Grade III Acromio-clavicular Joint Dislocation: Conservative Treatment Compared to Hook Plate Fixation
Stéphane Pelet, QC; Luc Bédard, QC; Karine Sinclair, QC

Purpose: Acute acromio-clavicular (AC) joint dislocation is a frequent injury. Surgical treatment was proposed for Rockwood’s grades III or higher, especially in young athletes. A recent multicenter prospective trial demonstrated, at a one-year follow-up, similar clinical results between the surgical and the conservative management of these lesions, for grades III or higher. The goal of this study is to compare the conservative functional treatment to a modern surgical treatment with a hook plate with a minimum 3-years follow-up, for exact grade III lesions.

Method: Prospective randomized trial including 56 patients with exact grade III lesions in a level one trauma center. Clinical follow-up by an independent observer for one year with Constant score as main outcome measure, telephonic follow-up for two consecutive years for complications and need for surgeries. Secondary outcomes include DASH score, specific shoulder scores and reoperation rate. Sample size for null hypothesis for Constant score. Descriptive statistics with Student unpaired t test and Fisher’s exact test (alpha = 0,05).

Results: Four patients lost to follow-up (refused to participate), 52 patients available at 3 years. No difference between the two groups for the Constant score after one year (Conservative 93.3 ± 7.4 vs 92.7 ± 6.7, p=0,41), but faster functional recovery for conservative management (3 months 87.9 ± 9.9 vs 67.9 ± 20.1, p<0,01; 6 months 89.4 ± 8.8 vs 80.8 ± 12.2, p<0,01). Same results for other clinical scores. Reoperation rate higher with surgical treatment (23 surgeries = one plate exchange and 22 plate removal, vs 0 reoperation, p<0,01).

Conclusion: Conservative treatment of acute exact grade III AC joint dislocations gives better short-term functional results with a faster rehabilitation than surgical management. No difference between the two groups after one year (excellent clinical scores for both groups). Conservative treatment is associated with a very low reoperation and complication rate even after three years (no late reoperation for symptomatic acromio-clavicular instability).

Management of Clavicle Fractures in Patients with Thoracic Trauma
Daphne M. Beingessner, WA; Geoffrey S. Marecek, CA; David P. Barei, WA; Julie Agel, WA; Thomas K. Varghese, WA
**Purpose:** Clavicle fractures are associated with significant thoracic trauma. Fracture reduction and stabilization may improve proximal chest wall morphology and comfort and be secondary indicators for surgical intervention. We hypothesized that operative fixation of clavicle fractures may be beneficial for patients with thoracic chest trauma.

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3

**The Humeral Tip-apex Index to Detect Screw Penetration after Locking Plate for Proximal Humeral Fracture**

Maude Rivard-Cloutier, QC; Stéphane Pelet, QC

**Purpose:** Proximal humeral fractures account for 4-5% of all fractures and their number is increasing with the older population. Surgical treatment is proposed for displaced fractures. The use of locking plates is associated with good clinical results. However, the last published series demonstrated significant complication rates, mainly the intra-articular screw penetration (IASP). The goal of this trial is to assess the reliability of the standard post-operative X-rays to detect the IASP, and to determine a new tool to help the orthopaedic surgeon to early suspect this complication.

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4
A Systematic Review and Meta-analysis of the Outcomes of Operative vs. Nonoperative Management of Distal Radius Fractures in Patients > 50
Lisa C. Howard, BC; Jeremie Larouche, BC; Kelly A. Lefaivre, BC

Purpose: Distal Radius fractures are the second most common fragility fracture in the elderly population. Management of these fractures has been controversial as the literature has suggested that despite high rates of malunion with nonoperative management, the functional outcomes are not significantly different than those with operative management. Our aim was to carry out a systematic review and meta-analysis of the level one evidence involving operative vs. nonoperative management of distal radius fractures in patients > 50 years of age.

Method: We conducted our search using MEDLINE and Embase with two independent reviewers involved in the article selection process. Our inclusion criteria included Level one Randomized Control Trials, English, age > 50, nonsurgical vs surgical management and acute treatment (within two weeks). Our exclusion criteria included case reports, studies with < 10 participants, review articles and foreign language articles without translation. We will be focusing primarily on functional and radiographic outcomes.

Results: Our initial search algorithm resulted in 1483 potential articles. After abstract selection, 132 papers were selected for full text review and from these, 9 papers were ultimately included. The pooled number of patients from the included studies was 521. All studies compared an operative technique to cast immobilization. One study compared locked volar plating, four compared external fixation, two compared percutaneous pinning and two compared open reduction with bone cement. Meta-analysis of the radiographic outcomes favored operative management with regard to volar tilt (p < 0.001), radial inclination (p < 0.001) and ulnar variance (p = 0.018). Three studies reported generic functional outcomes while eight reported injury specific outcomes. The functional outcome scores in six of the nine studies did not show any statistically significant difference between operative and nonoperative management at final follow-up. The heterogeneity of the type and reporting method of outcome scores used did not allow for meta-analysis.

Conclusion: Meta-analysis of level one studies showed that operative intervention allows for a statistically significant improvement in radiographic outcomes. However, the majority of final functional outcome scores were not shown to be superior with operative treatment. The results of this systematic review and meta-analysis suggest that operative intervention is not necessary for improved functional outcomes in patients > 50.

5
A Randomized Controlled Trial Assessing the Outcome of Dorsally Displaced Unstable Extraarticular Distal Radius Fractures in the Aging Population: External Fixation with Percutaneous Pinning vs. Open Reduction Internal Fixation
Cassandra Lane Dielwart, NC; Bertrand Perey, BC; Matthew Menon, AB; Simon Garceau, BC
Purpose: The treatment of dorsally displaced, unstable, extra-articular distal radius fractures remains controversial. The management of these injuries in the aging population, with incidence of osteopenia can pose further difficulty for the treating surgeon, most importantly, the ability to obtain stable fixation of the implant. The purpose of this study is to compare outcomes of dorsally displaced, extra-articular distal radius fractures in the aging population, females>55 and males>65 years of age, treated with percutaneous K-wire pinning with external fixation, versus open reduction and internal fixation using a volar locked plate.

Method: Sixty-five patients were recruited and prospectively enrolled between 2002 and 2011, and randomized into two surgical arms; External fixation with percutaneous K-wire pinning, versus open reduction internal fixation with a locked volar distal radius plate. The primary outcome measurement used, was the Patient Rated Wrist Evaluation (PRWE), at 6 weeks, 3, 6 and 12 months. Secondary outcome measures included Disabilities of the Arm, Shoulder and Hand (DASH) scores, and the Michigan Hand Questionnaire (MHQ) done at the same time points, 6 weeks, 3, 6, and 12 months.

Results: Data analysis revealed a statistical difference in the PRWE at the 6-week mark in favor of open reduction internal fixation. However, there was no significant difference seen between the groups at 3, 6 or 12 months after intervention.

Conclusion: There was no significant difference between External fixation with K-wires versus ORIF with volar locked plating, outside of the 6 week post operative period, when analyzing both primary and secondary outcomes. At 6 weeks Open reduction internal fixation was superior when assessed with the PRWE, DASH and MHQ scoring tools. These differences equalized by the 3 month follow up, and there was no difference seen between patients in all assessment tools by the one-year mark. The results of this study are consistent with previous literature, showing a potential early benefit to functional outcome with open reduction internal fixation, however no difference in the groups was noted with longer follow-up.

6
Impact of Olecranon Fracture Malunion: Study on the Importance of PUDA (Proximal Ulna Dorsal Angulation)
Julien Chapleau, QC; Frédéric Balg, QC; Frédéric Vauclair, QC; Edward J. Harvey, QC; Jérémie Ménard, QC; G-Yves Laflamme, QC; Dominique M. Rouleau, QC

Purpose: Olecranon fractures are associated with permanent and significant decrease of range of motion (ROM) in 30% of the patients. The PUDA is the physiologic dorsal bow the proximal ulna (mean 60, range 0-140) that is symmetrical from the right and left elbow. A previous biomechanical study showed impaired elbow alignment with a PUDA malunion of five degrees or more. The goal of this study is to evaluate the impact of a PUDA malunion on elbow ROM and function one year or more after olecranon ORIF.

Method: The radiological and surgical database of three trauma centers were reviewed and all adults who underwent open reduction and internal fixation (ORIF) for olecranon fracture were invited to join the study. Bilateral elbow X-rays, radiographic ROM measurement, PUDA malunion, demographic data and quality of life questionnaires were recorded (PREE, Q-DASH, SF12, VAS). ROM and PUDA were measured using Slice-o-Matic© software and following a validated method. In this case control study, patients were classified according to the difference of the PUDA between the fracture side and the normal side. Patients were categorized as “PUDA malunion” when the PUDA difference was five degrees or more. Our hypothesis was that 50% of patients would present a PUDA malunion and subsequently affect their ROM and function.
Results: Forty-nine patients entered the study, 28 of them were females. Mean age was of 54 years old (21-76). The mean follow up was 3 years and 9 months (1 to 7 years). ORIF method was tension band in 23 cases and plate-screws in 26. There was no difference in terms of outcome, quality of reduction or range of motion between those two methods. The mean ROM on the fracture side was of 1220 compared to 1350 on normal side. (p<0.001) The mean PUDA on the fracture side was different from the normal side (30 vs 4.20, p=0.013). Twelve patients (25%) presented PUDA malunion. Those patients had decreased elbow flexion of 80 (p=0.05) as opposed to the control group. Decrease elbow flexion was the strongest predictor of functional outcome and showed moderate correlation with Q-DASH (r=-0.3, p=0.025), MEPS (r=0.4, p=0.007) and PREE (r=-0.3, p=0.019).

Conclusion: PUDA malunion was present in 25% of patients and was associated with decreased elbow flexion. Flexion loss has a greater impact than extension on functional outcome. Tension band and plate fixation can maintain good reduction in terms of PUDA and are not influencing outcome.

7 Factors Associated with Non-union of Open Fractures: A Prospective Cohort Study of 736 Subjects
Donald Weber, AB; Joseph Westgeest, AB; Sukhdeep Dulai, AB; Joseph Bergman, AB; Richard Buckley, AB; Lauren Beaupre, AB

Purpose: To determine factors associated with non-union after an open long bone fractures including time to antibiotic administration and time to surgery.

Method: Between 2001 and 2009, 939 subjects were screened for a prospective cohort study at three Level One trauma centres in Canada with broad catchment areas and subsequent prolonged extraction times to the surgical hospital. Eligible subjects were skeletally mature, had open fracture(s) of the humerus, radius/ulna, femur and/or tibia/fibula and presented for initial surgical debridement. Those with medical conditions precluding surgery, pathologic fractures or fractures resulting from penetrating trauma (e.g. gunshot wounds) or requiring primary amputation were excluded. Demographics, fracture and injury information, and time to surgery and antibiotics were recorded. Subjects were evaluated using standardized forms until fracture healed. Phone interviews and chart reviews were conducted one year post-fracture. The primary outcome, non-union, was defined as lack of bony union requiring unplanned surgical intervention following definitive wound closure at >6 months after lower extremity or >4 months after upper extremity fracture. Multivariate logistic regression was used to determine factors associated with development of non-union.

Results: Of 939 screened subjects 736 (78%) subjects [791 fractures] were subsequently enrolled; 690 (94%) subjects (740 fractures) had outcomes via 1-year interview and/or clinical follow-up >90 days. The median age was 39.6 (minimum 17, maximum 93) years and 530 (72%) were males. Motor vehicle accidents accounted for 359 (49%) injuries with 230 (31%) falls, 131 (18%) crush injuries and 16 (2%) assaults. Tibia/fibular fractures were the most common (n=413 [52%]), followed by upper extremity (n=285 [36%]) and femoral (n=93 [12%]) fractures. Using Gustilo grade, 226 (29%) were Grade 1, 291 (37%) Grade 2, 162 (21%) Grade 3A, 96 (12%) Grade 3B and 7 (1%) Grade 3C fractures. Of 740 fractures with defined outcomes, 122 (17%) developed non-union. The median time to antibiotic administration was 3 (Interquartile Range [IQR] 1.8, 7.3) hours for healed fractures and 2.8 (IQR 1.5, 7.3) hours for non-united fractures (p=0.75). The median time to initial surgery was 9 (IQR 6.8, 11.3) hours for healed fractures and 8.3 (IQR 6.3, 11.3) for non-united fractures (p=0.48). Using logistic regression, deep infection was the factor most strongly associated with developing a non-union (Odds Ratio [OR] 11.5; 95%CI 5.6, 23.7). Grade 3A injuries were also significantly associated with non-union relative to Grade 1 injuries (OR 2.2; 95%CI 1.1, 4.2) as was having other injuries (OR 1.6; 95%CI 1.01, 2.6). Timing of
antibiotic administration or surgery, fracture site and transfusions were not associated with developing a non-union (p>0.21).

**Conclusion:** Deep infection is strongly associated with developing a non-union after open extremity fractures. Timing of antibiotics or surgery is not associated with non-union.

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**Timing of Irrigation and Debridement and Infection Risk in Severe Open Fractures**

**Raman Mundi, ON;** Clary J. Foote, ON; Parag Sancheti, India; Vijay Shetty, India; Mandeep S. Dhillon, India; Ilyas Aleem, ON; Rebecca Ivers, Australia; Mohit Bhandari, ON

**Purpose:** Open fractures are common injuries in musculoskeletal trauma patients. Detailing the open fracture burden and simple modifiable factors associated with infection risk in developing regions remains a global surgical priority.

**Method:** A prospective, observational, cohort study of 4612 patients was conducted in 14 private and public hospitals across India between October 2011 and June 2012. Adult patients admitted to hospital with a fracture and/or dislocation were eligible for inclusion over an 8-week enrolment period at each center. This sub-study considered only those patients presenting with open fractures. Patients were followed for 30-days or until discharge, whichever occurred first, to assess for the occurrence of wound infection. Binomial logistic regression was performed to examine the association between delayed irrigation and debridement (I&D) and infection risk.

**Results:** Seven hundred and seven patients presented with 820 open fractures. The mean patient age was 37 (SD14), with the majority being male (81%) and sustaining an open fracture of the lower extremity (74%). For those patients assigned a Gustilo-Anderson classification (527), 115 experienced type 1 injuries (22%), 174 type II injuries (33%), and 238 type III injuries (45%). Only 374 (53%) patients underwent surgical I&D within 6 hours of injury. The overall infection rate in patients with open fractures was 27%, ranging from 10% in type I injuries to 25% and 34% in type II and III injuries, respectively. When controlling for open fracture severity and number of open and non-orthopaedic injuries, delay in I&D beyond 12 hours of injury was associated with a nearly 10-fold increase in infection risk compared to I&D within 6 hours (I&D 6-12 hours: OR 2.1, 95CI: 1.2-3.9; I&D >12 hours: OR 9.9, 95CI: 5.7-17.1).

**Conclusion:** Infection rates following severe open injuries are unacceptably high and predicted, in part, by delays to wound irrigation. Irrigating open wounds as soon as possible after injury may decrease the burden of infection.

9

**Long-term Implantation of Polymethylmethacrylate Antibiotic Beads**

**Shawn Werner, WA;** Reza Firoozabadi, WA

**Purpose:** Clavicle fractures are associated with significant thoracic trauma. Fracture reduction and stabilization may improve proximal chest wall morphology and comfort and be secondary indicators for surgical intervention. We hypothesized that operative fixation of clavicle fractures may be beneficial for patients with thoracic chest trauma.
Method: We reviewed a prospectively recorded trauma database for all patients with clavicle fractures (OTA 05, 06, 07) from April 2005 to June 2010. We identified 1074 patients with clavicle fractures. Minors and those with missing data were excluded. We recorded age, chest Abbreviated Injury Score (AIS), length of Intensive Care Unit (ICU) stay, and other demographic information. ICU admission was made at the discretion of the general trauma team and the orthopaedic trauma staff in consultation with the ICU team made the decision for surgery. The primary indication for clavicular ORIF was the magnitude of fracture displacement, and Fellowship-trained orthopaedic trauma surgeons performed all surgeries. The operative tactic and implant selection were made at the discretion of the treating surgeon. Postoperatively patients were placed into a sling and, when possible, patients began range of motion exercises beginning postoperative day 1.

Results: Mean chest AIS was 3.56 ± 0.71 (mean ± standard deviation). 763 patients had a chest AIS ≥ 2. Of these, 75 patients had operative treatment of their clavicle fracture (9.8%). Forty-nine of these patients required an ICU stay (78.6%) with a mean length of stay (LOS) of 4.5 days (range 1 – 24). Of the 688 patients who had non-operative treatment of their clavicle fracture, 493 patients required an ICU stay (72%) with a mean length of stay of 7.8 days (range 1 – 98). ICU stay was significantly shorter in patients with operatively treated fractures (p < 0.001). We further stratified those patients who had minimum ICU stay of 2 days. Of these 359 patients, 340 were treated nonoperatively during the initial hospital course with a mean ICU stay of 10.7 days. Thirteen patients had operative fixation of the clavicle while in the ICU with a mean length of stay of 8.8 days. This difference was significant (p < 0.001)

Conclusion: Polytraumatized patients with clavicle fractures commonly have significant thoracic trauma. Operative stabilization of the fractured clavicle is associated with shorter ICU stays. Further research is needed to better identify those patients who may benefit from operative fixation of the clavicle.

10
Prospective Study Investigating the Prevalence and Evolution of Malnourishment in the Acute Orthopaedic Trauma Patient
Benjamin Hamilton, WA; Courtney O'Donnell, WA; Julie Agel, WA; Patricia Kramer, WA; Stephen Benirschke, WA; Bradford Henley, WA; Reza Firoozabadi, WA

Purpose: Malnutrition in the acute setting is a well-documented complication that can negatively impact prognosis. Undernutrition is associated with increased infection rates, impaired wound healing, depression of the immune system, longer length of stay, and increased recovery time and mortality. Within orthopaedic literature, incidence of malnutrition in hip fracture patients ranges from 6-78% and has been identified as the most costly co-morbidity associated with this patient group. Despite this recognition, to our knowledge malnutrition has not been studied specifically in a large group of orthopaedic trauma patients. The primary aim of this study was to investigate the prevalence and evolution of malnourishment in the setting of acute orthopaedic injury.

Method: We performed a prospective study by enrolling a sample of patients that required admission for isolated orthopaedic trauma. Labs were drawn at admit, day three, day seven, and at six week follow-up, and included albumin, prealbumin, transferrin, CRP, and vitamin D. Nutritional status was determined using the Rainey MacDonald nutritional index (RMNI). Type of orthopaedic injury, significant co-morbidities, and incidence of complications (delayed wound healing and infection) were also recorded.

Results: One hundred one orthopaedic trauma patients enrolled of which 30 were excluded because they were discharged and/or did not get appropriate lab results drawn. There were 35 males and 35 females with a
mean age of 50; 16 cases with tibia fractures, 23 femur fractures, 10 ankle fractures, 15 acetabular/pelvic fractures, and 14 other fracture types. Seven patients experienced complications with three cases of delayed wound healing and four infections. Eighteen of our patients required more than one surgery for their injuries. On admission, 70%, 40%, and 43% of patients were malnourished based on albumin, prealbumin, and RMNI values, respectively, with 77% in an acute-phase response (APR) as determined by CRP. By day three, malnourishment worsened with a statistically significant increase to 97%, 88%, and 91%. At day seven, values stabilized at 96%, 89%, and 81%. At six week follow-up malnourishment was seen in 20%, 20%, and 15%, with 25% in APR. 80% of patients had low vitamin D levels on admission; 64% had low levels at 6 week follow-up. There was a trend towards lower laboratory nutritional markers and higher rates of malnutrition seen in those patients experiencing complications.

Conclusion: Malnutrition in the acute orthopaedic trauma patient, as defined by commonly used biochemical markers, is a common disease that increases in prevalence throughout hospital stay. Routine assessment of nutritional status in this population is encouraged, given the potential impact of this condition on patient outcomes. Larger multicentered prospective studies need to be performed to determine to what degree malnutrition effects outcomes in orthopaedic trauma patients.

11
Fgfr3 Regulates Fracture Repair by Controlling the Balance Between Intramembranous and Endochondral Bone Formation
Simon P. Kelley, ON; Chunying Yu, ON; Benjamin Alman, ON

Purpose: Fgfr3 mutations cause skeletal dysplasias such as achondroplasia (gain of function) and CATSHL syndrome (loss of function). Furthermore patients with achondroplasia show enhanced bone formation when undergoing distraction osteogenesis. This suggests fgfr3 has a role in both skeletal development and repair by regulating the differentiation of precursor cells between the mesenchymal lineages. Thus, we examined the role of Fgfr3 in fracture repair, to determine its effects on cellular proliferation and differentiation during a reparative process.

Method: A closed tibial fracture model was used in Wild Type (WT) and genetically modified Fgfr3+/- mice. Fractures were harvested and analyzed at serial time points using histology and micro-CT to assess callus structure and composition. A BrdU assay was used to assess cell proliferation within the callus. In addition fracture RNA was harvested for gene expression analysis. An in-vitro BrdU assay was used to assess the proliferation of colony-forming-unit fibroblasts (CFU-F) from Bone Marrow MSCs (BM-MSCs). The ability of BM-MSCs to differentiate to osteoblasts (CFU-O) and chondrocytes (CFU-C) was analyzed using staining techniques and real-time PCR.

