplasty (TKA). The purpose of this study was to assess recent national trends in PE occurrence after TKA and evaluate patient outcomes.

**METHODS:** International Classification of Disease - 9th Revision (ICD-9) procedure codes were used to search the National Hospital Discharge Sur-

vey (NHDS) for patients admitted to U.S. hospitals after primary TKA for the years 2001-2010. ICD-9 diagnosis codes were used to identify patients who developed an acute PE during the same admission. Data regarding patient demographics, hospitalization length, discharge disposition, lower-extremity deep vein thrombosis (DVT), mortality, and hospital size/location were gathered. Trends were evaluated by linear regression with Pearson's correlation coefficient ( $r$ ), and statistical comparisons were made using Student's t-test, z-test for proportions, and chi-square analysis with a significance level of 0.05.

**RESULTS:** 35,220 patients admitted for primary TKA were identified; 159 (0.045%) of these patients developed an acute PE during the same admission. After adjusting for fluctuations in annual TKA performed, the development of PE after TKA demonstrated a weak negative correlation with time ( $r=0.17$ , Figure 1), insignificantly decreasing from an average rate of 0.049% between 2001 and 2005 to 0.041% between 2006 and 2010 ( $p=0.26$ ). The size of the hospital was found to significantly impact the incidence of PE and primary TKA, with the lowest rate seen in hospitals under 100 beds (0.23%) and the highest rate seen in those with over 500 beds (0.65%,  $p=0.01$ ). No significant differences in PE incidence were noted based on U.S. region ( $p=0.38$ ).

The mean age of patients with PE was 67.7 years. This group included 54 men and 105 women. The non-PE group had a mean patient age that was insignificantly lower at 66.6 years ( $p=0.21$ ) and included 12,450 men and 22,611 women. Gender was also not significantly different ( $p=0.68$ ) between PE groups. The number of medical comorbidities was significantly higher in those with PE (mean 6.42 diagnoses) than those without PE (mean 4.89 diagnoses,  $p<0.01$ ). Average hospitalization length also varied based on PE status, with significantly longer stays for those with PE (8.2 days versus 3.7 days,  $p<0.01$ ). The rate of DVT was higher in the PE group (12.7% versus 0.48%,  $p<0.01$ ). Mortality was also significantly higher for the PE group (3.9% versus 0.09%,  $p<0.01$ ). Discharge disposition did not significantly vary based on PE status, with 61.5% of PE patients and 64.0% of non-PE patients able to go directly home ( $p=0.59$ ) after their inpatient stay.

**DISCUSSION/CONCLUSION:** This study demonstrates that PE can have a significant impact on

patient outcomes and healthcare costs, with an associated 43-fold increase in mortality and a doubling of the inpatient admission duration. Additionally, although the risk of PE after primary TKA remains rare, efforts to prevent or minimize this complication over the last 10 years have not had a significant impact on its occurrence. This risk of PE appears to be greatest in patients with multiple medical comorbidities and established DVTs. Interestingly, the PE rate also demonstrated variability based on hospital size.

## Bilateral Total Knee Arthroplasty Perioperative Outcomes

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**INTRODUCTION:** Patients with bilateral knee arthritis often inquire about having both knees replaced simultaneously. Although single-stage/same-admission bilateral total knee arthroplasty (TKA) is an option, controversy exists regarding its risks and benefits over unilateral TKA. The purpose of this study was to assess recent national trends in unilateral and bilateral TKA and to evaluate perioperative outcomes.

**METHODS:** International Classification of Disease - 9th Revision (ICD-9) procedure codes were used to search the National Hospital Discharge Survey (NHDS) for patients admitted to U.S. hospitals after unilateral and bilateral TKA for the years 2001-2010. Data regarding patient demographics, hospitalization length, discharge disposition, blood transfusions, lower-extremity deep vein thrombosis (DVT), pulmonary embolism (PE), mortality, and hospital location were gathered from the NHDS. Trends were evaluated by linear regression with Pearson's correlation coefficient ( $r$ ) and statistical comparisons were made using Student's  $t$ -test,  $z$ -test for proportions, and chi-square analysis with a significance level of 0.05.

**RESULTS:** 35,220 patients admitted for TKA were identified; 2,154 (6.1%) of these patients had bilat-

eral TKA completed during a single admission, and 33,066 (93.9%) patients had a unilateral TKA performed. After adjusting for fluctuations in annual TKA performed, the use of bilateral TKA demonstrated a moderate negative correlation with time ( $r=0.61$ ), significantly decreasing from a utilization rate of 6.4% between 2001 and 2005 down to 5.8% between 2006 and 2010 ( $p=0.03$ ). The location of the hospital was found to significantly impact the utilization of bilateral TKA, with the lowest rate seen in the West region (4.3%) of the United States and the highest rate seen in the Midwest region (7.9%).