Results: Fracture healing in mice lacking fgfr3 showed profound differences to WT controls on micro-CT analysis with smaller and weaker callus, yet no difference in callus composition (BV/TV and Tissue Mineral Density). In-vitro findings indicate that fgfr3 is required for normal proliferation of progenitor cells (BM-MSCs) and in-vivo this is further demonstrated by fewer proliferating cells within fgfr3 deficient periosteum and callus. The effects of fgfr3 deficiency are also seen throughout the later stages of fracture healing with delayed upregulation of key osteogenic and chondrogenic genes suggesting a knock-on effect of the reduced proliferation of progenitors within the early callus. In-vitro findings also confirm that reduced fgfr3 signaling alters BM-MSC differentiation to cells of the mesenchymal lineages, as osteogenesis is reduced whereas chondrogenesis is increased.
Conclusion: Fgfr3 signaling has important effects on the proliferation and differentiation of mesenchymal progenitor cells, which is clinically manifested by an alteration in fracture healing. In this era of regenerative medicine it is crucial to understand how we can manipulate cells for the purposes of tissue engineering. Modulation of fgfr3 signaling may offer a novel ability to enhance proliferation of musculoskeletal progenitor cells and also to direct progenitor cells towards the osteoblast for bone regeneration or chondrocytes for articular cartilage regeneration. This has enormous appeal for treating a wide range of common musculoskeletal disorders, such as fracture repair, osteoporosis and arthritis, and indeed offer potential therapeutic options for rare genetic bone diseases such as achondroplasia.

12
The Effect of Local Delivery of Iron Chelators on Bone Ingrowth and Osteoclast Mediated Bioceramic Bone Graft Resorption
Justin Drager, QC; Zeeshan Sheikh, ON; Yu Ling Zhang, QC; Abishek Kumar, QC; Edward Harvey, QC; Jake Barralet, QC

Purpose: The clinical success of bioresorbable bone graft substitutes relies on rapid vascularization while temporizing resorption to maintain structure and strength during bone ingrowth. Local delivery of the widely available iron chelator, Desferoxamine (DFO) has been shown to augment both angiogenesis and osteogenesis in fracture models through activation of the Hypoxia Inducible Factor (HIF) signaling pathway. While hypoxic conditions are also known to induce osteoclast differentiation, mimicking this effect with iron chelators has shown contradicting results in vitro. We aimed to determine the effect of DFO on new bone growth and graft resorption in a rabbit ulnar defect bridged by 3D-printed calcium phosphate (monetite) grafts. Secondly, we aimed to quantify the effect of iron chelators on osteoclast mediated graft resorption using a cranial graft onlay model.

Method: Microporous 10mm monetite grafts were 3D printed to anatomically match a rabbit mid ulna. Cylindrical grafts (9mm diameter/ 4mm thick) were prepared for the cranial model. In six rabbits, grafts were inserted into bilateral 10mm mid-diaphyseal ulna defects. Starting on day four post-op 600ul of DFO (200uM) was injected into one graft of each rabbit every 48 hours for 6 doses. The contralateral limb received saline injections. For 10 rabbits, two circular grafts were fixed subperiosteally onto the cranium. Four rabbits had DFO injected in a similar fashion into both grafts and four were given saline. To verify if the results could be replicated using another chelator, two rabbits were injected with 1,10 Phenatroline. At 8 weeks micro-CT and histology was used to assess new bone growth and graft resorption. Additionally, histological sections of the onlay grafts were TRAP stained to assess for osteoclast density at the bone-graft interface.

Results: In the ulna model, micro-CT analysis demonstrated increased new bone growth in the DFO group compared to the saline group (BV/TV19.8% vs 13.15% (p=0.042). Graft resorption was similar in both groups (77.8 vs 75.3 mm3). Histological analysis showed more bone within the osteotomy gap and integrated with graft surface in the DFO group. In the cranial model micro-CT and histological analysis showed a marked lower resorptive front in the DFO and PHT group as compared to saline controls. TRAP stain quantification showed a 3-fold significant decrease in osteoclast density in the chelation groups compared to controls.

Conclusion: DFO increased bone formation in a long bone defect bridged by a bone graft substitute. The cranial onlay model exposes the grafts to a more static environment whereby cell mediated resorption can be tracked from a single front. Local delivery of chelators reduced graft resorption and osteoclast numbers at the bone graft interface in this model. This study proposes a second mechanism by which iron chelator's may
function as bone anabolic agents - in addition to HIF activators, they may also reduce osteoclast mediated resorption by independent mechanisms.

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Comparison of the Effect of Sclerostin Antibody to Complete Depletion on Fracture Healing
Mohammad M. Alzahrani, QC; Reggie C. Hamdy, QC

Purpose: Sclerostin is a secreted glycoprotein that interacts with LRP5 receptor on osteoblasts and inhibits the intracellular Wnt signaling pathway, leading to decreased bone formation. When sclerostin is inactivated bone formation is therefore stimulated. This stimulation has been proven in fracture studies, which showed that sclerostin deficient mice have larger and stronger calluses with accelerated fracture healing, both in sclerostin knockout and sclerostin antibody injection models. These observations suggest that sclerostin inhibition and depletion show improved and accelerated fracture healing, but the effect of these two mechanisms have not been compared to assess the accurate effect of the Scl-Ab injections. Therefore we designed a study to compare the effect of sclerostin depletion (sclerostin knockout) and inhibition (Scl-Ab injection).

Method: Ten-week-old male SOST knockout (KO) (N=20) and Wild-type (WT) (N=40) mice underwent insertion of a tibial intramedullary pin after which a mid-shaft tibial osteotomy was performed. The mice were divided into three groups: SOST KO (N=20), WT with Scl-Ab injection (N=20) and WT with saline injection (N=20). The Scl-Ab group received an intravenous dose of 100mg/kg weekly starting on day 7. Each group was managed and sacrificed according to the specified protocol. For data analysis, one-way ANOVA (Analysis Of Variance) was performed followed by Tukey’s post hoc test at each time point. P values<0.05 were considered statistically significant.

Results: Both Scl-Ab and KO groups showed significantly increased trabecular BV/TV (bone volume/total volume) at the fracture site (mid-shaft of the tibia) compared to the saline group at all time points and also showed no significant difference between them at all time points (except at 28 days postoperative). On biomechanical testing the Scl-Ab and KO groups showed significant increased strength in stiffness at days 14, 28 and 35 compared to the saline group. Concerning ultimate force and work to failure the KO group showed significant increase in the force required compared to both the Scl-Ab and saline groups at 21, 28 and 35 days. While the Scl-Ab group showed increased force required to fracture the callus compared to the saline group at these time points, but this was only significant for work to failure at 28 days.

Conclusion: Scl-Ab injections showed promising results, which were comparable to the complete depletion of sclerostin, especially at earlier stages of the healing process. In addition, our results indicate that sclerostin antibody exerts its greatest effect in the earlier stages of fracture healing (days 14 and 21), after which the healing process plateaus and thus completing this process at an earlier time point. Further research into accurate dosage and adequate timing of administration is required before these promising results can be implicated as a modality for accelerating fracture healing in humans and management of delayed / nonunion.

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Effect of Combined Bony Defects on Anterior Glenohumeral Stability: A Cadaveric Study
Anthony Miniaci, OH; Piyush Walia, OH; Lionel Gottschalk, OH; Ronak M. Patel, IL; Morgan H. Jones, OH; Stephen D. Fening, OH

Purpose: Bony Bankart and Hill-Sachs lesions contribute to recurrent instability of the glenohumeral joint. Previous biomechanical studies have demonstrated the critical size of anterior glenoid defects in instability. No
studies have investigated the effects of combined anterior glenoid and posterior humeral head defects. Nevertheless, more than half of recurrent dislocation cases have both a Hill-Sachs lesion and a bony Bankart defect. Previous studies have analyzed only the effects of isolated glenoid or humeral head defects at limited arm positions. Literature data suggests that instability might vary for envelop of motion. The aim of this study was to evaluate the effect of combined bony lesions on shoulder instability through varying glenohumeral positions.

Method: Experiments were performed at glenohumeral abduction angles (ABD) of 20°, 40°, and 60° and external rotations (ER) of 0°, 40°, and 80° for 18 specimens. The glenoid was translated in a posterior direction in order to cause an anterior dislocation under a 50N load using a custom built shoulder dislocation simulator. Translational distance and medial-lateral displacement, along with horizontal reaction force were recorded for every trial. Three different pathways were chosen (four levels of glenoid defect and five levels of humeral defect) to maximize defect combinations.

Results: At 20° ABD and 0° ER, % intact translations were 69.0± 9.7, 64.3±12.9, 64.9±11.1, 66.7±8.8, 69.3±13.9 for humeral defect sizes of 0%, 6%, 19%, 31%, 44% with a 20% glenoid defect, respectively. However, at a functional position of 60° ABD and 80° ER these values were significantly decreased (p < 0.05) for humeral head defects to 48.6±24.2, 26.6±25.2, and 1.6±3.6, respectively. Increasing glenoid defect size reduced translation values independent of changes in arm-position.

Conclusion: This study demonstrated that a smaller glenoid defect size of 10% combined with a 19% humeral head defect, can lead to a significant instability. Additionally, it was shown that a significant glenoid defect would lead to loss of translation independent of changes in the arm position. However, the loss of stability from a humeral head defect would lead to loss of translational stability significantly at a functional arm position of increased abduction and external rotation rather than a resting arm position. This rotational dependency of a humeral head defect further leads to a magnified instability during combined defects.

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Effect of Transforming Growth Factor Beta1 (TGFβ1) on the Gene Expression in Human Flexor Digitorum Profundus Tendon Cells in Culture

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Purpose: Hand injuries account for nearly 10% of hospital emergency department visits. Among these injuries, flexor tendon lacerations including flexor digitorum profundus (FDP) tendon remains a challenge for the surgeons and tissue engineers alike. While flexor tendons heal with reduced mechanical strength, the most clinically significant issue is the formation of adhesions that impair hand function upto 60% of cases regardless of surgical approach. Adhesions and scars in flexor tendons, like in other parts of the body, are orchestrated primarily by TGFβ1. The purpose of this study was to determine the effect of TGFβ1 on gene expression of human FDP tendon cells in vitro. This information will help in developing therapeutical strategies for repairing FDP tendon injuries, preventing adhesion formation, and achieving success in tendon grafting.

Method: Human FDP tendon was obtained from university hospital discarded after surgery. The normal part of tendon was cut isolated and was used to isolate tendon cells known as tenocytes. Tendon was minced into 1mm pieces, treated with 0.25% trypsin for 20 min, placed in organ culture in 20%-FBS medium (cell culture medium containing 20% fetal bovine serum). Tenocytes proliferated from tendon pieces by day-10, and the monolayer of cells was obtained by day-16. At p3, 0.6 million cells were plated in 100mm cell culture dishes in
10%-FBS medium. Medium was replaced by 1%-FBS medium after 48h. After serum starving for 16h, medium was replaced by fresh 1%-FBS (control) and 1%-FBS medium containing 5ng/ml hrTGFb1. The cell culture was terminated at 6h and 24h, and cells were processed for RNA isolation. Expression of several genes was determined by RTPCR using beta-actin gene as an internal control. Data at each time-point, in triplicates, were presented as the mean fold induction ±SD; p-value less than 0.05 differing from control, was considered, as significant. Experiment was repeated three times to observe the consistency of RNA data. Data were analyzed using one-way ANOVA followed by Tukey’s all-pair comparisons at alpha=0.05.

Results: As compared to controls, TGFb1 induced the up-regulation of CTGF, SCXA, TGFBR1, IGF1, TIMP3, IL6, COMP and SERPINE1 genes at 6h and 24h, and SMAD7, PLAU and MMP13 genes at 6h, and ACTA2 gene at 24h, significantly. As compared to controls, TGFb1 also caused down-regulation of DCN, ACAN, GDF5, MMP2, PLAU, TGFBR2 and MMP9 genes at 6h and 24h, significantly.

Conclusion: TGFb1 modulates genes for fibrinolysis (PLAU, PLUR, SERPINE1), contraction (ACTA2), fibrosis (TGFBR1, TGFBR2), regeneration (IGF1), neotendon formation (GDF5), differentiation (SCXA), collagen fibrillogenesis (DCN), remodeling (MMP2, MMP9, MMP13, TIMP3), ECM (ACAN), pro-inflammatory cytokine (IL6), mechanical strength (COMP), and repair and angiogenesis (CTGF), the information will help in developing therapeutical strategies for repairing FDP tendon injuries, preventing adhesion formation, and achieving success in tendon grafting.

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CT Landmark-Based Semi-Automated Mesh Morphing and Mapping Techniques: Generation and Validation of Patient Specific Models of the Human Pelvis
Zoryana Salo, ON; Maarten Beek, ON; David Wright, ON; Asmaa Maloul, ON; Cari Whyne, ON

Purpose: Finite Element (FE) Analysis has been successfully used to describe the complex behavior of multifaceted skeletal structures, such as the human pelvis. However, traditionally FE models of the human pelvis have been generated by manually segmenting patient-specific CT scans, which is labour intensive and time consuming. This study validates the performance of patient-specific FE models of the human pelvis generated without CT segmentation, using CT landmark-based semi-automated mesh morphing and mapping.

Method: CT images were acquired of five cadaveric pelvises (GE Lightspeed Plus). Traditional segmentation was used to generate a patient-specific pelvic FE (source) model from one patient-specific CT scan. A landmark set consisting of 329 landmarks was created and applied directly (in an automated fashion) onto the four target CT scans. Any landmark that deviated from its assigned location was manually adjusted. The source model was morphed to the skeletal CT landmarks, with ligament and cartilage elements morphing along with the bone structure. Each morphed model was further refined through mesh mapping to ensure that all surface nodes were located at the bone boundaries. In this, Houndsfield Unit (HU) values were determined for each surface node based on the voxel in which the node was located; the node was then translated along the normal direction until it reached the bone boundary. Finally, Laplacian smoothing was applied. The pelvic models were loaded through the fifth lumbar vertebrae in a double leg stance configuration to 345 N in axial compression and solved using non-linear static FE analysis (Abaqus). Experimentally, the human cadaveric pelvises were strain gaged (n=8 per specimen) and similarly loaded. Strains computed in the morphed/mapped FE models were compared to experimentally obtained strains.

Results: The landmark-based semi-automated mesh morphing and mapping techniques efficiently generated specimen-specific pelvic FE models that recreated experimental pelvic behavior. The morphing and mapping
procedures completed in ~5 minutes on a standard PC for each pelvic model. Comparison of the morphed/mapped FE calculated strain values to the experimentally measured strains yielded R2 values ranging from 0.61 to 0.93. Accurate assignment of load and boundary conditions (pelvic and femoral positioning) between the experimental set up and the FE models was found to be critical with respect to the accuracy of strain results.

**Conclusion:** Landmark-based semi-automated mesh morphing and mapping techniques were effectively applied in the reconfiguration of a segmented patient-specific pelvic source mesh without CT segmentation. This method enables efficient generation of multiple anatomically complex patient-specific FE models. Experimental validation highlighted the need for accurate pelvic and femoral orientation in order to represent boundary conditions simulating physiologic joint loading.

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**Does Delay in Surgery Affect the Temporal Expression of Growth Factors After Intramedullary Nailing of the Femoral Shaft Fractures**  
**Vivek Trikha, India; Arulselvi S. India; Budhadev Choudhury, India**

**Purpose:** Growth factors are considered to play an important role in the process of bone healing. Role of Delay in surgery leading to a deleterious impact on the bone healing process is not known. This study was conducted to assess the serum levels of TGF-β 1 and VEGF over a period of six months in patients undergoing intramedullary nailing for isolated fracture shaft of femur operated at various time periods after injury.

**Method:** TGF-β 1 and VEGF levels were evaluated, for 50 patients undergoing nailing and 15 patients of femoral plating, before the procedure and on postoperative 3rd day, 14th day, six weeks, 12 weeks and 24 weeks. The time lag between injury and surgery and the expression of the growth factors was also evaluated. 15 patients of same age group operated for femur fractures with plating were taken as control group while 15 healthy volunteers were also taken as the normal base levels of the growth factors. This study was ethically approved by the institute ethics committee. All patients were operated as soon as deemed medically fit for surgery. being a tertiary level trauma centre patients are referred to our centre from far flung areas leading to a delay in surgery.

**Results:** Out of the 50 patients, 30 patients were operated within the first 48 hours while the rest were operated after 48 hours but within the first seven days. There was a steady increase in the expression of VEGF with peak values in the first 10 days after surgery. This returned to near normal levels by the end of six months. TGF-β 1 level also showed increasing trend after surgery but the levels reached high peaks after 2 weeks and continued to remain high till the end of six months.

**Conclusion:** There is a definite and specific trend of serum levels of growth factors in the fracture healing process. There is no effect of delay in surgery on the serum levels of growth factors essential for fracture callus formation in isolated femur shaft fractures. The changes in the levels of these factors may be a pointer to the status of the bone healing. This the first study of its kind evaluating the expression of growth factors in the fracture healing process operated at various time duration after the injury process.

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**Reconstruction of a Critically-sized Radius Segmental Defect in a New Zealand White Rabbit Model Using Bone Allograft Requires Intramedullary Wire Fixation**
Purpose: Pre-clinical in vivo testing in animal models plays a critical role in advancing new orthopaedic therapies/implants for potential use in human patients. The New Zealand White rabbit (NZWr) radius segmental model is an appropriate long bone defect model to test biocompatibility of graft materials because the NZWr bone exhibits Haversian remodeling similar to human bone, matching the tubular shape of the radius in implants is easier, the model’s reproducibility allows for comparison of graft materials, and reportedly no fixation is required due to the support of the intact ulna. However, given the significant curvature of the radius, we would argue that fixation is required to achieve a stable anatomic reconstruction and avoid non-unions associated with biomechanical instability. The aim of this study was to establish and evaluate intramedullary (IM) wire as the ideal fixation method within the NZWr radius defect model.

Method: Ten female retired breeder NZWr (7-9 months old) were used. Younger rabbits with open growth plates were excluded to avoid epiphyseal slipping. Ethics approval was obtained. Bone allografts were first harvested from both radii of five donor age-matched female retired breeder NZWr. Under general anesthesia, a 15-mm critically-sized defect was created in the radius (mid-diaphysis) of recipient NZWr using a micro-oscillating saw. The previously harvested donor allograft was then cut and sized to fit the radial defect, and a 0.8 mm Kirschner wire (K-wire) was used for graft fixation as an IM device. The reconstructions were monitored with bi-weekly radiographs until sacrifice at 12 weeks. A musculoskeletal radiologist quantified the healing based on the radiographic scoring system described by An and Friedman. Upon retrieval of the reconstructed radii at 12 weeks, the specimens were scanned with microCT and analyzed using static histomorphometry.

Results: Stable IM wire fixation was achieved in nine rabbits, with only one graft minimally displacing after slight K-wire migration at 2 weeks. Radiographic scoring analysis revealed no healing at 2 weeks, mild-moderate periosteal bridging callus localized to the osteotomy sites and <50% bridging union by 4 weeks, and significant callus formation at the osteotomy sites and >50% bridging union by 6-8 weeks. Cortical remodeling was noted at 10 weeks. By 12 weeks, there was complete proximal osteotomy site union, near full circumferential union at the distal osteotomy site, significant cortical remodeling, and periosteal callus formation over the entire reconstruction, while the interosseous space between the radius and ulna was still maintained. Union and cortical remodeling at 12 weeks were confirmed with microCT and histologic analysis. No infections or mortality were observed.

Conclusion: This study demonstrates that IM wire fixation in the NZWr radius segmental model successful achieves an anatomic and stable construct to accurately study the biology of large segmental defect reconstruction using bone allograft.
study seeks to examine lower limb biomechanics and muscle activation during a functional task (stand-to-sit). A comparison will be made between the operated and non-operated limbs for two TKA groups: one with a medial pivot (MP) prosthesis and the second with a posterior stabilized (PS) prosthesis during stand-to-sit task.

**Method:** Subjects having undergone unilateral TKA with an MP (N=13; 10M/3F; age=61.9±6.4 years, BMI=29.8±4.5 kg/m2) or PS (N=6; 5M/1F; age=68.3±3.6 years; BMI=29.8±4.5 kg/m2) implant were recruited from the orthopaedic clinic of the Ottawa Hospital. Mean follow-op time was 11±3 months for the MP group and 9±2 months for the PS group. A 10-camera motion analysis system (Vicon MX) and two force plates captured 3D motion data and vertical ground reaction force (vGRF) during stand-to-sit trials. These values were subsequently normalized for body mass. Wireless surface electrodes collected EMG signals for vastus lateralis (VL), vastus medialis (VM), rectus femoris (RF), biceps femoris (BF), and semimembranosus (SM) muscles of the operated and non-operated lower-limb. Maximum voluntary isometric contractions were collected for EMG normalization. All EMG data were processed using Matlab to obtain the integrated EMG (iEMG) values. Paired t-tests (α=0.05) were conducted to compare iEMG and peak vGRF among the operated and non-operated limbs for both groups.

**Results:** Results showed that the PS group had significantly higher activation of the VL (p=0.019) and RF (p=0.043) muscles in the non-operated knee (VL=304±34V /V; RF=228±32V/V), compared to the operated side (VL=211±22/V; RF=186±22V/V) during stand-to-sit. This corresponded with a trend of higher vGRF values in the non-operated side (vGRF=5.94±0.8N/kg), compared to the operated limb (vGRF=4.88±0.7N/kg). No statistical differences were found between limbs for any muscles in the MP group and no significant differences were observed in the hamstrings for the PS group.