The mean age of bilateral TKA patients was 64.6 years. This group included 900 men and 1,254 women. The unilateral group had a mean patient age that was significantly higher at 66.8 years ( $p<0.01$ ) and included 11,604 men and 21,462 women. Gender was significantly different ( $p<0.01$ ) between those with bilateral TKA (41.8% male) and those with unilateral TKA (35.1% male). Average hospitalization length was significantly longer for those with bilateral (mean 4.2 days) compared to unilateral (mean 3.7 days,  $p<0.01$ ). The rate of blood transfusion was significantly higher in the bilateral TKA group (36.4% versus 16.9%,  $p<0.01$ ). There was no difference in the rate of DVT (0.65% versus 0.65%,  $p=0.99$ ) but the rate of PE was significantly higher in the bilateral TKA group (0.97% versus 0.42%,  $p=0.01$ ). Mortality was not significantly different for bilateral TKA (0.15% versus 0.11%,  $p=0.64$ ). Discharge disposition significantly varied based on TKA status, with only 46.2% of bilateral patients able to go directly home after their inpatient stay, compared to 64.9% of unilateral patients ( $p<0.01$ ).

**DISCUSSION/CONCLUSION:** This study demonstrates that, despite a younger patient population, bilateral TKA is associated with more blood transfusions, higher rates of PE, longer hospitalizations, and more post-admission rehabilitation requirements than unilateral TKA. Possibly due to these reasons, as well as diminishing reimbursement, the use of bilateral TKA in the United States appears to be declining.

## Critical Neurovascular Structure Location for Posterior Portals in Knee Arthroscopy

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**INTRODUCTION:** Injury to neurovascular structures is a rare complication of posterior portal placement during knee arthroscopy. Despite the risk, there is minimal data characterizing the anatomic course of the common peroneal nerve (CPN), saphenous nerve (SN), and popliteal artery (PA) in this area. The goal of this study was to define the location and variability of these structures.

**PATIENTS AND METHODS:** Magnetic resonance imaging (MRI) scans of the knee were retrospectively reviewed for 100 adult patients. On axial images at the level of the joint, the location of SN, CPN, and PA were identified. The posteromedial portal tract was simulated by a line from the posterior edge of the medial collateral ligament (MCL) to the posterior cruciate ligament. The posterolateral portal tract was similarly defined from the lateral collateral ligament (LCL) to the PCL. The vector distances between the tracts and the SN, CPN, and PA were recorded. Additional distances between these neurovascular structures and fixed ligamentous landmarks (MCL, LCL, and PCL) were also recorded. Patients' body mass index (BMI), height, weight, race, gender, and age were gathered from each patient's electronic medical record. Descriptive statistics were calculated using Student's t-test and ANOVA.

**RESULTS:** Mean height, weight, and BMI were 1.69 m (range 1.31 -1.82), 84.4 kg (60.3-118.8), and 29.1 (20.5-49.0) respectively. Mean distance between SN and posteromedial tract was 13.1 mm (range 6.8-20). From the posterolateral tract, mean distance to CPN was 15.9 mm (11.2-20.9) and to PA was 9.2 mm (2.7-

12.8). The vector, AP, and ML distances between the MCL and SN were 14.3 mm (range 6.8-20.4), 13.5 mm (6.1-19.4), and 2.8 mm (-0.6-9.2), respectively. The vector, AP, and ML distances between the LCL and CPN were 16.5 mm (range 11.2-22.1), 15.9 mm (8.3-21.0), and 2.7 mm (0.3-8.5), respectively. The vector, AP, and ML distances between the PCL and PA were 11.7 mm (range 5-16.9), 8.9 mm (3.3-13.1), and 6.1 mm (1.5-11.4), respectively.

A significant decrease in distance between the posteromedial portal tract and SN was found in patients with BMI  $\leq$  25 (mean 11.6 mm versus 13.9 mm). Significant decreases were also found between the posterolateral portal tract and CPN (mean 15 mm versus 17 mm) and between the PCL and PA vector (mean 8.3 mm versus 10.3 mm) for patients with a BMI of  $\leq$ 30. No other significant differences in distance were noted.

**DISCUSSION/CONCLUSION:** The location of CPN, SN, and PA can dangerously approach posterior arthroscopy portals, with closest distances seen in relatively low-BMI patients. Caution needs to be taken when creating posterior portals.

## Variability of Artery Location in Total Knee Arthroplasty

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**INTRODUCTION:** Injury to the popliteal neurovascular structures is a rare but known risk of total knee arthroplasty (TKA), particularly during proximal tibial osteotomy and osteophyte removal. The goal of this study was to define the location and variability of the popliteal artery (PA) as it relates to the tibial osteotomy site in TKA.

**METHODS:** Magnetic resonance imaging (MRI) of the knee was retrospectively reviewed for 100 consecutive adult patients. On axial images, the location of the PA was measured at a level approximately 5 mm below the joint, coinciding with the typical location of the tibial osteotomy during TKA. The distance between the PA and the posterior tibial plateau was recorded in vector, medial-lateral (ML), and anterior-posterior (AP) directions. The vector distance was measured as the closest distance from any point of the PA to any point on the tibial plateau. Then the anatomic medial-lateral axis for the tibial plateau was identified (the line through the greatest medial-lateral dimension) and a perpendicular bisector was drawn to this. The ML distance was the orthogonal distance from the PA to this perpendicular line. The third measurement was the AP distance from the PA to the tibial plateau, along a line orthogonal to the medial-lateral axis (Figure 1). Patient demographic data (age, gender, ethnicity, height, and weight) was gathered from a review of each patient's electronic medical chart. Statistical comparisons were made using Student's t-test and ANOVA analysis with a significance level of 0.05.