**Conclusion:** In summary, the MP group demonstrated greater symmetry in muscle activity and loading of the lower limbs, as well as less compensation in the non-operated limb than the PS group. The greater activation of the knee extensors, combined with the larger peak vGRF at the non-operated limb, for the PS group is in accordance with Mizner et al.’s (Mizner, Snyder-Mackler; 2005) findings. The differences in symmetry observed between the MP and PS groups suggest that further research is needed to examine how prosthetic design may influence the relationship between muscles and lower limb joint biomechanics within TKA.

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A Novel 3D CT Image Registration Technique for Evaluating Glenoid Baseplate and Screw Placement in Reverse Shoulder Arthroplasty
Ryan T. Bicknell, ON; Gabriel Venne, ON; Mike Pickell, ON; David Pichora, ON; Randy Ellis, ON

**Purpose:** Long term survivorship of reverse shoulder arthroplasty (RSA) relies on proper placement of the glenoid baseplate and screw fixation. Improper positioning of the glenoid implant can alter the joint biomechanics, potentially leading to undesired translation, instability, loosening, and premature wear of the components. Previous studies suggest that 3D-CT reconstruction is superior to 2D CT or radiographs for evaluating scapula anatomy or measurements. However, metal artifact from implants and screws is a limiting factor in using a 3D-CT reconstruction approach for post-operative analysis. The objective of this study was to describe a novel method for measurement of RSA glenoid implant and screw positioning using 3D CT reconstruction and to compare this technique to conventional approaches using 2D CT scans and radiographs.

**Method:** Pre- and post-op radiographs and CT scans were obtained from six patients that had a previous RSA. The novel 3D CT method used CT scans images that were imported into a medical imaging processing
software (Mimics, Materialise, Leuven, Belgium) and each scapula, glenoid implant and inferior screw were reconstructed as 3D models. Post-op 3D models were imported into the pre-op reference frame and matched to the pre-op scapula model using both a paired-point and a surface registration. Measurements on registered CT models were performed in reference to the pre-operative scapula model coordinate frame defined by a computer-assisted designed triad positioned with respect to the center of the glenoid fossa. Glenoid implant inclination and version and inferior screw percentage in bone was measured using the 3D CT method and compared to conventional approaches using 2D CT scans and radiographs. The inter-observer reliability of the three methods was measured for three qualified observers using an intra-class correlation coefficient (ICC) method.

**Results:** The 3D CT registration method showed excellent inter-observer reliability (ICC>0.75) for glenoid implant inclination (0.97), version (0.98) and screw volume in bone (0.99). Conventional 2D CT methods showed poor reliability (ICC<0.4) for inclination (0.02), version (0.07) and percentage of screw in bone (0.02). Traditional radiographs also showed poor reliability for inclination (0.05) and percentage screw in bone (0.05).

**Conclusion:** A novel method for measuring RSA glenoid implant positioning and screw volume in bone has been developed and showed excellent inter-observer reliability, compared to conventional 2D CT and radiographic methods. This method overcomes some metal-artifact limitations of post-operative CT evaluation of implants and may allow quantitative positioning analysis of RSA glenoid implants. Furthermore, conventional 2D CT scan and radiographic methods have poor inter-observer reliability for measurement of glenoid implant positioning and screw location in bone in RSA.

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**Quantifying the Relationship between Pre-operative Knee Joint Function during Gait with Improved Joint Function Due to Primary TKA**
Jerome Outerleys, NS; Michael J. Dunbar, NS; Cheryl Kozey, NS; Janie Wilson, NS

**Purpose:** Total knee arthroplasty (TKA) surgery is the primary treatment of end-stage knee osteoarthritis (OA), with the aim of increasing functional capacity of the joint, reduce pain, and increase the patient’s quality of life. It has been shown that TKA surgery does improve group average knee joint kinematic and kinetic patterns toward asymptomatic. However, there is considerable post-operative variability, with not all patient biomechanical patterns moving closer to asymptomatic (Hatfield et al., 2011). It has also been shown that features of pre-operative gait patterns in the sagittal plane are highly associated with their value postoperatively (Smith et al., 2006), suggesting that the pre-operative joint functional state is very important in describing the variability in functional response to TKA, and may dictate a patient’s expected functional improvement. The objective of this study was to therefore to examine the relationship between pre-operative knee kinematics and kinetics during gait and the improvement of these metrics due to primary TKA.

**Method:** Forty-six patients (17M, 29F) diagnosed with end-stage knee OA and scheduled for primary TKA surgery underwent a three-dimensional gait analysis (NDI Optotrat 3020, AMTI force platform) within one week prior to, and one year after primary TKA. Three-dimensional knee joint kinematics and kinetics, normalized to 100% of the gait cycle, were captured during self-selected speed walking, consistent with the joint coordinate system model (Grood and Suntay, 1983). Patients received 1 of 3 implant designs (non-randomized): 21 Zimmer NexGen PS, 12 Stryker Triathlon PS, and 13 Stryker Triathlon CR. Pre- and post-operative peak and range values of kinematic and kinetic waveforms (Astephen et al., 2008) were extracted, and a change score was calculated between the two time points. Two-tailed Pearson correlation coefficients
were calculated using SPSS (IBM Corp., Armonk, NY, 2012) to test for significant linear associations between pre-operative and change scores.

**Results:** Statistically significant (p < 0.05) negative correlations were found between all pre-operative metrics and their associated change score. The minimum knee adduction moment at mid-stance was found to have the highest significant correlation (R = -0.87, p < 0.001), followed by the peak knee flexion angle (R = -0.81, p < 0.001), and the 2nd peak of the knee adduction moment (R = -0.81, p < 0.001).

**Conclusion:** The change in knee joint level kinematics and kinetics due to TKA surgery was shown to be highly associated with the pre-operative functional state of the joint. Highest correlations were found for metrics such as the mid-stance and late knee adduction moment, and peak knee flexion angle, which have been shown to be significantly associated with knee OA severity in our previous work (Astephen et al., 2008). Therefore, any innovations in TKA surgery aimed at improving joint-level function needs to consider the pre-operative functional state of the individual.

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**Validation of Three-dimensional Models of the Distal Femur Created from Surgical Navigation Data**

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**Purpose:** Long term satisfaction of patients with total knee arthroplasty has lagged behind that of total hip arthroplasty. One explanation is a mismatch between the shape of the native distal femur and its shape post-operatively. The shape of the distal femur following surgery is dependent of two factors, the shape of the femoral component and its positioning when implanted. The impact of this mismatch is unknown as the three dimensional morphology of the distal femur is not measured during surgery, nor is the exact position the implant recorded in conventional knee arthroplasty surgery. A technique that would allow for measurement of morphologic concordance between the native femur and implanted femur with no additional imaging requirement could offer a pathway to optimize implant positioning leading to improved function and satisfaction. The objective of this study was to develop and validate a fitting procedure for a statistical shape model of the distal femur using data collected routinely intraoperatively as part of surgical navigation total knee arthroplasty.

**Method:** A total of 20 patients who underwent navigated total knee arthroplasty also had an MRI performed within 2 months preoperatively as part of a previous study protocol. These patients data were selected to be used in this study. Of these subjects the first 3 processed cases are presented here. During surgery the anterior cortex, the distal and posterior femoral condyles, the medial and lateral epicondyles and the femoral center were digitized. Post-operatively these data were extracted from the navigation unit and imported into Matlab. A statistical shape model adapted from previous work was optimized to approximate the shape of the distal femur from available point clouds. The MRI data was segmented to develop 3-D models. The segmented MRI data was used as the control against which the statistical shape model was compared.

**Results:** Comparison of the statistical shape model with the femoral models obtained from the segmented MRI data showed good agreement in all cases. The average error between the statistical shape model and the MRI for the three cases was 1.21, 1.56 and 1.61mm. The standard deviation was 1.02, 1.07 and 1.15mm. The root mean squared error was 1.58, 1.89 and 1.85mm.

**Conclusion:** As total knee arthroplasty evolves, a patient specific approach is going to be demanded by patients. The results of this study show that with the sparse data set available from routine navigated knee
surgery, the statistical shape model can provide an accurate approximation of the distal femur. In the future these models could be incorporated into a surgical navigation unit and provide a surgeon with accurate measurement of the concordance of the proposed femoral component positioning with the native anatomy. This technique is an important step in the development of a patient morphology-specific TKA protocol and could allow for optimization of implant selection and positioning for patients.

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The Effect of Hemiarthroplasty Contact Geometry on Early in-vitro Cartilage Wear
Alana Khayat, ON; Daniel G. Langohr, ON; John B. Medley, ON; Graham J. King, ON; James A. Johnson, ON

Purpose: Hemiarthroplasty (HA) procedures restore joint function, stability, and kinematics while preserving more native anatomy than total joint replacement. Previous studies have demonstrated that HA implant geometry may be optimized to reduce contact pressure by increasing contact area and congruency with the adjacent articular cartilage. The purpose of this in-vitro study was to investigate the effects of implant shape on the wear of cartilage specimens in linear reciprocal sliding using a pin-on-plate wear simulator. We predicted that as the radius of curvature of the implant model increased, both volumetric wear and the depth of the resulting wear track would decrease.

Method: Cylindrical specimens of cartilage and underlying subchondral bone (n=36) were harvested from thawed fresh-frozen bovine tibial plateaus, potted into custom fixtures, and scanned to generate a digital surface model of the cartilage. Specimens were worn on a pin-on-plate wear simulator in reciprocal sliding mode at a rate of 1.2Hz, a linear range of 5mm, under a load of 27.5N for 140 minutes while submerged in alpha calf serum diluted to a 17g/L protein concentration, as per ISO standards. The implant models were custom-made stainless steel pins of varying radii of curvature: a hemispherical tip with a 4.7mm radius, a slightly less-curved tip with a 5.1mm radius of curvature, and an almost flat tip with an 11.7mm radius of curvature. After testing the worn cartilage surface was rescanned. A novel inter-surface distance algorithm was used to compare the surfaces by calculating the normal distance from the centroid of each triangular element on the unworn surface to the closest point on the worn surface. The area of each element was then multiplied by that distance and summed over the entire surface to compute the total wear volume. Average wear depth was calculated using the known pin-cartilage contact area.

Results: All contact geometries investigated produced visible evidence of cartilage wear. The 5.1mm radius tip wore away significantly more cartilage (3.6mm±0.6, p<0.01) than the flatter, 11.7mm radius tip (1.8mm±0.8). The 11.7mm radius tip generated a significantly shallower wear track (0.05mm±0.02) than the both 4.7mm radius tip (0.10mm±0.05, p<0.01), and the 5.1mm radius tip (0.12mm±0.03, p=0.016).

Conclusion: The data suggest that when the HA contact surface is more conforming and load is distributed over a greater area, less acute cartilage damage occurs as shown by the shallower wear tracks produced by the 11.7mm radius pin. This may be attributed to an improvement in contact mechanics resulting from reduced contact stress concentrations between the pin and the cartilage that result from the increased contact radius. Fewer differences were observed in net volumetric wear among implant geometries, which may indicate that the severity of wear is more closely tied to depth. This indicates that incorporating gradual curves into the design of HA implants may increase their longevity and performance.

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Determining the Effect of Implant Design Variables on Impingement and Range-of-Motion in Reverse
Shoulder Arthroplasty using a Novel Component Tracking Method
Ryan T. Bicknell, ON; Lydia North, ON; Mike Pickell, ON; Kevin Deluzio, ON; Tim Bryant, ON

Purpose: While reverse shoulder arthroplasty (RSA) is successful in treating a variety of diagnoses, implant impingement often causes complications, including reduced range of motion, bone loss, and instability. Attempts to simulate this problem in vitro typically rely on subjective visual methods to detect impingement. The objective was to determine the effect of humeral neck-shaft angle, implant diameter, humeral cup depth, and glenoid eccentricity on adduction deficit and range of motion using a novel objective implant-tracking method for impingement detection.

Method: A previously developed kinematic shoulder simulator was used. RSA components (Delta Xtend, DePuy Inc., Warsaw, IN) were implanted in an artificial scapula and humerus (Sawbones, Pacific Research Labs Inc., Vashon, WA). The scapula was fixed, and three cables attached to deltoid insertion points on the humerus were fed through wrapping points on the scapula, and coupled to linear electric actuators. Motion tracking used an optical tracking system (Optotrak, Northern Digital, Waterloo, ON). A force was applied to the humerus in each direction, until impingement occurred. The absolute distance between the centres of the glenosphere and humeral cup was tracked. When this value increased beyond a threshold, resulting in a "levering out", impingement was determined to have occurred. Factors included: (i) humeral component neck-shaft angle (135o or 155o), (ii) glenosphere diameter (38 or 42 mm), (iii) humeral cup depth (high mobility or retentive), (iv) glenosphere eccentricity (standard or inferior offset), and (v) impingement direction (superior, inferior, anterior or posterior). Outcome measures included adduction deficit and overall range-of-motion. Statistical analysis used a four-way ANOVA (p<0.05).

Results: Neck-shaft angle, humeral cup depth, and glenosphere eccentricity all had a significant effect on adduction deficit and range-of-motion (p<0.05). Implant diameter had a significant effect on adduction deficit (p<0.05) but not range-of-motion (p>0.05). Humeral cup depth had the largest effect on adduction deficit and range of motion, with a retentive cup reducing adduction deficit by 14 degrees and range of motion by 26 degrees. A decreased neck-shaft angle reduced adduction deficit by 10 degrees and range of motion by 6 degrees.

Conclusion: This novel centre-tracking technique is a consistent, objective method to detect impingement in RSA, which could also be applied to range-of-motion and instability measurements. An increased humeral cup depth increases adduction deficit and decreases range of motion, and these disadvantages should be weighed against the benefits of increased joint constraint when selecting implant components. A humeral component with a 135-degree neck-shaft angle reduces adduction deficit, but has a small affect on overall range of motion. Implant diameter and glenosphere eccentricity have small effects on adduction deficit and range of motion.

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In vivo Wear Performance of Ethylene Oxide Sterilized PE Inserts from Modular Total Knee Replacements
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Purpose: In recent decades, significant effort has gone into reducing polyethylene (PE) bearing wear in total knee arthroplasty (TKA) to increase longevity of the device and reduce wear-particle induced osteolysis. The Genesis II TKA (Smith & Nephew) is a well-functioning prosthesis with an ethylene-oxide sterilized PE bearing articulating against either a cobalt-chromium (CoCr) or oxidized zirconium (OxZr) femoral component. The
OxZr components are more expensive than the CoCr components and are often indicated for patients with suspected nickel sensitivity. However, in patients with no suspected nickel sensitivity, the selection of OxZr components should be justified through clinical benefit. Accordingly, the purpose of this study was to examine differences in the damage and wear on the PE inserts of a series of 26 matched pairs of CoCr and OxZr Genesis II TKAs.

**Method:** Twenty-six retrieved TKAs of each femoral material type were matched based on implantation period, body-mass index, gender, and PE insert design. Damage assessment was performed on all PE inserts rating the severity and area of coverage for all observed damage features. The damage scores (DS) for each damage feature were averaged between three observers and summed to obtain an overall DS for each PE insert. The volume and linear depth of PE wear was obtained for each PE insert through reverse engineering. Micro-computed tomography (microCT) was used to obtain the external surface geometry of all retrieved PE inserts as well as new, never implanted PE inserts matching the retrievals to serve as reference geometries. Deviations between the retrieved and reference geometries were quantified as maximum linear penetration and volumetric wear. Non-parametric statistics were applied to the data.

**Results:** The majority of observed PE insert damage was burnishing of the topside (articulating) surface. No significant differences in surface damage were noted between CoCr and OxZr components, except for higher deformation on the top and backside surfaces in the OxZr group (p<0.05). No significant differences in linear penetration or volumetric wear were found between CoCr and OxZr groups. The OxZr group experienced slightly higher median linear penetration (0.12 mm/yr) and volumetric wear (28.4 mm3/yr) than the CoCr group (0.10 mm/yr & 23.6 mm3/yr, respectively); however, not statistically significant (p>0.05). A confounding factor may be the significantly younger age group of the OxZr patients compared to the CoCr patients (59.8 yrs, 66.1 yrs; p=0.013).

**Conclusion:** The more expensive OxZr femoral components of the Genesis II TKA do not appear to have any advantages over the CoCr components in terms of PE damage or wear. However, the OxZr group consisted of younger patients whom are potentially more active and thereby impart greater wear and damage on their PE inserts. Future studies should examine longer-term data to determine superiority of one femoral component material after >5 years of implantation.

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**The Effect of Positioning of Partial Joint Resurfacing Implants on the Contact Mechanics of the Opposing Intact Cartilage: A Finite Element Study**

**Jacob M. Reeves, ON; Najmeh Razfar, ON; G. Daniel G. Langohr, ON; George S. Athwal, ON; Graham J.W. King, ON; James A. Johnson, ON**

**Purpose:** Partial joint resurfacing implants (PRJs) are becoming increasingly popular as an alternative to traditional arthroplasty. Accordingly, there is a need to investigate properties of joints subjected to PJR. This study compared the effect of varying PJR position on the contact area and stress of articular cartilage, and contrasts these against the intact joint, using the glenohumeral joint as a model.

**Method:** CT data was used to develop three-dimensional models from three cadaveric joints. Each was oriented (75° abduction) such that the joint reaction force ran between the centers of the humeral head and glenoid articular surface. A generic PJR (15mm diameter, 3mm deep, 22mm radius of curvature) was placed in the humeral surface such that its center was in-line with the joint reaction force. The PJR position was then varied so its face was flush with, 0.5mm proud of, and 0.5mm subsided compared to the humeral cartilage.
Material stiffness was assigned to bone based on CT data, and a stiffness of 210GPa was assigned to the PJR to represent CoCr. Cartilage was modeled as a non-linear elastic material. A load of 400N compressed the articulation. Results were compared on the basis of contact area and peak contact stress in both the glenoid and humeral cartilage, with all results presented as percentages of the intact joint values. Statistical significance was assessed using a one-way RM ANOVA ($\alpha = 0.05$).

**Results:** Joint contact area was found to differ significantly ($p \leq 0.018$) between all configurations except the subsided vs. intact models (Intact = 100%; Flush = 91±5%; Proud = 81±6%; Subsided = 100±5%). All PJR positions were found to vary significantly from the intact joint ($p \leq 0.039$) in terms of both peak stresses in the glenoid (Intact = 100%; Flush = 137±24%; Proud = 146±28%; Subsided = 134±28%) and humeral cartilage (Intact = 100%; Flush = 26±12%; Proud = 13±7%; Subsided = 45±22%). Moreover, peak humeral stresses in the subsided models were significantly higher than either the flush or proud configurations ($p \leq 0.045$), though still lower than the intact joint.

**Conclusion:** Overall, none of the resurfaced joints achieved the same peak contact stresses observed in the intact joint. This is perhaps since the implants were stiffer than cartilage. Accordingly, proud and flush configurations prevented the surrounding cartilage from compressing similar to the intact joint, while subsided implants engaged after the surrounding cartilage, leading to a contact area that matched the intact joint. In general, the trend towards recreating the intact state with subsiding the implant demonstrates that PJR positioning is an important surgical parameter that may have implications for joint wear and ultimately PJR longevity. Accordingly, softer and further subsided implants require investigation. Regardless, differences between intact and resurfaced joints suggests perhaps that other implant parameters (e.g., geometry) may play a role in recreating the contact mechanics of the native joint.

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**An RCT Examining the Effect of Adductor-canal Peripheral Nerve Block with Periarticular Infiltration vs. Adductor-canal Nerve Block Only vs. Periarticular Infiltration Only**

**Mona Sawhney, ON; Hossein Medhian, ON; Brian Kashin, ON**

**Purpose:** Total knee arthroplasty (TKA) is a painful surgery but it requires early mobilization for successful joint function. Therefore, effective pain management is essential for rehabilitation. Multimodal analgesia including: spinal anesthetic, nerve blocks, periarticular infiltration, opioids, and co-analgesics have been shown to effectively manage post-operative pain. One of the criticisms of nerve block is the potential to impair quadriceps muscle strength which limits mobility. Both adductor canal (AC) and peri-articular infiltration (PI) have been shown to manage pain without impairing motor function. However, it is unclear which technique is most effective. The purpose of this 3 arm trial was to examine the effect of both AC+PI vs AC vs PI.

**Method:** Following Ethics Board approval, patients undergoing unilateral TKA were approached to participate in this trial. Inclusion criteria included: 18 years or older, ASA I-III, able to speak and read English. Patients were excluded if they had a contraindication to regional anesthesia/local anesthetics, chronic pain not related to their knee, were using opioids for 3 months or longer, or had a peripheral neuropathy. The sample size was calculated based on the primary outcome, and with a $\alpha0.5$ and 15% attrition rate, a sample of 159 participants was required. Eligible and consenting participants were randomized into 1 of the 3 groups. On the day of surgery, the participant was admitted to the 'block room' where they received either AC block with 30mL of 0.5% Ropivacaine or sham block. PI was performed intra-operatively with a 110mL solution of Ropivacaine 300mg, morphine 10mg, ketorolac 30mg, in normal saline. Those patients randomized to AC only received
normal saline. Outcomes measured on POD1 and 2 were pain, analgesic consumption, distance walked and pain related interference.

**Results:** A total of 159 participants consented and 144 completed the trial. The mean age was 67 years, and 63% were female. On POD1 participants who received AC+PI reported statistically lower pain on walking (3.3) as compared to those who received AC (6.2) or PI (4.9). Participants who received AC reported statistically higher pain scores at rest and knee flexion as compared to those who received AC+PI or PI. On POD2 participants who received AC+PI reported statistically less pain on walking (3.3), as compared to those who received AC (6.2) or PI (4.9). On POD2 there was no difference between the groups for pain at rest, or flexion. Participants who received AC used more IV PCA on POD 0. There was no difference between the groups regarding distance walked.

**Conclusion:** Participants who received both AC + PI reported statistically less pain on walking on POD1 and 2. There was no difference between the groups on distance walked, however, this was only reported one time per day and did not capture distance walked over a 24 hour period if the participant walked multiple times.

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**Trunnionosis: Does Head Length Affect Fretting and Corrosion in Total Hip Arthroplasty?**

Christopher Del Balso, ON; Matthew Teeter, ON; Sok Chuen Tan, ON; Brent A. Lanting, ON; James L. Howard, ON

**Purpose:** The modularity of modern hip implant designs offers a number of advantages in contemporary total hip arthroplasty (THA). This modularity may not be without cost, however. Wear and tribocorrosion at the head-neck taper interface, so-called “trunnionosis”, may be a source metal ions and particulate debris in metal-on-polyethylene THA. Trunnionosis may be an as yet unrecognized cause of THA failure. The purpose of the present investigation is to elucidate the effect of femoral head length on fretting and corrosion in retrieved head-neck tapers.

**Method:** A retrieval analysis of THA prostheses in vivo for a minimum 2 years was performed. 56 femoral heads of 28mm diameter with lengths ranging from -3mm to +8mm, and 17 femoral stems featuring a single taper design from the same manufacturer were included. Demographic data were obtained from chart review. Fretting and corrosion damage scoring was completed for three horizontally oriented concentric zones of the tapers under stereomicroscopic visualization resulting in summed total fretting and corrosion scores for each implant.

**Results:** Head length was observed to affect total fretting scores (p=0.03), with 28mm +8mm femoral heads exhibiting greater total fretting scores than all other head lengths. Increased fretting damage (p=0.01) was noted in the central concentric zone of the femoral head bore tapers, regardless of head length or stem offset. High offset femoral stems were associated with greater total fretting scores of the bore taper when compared to standard offset stems (p=0.04). No significant effect on total corrosion scores was observed for any head or stem variable. Retrieved implant total corrosion scores were positively correlated (p=0.41, p<0.001) with implantation time.

**Conclusion:** Increased femoral head lengths and offset in THA may produce greater fretting damage owing to an increased head-neck moment arm, but there is no associated increase in corrosion with 28mm heads of this taper design. The longer a THA prosthesis is implanted, the greater the risk of damage due to corrosion.
Further investigation is required to determine the effect of increased head size, and variations in head-neck taper design.

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Prognosis of Advanced Local Tissue Reactions (ALTR) Around Hip Arthroplasty as Identified by MARS MRI
Mohammed Ahmed O. Al Sobeai, QC; Laura M. Epure, QC; Adrian Carteleanu, QC; Olga L. Huk, QC; David J. Zukor, QC; John Antoniou, QC

Purpose: The clinical significance and management of adverse local soft tissue reactions (ALSTRs) following total hip arthroplasty (THA) and hip resurfacing arthroplasty (HRA) continues to be controversial. The reported prevalence of ALTRs ranges between 1% to 71%. The purpose of this study was to evaluate sequential MARS MRIs in patients with painful hip arthroplasties in order to establish management criteria.

Method: Seventeen patients (18 hips) were retrospectively identified to have had sequential MARS MRIs for pain. The group consisted of two metal-metal THA, three metal-cross-linked polyethylene THA and 13 metal-metal HRA. Two board certified musculoskeletal radiologists evaluated all the MRIs. A previously used and standardized form was used to evaluate the MRIs: 1) presence of adverse soft tissue reaction; 2) thickness of wall mass; 3) intensity on T1 and T2 weighted images; 4) contents of mass (fluid, solid or complex); 5) location relative to joint. Changes in the size of the lesions were evaluated between initial and final scans.

Results: MARS MRI evaluation revealed that eight hips (44%) were cystic fluid filled lesions, one hip (5%) was a solid mass and nine hips (50%) were a complex mixed lesion. The mean follow up is 8.44 years (range from 6.25 to 12.06 years). The mean time between the first and last MRI is 20.66 months (range from 8.3 months to 56.4 months). The mean initial volume of the ALTRs was 274ml and the final volume was 408ml. There was one outlier lesion that measured 808 ml and consisted of a large anterior fluid mass that completely resolved in the follow up MRI nine months later and is thought to be a psoas bursal lesion. Four cases (22%) increased in size, eight cases (44%) decreased in size and the remaining cases did not change significantly with sequential MRIs. Seven cases required revision surgery and five of these cases had either increase in size or were initially large enough and patient keep complaining indicating the surgery.

Conclusion: Serial MARS MRI imaging is essential for evaluating patients with painful hip arthropalsty. Larger lesions that increase in size over time tend to be more aggressive and can lead to more soft tissue and bony destruction. Stable ALTR should be followed and can be treated conservatively. Cystic fluid filled masses can resolve or decrease spontaneously.

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Histological Analysis of Pseudotumours Associated with Metal-on-Metal and Metal-on-Polyethylene Hip Implants
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Purpose: Pseudotumours have been traditionally described as aseptic benign lesions that arise in the articulation’s soft tissues of patients with metal-on-metal hip prosthesis. They are composed by a dense connective tissue infiltrated by immunocompetent cells, fibrin deposition and variable degree of necrosis. Recent studies have reported pseudotumours in metal-on-polyethylene articulations; however no morphological description has been published to date. The objective of this study is to describe
histopathologically the pseudotumours on metal-on-polyethylene implants and compare them with those of metal-on-metal.

**Method:** Seventeen consecutive patients with pseudotumours on metal-on-metal implants who underwent revision surgery between March 2012 and March 2014 and all of the eleven patients with pseudotumours on metal-on-polyethylene implants that have been attended in the Vancouver General Hospital were included in the study. Biopsies of the periprosthetic tissue were fixed, dehydrated and paraffin embedded. Up to six 5μm-thick sections from each sample were stained and blindly assessed for histopathological parameters and ALVAL score. To quantify the cellularity of the samples, seven metal-on-metal and seven metal-on-polyethylene cases were randomly selected. Three slides from each sample were stained with HOETSCH, and consecutive images from the internal surface until 1.5mm of the sample’s depth were taken. The fluorescent-dyed cell nuclei were counted by use of ImageJ software. The structure of the collagen fibrils in the extracellular matrix was observed by means of polarized light and second harmonic generation microscopy.

**Results:** The histological observation showed that pseudotumours on metal-on-polyethylene are solid necrotic masses of fibrotic tissue, in which immunocompetent-cell infiltration can be observed in discrete locations. Pseudotumours on metal-on-polyethylene showed a higher degree of necrosis (P<0.000) and ALVAL score (p=0.009) than metal-on-metal. All the metal-on-polyethylene samples showed a necrosis score of 3+ (more than 1cm of the tissue depth is necrotic). The measurement of cellularity revealed a higher cell count for metal-on-metal pseudotumours than for metal-on-polyethylene (P<0.000). The observation with polarized light and Second Harmonic Generation microscopy showed that the collagen fibres of the extracellular matrix remains intact and are not affected by the massive cell death in the metal-on-polyethylene pseudotumours.

**Conclusion:** Adverse local tissue reactions are seen in both metal-on-metal and metal-on-polyethylene articulations. From our observations the reactions metal-on-polyethylene seems to be histopathologically more aggressive as evidenced by the marked necrosis and low cellularity seen in all the metal-on-polyethylene cases. The preserved structure of the extracellular matrix suggests that a necrobiotic process occurs, but the origin of this process is still unknown.

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**Comparison of Backside Damage in Acetabular Shells with Roughened and Polished Inner Surfaces: A Retrieval Study**
**Kamal Bali, AB;** Richard W. McCalden, ON; Douglas Naudie, ON; Steven J. MacDonald, ON; Matthew G. Teeter, ON

**Purpose:** Periprosthetic osteolysis due to polyethylene wear continues to be an important cause of long-term failure in total hip arthroplasty (THA). While articular sided wear of polyethylene has been well documented and studied, there is limited data regarding backside damage in polyethylene acetabular liners for various socket designs. The primary objective of this retrieval study was to quantify differences in damage scores on the backside of modular polyethylene liners for two commonly implanted acetabular sockets: one with a polished inner surface and tapered dovetail locking tabs, and one with a roughened inner surface and flexible metal locking wire. The secondary objective of the study was to find if damage scores were any different in highly crosslinked polyethylene liners (XLPE) as compared to conventional polyethylene liners (CPE).

**Method:** This retrieval analysis involved visual damage scoring on the backside of 233 modular polyethylene inserts for the polished (P) and roughened (R) acetabular sockets. All the inserts had been retrieved at a single academic center between 2002 and 2013. The inserts were subdivided into four groups based on surface and
polyethylene treatment: P-CPE (n=105), P-XLPE (n=16), R-CPE (n=99) and R-XLPE (n=13). All groups were matched on age, body mass index, and time in vivo for analysis. The backside of each insert was divided into five zones: antero-superior, antero-inferior, postero-inferior, postero-superior, and peripheral/locking mechanism. Each zone was subjectively graded from a scale of zero to three for seven different damage modes (burnishing, abrasion, cold flow, scratching, pitting, delamination and embedded debris). The maximum possible damage score by this method was 105.

Results: The mean damage scores were 7.6 ± 4.1 for P-CPE, 4.4 ± 4.2 for P-XLPE, 18.8 ± 8.1 for R-CPE, and 8.6 ± 8.9 for R-XLPE. Total damage scores were higher (p < 0.01) with R-CPE compared to all the other groups. There was no difference between R-XLPE, P-CPE, and P-XLPE. Zonal analysis revealed higher (p < 0.0001) damage scores in the superior zones (6.6 ± 4.0) compared to the inferior zones (3.0 ± 2.8). Damage scores in the peripheral/locking mechanism zone were higher (p < 0.0001) in the roughened groups compared to the polished groups.

Conclusion: Acetabular cups with a roughened inner surface and a conventional polyethylene liner demonstrated the greatest backside damage. All cups utilizing a flexible locking wire had greater damage surrounding the peripheral locking mechanism zone of the polyethylene than the cups utilizing a dovetail locking tab. Crosslinked polyethylene was shown to be more resistant to backside damage with both polished and roughened cup surfaces.

32 Randomized Clinical Trial of Hip Resurfacing vs Large Head Metal-on-Metal Total Hip Arthroplasty
Donald S. Garbuz, BC; Nicholas E. Ohly, Scotland; Michael Tanzer, QC; Nelson V. Greidanus, BC; Bas Masri, BC; Clive P. Duncan, BC

Purpose: A previous randomized clinical trial comparing large head metal-on-metal total hip arthroplasty (THA) with hip resurfacing was discontinued after one year due to early reports of significantly elevated metal ion levels in the large head group. Those patients have been followed out to five years and the medium-term results are reported.

Method: One hundred and four (104) patients were randomized to receive either large head metal-on-metal THA or hip resurfacing. 80 patients were available for follow up at a minimum of 5 years. Outcome measures were Paper Adaptive Test in 5 Domains of Quality of Life in Arthritis Questionnaire (PAT-5D), WOMAC, short Form-36 (SF-36), and the UCLA activity score. Serum levels of cobalt and chromium were measured in a subset of 25 patients treated at the primary center.

Results: At five years there were equivalent improvements between the two groups in quality-of-life outcomes (PAT-5D index, WOMAC, SF-36, and UCLA activity score). Seven hips had been revised (5 large head group (8.9%), 2 hip resurfacing group (4.2%)) due to either loose acetabular components (5 hips) or adverse reaction to metal debris (2 hips). Serum chromium and cobalt ion levels were elevated compared to baseline in both groups, but significantly higher in the large head group compared to resurfacing at one year (chromium: 2.62µg/L vs 1.11µg/L, p=0.016, cobalt: 5.55µg/L vs 0.63µg/L, p=0.005), and five years (chromium: 3.57µg/L vs 0.94 µg/L, p=0.002, cobalt: 7.38µg/L vs 0.72µg/L, p=0.001).

Conclusion: Large head metal-on-metal THA is associated with high revision rates and significantly elevated cobalt and chromium ion levels compared to hip resurfacing. Furthermore, the ion levels continue to rise until
at least 5 years post-operatively. The authors recommend continued surveillance of metal ions of patients with large head metal-on-metal THA, regardless of functional outcome.

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The Incidence of Pseudotumours in Asymptomatic Female Patients Following Hip Resurfacing Arthroplasty
Kamal Bali, MB; Pamela Railton, AB; Peter Farris, AB; Bevan Frizzell, AB; Emil Schemitsch, ON; Paul E. Beaulé, ON; James Powell, AB

Purpose: The primary objective of the current study was to determine the incidence of pseudotumours and fluid collections using ultrasound in asymptomatic female patients with metal-on-metal hip resurfacings. The secondary objective was to ascertain any correlation between increased whole blood levels of cobalt and chromium, component placement, pain or function; and formation of asymptomatic fluid collections/masses.

Method: This was a multi-site study involving three academic centers in Canada that included asymptomatic female patients with a minimum of 2 years from metal on metal hip resurfacing. Patients who consented to participate were assessed clinically and evaluated using hip ultrasound, radiographs and collection of whole blood for ion levels (cobalt and chromium).

Results: Seventy-seven patients (89 hips) with a mean follow-up from time of 5.2 years (range: 2.5 – 9.4 years) from procedure were evaluated. This included 75 hips with Birmingham hip resurfacing (BHR) and 14 hips with Conserve Plus (C-plus) hip prosthesis. Mean age at time of procedure was 51 years (Range: 30 - 73 years). Twelve patients had bilateral resurfacings. Head sizes ranged from 42 – 52 mm (mean 45.8). Ion levels ranged from 0.06 ppb – 85.57 ppb for cobalt and 0.81 ppb – 67.07 ppb for chromium. Only two patients had cobalt levels over 6ppb. Ultrasound revealed positive findings in 11 out of 89 hips (12.5%). A soft tissue mass (pseudotumour) was seen in 4 hips (all BHR group) while there were 7 hips (3 C-plus, 4 BHR) with periprosthetic fluid collections (not qualifying as pseudotumours). There was no difference in age, BMI, duration of surgery, Harris hip scores, metal ion levels, femoral head size or radiographic abduction angles in patients with or without positive ultrasonographic findings. Of the 4 patients with pseudotumours, two patients had increased abduction angles (46 degrees) and the femoral head size was 44 in both. This included one patient with elevated cobalt ion level of 47 ppb and chromium level of 21 ppb. The other patient with elevated metal ions had a completely normal hip ultrasound. Two of the hips with pseudotumours eventually became symptomatic (within 1 year of ultrasound) and were revised. To date all the other hips in the current study continue to remain asymptomatic.

Conclusion: The incidence of pseudotumours in asymptomatic females in our study was as high as 4.5% and that of asymptomatic fluid collections (including pseudotumours) was as high as 12.5% (one is to eight). Metal ion levels/radiographic parameters did not correlate with the presence of pseudotumours/fluid collections. We believe that asymptomatic patients with pseudotumours may eventually become symptomatic and require revision. A close surveillance in the form of screening ultrasound may help identify the potential group of female patients with hip resurfacing that are likely to become symptomatic in future.

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Effect of Taper Design on Trunnionosis in Total Hip Arthroplasty
Sok Cheun Tan, ON; Matthew G. Teeter, ON; Christopher DelBalso, ON; James L. Howard, ON; Brent A. Lanting, ON
**Purpose:** Trunnionosis in modular hip arthroplasty has recently been recognized to be clinically important. Gaining an understanding of how the trunnion design affects the tribology at the modular junctions has current clinical implications as well as an implication on future implant design. The purpose of this study is to examine if taper design affects the incidence and magnitude of corrosion and fretting at the head trunnion surface.

**Method:** All hip prostheses retrieved between 1999 to 2013 at one centre were reviewed. To create a homogeneous sample and to decrease confounders, only the implants with 28mm +0 heads were selected. This resulted in a total of 44 cobalt-chrome on polyethylene implants, representing six different taper designs. Mean age of the patients at time of revision was 69.4 ± 13.5 years. Mean body mass index (BMI) was 29.6 ± 7.3 kg/m2. Male to female ratio was 20:24. Mean time in vivo for the implants was 8.9 ± 3.7 years. The femoral head tapers were examined by two independent observers, and scored for fretting and corrosion severity using the Goldberg damage classification scale. The tapers were divided into three zones (apex, central, and base) and scored from one to four (no damage to severe damage). Both observers were blinded to clinical and component data where possible.

**Results:** There was no difference in age at revision (p = 0.34), BMI (p = 0.29), or implantation time (p = 0.19) between taper groups. The 11/13 taper had the highest combined corrosion score, but no difference (p = 0.22) was found between groups for the combined score. However, in a zone-specific analysis there was a difference (p = 0.02) in the base zone with the 11/13 taper again having the highest corrosion score. The 11/13 taper also had the highest combined fretting score, although again no difference (p = 0.19) was found between the groups.

**Conclusion:** Trunnionosis is a clinical problem of significant controversy. In this cohort of retrieved femoral heads controlled for head dimensions and articular properties, trunnion design was found to have a significant effect on the amount of corrosion at the base of the head trunnion. How the mechanical and biologic factors interact with taper design needs further review and discussion.

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**Dual Mobility Hip Cup Migration and Liner Mobility at One Year**
**Glen Richardson, NS; Michael J. Dunbar, NS; Elise Laende, NS**

**Purpose:** The dual mobility design concept for acetabular liners is intended to reduce the risk of dislocation and increase range of motion, but the wear pattern of this design is unclear and may have implications in implant fixation. Additionally, the solid back cups do not have the option for supplementary screw fixation, providing an additional smooth articulating surface for the liner to move against. The objective of this study was to assess cup fixation by measuring implant migration. A secondary objective was to evaluate the mobile bearing motion after rotating the hip.

**Method:** Thirty subjects were recruited in a consecutive series prospective study and received Anatomic Dual Mobility (Stryker Orthopaedics) uncemented acetabular components with mobile bearing polyethylene liners through a direct lateral approach. Femoral stems were cemented (Exeter) or uncemented (Accolade, Stryker Orthopaedics). The femur, acetabulum, and non-articulating surface of the polyethylene liner were marked with tantalum beads. Radiostereometric analysis (RSA) exams were performed post-operatively and at 6 weeks, 3, 6, months, and at 1 year. At the 1 year exam, a frog leg RSA exam was performed to assess the mobility of the cup compared to its position during a supine exam.
Results: Proximal translation of the cup was 0.16 ± 0.28 mm (range -0.18 to 0.92 mm) and sagittal rotation was 0.08 ± 0.86 degrees (range -1.81 to 2.18 degrees) at 1 year. Analysis of the motion of the mobile bearing liner during the frog leg RSA exam showed total motions of between 0.10 to 5.58 mm (maximum total point motion).

Conclusion: The migration of the cup has a low group average and is on track to be in the “acceptable” range as defined by Pijls et al. (2012) of less than 0.2 mm of subsidence at 2 years. The combination of low subsidence and low sagittal rotations of the cup are favorable predictors of good long-term performance (Nieuwenhuijse et al. 2012). The wide range of motions of the mobile bearing suggest that in some patients the liner is moving freely, while in a subset of subjects there is no motion. The implications of this in terms of the generation of wear particles and affect on implant migration will be monitored to 3 years.

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Trunnionosis: Does Head Size Affect Fretting and Corrosion in Total Hip Arthroplasty?
Christopher Del Balso, ON; Matthew G. Teeter, ON; James L. Howard, ON; Brent A. Lanting, ON

Purpose: Wear and tribocorrosion at the head-neck taper interface of modular total hip arthroplasty (THA) implant designs may potentially be a cause of THA failure. Currently little is known about the factors that result in “trunnionosis” of metal-on-polyethylene THA. The purpose of the present investigation is to elucidate the effect of femoral head size on fretting and corrosion in retrieved head-neck tapers.

Method: A retrieval analysis of THA prostheses in vivo for a minimum 1 year was performed. Twenty-three femoral heads of 32mm diameter with 13 accompanying femoral stems were matched with 28mm heads and seven accompanying stems based on time in vivo and head length (-3mm to +8mm). All included implants featured a single taper design from a single manufacturer. Demographic data were obtained from chart review. Fretting and corrosion damage scoring was completed for three horizontally oriented concentric zones of the tapers under stereomicroscopic visualization resulting in summed total fretting and corrosion scores for each implant.

Results: Head size was observed to affect fretting (p=0.03), with 32mm femoral heads exhibiting greater total fretting scores than 28mm heads. Fretting damage was greatest (p=0.01) in the central concentric zone of the femoral head bore tapers, regardless of head size, length or stem offset. No significant effect on total corrosion scores was observed for any head or stem variable. Retrieved implant total corrosion scores were positively correlated (p=0.46, p<0.001) with implantation time.

Conclusion: Increased femoral head size in THA may produce greater fretting damage owing to and increased head-neck moment arm. There is no associated increase in corrosion with 28mm and 32mm heads of this taper design. The longer a THA prosthesis is implanted, the greater the risk of damage due to corrosion. Further investigation is required to determine the effect on fretting and corrosion of head sizes greater than 32mm, and variations in head-neck taper design.