**RESULTS:** The study included 47 males and 53 females. Mean patient age was 41.5 years (range 18-76). Mean patient height and weight were 169.2 cm (range 129-193 cm) and 84.8 kg (range 49-142 kg). 52% of patients were African-American, 26% non-Hispanic Caucasian, 20% Hispanic, and 2% Asian. The mean vector distance from the tibial plateau to the PA was 7.06 mm (range 2.2-15.1, standard deviation=2.94), mean medial-lateral (ML) distance was 4.83 mm lateral (range 0.0-13.0, standard deviation=3.55), and mean anterior-posterior (AP) distance was 7.87 mm (range = 2.2-15.7, standard deviation=3.18).

Comparing patients  $\leq 40$  years to those  $>40$  years, patients  $<82$  kg to those  $\geq 82$  kg, patients with body mass index (BMI)  $<29$  kg/m<sup>2</sup> to those  $\geq 29$  kg/m<sup>2</sup>, the PA was significantly closer to the tibial plateau in younger patients and patients with lower weights and BMIs. Location of the PA did not vary significantly based on patient gender, ethnicity, or height.

**CONCLUSIONS:** This study demonstrates that the course of the PA is variable but can dangerously approach the posterior tibia plateau, reaching as close as 2.2 mm in some patients. The location of the PA also appears to vary, with closest values found in pa-

tients who are  $\leq 40$  years old, weigh  $<82$  kg, and have a BMI  $<29$  kg/m<sup>2</sup>. Caution needs to be taken during TKA, particularly when demographic risk factors are present.

## Perioperative Outcomes of Revision Total Knee Arthroplasty

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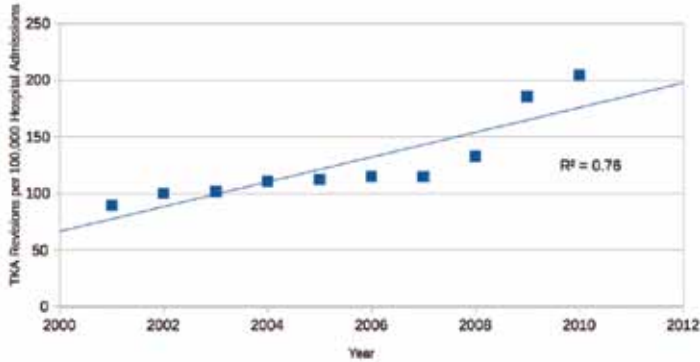
**INTRODUCTION:** Over 620,000 total knee arthroplasties (TKA) are performed each year in the United States, and the rate continues to rise. The purpose of this study was to assess recent national trends in TKA revision and to evaluate perioperative outcomes.

**METHODS:** The National Hospital Discharge Survey (NHDS) database was searched using International Classification of Diseases - Ninth Revision (ICD-9) procedure codes for patients admitted to U.S. hospitals for primary TKA and revision TKA for the years 2001-2010. ICD-9 diagnosis and procedure codes were used to identify patient demographics, hospital length of stay, in-hospital adverse events (pulmonary embolus [PE], deep vein thrombosis [DVT], blood transfusion, mortality), and discharge disposition. Trends were evaluated by linear regression with Pearson's correlation coefficient (r), and statistical comparisons were made using Student's t-test, z-test for proportions, and chi-square analysis with a significance level of 0.05.

**RESULTS:** 35,220 patients who underwent primary TKA and 3,462 patients who underwent revision TKA were identified. After adjusting for fluctuations in annual hospital admissions, the rate of TKA revision demonstrated a strong positive correlation with time ( $r=0.76$ ). Revision TKA accounted for 103.2 per 100,000 hospital admissions between 2001 and 2005, significantly increasing to 137.8 per 100,000 between 2006 and 2010 ( $p<0.01$ ) (see Figure 1). The primary TKA group had a mean patient age of 66.6 years and included 12,504 men and 22,716 women.



Figure 1



The revision TKA group had a mean patient age that was significantly lower at 65.9 years ( $p < 0.01$ ) and included 1,416 men and 2,046 women. Gender was significantly different between the groups, with men accounting for more revision TKA (40.9% versus 35.5%) ( $p < 0.01$ ). Average hospitalization length was significantly longer for revision TKA (4.9 days versus 3.7 days,  $p < 0.01$ ). PE rate was significantly lower for unilateral revision TKA (0.11% versus 0.42%,  $p < 0.01$ ). Mortality also varied by treatment group, with a mortality of 0.11% in the primary TKA group and 0.38% in the revision TKA group ( $p = 0.0112$ ). No significant difference was noted between unilateral primary and unilateral revision TKA in regards to rate of DVT (0.65% versus 0.45%,  $p = 0.10$ ), rate of blood transfusion (18.1% versus 18.3%,  $p = 0.68$ ), or discharge to home status (64.0% versus 64.6%,  $p = 0.46$ ).

**CONCLUSIONS:** This study demonstrates that the rate of revision TKAs is rising (its use increasing 34.6% in the 10 years studied), and the revision TKA group had more mortality, longer length of stay in the hospital, and younger patients. Men accounted for a larger percentage of the revision TKA group. The reasons for some of these findings are not immediately clear. Perhaps men suffer from more primary TKA complications and/or more men are interested in pursuing TKA revision. Though the number of DVTs is not significantly different, more PEs were seen in the revision TKA group for unclear reasons.