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Comparison of Metal Ion Levels in Modular Neck Short Metaphyseal and Nonmodular Neck Standard Metaphyseal Cementless Stems
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**Purpose:** Certain designs of modular neck total hip arthroplasties (THA) have been implicated in early clinical failures. Serum metal ion levels may serve as an indicator of failure, with higher levels suggestive of adverse local soft tissue reactions. The purpose of the current study was to compare the metal ion levels in two cohorts of patients, a short metaphyseal stem with a modular neck and a standard length metaphyseal stem with a nonmodular neck, previously enrolled as a prospective randomized controlled trial to assess migration patterns.

**Method:** Forty-three patients were consented and enrolled in a randomized controlled trial in which 22 patients received a modular neck short metaphyseal stem (cohort 1) and 21 patients received a monoblock neck standard length metaphyseal stem (cohort 2). Demographic, surgical data, and patient outcome scores, including WOMAC, SF-12 and Harris Hip Scores, were collected. Serum metal ion levels (cobalt (Co), chromium (Cr) and titanium (Ti)) were obtained in 15 patients in cohort 1 at 4.31 +/- 0.47 years from surgery and in 12 patients in cohort 2 at 4.40 +/- 0.40 years from surgery.

**Results:** There were 9 males and 6 females in cohort 1 and 6 males and 6 females in cohort 2. The mean age and body mass index was 62.83 +/- 7.72 years, and 31.58 +/- 6.45 kg/m2, in cohort 1 and 69.00 +/- 6.32 years and 30.75 +/- 5.15 kg/m2, in cohort 2, respectively. No difference was found in any of the clinical outcome measures preoperatively or postoperatively between cohorts. The mean levels of cobalt, chromium, and titanium were 2.63 +/- 3.64, 1.22 +/- 2.03 and 3.24 +/- 1.26 ppb in cohort 1 and 0.74 +/- 1.33, 0.38 +/- 0.28, and 4.10 +/- 1.84 in cohort 2, respectively. Cohort 1 had significantly higher (p<0.001) mean cobalt levels than Cohort 2. One patient in cohort 1 with a cobalt level of 13.26 ppb is currently experiencing symptoms and undergoing work-up for a local soft reaction related to metal derbis.

**Conclusion:** The long-term performance of short stems with modular necks has yet to be established. The cohort of patients implanted with the short metaphyseal stem with a modular neck in this study has significantly higher cobalt ion levels than the group with the standard length metaphyseal stem with the nonmodular neck. While metal ion levels may not serve as an absolute indicator of failure, longer term follow-up of this patient cohort is required to determine if the higher cobalt ion levels translate into early clinical failure.

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**Ca2+ Down-regulates the Expression of Aggrecan and Type II Collagen in Human Cartilage**

**Omar Salem, QC; Laura M. Epure, QC; Olga L. Huk, QC; John Antoniou, QC; Fackson Mwale, QC; Michael P. Grant, QC**

**Purpose:** Osteoarthritis (OA) is a multifactorial debilitating disease that affects over four million Canadians. Although the mechanism(s) of OA onset is unclear, the biological outcome is cartilage degradation. Cartilage degradation is typified by the progressive loss of extracellular matrix components - aggrecan and type II collagen (Col II) – partly due to the up-regulation of catabolic enzymes - aggrecanases a disintegrin and metalloprotease with thrombospondin motifs (ADAMTS-) 4 and 5 and matrix metalloproteinases (MMPs). There is currently no treatment that will prevent or repair joint damage, and current medications are aimed mostly at pain management. Interest has developed over the presence of calcium crystals in the synovial fluid of OA patients, as they have been shown to activate synovial fibroblasts inducing the expression of catabolic agents. We recently discovered elevated levels of free calcium in the synovial fluid of OA patients and raised the question on its role in cartilage degeneration.

**Method:** Articular cartilage was isolated from 5 donors undergoing total hip replacement. Chondrocytes were recovered from the cartilage of each femoral head by sequential digestion with Pronase followed by
Collagenase, and expanded in DMEM supplemented with 10% heat-inactivated FBS. OA and normal human articular chondrocytes (PromoCell, Heidelberg, Germany) were transferred to 6-well plates in culture medium containing various concentrations of calcium (0.5, 1.0, 2.5, and 5.0 mM CaCl₂), and IL-1β. Cartilage explants were prepared from the same donors, and included cartilage with the cortical bone. Bovine articular cartilage explants (10 months) were used as a control. Explants were cultured in the above mentioned media; however, the incubation period was extended to 21 days. Immunohistochemistry was performed on cartilage explants to measure expression of Col X, MMP-13, and alkaline phosphatase. The sulfated glycosaminoglycan (GAG) content of cartilage was analyzed using the 1,9-dimethylmethylene blue (DMMB) dye-binding assay, and aggrecan fragmentation was determined by Western blotting using antibody targeted to its G1 domain. Western blotting was also performed on cell lysate from both OA and normal chondrocytes to measure aggrecan, Col II, MMP-3 and -13, ADAMTS-4 and -5.

**Results:** Ca²⁺ significantly decreased the proteoglycan content of the cartilage explants. The presence of aggrecan and Col II also decreased as a function of calcium, in both the human OA and bovine cartilage explants. When normal and OA chondrocytes were cultured in medium supplemented with increasing concentrations of calcium (0.5-5 mM Ca²⁺), aggrecan and Col II expression decreased dose-dependently. Surprisingly, increasing Ca²⁺ did not induce the release of MMP-3, and -13, or ADAMTS-4 and -5 in conditioned media from OA and normal chondrocytes.

**Conclusion:** We provide evidence that Ca²⁺ may play a direct role in cartilage degradation by regulating the expression of aggrecan and Col II.

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**An Anatomic Study of Normal and Osteoarthritic Humeral Head Size**

**Nikolas K. Knowles, ON; Michael J. Carroll, ON; Louis M. Ferreira, ON; Jay D. Keener, MO; George S. Athwal, ON**

**Purpose:** Cartilage degradation in glenohumeral osteoarthritis (OA) and the altered loading environment leads to extensive bone remodeling. This often results in deformation of the articulation with associated osteophyte formation. On the humeral head, it is observed that OA leads to an often flattened articular surface. The purpose of this study was to evaluate normal and osteoarthritic humeral heads on the basis of the articular surface radius of curvature. Additionally, we sub-classified our OA group as having symmetric and asymmetric (type B2 biconcave) glenoid erosion, in order to assess whether humeral head morphology varied by the type of glenoid erosion.

**Method:** One hundred thirty four computed tomography scans of the shoulder were studied. Three-dimensional models were constructed for each shoulder using medical imaging software validated for anatomical measurements. The subjects were separated into two groups, (1) normal glenohumeral joint and (2) osteoarthritic joint. The normal group consisted of 55 (age: 71±15, 39 male) subjects while the osteoarthritic group consisted of 79 (age: 64±10, 50 male) subjects. The osteoarthritic group was further sub-classified based on glenoid morphology in to symmetric glenoid erosion (24 subjects) and asymmetric glenoid erosion Walch type B2 (55 subjects). Three-dimensional point coordinates were collected on the articular surface of all humeral heads and a sphere fit algorithm was used to determine the radius of each humeral head.

**Results:** The radius of curvature of the osteoarthritic humeral head was a mean 6.3 mm larger than the normal humeral head (p<0.001) for all shoulders measured. By gender, OA humeral heads were larger than their normal counterparts by 7.2 mm for males (p<0.001) and 5.7 mm for females (p<0.001). In patients with
asymmetrically eroded type B2 glenoids, the humeral head radius was a mean 3.0 mm larger than for symmetrically eroded glenoids (p=0.023). The mean radius of curvature of the normal humeral heads was 24.7±2.3 mm, while it was 29.0±4.3 mm for OA with symmetric erosion and 31.9±5.7 for OA with asymmetric B2 erosions.

**Conclusion:** Significant differences were observed between osteoarthritic and normal humeral head sizes and between osteoarthritic humeral head sizes in two common glenoid erosion morphologies. The results of this pilot study indicate that the radius of curvature of the arthritic humeral head varies as a function of the Walch classification between symmetric and B2 asymmetric glenoids. This information may have implications in our understanding of posterior erosion patterns and their treatments.

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**The Effect of Platelet Rich Plasma and Hyaluronan on the Mesenchymal Stroma Cell Mediated Immunoregulation**

**Alejandro Gómez-Aristizábal, ON; Kyung-Phil Kim, ON; Jas Chahal, ON; Darrell Ogilvie-Harris, ON; Sowmya Viswanathan, ON**

**Purpose:** Both platelet rich plasma (PRP) and hyaluronic acid (HA) are currently used for symptomatic treatment of osteoarthritis (OA). New therapies that have the potential to be symptom and disease modifying such as the use of mesenchymal stromal cell (MSC) are of enormous interest to a globally ageing population. Animal studies and early clinical trials show both an anti-inflammatory and preliminary reparative effect requiring further investigation. In our study we investigate whether there is a mechanistic basis for combining MSCs with existing therapies, with a focus on immunosuppresion.

**Method:** To test the effect of HA and PRP on MSCs and their immune interaction with lymphocytes, PRPs (5X and 2.5X), platelet poor plasma (PPP) and HA of different molecular weights (MW) ranging from 1.6 MDa (hMWHA) to 7.5 kDa were added to MSCs alone or to co-cultures of MSCs with lymphocytes.

**Results:** MSCs were able to significantly suppress peripheral blood mononuclear cell (PBMC) proliferation in all conditions except PPP: 74%, 57%, 76%, 88%, 89% and 84% suppression relative to PBMCs alone for 5X and 2.5X PRP, 1.6 MDa, 150 kDa and 7.5 kDa HA and control, respectively. Higher MW of HA had a pro-proliferative effect on PBMCs in co-culture with MSCs, with a proliferation of 15.2% vs. 9.5%. HA alone (in the absence of MSC) had a negligible effect on PBMC proliferation. Further examination of lymphocytes subsets showed that higher MW of HA had a pro-mitogenic effect on T helper cells, with a proliferation of 87% vs. 79% (control). There was no difference in gene expression pattern of MSCs cultured in the presence or absence of HA despite the presence of CD44, a HA receptor on MSCs. Conversely, 5X and 2.5X PRP and PPP had an anti-mitogenic effect on PBMC proliferation: 26.2%, 49.3% and 6.7% proliferation for 5X, 2.5X and PPP vs. 85.8% (control). 5X PRP had an additive effect on MSC-mediated inhibition of PBMCs in co-culture, having a PBMC proliferation of 6.9% vs. 14.8% (control). All concentrations of PRP, 5X and 2.5x, and PPP up-regulated (>5 fold) genes NKBI, indicating activation of the NF-kB pathway, IL-8 and CD274 (implicated in angiogenesis and immunosuppression, respectively). However only PRPs up-regulated (>4 fold) other genes implicated in angiogenesis, immunosuppression and homing. Importantly, there was a linear correlation between fold change in gene expression and concentration of platelets in the PRP for genes such as VEGFA, IL8, COX2, IL6 and PRG4, with slopes: 0.35, 0.14, 0.07, 0.07 and 0.05 respectively.

**Conclusion:** Our results show that both PRP and high MW HA affect MSC interactions with lymphocytes, and the mechanisms for these interactions are different. Further studies are warranted to better understand and
define optimum roles and doses of PRP or HA in combination therapies with MSCs in the context of osteoarthritis.

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Hypoxic Isolation, Expansion and Differentiation of Bone Marrow-derived Mesenchymal Stem Cells
Enhance in vitro Chondrogenesis within Cell-seeded Collagen and Hyaluronic Acid Porous Scaffolds
Troy D. Bornes, AB; Nadr M. Jomha, AB; Aillette Mulet-Sierra, AB; Adetola B. Adesida, AB

Purpose: Quality of cartilaginous tissue derived from bone marrow mesenchymal stromal stem cell (BMSC) transplantation has been correlated with clinical outcome. Therefore, culture conditions capable of modulating tissue phenotype, such as oxygen tension and scaffold composition, are under investigation. The objective of this study was to assess the effect of hypoxia on in vitro BMSC chondrogenesis within clinically approved porous scaffolds composed of collagen and hyaluronic acid (HA). It was hypothesized that hypoxic isolation/expansion and differentiation would improve BMSC chondrogenesis in each construct.

Method: Ovine BMSCs were isolated and expanded to passage two under hypoxia (3% oxygen) or normoxia (21% oxygen). Cell proliferation and colony forming characteristics were assessed. BMSCs were seeded at 10 million cells/cm3 on cylindrical scaffolds composed of either type I collagen sponge or esterified hyaluronic acid (HA) non-woven mesh. Chondrogenic differentiation was performed in a defined serum-free medium under hypoxia or normoxia for 14 days. Cultured constructs were assessed for gene expression, proteoglycan staining, glycosaminoglycan (GAG) quantity, and diameter change.

Results: Isolation/expansion under hypoxia resulted in faster BMSC population doublings per day (p<0.05), while cell and colony counts were not significantly different (p=0.60 and 0.30, respectively). Collagen and HA scaffolds seeded with BMSCs that were isolated, expanded and differentiated under hypoxia exhibited superior aggrecan and collagen II mRNA expressions (p<0.05), GAG quantity (p<0.05) and proteoglycan staining in comparison to normoxia. GAG/DNA was augmented with hypoxic isolation/expansion in all constructs (p<0.01). Comparison by scaffold composition indicated increased mRNA expression of hyaline cartilage-associated collagen II, aggrecan and SOX9 in collagen scaffolds, although expression of collagen X, which is related to hypertrophic cartilage, was also elevated (p<0.05). Proteoglycan deposition was not significantly improved in collagen scaffolds unless culture involved normoxic isolation/expansion followed by hypoxic differentiation. During chondrogenesis, collagen-based constructs progressively contracted to 60.1±8.9% of the initial diameter after 14 days, while HA-based construct size was maintained (109.7±4.2%).

Conclusion: BMSC chondrogenesis on clinically relevant collagen I and HA porous scaffolds was enhanced with hypoxic incubation during distinct isolation/expansion and differentiation culture periods. Accordingly, hypoxic culture of BMSCs may play a role in improving cartilaginous tissue formation following transplantation of BMSC-seeded scaffolds. Both collagen and HA scaffolds supported the creation of hyaline-like engineered cartilage with differences noted in chondrogenic gene expression, ECM deposition and cell-scaffold construct size. Therefore, collagen or HA may be suitable biomaterials for use in BMSC transplantation, although each has characteristics that should be considered during scaffold selection.

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Regional Bone Density Variations in Osteoarthritic Glenoids: A Comparison of Symmetric and Asymmetric Erosions
Nikolas K. Knowles, ON; George S. Athwal, ON; Jay D. Keener, MO; Louis M. Ferreira, ON
**Purpose:** During glenoid implantation in total shoulder arthroplasty, preservation of the dense sclerotic subchondral bone has been recommended to provide uniform underlying support to the glenoid implant. The density of the sclerotic bone is theorized to be uniformly distributed over the articular surface in cases with symmetric erosion and is unknown in asymmetric cases. Accurate characterization of regional variations in bone density in symmetric and asymmetric glenoid erosion patterns can assist with surgical planning, intraoperative reaming, and direct reconstructive strategies for addressing bone loss. The purpose of this study was to characterize regional bone density and porosity variations in symmetric and asymmetric (type B2) osteoarthritic glenoids.

**Method:** Symmetric (n=25) and asymmetric (type B2) (n=25) glenoid erosion patterns were compared. Patient CT scan DICOM data was used to construct 3D models of each patient’s scapula. An orthogonal coordinate system separated the glenoid into quadrants. In addition, a linear best-fit line defined the line of erosion between the paleoglenoid and neoglenoid regions in the asymmetric (B2) cohort. All glenoids were divided into volumes at depths of 0 to 2.5 mm and 2.5 to 5 mm from the most medial location on the articular surface. Average bone density was measured in each glenoid quadrant or anterior/posterior region. Void volumes corresponding to cysts and/or low density cancellous bone were included to quantify bone quality as the fraction of void volume to total volume (void fraction) in each region.

**Results:** For the symmetric erosion cohort, no significant differences in bone density between quadrants at either depth (p=0.759 at 0-2.5 mm; p=0.089 at 2.5-5 mm) were identified. For the asymmetric (B2) cohort, however, there was a significant difference (p<0.01) between quadrants at both depths. Additionally, there were significant differences in void fraction between quadrants for both cohorts, at both depths (p<0.05). There was also a significantly higher density (p<0.001) and lower void fraction (p<0.001) in the neoglenoid (posterior facet) as compared to the paleoglenoid for the asymmetric (B2) cohort.

**Conclusion:** This study demonstrates important bone density variations in patients with glenohumeral osteoarthritis and a biconcave asymmetric deformity (type B2). In B2 glenoids, the densest bone with the least porosity was found in the posterior quadrants, with significantly diminished porosity and density in the anterior quadrants. These morphological changes in B2 glenoid substructure are likely caused by bone remodelling in response to the articulation migrating to the posteroinferior neoglenoid. We found that these regional variations in bone density and porosity are predictable in biconcave type B2 deformities. This knowledge will assist clinicians by highlighting regions where preservation of bone stock is desired, and may allow implant manufacturers to optimize designs and fixation methods for glenoid components.

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Isolation and Expansion Under Hypoxic Conditions on a 3D Scaffold Enhances the Chondrogenic Capacity of Bone Marrow Derived Mesenchymal Stromal Stem Cells

Nadr M. Jomha, AB; Janan Jomha, AB; Aillette Mulet-Sierra, AB; Adetola B. Adesida, AB

**Purpose:** Articular cartilage (AC) allows for near frictionless and painless joint motion but is avascular with limited capacity to repair often leading to osteoarthritis. There is a growing interest in mesenchymal stromal stem cells (MSSCs) to engineer biological cartilage for repair. MSSCs can be differentiated to cartilage cells (chondrocytes) through chondrogenesis. Presently, MSSCs are isolated via sequential expansion of the adherent cell population of mononucleated cells (MNCs) from the stroma of adult tissues via monolayer (2D) plastic cell culture flasks under normoxic (21% O2) conditions. Sequential expansion in 2D plastic flasks leads to a significant reduction in MSSC chondrogenesis. This study characterized chondrocytes produced when MSSCs were expanded in a porous 3D collagen scaffold compared to cells that were expanded in a 2D plastic
dish prior to differentiation in a collagen scaffold, in both 21% O2 and 3% O2 conditions. Low O2 tension has been reported to enhance MSSC differentiation to chondrocytes. We hypothesized that 3D expansion of MNCs under hypoxic conditions would enhance chondrogenic differentiation and lead to higher quality chondrocytes.

**Method:** Bone marrow aspirates from four males were obtained after ethical approval. One million MNCs were seeded onto porous 3D collagen scaffolds (MNC-scaffold groups) and placed in growth media for 2 weeks of cell expansion under 3% or 21% O2. The constructs were then cultured in a defined serum free chondrogenic media (SFCM) for 3 weeks. For the 2D aspect of the study, 1 million MNCs were seeded per cm² of plastic cell culture flasks. The MNCs were expanded in 2D under 3% and 21% O2 until passage 2 (p2) to obtain plastic adherent MSSC populations. Thereafter, 1 million MSSCs at p2 were seeded into 3D porous collagen scaffolds (MSSC-scaffold groups). The MSSC-scaffold groups were cultured in SFCM for 3 weeks under 3% or 21% O2. After full culture, all groups were processed for glycosaminoglycan (GAG), DNA, histology and gene (mRNA) expression analyses. Statistical analysis included two-tailed t-test with P<0.05 considered significant.

**Results:** There was no significant difference between GAG nor DNA contents of MNC-scaffold groups under 3% or 21% O2. The tissues formed were histologically similar and positive for safranin O and collagen II. However, gene expression analysis revealed significant differences with aggrecan, collagen II and chondromodulin up-regulated 3-fold \( (p=0.02) \), 2.5-fold \( (p=0.05) \) and 4-fold \( (p=0.02) \) under 3% O2, respectively. Similarly to MNC-scaffold groups, the GAG and DNA contents of MSSC-scaffold groups were not significantly different between 3% and 21% O2. Safranin O and collagen II staining were also similar. In contrast to MNC-scaffold groups, the mRNA expression in the MSSC-scaffold groups were not significantly different between 3% and 21% O2.

**Conclusion:** This study demonstrated that the combination of a low oxygen tension and a 3D microenvironment enhanced the chondrogenic potential of MNCs.

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**Mitigation of Cryoprotective Agent Toxicity to Chondrocytes by Chondroitin Sulphate and Tetramethylpyrazine**

*Joshua Hahn, AB; Leila Laouar, AB; Thomas Goodine, AB; Gregory Korbutt, AB; Janet A.W. Elliott, AB; Nadir M. Jomha, AB*

**Purpose:** Vitrification is a method of cryopreservation that preserves cells and tissues at temperatures low enough to halt all biological activity without the damaging effects of ice formation. However, the process requires the use of high concentrations of cryoprotective agents (CPAs) to achieve this, which introduce a toxic effect on the cells involved. As such, various compounds can be added to the vitrification solutions to improve the viability outcome by either reducing the toxicity of the CPAs or by increasing the ability of the cells to resist or recover from these damaging effects.

**Method:** Cartilage slices (~75µm thick) recovered from human articular cartilage samples were exposed to CPA (1 mL, 1.6M Glycerol in X-VIVO, 90 min. at 22oC followed by two 5 min. X-VIVO washes) which caused ~50% of the chondrocytes to lose membrane integrity, in addition to a dissolved compound (0.1mg/mL chondroitin sulphate (CS), 200µM or 400µM tetramethylpyrazine (TMP), or a combination of these). Controls were exposed to 8M glycerol (neg - 0% viable), X-VIVO (pos - 100% viable) and 1.6M glycerol (exp - ~50% viable). Viability was assessed with a fluorescent membrane integrity stain immediately after exposure to indicate a reduction/resistance to CPA toxicity \( (N=16) \) or after 48 hr incubation at 4oC in wash solution.
indicating the ability of cells to recover from damage (N=10). Data was statistically analyzed with a t-test analysis compared to control (exp).

**Results:** In the immediate trials, none of the tested compounds produced significantly better results than controls. Cell viability in the controls was approximately 56%, with experimental cell viability ranging from 55% to 60.7% with large variability. In the 48 hr incubation trials there were three treatments that provided a statistically significant improvement over controls. The controls averaged 43.0 ± 6.7% (SEM) viability while the trials of 200µM TMP with CS, 400µM TMP with CS, and 400µM TMP alone averaged 56.0 ± 6.2 % p=0.015, 55.1 ± 5.9% p=0.023, and 51.0 ± 4.1% p=0.051 respectively.

**Conclusion:** The trials that were assessed immediately after exposure to toxic CPA showed no benefit compared to controls, indicating that these compounds did not provide a benefit in reducing the direct toxicity of the CPA. However, when assessed after 48 hr incubation the chondrocytes exposed to these compounds showed a significant improvement over the controls. An interesting observation is that the controls in the immediate vs. 48 hr trials decreased from 56% to 43% viability, while the groups that reached significance in the 48 hr trials ranged from 51-55% viability. This suggests that sub-lethal damage occurs during CPA exposure that will result in further cell death with time, and that these compounds are able to mediate this damage and aid in the recovery of these cells.

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**The Effect of Active and Passive Flexion on Elbow Joint Loading**

Jennifer Ng, ON; Masao Nishiwaki, Japan; Braden Gammon, ON; George S. Athwal, ON; Graham King, ON; James A. Johnson, ON

**Purpose:** Some in vitro studies have investigated radiocapitellar joint loads throughout flexion. However, we are unaware of any investigations of load in both the radiocapitellar and ulnohumeral joints simultaneously during arm movement. Hence, the purpose of the study was to quantify the axial loads experienced at both joints during flexion with the elbow in the horizontal, vertical, varus and valgus orientations.

**Method:** Nine cadaveric arms were used. Each specimen was prepared and secured into an elbow motion simulator. To quantify loads at the radiocapitellar and ulnohumeral joints, load cells were implanted in the proximal radius and ulna. The elbow was moved through a full range of flexion both actively and passively. To simulate active flexion, the tendons of the biceps, brachialis, brachioradialis, and triceps were attached to servo motors. Each specimen was tested in horizontal, vertical, varus and valgus orientations with the forearm maintained in supination.

**Results:** Loads in both the radiocapitellar and ulnohumeral joints during active and passive flexion varied with flexion angle in all four positions, though more variation was observed during active flexion. In comparing the largest average loads, during active flexion, the radial load was 47±44N in horizontal position, while the ulnar load was 47±33N in varus. Conversely, in passive flexion the radial load was 12±15N in valgus and the ulnar load was 53±7N in varus. For both joints, statistical differences were observed for all flexion angles in all arm positions during active flexion (p=0.0001), except for radial loading in varus position (p=0.52). Similarly, in passive flexion, statistical differences were measured in the radius and ulna loading for all arm positions (p<0.05) except for the ulna in horizontal (p=0.14) and radius in varus (p=0.34).

**Conclusion:** Little load variation was noted during passive flexion because no muscles were activated. In contrast, active flexion caused loads to vary throughout flexion. Radial loading correlated with activation of the
biceps and brachioradialis muscles, which anatomically insert on the radius, while ulnar loading correlated with the triceps and brachialis activation loads, due to their insertion on the proximal ulna. The orientation of the arm causes major differences in loading of the elbow. The horizontal position created the greatest load variation in both joints while valgus position had greater radial loading and varus produced greater ulnar loading, relating to the gravitational pull of the arm and joint compression. Therefore, muscle activation and the orientation of the arm affect both radial and ulnar loading during flexion. A better understanding of elbow loading will improve rehabilitation regimes of injured or newly reconstructed elbows as well as implant design. These findings also suggest that the classic 60:40 load sharing ratio between the radius and ulna, respectively, is not necessarily representative for all activities and angles of flexion.

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Minimal Effect of Compressive Loading on the Glenohumeral Joint Stability Ratio
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Purpose: Many biomechanical studies have investigated the changes in shoulder instability due to either bone defects or surgical repair. However, in past, many of these shoulder studies have used different axial load for simulating the compressive force of soft tissue. This variation in compressive load sometimes poses a challenge to compare force or stability ratio results across past studies. The aim of the present study was to investigate if the stability ratio changes with variation of compressive force.

Method: Eighteen cadaveric specimens were tested at glenohumeral abduction angle of 60° and 0° external rotation. The glenoid was translated in a posterior direction to cause an anterior dislocation. Four different medial loads of 50N, 100N, 150, and 200N were randomized and applied on the humeral head. Translational distance, and medial-lateral displacement and horizontal (tangential) reaction force were recorded. Stability ratio was calculated as the ratio of horizontal reaction force to compressive load. One-way repeated measures analysis of variance was performed at a significance level of p<0.05.

Results: The results showed that the force had a significant effect on the stability ratio (p <0.001). Stability ratio was decreased significantly for a 150N (p<0.05) force and for a 200 N force (p<0.05). The average slope obtained from linear regression for all specimens was -0.00017 ± 0.00017. R square value for the fit was 0.57.

Conclusion: This is the first study to show the effect of different compressive loading on the stability ratio of the glenohumeral joint. One important finding of this study is that the increasing compressive force after 100N leads to reduced values of the stability ratio, however the decrease is very small. The decrease in stability ratio was also shown in a study by Lippit et al., although these authors measured the effect of concavity depth.

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Short Link N as a Therapeutic Agent to Treating Early Intervertebral Disc Degeneration
Nizar Algarni, QC; Michael P. Grant, QC; Laura M. Epure, QC; Omar Salem, QC; Rakan Bokhari, QC; John Antoniou, QC; Fackson Mwale, QC

Purpose: Although the disc has limited endogenous repair activity, induced repair of disc tissue may be possible by the intradiscal injection of growth factors to stimulate the production of disc matrix. We previously demonstrated that Link N (DHLSDNYTLHDRAIH), a naturally occurring peptide generated by the N-terminal proteolytic fragmentation of link protein during tissue turnover, can act as a growth factor in the disc. It can stimulate matrix production in vitro, in vivo and in intact ex vivo human intervertebral discs (IVDs). We have
recently discovered that AF cells have the ability to proteolytically process Link N resulting in a fragment spanning amino acid residues 1-8 (US Patent # 61870394) – short Link N (sLink N). Our in vitro data indicates that the biologically active sequence is preserved within this fragment and, thus, sLink N could represent a potential stable growth factor able to stimulate disc repair. Separately, we developed a long-term organ culture model with vertebral bone. The purpose of the present study was to evaluate the effect of sLink N and compare its efficacy to Link N in this novel organ culture model of early disc degeneration.

Method: Caudal IVDs from the tails of 20-24 month old steers were isolated with adjacent vertebral bone. After 7 days of preconditioning in culture, degeneration was induced in IVDs by a single injection of 50 mg trypsin into the NP. Seven days after induced-degeneration, the trypsin-treated discs were injected with either sLink N or Link N (100 µg/disc, n=6 discs/group). Four of the trypsin-treated degenerate discs were injected with PBS alone to serve as a control for degeneration while four discs served as non-degeneration controls. At 2, 4 and 8 weeks post treatment, two discs from each treatment and control groups were processed for biochemical analyses. Proteoglycan (predominantly aggrecan) synthesis in the NP was monitored as sulfated glycosaminoglycan using the 1,9-dimethylmethylene blue dye-binding assay, and Western blotting was performed to determine the expression of aggrecan and type II collagen in the tissue.

Results: The GAG content in the degenerate discs decreased approximately 50% when compared to controls. When degenerate discs were treated with sLink N or Link N, significant increases in GAG content was observed. However, sLink N was more potent at inducing proteoglycan and type II collagen in degenerate discs compared Link N treatment.

Conclusion: Our results reveal that sLink N or Link N have the ability to restore tissue content and that sLink N may be more potent than Link N in treating early disc degeneration.

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Investigation on Accuracy of Ultrasound Measurements for Different Curve of Scoliosis - a Pilot Study
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Purpose: Ultrasound (US) imaging technique has been applied to measure coronal curvature on children who have adolescent idiopathic scoliosis (AIS) and demonstrated good reliability and accuracy, comparable to radiography. This study is to investigate the sensitivity of ultrasound measurements in different curve severities to monitor children with AIS.

Method: Sixty-five subjects (54F;11M; Age: 14.7±1.9 years) were recruited. All subjects met the following inclusion criteria: a) diagnosed with AIS; b) had no surgical treatment prior to participation; c) had no in-brace radiographs in both previous and current exams, and d) the major Cobb angle was less than 45° in the previous radiograph. The standing posteroanterior (PA) radiograph and US spine scan (C-seven to L-five) were obtained within one hour. A researcher experienced in ultrasound measured the US images. The current US image was overlaid on top of the previous radiograph during measurement to simulate clinical practice in which the previous radiograph is used for comparison. The clinical records of the Cobb angle measurements were used to evaluate the US measurements.

Results: Overall, 109 curves including 62 mild (10-25°) and 47 moderate curves (26-45°) were analyzed. Two mild curves were not detected in the US images. The mean differences (US minus radiographic) of the mild and moderate curves were 0.6±3.1° and -1.7±3.1°. The absolute mean differences were 2.6° versus 2.8°, respectively. The measurement difference between the US and radiographic measurement was greater than
five degrees on 6.7 percent (four out of 60) curves in the mild category and 10.6 percent (five out of 47) in moderate curves.

**Conclusion:** There is no significant difference on the US measurements between the mild and moderate curves. Overall eight percent (nine out of 107) of the US measurements had greater than a five degrees difference from that attained from the radiograph. Ultrasound imaging shows great potential for monitoring children who have mild or moderate AIS without exposing them to ionizing radiation.

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**Closure of the Intervertebral Disc Annulus Fibrosus using a Novel Suture Application Device – In vivo Porcine and ex vivo Biomechanical Evaluation**

**Andrea Chan, ON; Antony Bateman, ON; Christian Balkovec, ON; Margarete Akens, ON; Robert Harrison, ON; Albert Yee, ON; Stuart McGill, ON**

**Purpose:** Defects in the annulus fibrosus (AF) remain a challenge in the surgical treatment of lumbar disc herniations with persistent defects allowing potential re-herniation of nucleus pulposus (NP) tissue. We performed an in vivo proof of principle and feasibility study of a minimally invasive kerrison-shaped suture device designed to achieve closure of AF defects in the intervertebral disc. A cervical porcine model was chosen to simulate human lumbar discs based on size of the cervical porcine disc and a review of the literature.

**Method:** Three pigs (53-57 kg) were anaesthetised and underwent a ventral surgical approach to the cervical spine (C2/3 – C5/6). The AF of two discs was incised with a scalpel in a vertical fashion and a simulated partial NP discectomy performed. The resultant annular defect was closed at one randomly selected level using the AnchorKnot™ device to apply a 2-0 non-absorbable ultra-high-molecular-weight polyethylene (UHMWPE) suture and Dines knot. The defect at the remaining level served as sham control. Based on preliminary biomechanical testing the optimal configurations of four half hitches were cast over the Dines knot. The pigs were then observed for four weeks before euthanasia. The excised cervical spine underwent seven Tesla magnetic resonance imaging (MRI) followed by histological H&E evaluation.

**Results:** Preliminary ex-vivo biomechanical assessment of the sutures showed that a Dines knot with four half hitches was optimal when comparing knot slippage and breakage after 4000 cycles of flexion and extension with 1500N of axial load and further straight pull testing. The mode of failure for knots greater than four half hitches was suture breakage rather than knot slippage. Clinically, the neurological examination in treated pigs was normal following surgery. Histological and MRI assessment confirmed sustained defect closure at four weeks. There was no significant reaction to the suture material and no nucleus pulposus extrusion at any of the sutured levels. Volumetric assessment using MRI showed decreased disc material in both sham and sutured discs when compared to normal discs.

**Conclusion:** Our in vivo porcine study demonstrates that it is technically feasible to perform a suture repair of an AF defect using this novel device with sustained defect closure through four weeks. Ex vivo biomechanical experiments demonstrated that a Dines knot with four half hitches is the optimal strength configuration under the described testing conditions. This technique may reduce the incidence of early disc re-herniation following discectomy through closure of the AF defect, although further study is required to assess this potential application.
Ca2+ Regulates the Expression of Type II Collagen and Aggrecan in Intervertebral Disc Cells by Activating the Extracellular Calcium-Sensing Receptor

Rakan Bokhari, QC; Ahmed Habis, QC; Laura M. Epure, QC; Nizar AlGarni, QC; John Antoniou, QC; Fackson Mwale, QC; Michael P. Grant, QC

Purpose: Degenerative disc disease (DDD) is a common cause of lower back pain. Calcification of the intervertebral disc (IVD) has been correlated with DDD, and is especially prevalent in sciotic discs. The appearance of calcium deposits has been shown to increase with age, and its occurrence has been associated with several other disorders such as hyperparathyroidism, chondrocalcinosis, and arthritis. Trauma, vertebral fusion and infection have also been shown to increase the incidence of IVD calcification. The role of IVD calcification in the development DDD is unknown. Our preliminary data suggest that ionic calcium content and expression of the extracellular calcium-sensing receptor (CaSR) are increased in the nucleus pulpous (NP) and annular fibrosis (AF) of degenerate discs, however, its role in DDD remains unclear.

Method: IVD Cells: Bovine and human NP and AF cells were incubated in culture media supplemented with various concentrations of calcium (1.0, 1.5, 2.5, 5.0 mM) a CaSR agonist [5 µM], or IL-1β [10 ng/ml] for 7 days. Lysates were extracted and the expression of aggrecan and type II collagen (Col II) were measured by Western blotting. IVD Cultures: Caudal IVDs from the tails of 20-24 month old steers were isolated and the vertebral bone was removed. IVDs were cultured for 4 weeks in culture medium supplemented with calcium (1.0, 2.5, or 5.0 mM), or a CaSR agonist [5 µM]. NP and AF tissue were subjected to guanidium extraction and Western blotting was performed to determine the expression of aggrecan and Col II. Histological sections were prepared to determine degree of mineralization by von Kossa staining and expression of alkaline phosphatase.

Results: The expression of aggrecan and Col II decreased dose-dependently in both NP and AF cells following supplementation with calcium or the CaSR agonist. A similar phenomenon was observed for the expression of aggrecan and Col II in IVDs following calcium supplementation. In addition to decreases in Col II and aggrecan, increases in mineralization and expression of alkaline phosphatase was observed in IVDs supplemented with calcium.

Conclusion: Our results suggest that changes in the local concentrations of calcium are not benign, and that activation of the CaSR may be a contributing factor in IVD degeneration.

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Characterization of a Novel, Magnetic Resonance Imaging-compatible Rodent Model Spinal Cord Injury Device
Tim Bhatnagar, BC; Jie Liu, BC; Thomas Oxland, BC

Purpose: Traumatic spinal cord injury (TSCI) involves mechanical deformation of the spinal cord that leads to biological and functional damage. However, the relationship between the pattern of spinal cord deformation during TSCI and the ensuing damage is not well characterized. Studies have shown a relationship between cellular damage in neural tissues and mechanical deformation during simple loading experiments, but TSCI loading conditions are very complex and not well-approximated by simple loading conditions. Current experimental TSCI devices are capable of producing clinically relevant injury mechanisms in animal models, but are limited to measuring the mechanical response of the gross spinal cord. In this study, we have developed an apparatus (the ‘MR Rig) that can produce two different clinically relevant mechanisms of cervical TSCI (i.e. contusion and dislocation) in an in vitro rat model. We have characterized the MR Rig with regard to contusion injury magnitude, as well as injury speed for both the contusion and dislocation mechanisms.
Furthermore, we demonstrated that the MR Rig can be used inside of a magnetic resonance (MR) scanner and facilitated observation of the internal deformation of the spinal cord during TSCI, in an in vivo rat model.

**Method:** The MR Rig was designed to produce contusion or dislocation injuries in an in vitro rat model, at injury magnitudes and speeds similar to existing TSCI devices. The MR Rig was constructed from MR-compatible plastics and was designed to be used inside of a 7T MR scanner (Bruker Biospec). The injuries were produced using a custom pneumatic actuator (BECO, USA). The accuracy and precision of the contusion injury magnitude produced in the MR Rig was assessed using a transverse-plane static x-ray analysis to measure intrusion of the contusion tip into the canal of a cadaveric specimen (n=7). The injury speeds for both contusion (n=14) and dislocation (n=8) injuries were measured from high-speed video data of trials using cadaveric specimens. Preliminary MR images of the spinal cord during ‘normal’ and ‘injured’ conditions were acquired for qualitative assessment.

**Results:** The MR Rig produced a mean contusion injury magnitude of 1.78 mm (SD 0.12 mm) for an intended 1.8 mm injury. The injury speed for a 1.8 mm contusion injury was 1100 mm/s (SD 250 mm/s) The injury speed for a 2.5 mm dislocation injury was 184 mm/s (SD 101 mm/s). The MR images obtained qualitatively illustrate that the morphology of the gray and white matter of the spinal cord can be observed both prior to injury and during injury.

**Conclusion:** The ability to observe the internal aspects of the spinal cord during injury is crucial to understanding the biomechanics of the cord during a TSCI event. The development of this MR rig provides internal spinal cord deformation data that has not been attainable previously and will be useful in furthering models of in vivo rodent spinal cord injury.

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In *vivo* Measurement of Spinal Cord Deformation during TSCI

**Tim Bhatnagar, BC; Jie Liu, BC; Andrew Yung, BC; Peter Cripton, BC; Piotr Kozlowski, BC; Wolfram Tetzlaff, BC; Thomas Oxland, BC**

**Purpose:** During traumatic spinal cord injury (TSCI), the spinal cord is subject to deformation. The deformation of the spinal cord results in mechanical injury to the neural tissues and physiological dysfunction of the spinal cord. Studies have shown that different injury mechanisms (i.e. contusion, dislocation, etc.) result in different manifestations of damage in the spinal cord. However, the complex relationship between deformation of the spinal cord, trauma induced in the neural tissue and the ensuing cascade of pathophysiological processes following TSCI, is currently not well understood. This limitation is due to the inability of current experimental TSCI models to facilitate observation of the internal tissue behaviour of the spinal cord where mechanical damage occurs. Therefore, this study aimed to report novel quantified internal spinal cord deformations due to contusion and dislocation injury mechanisms of TSCI.

**Method:** A novel apparatus was used to create either a contusion or dislocation cervical TSCI, which was sustained for 30 minutes, in an in vivo rat model (n=24; twelve in each mechanism group), inside of a magnetic resonance scanner (7T Bruker Biospec, Germany). Three-dimensional image sets were acquired of the spinal cord in the normal state and in the deformed state during the imposed TSCI. A validated image registration approach was then used to quantify the three-dimensional internal spinal cord morphological change using displacement fields. Transverse- and sagittal-plane deformation fields were reported as well as strain fields of spinal cords undergoing TSCI.
**Results:** The contusion and dislocation injury mechanisms produced different patterns of spinal cord deformation. Contusion injuries produced a region of high-magnitude dorso-ventral compression and medio-lateral tension at the injury epicenter, whereas the dislocation injuries produced a laterally-oriented band of dorso-ventral tension. The gray matter of the spinal cord appeared to retain its cross-sectional morphological appearance after injury more than the white matter in both injuries, indicating that the gray matter may be less susceptible to deformation than the white matter in the transverse-plane. Furthermore, the lateral and ventral white matter consistently experienced transverse-plane compression during contusion injuries.

**Conclusion:** This work quantifies distinctly different internal spinal cord deformations due to two clinically relevant TSCI mechanisms, emphasizing the need to consider mechanism of TSCI when predicting the biological response of the cord. The methods presented in this study will facilitate further study of the relationship between mechanical deformation of the spinal cord tissues during TSCI and the ensuing tissue damage. Experimental in vivo TSCI has never before been visualized internally, and the capabilities shown in this study open up new avenues for TSCI research.

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**Relating Histological Damage and Mechanical Deformation in Experimental Traumatic Spinal Cord Injury**

**Tim Bhatnagar, BC; Jie Liu, BC; Andrew Yung, BC; Peter Cripton, BC; Piotr Kozlowski, BC; Wolfram Tetzlaff, BC; Thomas Oxland, BC**

**Purpose:** The relationship between mechanical deformation of the spinal cord during traumatic spinal cord injury (TSCI) and the ensuing biological and functional damage is not well-understood. Studies have shown that a greater deformation of the spinal cord results in more severe tissue damage and neurologic deficit. Furthermore, different mechanisms of TSCI produce distinctly different patterns of tissue damage, indicating that the pattern of deformation that the spinal cord undergoes is of key importance. However, there is currently no recognized quantitative relationship between mechanical deformation of tissue and the biological response during TSCI. This study aimed to determine if there was a relationship between quantified deformation of the spinal cord and ensuing biological damage in an in vivo rat model of cervical contusion TSCI.

**Method:** A novel apparatus was used to create sustained cervical contusion TSCI at various severities, which were sustained for 30 minutes, in an in vivo rat model (n=12), inside of a magnetic resonance (MR) scanner (7T Bruker Biospec, Germany). Three-dimensional images of the spinal cord in the normal state and in the deformed state, during the imposed TSCI, were input to a validated image registration approach to quantify the internal spinal cord mechanical strains during injury. The transverse-plane strains observed in the spinal cord throughout a cranio-caudal region of interest around the injury epicenter were then compared to a measure of gray matter neuron survival in the ventral horns. Regression analyses were performed to determine the mechanical strain type that best explained the observed tissue damage.