## Higher Tissue Concentrations of Vancomycin with Low-Dose Intraosseous Regional Versus Systemic Prophylaxis in TKA - A Randomized Trial

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**BACKGROUND:** In response to increasing antibiotic resistance, vancomycin has been proposed as an alternative prophylactic agent in total knee arthroplasty (TKA). However, vancomycin requires a prolonged administration time, risks promoting further antibiotic resistance, and can cause systemic toxicity. Intraosseous regional administration (IORA) is known to achieve markedly higher antibiotic concentrations than systemic administration and may allow the use of a lower vancomycin dose.

**QUESTIONS/PURPOSES:** To assess whether low-dose IORA vancomycin can achieve equal or superior tissue concentrations to systemic administration in TKA.

**PATIENTS AND METHODS:** Thirty patients undergoing primary TKA were randomised into three

Figure 1

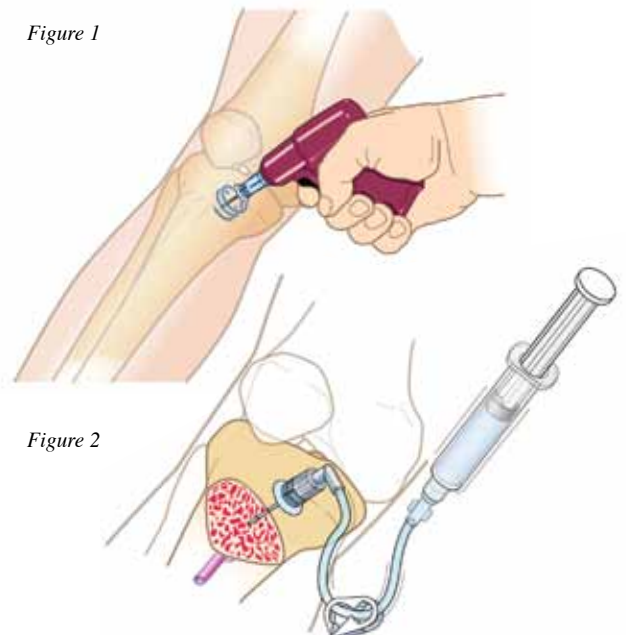


Figure 2

groups. Group 1 received 250 mg and Group 2 received 500 mg of vancomycin via IORA. Group 3 received 1 g of systemic vancomycin over 1 hour prior to tourniquet inflation. IORA was performed as a bolus injection into a tibial intraosseous cannula below an inflated thigh tourniquet, and it occurred after prep and draping and immediately prior to skin incision. Subcutaneous fat and bone samples were taken at 15-minute intervals during the procedure, and antibiotic concentrations were measured using a validated technique involving liquid chromatography coupled with tandem mass spectrometry (LC-MS/MS). All bone samples were taken from the femur, distant from the tibial intraosseous injection site. Systemic serum vancomycin levels were measured intraoperatively and at 1, 4, 8, and 24 hours postoperatively.

**RESULTS:** The overall mean tissue concentration of vancomycin in subcutaneous fat was 14 µg/g in the 250-mg IORA group, 44 µg/g in the 500-mg IORA group, and 3.2 µg/g in the systemic group. Mean concentrations in bone were 16 µg/g in the 250-mg IORA group, 38 µg/g in the 500-mg IORA group, and 4.0 µg/g in the systemic group. One patient in the systemic group developed “red man syndrome” during infusion.

**CONCLUSION:** Low-dose IORA vancomycin results in equal or higher tissue concentrations to systemic administration.

**SIGNIFICANCE:** IORA optimises timing of vancomycin administration, and the lower dose may reduce the risk of systemic side effects while providing equal or enhanced prophylaxis in TKA.

## Does Speed Kill? Revision Rates and Functional Outcomes in TKA in Relation to Duration of Surgery

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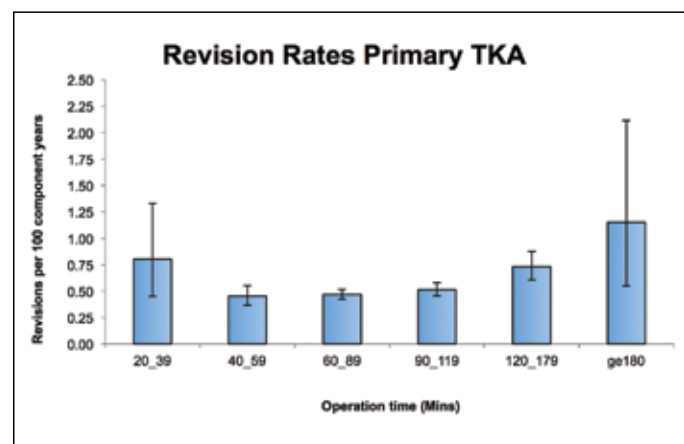
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**INTRODUCTION:** There is increasing pressure on surgeons to reduce operative time in total knee arthroplasty (TKA) and maximise throughput. While

in general improvements are made by increased operative efficiency, such pressure could potentially lead to compromises in surgical technique in order to maximize speed. Longer operative times in TKA are required in complex cases or if an intraoperative complication occurs, therefore poorer functional outcomes or higher revision rates may be expected. However little is known about TKA outcomes in procedures performed very rapidly (<40 minutes). The aim of this study was to analyse functional outcome and revision rates by surgical duration in primary TKA.