**Results:** This study showed that the average transverse-plane minimum principal strain in the ventral horns of the gray matter during contusion TSCI was significantly correlated (R² = 0.19) to a loss of neuron viability. The observed spinal cord strain patterns were similar to predictions reported from computational simulations of TSCI. Although there were consistent trends between strain and tissue damage, the results suggest that there are additional parameters of injury that should be considered when predicting tissue damage following TSCI.

**Conclusion:** This work comprises the first study of experimental TSCI that provides both quantified mechanical deformations of the internal spinal cord and a measure of ensuing tissue damage. Previously,
relationships between tissue deformation and damage were inferred, but never directly evaluated. Further development of the presented methods will enable characterization of the effects of mechanical parameters of injury on tissue damage. Furthermore, the link that this study establishes between mechanical deformation and tissue damage during TSCI will provide greater insight into tissue damage tolerances. This information will contribute to the ability to use computational simulations of TSCI as a clinical tool to predict patterns of tissue damage that will ensue observed patterns of cord deformation.

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Identifying Variability in a Rodent Dislocation Spinal Cord Injury Rodent Model Using High-speed X-ray Imaging
Stephen Mattucci, BC; Jie Liu, BC; Paul Fijal, BC; Kenny Wu, BC; Wolfram Tetzlaff, BC; Thomas Oxland, BC

Purpose: During a spinal cord injury (SCI), various combinations of forces result in different primary injury mechanisms. The most common, and most severe mechanism is fracture-dislocation, and occurs in roughly 45% of SCI cases [Sekhon 2001], where injury occurs as one vertebra slides over the other, pinching the cord. Our group can produce distinct types of clinically relevant SCI including dislocation in a rat model, where findings mimic clinical observations that dislocation is a more severe injury than contusion. Additionally, different patterns of tissue damage [Choo 2007, 2008, 2009] could narrow the therapeutic time-window for surgical intervention. Despite the high precision in injury parameters; previous results demonstrate variable injury outcomes in both tissue damage and behaviour [Chen 2014]. The research objectives were to i) precisely measure intervertebral kinematics during a high-speed dislocation injury in an in vivo rat model; and ii) to determine whether there is slippage (i.e. relative motion) at the vertebral-clamp interface.

Method: Rats were tested in vivo (n=17) and sacrificed immediately post-injury. A high-speed camera x-ray device captured the motion during injury, by tracking 0.4mm tantalum beads affixed to the vertebrae and clamps. The rostral clamps held C3 and C4 in place, while the caudal clamps held and dislocated C5 and C6 dorsally.

Results: Kinematics were compared between vertebrae and clamps for dorsal/ventral and rostral/caudal translation, and rotation. Vertebral motion that exceeded two standard deviations of the average clamp motion was identified as slipping. The most important metrics to assess slippage included C4 or C5 with respect to (w.r.t.) their respective clamps in dorsal translation and rotation. C5 w.r.t. C4 compared to caudal clamp w.r.t. rostral clamp determined if the vertebral dislocation distance was equivalent to actuator distance – as slipping could occur at both clamps. The sum of C4 and C5 rotation was observed as the overall integrity of the spinal canal – a large combined rotation value would indicate the canal remaining open, and not imparting a shear force on the cord. Slippage was observed in 4 – 8 animals for each metric, and relative motion was often present at more than one interface. Further, histology demonstrated the cords that had more relative motion had noticeably less hemorrhaging from the most rigid, suggesting the slipping instances resulted in less injury.

Conclusion: This study demonstrates the importance of measuring the high-speed kinematics of pre-clinical models for SCI and emphasizes the need for precision vertebral clamps to prevent slippage at the vertebra-clamp interface.

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Role of Muscle Damage on Loading at the Level Adjacent to a Lumbar Spine Fusion – A Biomechanical Analysis
Masoud Malakoutian, BC; John Street, BC; Hans-Joachim Wilke, Germany; Ian Stavness, SK; Marcel Dvorak, BC; Sidney Fels, BC; Thomas Oxland, BC

**Purpose:** Adjacent segment changes to a spinal fusion have been studied using in vitro techniques, but these produce obvious results. Therefore, alternative approaches are needed that better represent the complexity of the lumbar spine, particularly in situations where the paraspinal muscles are dysfunctional. Newly developed musculoskeletal models of the lumbar spine hold promise in this regard, but have not been used to address the effect of muscle damage on adjacent segment loading. The objective of this study was to investigate the effect of muscle damage on post-operative spinal loading at the adjacent levels to a spinal fusion during upright postures by using a recently developed physiological musculoskeletal model of the lumbar spine.

**Method:** A musculoskeletal model of the spine was created in ArtiSynth, a biomechanical modelling software toolkit. The model included the entire spine and rib cage, with the lumbar vertebrae being mobile, and 210 muscle fascicles. The loading at the L1-L2 and L5-S1 were estimated before and after simulated paraspinal muscle damage along the lumbar spine, both with a spinal fusion at L2-L5 and with no spinal fusion.

**Results:** The axial compressive forces at the adjacent levels increased after simulated muscle damage, with the largest changes being at the rostral level (78% increase in presence of spinal fusion; 73% increase without spinal fusion) compared to the caudal level (41% in presence of fusion and 32% without fusion). Shear forces increased in a similar manner at both the rostral and caudal levels. These changes in loading were due to a redistribution of muscle activity from the local lumbar to the global spinal musculature.

**Conclusion:** A musculoskeletal dynamic model of the lumbar spine predicted increased compressive forces after muscle damage at the adjacent levels to a spinal fusion. The largest increases were at the rostral adjacent segment compared to the caudal level, and the changes occurred with or without a spinal fusion. This suggests that the paraspinal muscles of the lumbar spine play an important role in the etiology of adjacent segment changes beside a spinal fusion.

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**A Reliable and Valid Competency Based Simulated Learning Module for the Application of a Pavlik Harness Based on International Expert Consensus**

Simon P. Kelley, ON; Catharine S. Bradley, ON; Joel Moktar, ON; John H. Wedge, ON; M. Lucas Murnaghan, ON

**Purpose:** The use of simulated learning is increasing in medical education as it offers unlimited learning opportunities in a low risk setting. In orthopaedic surgery, the mainstay of educational programs has been the training of surgical skills with lesser emphasis on non-operative techniques. Accordingly, formal educational methods and evaluation tools specific to Pavlik Harness application do not exist, despite its widespread use and potential complications related to inappropriate application. This study sought to develop a reliable and valid learning simulation module and evaluation tool based on international expert consensus to standardize, teach and evaluate Pavlik Harness application for treatment of Developmental Dysplasia of the Hip.

**Method:** Consensus was sought from 10 content experts using Delphi methodology on the key items for safe and effective Pavlik Harness application. The resulting items were listed to form an Objective Structured Assessment of Technical Skill (OSATS). The OSATS was used as a framework for the development of a learning simulation module, including an infant model and audiovisual instructional media. Thirty-five participants were selected into three a priori groups (expert, intermediate and novice) based on perceived
competence with the application of the Pavlik Harness. On two occasions separated by two weeks, three content experts assessed randomized and de-identified videotapes of each participant applying a Pavlik Harness to the model using the OSATS and two global rating scales (GRS). The reliability and validity of the OSATS were then evaluated using ICC statistics and ANOVA.

**Results:** Consensus was obtained after two rounds of structured surveying. The Delphi methodology used for OSATS development ensured face and content validity. The resulting OSATS contained 25 items. The reliability of the OSATS was excellent with an ICC of 0.96 for inter-rater and 0.98 for test-retest reliability. Construct validity was excellent with the OSATS correlating highly with both GRS (>0.90). In addition, the OSATS clearly discriminated between expert, intermediate and novice users of the Pavlik Harness.

**Conclusion:** We have developed a competency based simulation module for learning the application of a Pavlik Harness based on the consensus of an international group of experts in hip dysplasia. The corresponding OSATS has been shown to be a reliable and valid method for assessing correct Pavlik Harness application that can discriminate between expert, intermediate and novice users. This learning module will form the cornerstone of formal teaching for the application of the Pavlik Harness for Developmental Dysplasia of the Hip.

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**A Validated Orthopaedic Surgical Simulation Model for Training and Evaluation of Basic Arthroscopic Skills**

**Ryan Coughlin, QC; Thierry Pauyo, QC; Carl Sutton III, QC; Lawrence Phillip Coughlin, QC; Stephane Bergeron, QC**

**Purpose:** There is currently no validated educational model to evaluate and teach basic arthroscopic skills that is widely accessible to orthopaedic residency training programs. The primary objective was to design and validate a surgical simulation model by showing that subjects with increasing level of training perform better on basic arthroscopic simulation tasks. The secondary objective was to evaluate inter-rater and intra-rater reliability of the model.

**Method:** A nominal group technique was used to design an arthroscopic simulation skills model. Participants were prospectively recruited between February and March 2014 and grouped by level of training into four groups. Subjects performed six basic arthroscopic tasks using a box model: 1) probing, 2) grasping, 3) tissue resection, 4) tissue shaving, 5) tissue liberation and suture passing, and 6) arthroscopic knot tying. A score was calculated according to time required to complete each task and deductions for technical errors. A priori total global score out of a possible 100 points was calculated by averaging the scores from all six tasks using equal weights. The grading was done by two independent and blinded reviewers.

**Results:** A total of 49 participants out of a possible 56 eligible subjects were voluntarily recruited for this study. Participants consisted of fourth-year medical students (N=7/7), orthopaedic residents (N=36/40), and subspecialty trained arthroscopic surgeons (N=6/9) from a single academic institution. The mean total global score differed significantly between groups (p<0.001): Group 1= 29 (± 13.6); Group 2= 40.3 (± 12.1); Group 3= 57.6 (± 7.4); and Group 4= 72.4 (± 3.0). Pairwise comparison with Tukey correction confirmed construct validity by showing significant improvement in overall performance by increasing level of training between all groups. The model also proved to be highly reliable with an intraclass correlation coefficient of 0.99 for both inter-rater and intra-rater reliability.
Conclusion: A simulation model was successfully designed to teach and evaluate basic arthroscopic skills showing good construct validity. This arthroscopic simulation model is inexpensive, valid and reliable, and has the potential to be implemented in other training programs.

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An Evaluation using Google Glass and a GoPro Camera in Orthopaedic Surgical Teaching
Hans Van Lancker, QC; Thierry Pauyo, QC; Jan Kruijt, QC; Aileen Roman, QC; Edward Harvey, QC

Purpose: Google Glass is a new low-profile wearable technology that allows physicians to record hands free video and pictures and to directly video link and communicate with other wearers of this device. The GoPro Camera is a wearable, wide-angle, waterproof HD camera that can be worn on the head during a procedure to record the primary surgeon’s technique and commentary. These devices have clear teaching implications and will enable academic physicians to disseminate information to more students and in situations not previously possible. As the device evolves it’s potential to do more will likely develop further. It is important to assess the how well this device will work in enhancing surgical teaching.

Method: Patients undergoing a surgery relevant to teaching will be asked to consent for potential video/picture recording using the Google Glass or GoPro device during their operation. Data pertaining to the effectiveness of the Google glass or GoPro device in this scenario was be evaluated with a questionnaire filled out by the students and residents benefiting from the teaching using the cases recorded with the devices. The Google Glass device and GoPro Camera were assessed in their video recording and teaching applications through a comparative survey of each resident or student.

Results: Both devices were universally well received as a teaching tool by the residents and students surveyed. While the Google Glass device is more ergonomic for the wearer, the GoPro Camera provided better video quality. Many new applications for both devices were suggested and the benefit of both in academic surgery was clearly defined by the survey results.

Conclusion: The Google Glass and GoPro camera devices both provide novel means of depicting a rare intraoperative experience to a large population of residents and students. The potential of these devices in academic surgery is apparent and evaluated in this study. Future work using these devices on an international educational level is an exciting direction we plan to take our research.

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Competency-based Medical Education: Can Junior Residents Achieve the Same Level of Clinical Skills as Senior Residents?
Tim Dwyer, ON; Sarah Wright, ON; John Theodoropoulos, ON; Jas Chahal, ON; David Wasserstein, ON; Mahan Kulasegaram, ON; Charlotte Ringsted, ON; Brian Hodges, ON; Veronica Wadey, ON; Darrell Ogilvie-Harris, ON

Purpose: The implementation of competency-based medical education (CBME) as the orthopaedic resident training format at our institution has moved post-graduate training away from a time-based training model, to a model based upon observable and measurable outcomes. The purpose of this study was to determine whether junior and senior residents could demonstrate and apply clinical skills to a similar level, after being exposed to the same sports medicine rotation. We hypothesized that, with intensive training to a set curriculum, that junior and senior residents would be able to demonstrate and apply clinical skills to an equivalent level.
**Method:** All residents undertaking a three-month sports medicine rotation were expected to pass a six station OSCE. Participants included both junior (PGY 1,2&3) and senior (PGY 4&5) residents. Computer-based stations were created, with clinical photographs, radiographic imaging and intraoperative photographs displayed, in accordance with each clinical scenario. All stations were marked with a binary station-specific checklist and a 5-point overall global rating scale (GRS) – the GRS was also given for each domain of knowledge (history-taking, examination, image interpretation, clinical decision-making, consent, surgical technique). Examiners were instructed to assign global ratings of competence in accordance with the orthopaedic certifying exam level, regardless of the postgraduate year of the trainee. In order to determine whether each resident passed the exam, a non-compensatory method was applied, whereby an overall global rating of competent had to be obtained at a minimum of 4/6 stations.

**Results:** Over 18 months, 39 residents (21 junior, 18 senior) sat the OSCE at the end of their sports rotation. A further six fellows also participated, for a total of 45 participants. The Cronbach’s alpha of the six stations was high (0.87). Analysis using a two-tail t test demonstrated a significant difference between junior and senior residents in both total checklist score (%) (56.15 (SD 10.99) versus 71.87 (SD 8.94)) and total global rating (2.44 (SD 0.55) versus 3.79 (0.49)) (p<0.01). A significant difference was also seen for each of the six station’s total checklist scores, for the total global rating on every station, and for each of the individual clinical skills (p<0.01). There was no significant difference between the fellows and the senior residents. Using this method, 8/21 (38%) junior residents, 18/18 (100%) senior residents, and 5/6 (83%) fellows passed the end of rotation exam.

**Conclusion:** Despite identical intensive teaching to a set curriculum within a CBME model, junior residents were not able to demonstrate or apply clinical skills as well as senior residents, suggesting that experience is a critical factor. To avoid using separate examinations for junior and senior residents at the end of rotations, alternative standard setting methods need to be studied and applied in the setting of CBME.

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**Effect of Functional Laterality on Simulated Shoulder Arthroscopy**

**John J. Amirault, MB; Jeff Leiter, MB**

**Purpose:** Traditionally, surgical education follows a master-apprentice model, similar to that of the tradecrafts, where senior staff function as mentors for trainees. In today's medical education environment, changes have had the net effect of decreasing both the quantity and quality of the teaching opportunities for trainees. These include concern about patient safety, restrictions on funding and work hours, and new policies to reduce patient waiting times. These limitations have resulted in trainees having to deal with an increasingly steep technical learning curve with relatively less time to do so compared to their predecessors. Simulator technology for surgical training is a new facet of medical education that could potentially fill this void. Previous research has demonstrated significant performance difference amongst right and left hand dominant individuals in simulated laparoscopic surgical tasks. No evidence exists to date regarding applicability of this conclusion to simulated shoulder arthroscopic surgery.

**Method:** Using the Touch of Life Technologies ArthroSim™ - a virtual reality based arthroscopic simulator - 44 participants have been recruited to date and performed two simulated diagnostic shoulder arthroscopy training modules: one left shoulder while holding the arthroscope in their right hand for the majority of tasks, and one right shoulder while holding the arthroscope in their left hand for the majority. Demographic data was collected on each participant - outcome measures of completion score, and time to completion were measured by the simulator for each component task of a diagnostic shoulder arthroscopy. Subjective difficulty was recorded.
using visual analogue scales. In total, 50 variables were recorded including demographic data, objective, and subjective performance.

**Results:** Using SPSS, non-parametric statistical analysis (Wilcoxon Signed Rank Test) was conducted to discern if there was a performance difference amongst the cohort when performing the arthroscopy on the left versus right side, stratified across subgroups of different demographics, especially hand dominance. When analyzing subgroups by right or left hand dominance, significant differences exist across a number of the performance variables measured by the simulator.

**Conclusion:** This study has demonstrated that whether an individual is right or left handed, there is a significant performance difference when they are performing an arthroscopy on a right or left shoulder. In other words, within this cohort individuals are 'better' at performing a diagnostic shoulder arthroscopy on either a left or right shoulder. To the author's best knowledge, to date this data has not been reported in the literature. This knowledge can be used to lend support to potential modifications in training or equipment in future medical education curricula.

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**Entrustable Professional Activities (EPAs) in Orthopaedics: Simulation-based Assessment of Competency**

Tim Dwyer, ON; Veronica Wadey, ON; William Kraemer, ON; Peter Ferguson, ON; Doug Archibald, ON; Darrell Ogilvie-Harris, ON; Jeremy Hall, ON; John Murnaghan, ON; Markku Nousiainen, ON

**Purpose:** To bridge the gap between Competency-Based Medical Education (CBME) theory and practice, the concept of an Entrustable Professional Activity (EPA) has been introduced. The EPA is a concept that describes a professional task that that faculty entrust to a trainee to execute, unsupervised, once an adequate level of competence has been achieved. The faculty at our institution has created a list of the top ten EPAs for the program, which all residents are required to display sufficient competency to be performed unsupervised prior to graduation from the program. We hypothesized that simulation-based assessment could be used to determine the ability of orthopaedic residents to perform EPAs independently.

**Method:** Three EPAs were chosen from a previously established list of competencies: 1) management of the patient for total knee replacement (TKR), 2) management of the patient with hip fracture, and 3) management of the patient with ankle fracture. Each of the three EPAs is typically completed within the first phase of CBME, or first year of training. Each EPA was 40 minutes long, and divided into three components; preoperative assessment (history taking and examination with a standardized patient, image interpretation), performance of technical skill on a sawbones model, and postoperative management (postoperative orders, management of complications). Residents were assessed by faculty using checklists was created via a modified Delphi technique, in conjunction with an overall global rating scale (GRS) based on the Drefus model of competency. Finally, residents were graded from 1 – 5 on their level of entrustment as described by Ten Cate et al 2005.

**Results:** Nine PGY1 and nine PGY4 residents participated. The reliability for the exam was high (> 0.8). On the hip fracture EPA, there was a significant difference in the GRS and the EPA rating between the PGY1 and the PGY4 groups in both the preoperative assessment and the postoperative management (p<0.001). On the technical component, there was a significant difference between the two groups using the overall GRS (p=0.015), but not with the EPA rating. On the TKR EPA, while no significant difference was seen with regards the preoperative assessment, a significant difference was seen between the groups for both the postoperative management, and the performance of technical skill component for the overall GRS and the EPA (p<0.05). No
significant difference was seen between groups for the preoperative assessment of the ankle fracture patient. However, a significant difference was seen for the overall GRS and EPA rating for the postoperative management (p<0.05), and for the overall GRS for the performance of technical skill component (p=0.02).

Conclusion: This study has demonstrated that it is valid and reliable to use simulation-based assessment of residents' ability to perform an EPA. This method of assessment may allow faculty to determine a resident's ability to manage patients with decreasing levels of supervision.

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Use of an Objective Structured Assessment of Technical Skill (OSATS) After a Sports Rotation
Tim Dwyer, ON; Jesse Slade Shantz, ON; Jas Chahal, ON; David Wasserstein, ON; Brian Devitt, ON; John Theodoropoulos, ON; Brian Hodges, ON; Charlotte Ringsted, ON; Darrell Ogilvie-Harris, ON

Purpose: The introduction of Competency Based Medical Education (CBME) in postgraduate medicine demands validated methods of evaluation. As all postgraduate medical training slowly shifts to a competency-based model, effective assessments of surgical and other technical skills after modules will become necessary. However, the best method for of assessing competence in technical skill in this setting is unknown, and is limited by both cost and access to resources. We hypothesized that a multi-station Objective Structured Assessment of Technical skill (OSATS), using sawbones models, would be a valid and reliable method of assessing resident competence in surgical skills after a sports medicine rotation.

Method: At the start of their three-month sports medicine rotation, each resident was provided a list of 10 surgical skills in which they were expected to demonstrate competence. Skills included anterior cruciate ligament reconstruction, meniscectomy, shoulder labral repair, rotator cuff repair, and arthroscopic knot tying. At the end of the rotation, each resident undertook an OSATS comprised of six randomly chosen stations. Low-fidelity sawbones models were used in all stations. Residents were evaluated by faculty using a previously validated global rating scale (the Arthroscopic Surgical Skill Evaluation Tool (ASSET)), task-specific checklists created using a modified Delphi procedure, and a final five-point rating using the Drefus model of skill acquisition (1=novice, 2=advanced beginner, 3=competent, 4=proficient, 5=expert). All arthroscopic procedures were recorded, and all hand movements were videotaped – the videos were reviewed by a single, blinded observer, and correlation sought between the faculty ratings and the observer ratings.