**METHODS:** 43,196 primary TKA procedures performed between 1998 and 2010 from the New Zealand National Joint Registry were analysed. Operations were grouped by surgical duration into those lasting <40minutes, 40-59, 60-89, 90-119, 120-179, and >180 minutes. Functional outcomes were assessed using Oxford knee score questionnaires sent at 6 months, 5 years, and 10 years postoperatively. The effect of surgical duration on functional outcome and revision rates was analysed.

**RESULTS:** The mean surgical duration for primary TKA was 89 minutes (range 24-421 minutes). Primary TKAs lasting <40 minutes had a 77% higher revision rate compared to procedures lasting 40-59 minutes (0.80 versus 0.45 revisions per 100 component years,  $p=0.035$ ) and 60-89 minutes (0.80 versus 0.47 revisions per 100 component years,  $p=0.039$ ). Procedures lasting longer than 120 minutes also had significantly higher revision rates. In patients whose operation lasted <40 minutes, the mean Oxford knee score was 1-2 points lower at 6 months (36.4 versus 37.4) and 5 years (38.1 versus 40.1) than patients whose operation lasted 80-89 minutes.



**CONCLUSIONS:** While prolonged operative times are likely to be required in more complex cases and thus poorer outcomes may be expected, this study suggests that TKA procedures can also be performed too rapidly. Surgical duration depends on multiple factors and no “minimum time” can be stipulated for an individual surgeon. However, surgeons routinely completing TKAs in <40 minutes should critically appraise their results to ensure surgical technique is not being compromised in the pursuit of a more rapid operation.

### Do Space Suits Increase Contamination & Deep Infection in Total Joint Arthroplasty? A Systematic Review

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**BACKGROUND:** Charnley developed the body exhaust suit (BES) aiming to reduce wound contamination caused by particles shed from the surgical team. A key feature of BES is inlet/outlet air tubing, creating negative pressure inside the gown, thus removing shed particles. However modern “space suit” (SS) systems use a helmet-based intake fan, drawing air in through the hood material, and then expelling it inside the gown, creating positive pressure. Recent work has shown this positive pressure allows egress of air and particles through non-sealed areas such as the surgeon’s cuff.

**QUESTIONS/PURPOSE:** We conducted a systematic review of the literature asking the question: Do Charnley-type BES or helmet-based SS systems reduce deep infection rates or contamination in hip and knee arthroplasty?

**METHODS:** A primary search was performed employing the electronic databases of Medline

**Table 1a** Literature review – Charnley Body Exhaust Suits versus Conventional Gowns

Author	Suit type evaluated	Assessment	Results	In favour of Suit?
Ritter <sup>1</sup> 1980	BES (Charnley Type)	Settle plates in Operating room simulation	69% reduction in CFU on plates	YES
Whyte <sup>2</sup> 1976	BES (Charnley Type)	Settle Plates in Dispersal Chamber	92% reduction in bacterial dispersion rate	YES
Nelson <sup>3</sup> 1976	BES (Charnley type)	Deep Infection rates at 2 years in THR	7.6% (10/131) conventional and 1.6% (5/319) with BES.	YES
Franco <sup>4</sup> 1977	BES (Charnley Type)	Air bacterial count with slit sampler next to surgical wound, AND Wound swabs	Mean air counts 0.06cfu/ft <sup>3</sup> with BES versus 0.13cfu/ft <sup>3</sup> with conventional (p<0.05)	YES
Whyte <sup>5</sup> 1983	BES (Charnley Type)	Air bacterial count with slit sampler 30cm from wound.	Median 0.7cfu/m <sup>3</sup> for BES vs 0.7cfu/m <sup>3</sup> disposable system	NO
Blomgren 1983 <sup>6</sup>	BES (Charnley Type)	Culture of wound washouts	Positive cultures in 10% BES wounds vs 43% conventional	YES
Lidwell 1982 <sup>7</sup>	BES (Charnley Type)	Joint sepsis and infection after THJR and TKJR	0.3% Incidence joint sepsis BES vs 1.3% conventional	YES
Sanzen <sup>8</sup> 1990	BES (Charnley Type)	Slit sampler 20cm from wound	Median 0.3cfu/m <sup>3</sup> for BES vs 1.4cfu/m <sup>3</sup> conventional p<0.002	YES

**Table 1b** Literature review – Modern ‘Space Suits’ versus Conventional

Author	Suit type evaluated	Assessment	Results	In favour of Suit?
Bohn 1996 <sup>9</sup>	SS	Air sampling 30cm from wound	Mean 3.6 CFU/ft <sup>3</sup> for SS vs 3.6 CFU/ft <sup>3</sup> for conventional	NO
Shaw 1996 <sup>10</sup>	SS	Air sampling next to the wound	Mean CFU 37.0 for SS vs 29.6 for Conventional	NO
DerTavitan 2003 <sup>11</sup>	SS	Air Counts AND Wound bacterial count tetrazolium-stained membrane (TSMI)	64% of SS and 60% of conventional wounds were contaminated	NO
Pasquarella 2003 <sup>12</sup>	SS	Surface contamination in OR using Settle plates (Air)	Mean 210 CFU/m <sup>2</sup> /h for SS vs 250 CFU/m <sup>2</sup> /h conventional p=0.68	NO
Hooper 2011 <sup>13</sup>	SS	6 month Revision rates for infection	0.243% with SS vs 0.098% conventional p <0.001	NO
Namba <sup>14</sup> 2012	SS	Deep SSI within one year post operatively	Hazard Ratio 1.55 (95% CI 1.01-2.37) with SS use on univariate analysis p=0.045	NO
Namba <sup>15</sup> 2013	SS	Deep SSI within one year post operatively	Hazard Ratio 0.87 (95% CI 0.68-1.11) with SS use on multivariate analysis p=0.26	NO

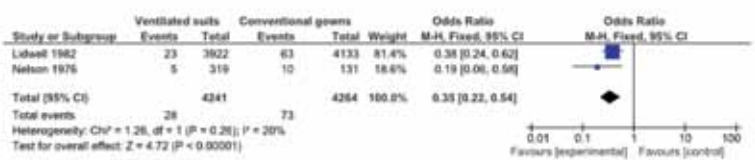


Figure 1a. Meta-analysis of deep infection rates in Charnley-type BES suits vs conventional gowns



Figure 1b. Meta analysis of deep infection rates in Space Suits vs conventional gowns

(1950 to March 2013), AMED (1985 to March 2013), and EMBASE (1980 to March 2013). A secondary search assessed unpublished literature using trial registries and the reference lists of relevant papers.

As no study directly compared SS to BES, inclusion criteria were comparative arthroplasty studies comparing suits (BES or SS) to conventional theatre attire, using one of three outcomes: 1) deep infection rates, 2) wound contamination, or 3) air contamination. Only data on deep infection rates were combined for meta-analysis.

**RESULTS:** A total of 15 studies met the inclusion criteria (Table 1). Two studies (4,241 patients) compared deep infection rates with BES to conventional gowns, giving a combined odds ratio of 0.35 ( $p < 0.0001$ ) in favour of BES. Three studies (86,616 patients) compared deep infection rates with SS to conventional gowns, giving a combined odds ratio of 1.2 ( $p = 0.03$ ) in favour of conventional gowns (Figure 1).

Among basic science studies comparing BES to conventional gowns, four out of five (80%) found less air contamination with BES and one out of two studies (50%) found less wound contamination. In contrast, among studies comparing SS to conventional gowns none of four (0%) found less air contamination with SS, and none of one (0%) found less wound contamination.

**CONCLUSION:** Based on current literature, modern SS designs appear to cause a paradoxical increase in deep infection rates following arthroplasty surgery. Basic science studies do not support reduced air or wound contamination with SS use. The previous positive findings in studies on BES systems should be distinguished from those using SS.

## **The Use of Pure Synthetic Calcium Sulfate (Stimulan) as a Bioabsorbable Antibiotic Delivery Vehicle in Hip and Knee Arthroplasty**

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**METHODS:** A retrospective review of patients undergoing primary or revision hip or knee arthroplasty by a single surgeon at a single institution. The inclusion criteria of this study included the use of STIMULAN mixed with antibiotics (tobramycin 1.2 g, cefazolin 1 g, vancomycin 1 g) as documented in the operative report in a primary or revision hip or knee arthroplasty, follow-up of at least 3 months, and postoperative imaging of the appropriate site. Patients who were considered high risk for infection if they had a documented immunodeficiency, uncontrolled diabetes mellitus, or prior joint infection. The antibiotic coverage was changed only if a patient had a documented allergy to tobramycin, cefazolin, or vancomycin, in which case the particular antibiotic was excluded and not replaced with another.

**RESULTS:** A total of 56 patients met inclusion criteria for this study. Radiographic evidence of bead placement was confirmed on the postoperative X-ray for all patients. Complete absorption was radiographically confirmed in all patients by 6 weeks. No postoperative infections were seen in any of the patients, and no cases of heterotrophic ossification were found. One patient who underwent a clean total knee replacement (TKR) showed radiographic signs of intra-articular ossification, which correlated clinically with persistent knee pain, which required surgical irrigation and a poly exchange. One case of persistent wound drainage occurred in a patient with type 2 diabetes mellitus. We saw no increased wound

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complications, no systemic affects, and no reoperations for infection during the evaluation period a supported with review of 50 primary knee patients.

With this limited study, it is likely that the use of the pure calcium sulfate may reduce the risk of persistent wound drainage. It offers a potential vehicle for continued dissolution of antibiotics for up to 6 weeks.

### **Correlation Between Intraoperative Kinematics During Navigation-Assisted Total Knee Arthroplasty with Postoperative Range of Motion**

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*Co-Author: Gavin C. Pereira (University of California Davis Medical Center, Sacramento, CA, USA)*

**METHODS:** In this retrospective review of 103 patients, 64 knees met the requirements for inclusion done utilizing Stryker R navigation by a single surgeon at a single institution. It is a comparison of preoperative range of motion (ROM) in flexion and extension as well as variation of coronal plane from flexion to extension with postoperative and a correlation between functional outcome at 3 months in ROM.

The data collected and saved at the beginning of surgery after navigational pins are set and the knee is registered is the basis of original arthritic kinematics of the knee. At the time of the finishing the surgery and before removing the trackers, the knee is taken through a final ROM, and this data is collected as well. The data collected in graph form was categorized into three groups. This data was then compared to the patient's ROM at the 3-month evaluation.

**CONCLUSIONS:** The initial kinematics compared to the balance post-implantation kinematics can vary as noted by data collection. We were able to develop a classification of the arthritic knee kinematics in the coronal plane as it flexes and extends. It is thought that a significant change in the kinematics may result in less than optimal outcomes for patient satisfaction as noted by postoperative ROM. Utilizing fisher exact test for each categorical variant in observed ki-

nematic graphs in the coronal plan, we were able to define a subset of patients that consistently resulted in less than optimal ROM at 3-month follow-up.

Using this information, it maybe possible to determine postoperative ROM intraoperatively by using the kinematic graph points as a tool for corrected motion.



### **Patient Demographics as Risk Factors for Manipulation Under Anesthesia After Total Knee Arthroplasty**

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**BACKGROUND:** Arthrofibrosis is the most prevalent early periprosthetic complication following total knee arthroplasty (TKA) and can result in decreased range of motion (ROM) and significant disability. Manipulation under anesthesia (MUA), which is the first line of treatment, can lead to complications from anesthesia, periprosthetic fracture, hemarthrosis, and no gain in ROM.

**OBJECTIVES:** Literature indicates that the need for MUA can be prevented with a combination of adequate physical therapy and positive patient-motivation techniques. The relationship between key demographic risk factors and MUA after TKA has not been explored previously. The purpose of this study was to identify if any key demographic characteristics are risk factors for MUA after TKA. This may allow physicians to identify patients who would benefit from more aggressive preventative measures. We hypothesized that certain patient demographics, including age, gender, race, and insurance (public versus. private) would alter the risk for MUA following TKA.

**METHODS:** A total of 1,087 patients received TKA for osteoarthritis (OA) at an urban hospital in Michigan from 2005 to 2012. Forty of these patients un-

derwent an MUA within 3 months of TKA. Patient demographics were extracted from the patient charts. To determine if there was a difference in those who received MUA by gender, race, or insurance status, chi-square analyses were performed. Additionally, an independent t-test was used to determine if there was a difference in age for those who had MUA compared to those who did not have MUA.

**RESULTS:** The overall incidence of MUA following TKA for OA at our institution was 3.7%. There was a significant difference ( $p < 0.001$ ) in the average age of those who had MUA compared to those who did not have MUA. The mean age of patients who needed MUA was 55 years, while the mean age of patients who did not require a MUA was 65 years. No significant difference in MUA status was detected for gender ( $p = 0.874$ ), race ( $p = 0.665$ ), or insurance ( $p = 0.158$ ).

**CONCLUSION:** Our study suggests that MUA patients are significantly younger than patients not receiving MUA following TKA. This finding is especially concerning since the average age of patients requiring TKA is decreasing. Therefore, the incidence of MUA for arthrofibrosis following TKA may continue to increase in the future. Younger patients may need to be targeted with more-aggressive rehabilitation efforts, although there may be other confounding variables with age that were not examined in this study. We are planning future research that will examine the impact of other risk factors, such as obesity and ROM, on the development of arthrofibrosis and the need for MUA following TKA.

## Comparison of Early Clinical Outcomes of CR-Flex Fixed and CR-Flex Mobile Total Knee Arthroplasty

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**BACKGROUND:** Mobile-bearing total knee arthroplasty (TKA) has several theoretical advantages over fixed-bearing TKA. The aim of the present study was to evaluate whether or not that the early clinical and radiographic results demonstrated the differences between cruciate-retaining (CR)-flex fixed and CR-flex mobile TKAs.

**METHODS:** Forty-seven consecutive patients underwent TKA (Zimmer) by the same surgeon using CR fixed bearing TKA (F group) and CR mobile bearing TKA (M group). Participants included 40 women and seven men, with a mean age at the time of surgery of 75.4 years. All patients had osteoarthritis. The mean follow-up was 10 months. We assessed pre-postoperative flexion and extension angles, JOA score, and component angles ( $\alpha, \beta, \gamma, \delta$ ).

**RESULTS:** In the F group, postoperative flexion angle was 115, postoperative extension angle -2.66, JOA score 78.3,  $\alpha$  angle 95.0,  $\beta$  angle 89.5,  $\gamma$  angle 2.11, and  $\delta$  angle 80.9; while in the M group, postoperative flexion angle was 121, postoperative extension angle -0.66, JOA score 80.0,  $\alpha$  angle 96.3,  $\beta$  angle 88.5,  $\gamma$  angle 3.76, and  $\delta$  angle 83.7. There were no significant differences in postoperative range of motion (ROM), JOA score and component angles between F and M groups. No osteolysis, loosening, dislocation, or revision occurred.

**DISCUSSION:** Satisfactory early results can be achieved in both groups. However, we could not find an early advantage for a mobile bearing TKA.

## Calculating the Position of the Joint Line of the Knee in Relationship to Anatomic Landmarks

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Restoration of the joint line of the knee during primary and revision total knee arthroplasty is one of many critical steps that directly influence patient outcomes.

In this study, fifty magnetic resonance imaging (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. On the femoral side, the epicondyles and the metaphyseal flares were used, and on the tibial side, the tibial tubercle and the proximal tibio-femoral joint were included (Figure 1).

Absolute distances of these anatomic landmarks to the joint line of the knee were highly variable due to patient size and gender. In order to negate the effect of size and gender, the ratios of these distances of the joint line of the knee were normalized to the

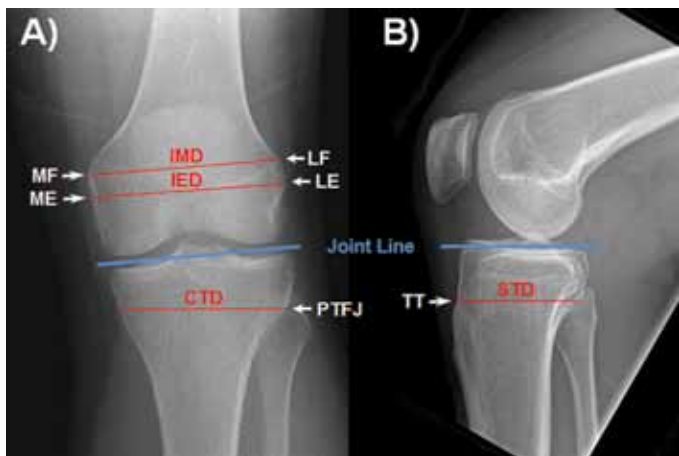


Figure 1

respective bony diameters. On the femoral side, the distance of the lateral epicondyle to the joint line of the knee was about one-third the inter-epicondylar diameter, and the distance of the lateral flare of the femur to the joint line of the knee was one-half the inter-metaphyseal diameter. On the tibial side, 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 proximal tibio-fibular joint to the joint line of the knee was one-third the diameter of the tibia in the coronal plane at the level of the proximal tibio-fibular joint.

The spatial relationship of the joint line of the knee to the femur and tibia was made by calculating ratios across the joint line. Of these, the most clinically relevant finding was that the joint line of the knee was halfway between the lateral epicondyle and proximal tibio-fibular joint in the coronal plane. This finding was constant irrespective of patient size or gender.

Our quantitative description of the absolute distances and relative relationship of the anatomic landmarks about the knee supports a simple three-step algorithm (Figure 2). This algorithm will allow orthopaedic surgeons or navigation software to calculate, instead of estimate, the location of the joint line of the knee. We have created a powerful new tool to assess the preoperative, intraoperative, and postoperative ability of primary and revision total knee arthroplasty to re-create the joint line of the knee.

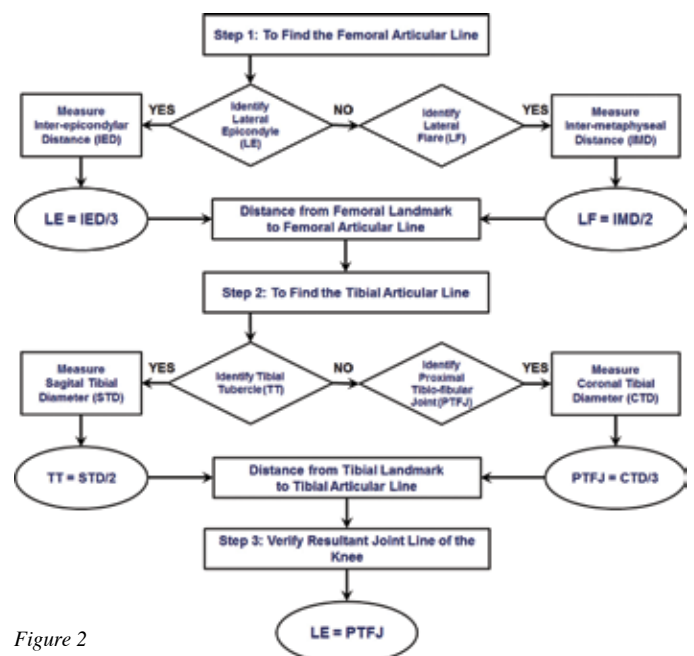


Figure 2

## **Fixed Versus Mobile Weight-Bearing Prosthesis in Total Knee Arthroplasty**

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*Institution: Kerman University of Medical Sciences, Kerman, Iran*

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**PURPOSE:** This study was designed to compare clinical, radiological, and general health results of two prostheses (mobile versus fixed weight-bearing devices) that are used in total knee arthroplasty (TKA) with a 5-year follow-up.

**METHODS:** This randomized controlled study was conducted from 2004 to 2010 in the Department of Orthopedic Surgery at two university hospitals in Isfahan, Iran. Three hundred patients with expected primary TKA without severe deformity (a fixed varus or valgus deformity greater than 20) received fixed weight-bearing (n = 150) or mobile weight-

bearing (n = 150) devices. Clinical, radiological, and quality-of-life outcomes were compared between the two groups at 6-month intervals for the first year, after which the comparisons were made annually for the next 4 years.

**RESULTS:** Both groups had similar baseline characteristics. Although there was significant improvement in both groups, there was no significant difference between the groups with regard to the means of the Knee Society Scores, which were 92 (SD: 12.1) for the fixed weight-bearing device and 93 (SD: 14.2) for the mobile weight-bearing device (n.s.) at the final follow-up point. Radiographs showed that there was no significant difference in prosthetic alignment and no evidence of loosening. After TKA, the SF-36 score increased in both groups, but there was no statistical difference between the groups in quality of life at the final follow-up (62 (12.2) versus 64 (14.3), n.s.). There was no revision after 5 years.

**CONCLUSIONS:** In terms of clinical, radiological, or general health outcomes for people who underwent TKA, the results of this study showed no clear advantage of mobile weight-bearing over the fixed weight-bearing prosthesis at the 5-year follow-up.

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7. Biomechanical therapy for patients suffering from anterior knee pain. *The Knee Journal* 2012

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