Results: Over 18 months, 27 residents (19 junior, 8 senior) sat the OSATS after their rotation, as well as seven sports medicine staff and seven fellows, for a total of 41 participants. The overall reliability of the OSATS as measured by Cronbach’s Alpha was very high, at 0.97. A significant difference by year in training was seen for the overall global rating (p<0.0001), and total checklist score (p=0.0001). A significant difference was also seen with regards the overall Drefus global rating, task specific checklists, and the ASSET global rating between junior and senior residents, as well as senior residents and fellows / staff (p<0.05). A high correlation was seen between the faculty assessments and the blinded observer assessments (>0.6).

Conclusion: The results of this study demonstrate that an OSATS using dry models is a valid and reliable means of assessing technical skill in orthopaedic residents after a sports medical rotation. Interestingly, junior residents were not able to perform technical skills as well as senior residents, suggesting that overall surgical experience and exposure is as important as intensive teaching.

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Validation of a Dry Model for the Assessment of Resident Performance of Anterior Cruciate Ligament
Reconstruction (ACLR)

Tim Dwyer, ON; Jesse Slade Shantz, ON; Jas Chahal, ON; David Wasserstein, ON; Rachel Schachar, ON; Brian Devitt, ON; John Theodoropoulos, ON; Charlotte Ringsted, ON; Brian Hodges, ON; Darrell Ogilvie-Harris, ON

Purpose: As the demand increases for demonstration of competence in surgical skill, the need for validated assessment tools has also increased. The purpose of this study was to validate the use of a sawbones model for the assessment of performance of anterior cruciate reconstruction (ACLR) by residents. We hypothesized that the combination of a checklist and a previously validated global rating scale (ASSET), designed to be applicable to a variety of arthroscopic procedures, would be a valid and reliable means of assessing ACLR when performed by residents in a dry model.

Method: All residents, sports medicine staff and fellows were invited to perform an ACLR on an ACL Sawbones model. Demographics regarding previous exposure to knee arthroscopy and ACLR were collected. All participants were asked to perform a hamstring ACLR using an anteromedial portal with Endobutton fixation on the femur – a detailed surgical manuscript and technique video was sent to all residents prior to the study. Residents were evaluated by staff using a task-specific checklist created using a modified Delphi procedure, and the ASSET global rating scale. Each procedure was recorded, with videotaping of the hand movements and instrument usage, and arthroscopic video recordings of the intra-articular procedure. These videos were scored by a fellow blinded to the year of training of each resident.

Results: A total of 29 residents, six staff and five faculty performed an ACLR on the sawbones model (40 total). The overall reliability (Cronbach’s Alpha) of the test using the total ASSET score was very high (>0.9). The reliability for the femoral checklist was 0.75, for the tibial checklist was 0.78, and 0.68 for the graft passage and fixation. One-way analysis of variance for the total ASSET score and the total checklist score demonstrated a difference between residents based upon year of training (p<0.001). Post hoc analysis demonstrated a significant difference in global ratings and checklist scores between junior residents (PGY1,2,3) and senior residents (PGY4&5), seniors and fellows, and fellows and staff (p<0.05). A good correlation was seen between exposure to knee arthroscopy (0.73) and ACLR (0.65). The inter-rater reliability (ICC) between faculty rating and blinded assessor was very high (>0.8) for the total ASSET score.

Conclusion: The use of a sawbones models to assess resident performance of ACLR using the ASSET GRS is valid and reliable. This allows the use of sawbone models to ensure a minimal level of competence prior to resident performance of ACLR in the operating room.

Virtual Reality versus Bench Top Simulation in the Acquisition of Arthroscopic Skill: A Randomized Control Trial

Daniel Banaszek, ON; Daniel You, ON; Michael Pickell, ON; Daniel Hesse, ON; Daniel Borschneck, ON; Davide Bardana, ON

Purpose: With modern restrictions in resident work hours, attempts have been made to incorporate virtual reality (VR) simulators and benchtop trainers (BT) to accelerate surgical skill acquisition. Prior research has established the benefit of these modalities in operative skill. To our knowledge, no studies have compared skill acquisition between virtual and bench top simulators concurrently. We hereby aim to directly compare two surgical simulation set-ups in a randomized control study, and assess efficiency in skill from the lab into the operating room.
Method: 39 surgical novices (medical clerks) were given an orientation to basic arthroscopy. Each participant performed a baseline ten-minute diagnostic exam on both VR and BT simulators. Participants were randomized to train in either of the modalities for 6-8 hours over a five-week period. Post-testing consisted of: 1) Repeat arthroscopy on both modalities, 2) arthroscopy in a cadaveric knee, and 3) a surprise task assessing skill transfer. A single expert blinded observer was used for all evaluations. Primary outcomes included total Global Rating Scale, Arthroscopic Checklist, and procedural time. Secondary outcomes included ArthroVR Motion analysis data, as well as Benchtop analysis data.

Results: Data reflects the first 17 subjects. There were no differences in baseline objective measures (GRS, checklist, procedure time) between the VR and BT groups. After training, both VR and BT groups demonstrated improvements in arthroscopy skill. In the BT group, mean GRS scores were higher on both simulators (VR and BT p=0.01). Although participants in the BT group were only able to complete significantly more tasks on the BT model, the group showed significant improvement in mean procedure time in both simulators (BT: p=0.01; VR: p=0.02). Similarly in the VR group, mean GRS scores were higher post-test (BT: p=0.01; VR: p=0.01), participants were able to complete more tasks on both simulators post-test (BT: p=0.01; VR: p=0.01) and procedural times decreased significantly (BT: p=0.01; VR: p=0.01). Post-test cross-over analysis showed increased improvement in outcomes for the VR group (GRS, Checklist, time; p=0.01). There were no differences in improvement post-test between groups on their trained modalities. There were no differences in between the VR and BT groups for primary outcomes in the cadaveric knee. However, mean VR group GRS scores and procedure time were improved in the skill transfer evaluation (p=0.01). Motion analysis showed significant decreases in camera distance (p=0.001) and probe distance (p=0.004). Mean camera roughness and probe roughness differences were not significant.

Conclusion: Surgical simulation training is a powerful tool in the efficient training of surgical residents. Our study suggests that while both BT and VR arthroscopic simulators are effective training modalities to accelerate surgical skills acquisition, virtual simulation may provide added benefit in transfer of skill to the operating room.

What Are Fracture Patients' Understanding of High Risk for Future Fracture?
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Purpose: To examine fracture patients’ understanding of high risk for future fracture.

Method: We conducted an in-depth qualitative study in patients who were high risk for future fracture. Patients were screened through the Osteoporosis Exemplary Care Program where they were educated about fracture risk in three ways: they were verbally told they were “high risk” for future fracture; they were given a numerical prompt that they had a 20% chance of future fracture over the next 10 years; and they were given a visual graph highlighting the “high risk” segment relative to the “moderate” and “low” risk segments. This information about fracture risk was also relayed to patients’ family physicians and specialists. Participants were interviewed for approximately one hour and asked to recall their understanding of risk and whether it applied to them.

Results: We recruited 27 patients (20 females, 7 males) aged 51-87 years old. Fractures were sustained at the wrist (n=6), hip (n=7), vertebrae (n=3), and other locations (n=11). While most participants recalled they had been labelled as “high risk”, approximately half did not believe they were high risk and most participants
were unable to correctly recall the other elements of the message about risk. For example, 12 participants overestimated their chance of future fracture. Participants also had difficulty explaining what they were at risk for. They described being at risk for: osteoporosis, low bone density, certain types of fractures but not others, falling, or fracturing if they fell.

**Conclusion:** Our findings suggest that health care providers’ messages about fracture risk are confusing to patients and that these messages need to be modified to better suit patients’ needs. Alternative ways of communicating fracture risk should be considered and evaluated before they are implemented.

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**Rate of Total Knee Arthroplasty After Tibial Plateau Fracture**

**Erin Donohoe, ON; David Sanders, ON; James L. Howard, ON; Lyndsay Somerville, ON; Abdel Lawendy, ON**

**Purpose:** Intra-articular tibial plateau fractures are considered a risk factor for the subsequent development of osteoarthritis. These fractures are therefore routinely treated surgically to anatomically restore the articular surface of the knee, and prevent the premature onset of post-traumatic osteoarthritis. The purpose of our study is to determine the rate of total knee arthroplasty (TKA) following a tibial plateau fracture. Furthermore, the rate of conversion to TKA based on fracture severity according to the Schatzker classification was evaluated.

**Method:** A retrospective review of patients aged 18 or older who had undergone surgical fixation of a tibial plateau fracture from January 2003 to December 2013 was undertaken. Patients were identified using ministry of health billing codes. Demographics, mechanism of injury, concomitant injuries, complications, and long-term outcomes were recorded. Each patient’s pre-operative imaging was reviewed, and fractures were classified according to the Schatzker classification, types I-VI. The rate of total knee arthroplasty was recorded as identified using our local health integration network (LHIN) arthroplasty database.

**Results:** A total of 577 patients were identified using the ministry of health billing codes for surgically treated tibial plateau fractures. Patients whose pre-operative xrays were not available, or those patients who had been incorrectly billed, were removed. Therefore, a total of 453 tibial plateau fractures were classified according to the Schatzker classification. Of those, 2.4% (N =11) went on to total knee arthroplasty.

**Conclusion:** Despite a significant injury to the articular surface of the knee, very few patients in our study population went on to require TKA following a tibial plateau fracture. This data supports the efficacy of operative management of these fractures.

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**Unicondylar Knee Replacement Results in a Shorter Length of Hospital Stay and Reduces 30 Day Readmission Rates Compared to Total Knee Arthroplasty: An Analysis of 37 000 Cases**

**Justin Drager, QC; Adam Hart, QC; Jad Aboukhalil, QC; Olga Huk, QC; David Zukor, QC; Stéphane Bergeron, QC; John Antoniou, QC**

**Purpose:** The demand for arthroplasty procedures for treatment of knee arthritis continues to increase. Adjustments in care are necessary to meet this demand and attention has focused on interventions aimed at reducing inpatient length of hospital stay (LOS) and rates of unplanned hospital readmissions. Readmissions, while detrimental to the patient’s recovery, represent a large healthcare expense and are increasingly being used as a benchmark of quality of care and hospital performance. Unicondylar knee arthroplasty (UKA) has resurfaced as an alternative to total knee arthroplasty (TKA) for selected patients. The aim of this study was to
query the National Surgical Quality Improvement Program (NSQIP) database to compare the length of hospital stay and the subsequent 30-day hospital readmission rates in patients undergoing primary TKAs and UKAs. Our secondary objective was to compare demographic differences and major and minor postoperative complications between the two procedures.

**Method:** The NSQIP database is a validated, risk-adjusted, outcomes-based program collecting data on preoperative morbidity, intraoperative variables, and 30-day postoperative complications for patients undergoing major surgical procedures at over 450 participating hospitals. We identified 36,274 primary elective TKAs and 1,340 UKAs from the 2011 and 2012 databases. Patient demographics, comorbidities, preoperative laboratories, intraoperative variables, as well as length of stay and 30-day readmission rates were compared between the two groups. Multivariate quantile and logistic regressions were then used to identify the independent effect of procedure type on length of stay and 30-day readmission rates respectively.

**Results:** The UKA group had a significantly lower proportion of female patients, was on average 3 years younger, and had lower incidence of most reported co-morbidities than the TKA group. Patients undergoing a UKA had a median LOS of 2 days compared to 3 days for TKA (p<0.001). The percentage of unplanned hospital readmissions within 30 days from the time of surgery was nearly doubled in the TKA group (4.1%) compared to the UKA group (2.2%) (p<0.0001). The majority of major and minor complications trended towards lower values in the UKA group, only the occurrence of pulmonary embolus reached statistical significance. From multivariate analysis, undergoing a UKA reduced median LOS by a coefficient of 1 day and was the only identified protective factor for 30-day readmission (OR 0.60, 95% CI 0.41-0.88)

**Conclusion:** This study shows a nearly 50% reduction in the number of unplanned 30-day hospital readmissions following UKA compared to TKA. Undergoing a UKA results in a shorter hospital admission and is a protective factor for hospital readmission independent of selected confounding factors. Together these findings demonstrate the potential beneficial impact of this procedure on both patient morbidity and hospital expenditure.

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**Comparison of Outcomes for Simultaneous and Staged Bilateral Total Knee Replacement Surgeries**

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**Purpose:** The safety of simultaneous bilateral total knee replacement (TKR) compared to staged bilateral TKR remains controversial. The potential benefits of having a single surgery under one anaesthesia may or may not outweigh the risks associated with undergoing two surgical procedures. We compared the outcomes of simultaneous bilateral to staged bilateral and unilateral TKRs using a comprehensive pan-Canadian data source.

**Method:** The study cohort was comprised of 243 000 patients who underwent primary elective TKR surgery, identified from the Hospital Morbidity Database using the Canadian Classification of Interventions codes. Patients were divided into three groups according to the timing of their TKR: simultaneous bilateral, staged bilateral and unilateral. Inpatient outcomes examined included rate of blood transfusions, complications including cardiac, pulmonary embolism and infection, and hospital length of stay. Discharge disposition paths were identified by group. Selected undesirable post-discharge outcomes were also investigated: readmission for infection within 90 days due to prosthesis-related infection and early revision rates. The two bilateral TKR
groups were compared using multivariate regression modelling. The analyses were adjusted for potentially confounding demographic and perioperative factors, presence of baseline comorbidities and facility TKR volume.

**Results:** The rate of blood transfusions for the simultaneous bilateral TKR group was twice that of the staged (41.0% versus 18.6%). At the same time, the rates of other inpatient complications did not differ, and were low across all groups. Patients undergoing staged procedures require two inpatient stays, resulting in more days in hospital on average than for the simultaneous group. After the second stage for staged TKRs, most patients were discharged home without support services (55.9%), while the majority of simultaneous TKR patients were transferred to continuing care (44.9%). Less than one percent of patients in each group were readmitted with infection, but the risk of readmission within 90 days for the staged TKRs was double that of the simultaneous TKRs (0.8% and 0.4%). Simultaneous bilateral TKRs had no increased risk of early revisions.

**Conclusion:** As the largest Canadian study to date comparing outcomes for staged and simultaneous bilateral TKR, this work provides high power to detect clinically important differences and inform decision making. The results provide evidence that staged and simultaneous procedures carry similar risks for many inpatient complications and early revision, however risks differ in several key outcomes. Staged TKRs require longer inpatient stays and have a higher rate of readmissions due to prosthesis-related infections in the first 90 days. Simultaneous TKRs are associated with increased risk of blood transfusions and increased likelihood of being discharged to continuing care.

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**Implant Wastage in the Arthroplasty OR: A Hidden Cost Burden?**

**Reina Yao, ON; James L Howard, ON; Richard W. McCalden, ON; Steven J. MacDonald, ON; James P. McAuley, ON; Douglas D. Naudie, ON**

**Purpose:** Cost containment in lower extremity arthroplasty surgery has grown in importance as the number of hip and knee arthroplasties performed in Canada continues to rise, with increases of 11% and 15% respectively from 2006-2007 to 2010-2011. Implant wastage has been identified as an area for cost control, some studies showing waste occurring in over 5% of arthroplasty cases. A provincially initiated surgical time out was established in April of 2010, with one of the goals being to reduce wastage and medical error by verifying the correct implants used in a particular surgery. The purpose of this study was first to evaluate if implementation of the surgical time out reduced implant wastage rates and second to evaluate wastage by component type in order to identify potential areas of wastage reduction.

**Method:** We conducted a retrospective review of implant wastage at a single institution, for all lower extremity arthroplasty surgeries performed between April 2007 to March 2014. Wasted implants were recorded and catalogued by the OR charge nurse and compiled in a database including implant number and cost. Component type was also recorded from April 2011 onwards. We divided the database into two cohorts: pre-surgical time out and post-surgical time out. Per case and total wastage and % wastage costs for hip, knee, and all arthroplasty cases were calculated for each cohort. Wastage cost was also broken down by component type for both knee and hip arthroplasty cases.

**Results:** On average, 23 knee and 40 hip components were wasted per year, with an implant waste occurrence rate of 2.9% in knee and 5.8% in hip cases. This translated to a total wastage cost of $33,394 per year, or 0.8% of all lower extremity arthroplasty costs. There was no statistically significant difference in wastage numbers or costs between the pre- and post-surgical time out cohorts (p=0.98). Polyethylene liners
made up 69.8% of waste costs and 74.7% of waste numbers in total knee arthroplasty, compared to femoral and tibial components, which made up 15.5% and 9.2% of cost and 5.6% and 7.0% of number respectively. Wastage cost breakdown was more evenly distributed between the polyethylene, femoral, acetabular, and head components in total hip arthroplasty at 30.7%, 26.9%, 18.1%, and 12.3% respectively. However, waste numbers showed a disproportionately higher percentage of polyethylene and head compared to femoral and acetabular components. When acetabular screws and femoral cables were factored out, polyethylene and head components together made up 48.9% of waste costs and 64.0% of waste numbers.

**Conclusion:** The provincially initiated surgical time out has not affected implant wastage rates for lower extremity arthroplasty at our institution. Polyethylene liners in knee arthroplasties and polyethylene liners and femoral heads in hip arthroplasties are disproportionately represented in component wastage, and are a potential target for waste reduction initiatives.

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**Results of Combined Unicompartmental Arthroplasty and Anterior Cruciate Ligament Reconstruction Compared with Total Knee Arthroplasty in Patients Under Age 55**

**Geoffrey Dervin, ON; Pascale Thibaudeau, QC; Jae-Jin Ryu, ON**

**Purpose:** Few reconstructive options exist for the young, active patient with end-stage medial compartment osteoarthritis (OA) and anterior cruciate ligament (ACL) deficiency. Unicompartmental knee arthroplasty (UKA) has classically been contraindicated in the ACL-deficient knee and concerns about the long-term survivorship of total knee arthroplasty (TKA) implants in young patients have made it a less desirable option. Recently, good results have been reported with combined ACL reconstruction and UKA (ACL/UKA). We sought to compare the functional outcomes of this procedure with those of TKA in patients under the age of 55.

**Method:** The study group (group 1) consisted of 15 ACL/UKA cases performed by a single surgeon. An age-, gender-, and BMI- matched control group (group 2) of TKA done by the same surgeon was used for comparison. Functional scores and activity scales were collected prospectively preoperatively and at 1-year intervals postoperatively. These consisted of the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Knee injury and Osteoarthritis Outcome Score (KOOS), Tegner scale, and University of California Los Angeles (UCLA) activity score. The patients were followed for a minimum of 2 years, with mean follow-up of 5.3 years in group 1 and 4.6 years in group 2.

**Results:** Mean age at the time of surgery was 48.4 in group 1 and 50.6 in group 2 (p=0.13). Mean BMI was similar in both groups. Both groups improved significantly with surgery on all subscales of the WOMAC and KOOS. Improvements in Tegner and UCLA scores were not statistically significant in group 1, while group 2 saw an improvement in UCLA (4.3 to 6.4, p=0.001) but not in Tegner score. When comparing the two groups, we found a trend towards higher Tegner scores in the ACL/UKA group at 2 years (4.2 vs. 2.6 in the TKA group). This was sustained at most recent follow-up. Despite not reaching statistical significance, these results likely are clinically significant. At most recent follow-up, 57% of the ACL/UKA patients could perform at least moderate activities (as indicated by a Tegner score of 4 or above), compared to only 23% in the TKA group. There was no difference in any of the other scores at any time point.

**Conclusion:** Combined ACL/UKA has recently gained popularity as a salvage treatment option for young patients with end-stage medial OA in an ACL-deficient knee. Survivorship has been shown to be similar to UKA performed for medial OA alone. Although technically more difficult than a TKA, it offers the potential advantage of an easier revision. Additionally, registry data has shown better results with revision of UKA to
TKA than with TKA to TKA. This is an important consideration in the young, active patient who will almost inevitably face a revision procedure in their lifetime. According to our results, combined ACL reconstruction and UKA is functionally at least equivalent to TKA in patients under age 55. It is a good treatment option for end-stage medial OA in the ACL-deficient knee.

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Sequential vs Staged Bilateral Total Knee Replacement: Determining Patient Appropriateness
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Purpose: The purpose of this study was to assess patient safety and appropriateness in a group of sequential-bilateral total knee replacements (SQ-BTKR; a single anesthetic session with one surgical team) and compare with outcomes in a matched group of staged-bilateral TKRs (ST-BTKR; two TKRs performed under two separate hospital admissions within a defined period of time). The secondary aim of the study was to compare patient-reported outcomes and length of stay between the two groups. The Charlson Comorbidity Index (CCI) has been used in other TKR research and was used here as a measure of patient appropriateness.

Method: Eligible patients were identified from hospital administrative data from 2003 to 2012. Patient charts were reviewed to collect data on comorbidities specific to the CCI, ASA scores, post-surgery ICU admission, and patient demographics. A survey packet was mailed to all patients for whom data had been collected. Each packet contained an informed consent letter for participation with an option to opt out their data, the Oxford Knee Score, questionnaires on satisfaction and related variables, patient demographics, and a postage paid return envelope.

Results: The final sample comprised 262 patients (106 SQ-BTKR and 156 age-matched ST-BTKR). The SQ-BTKR group had significantly higher mean pre-op hemoglobin levels than the ST-BTKR group with no other significant group differences identified. In both groups, lower CCI scores were significantly associated with length of stay (a proxy of cost). Survey response rates for patient-reported outcomes was 52.7% overall (57.5% for SQ-BTKR; 49.4% for ST-BTKR). No significant differences between groups on patient-reported satisfaction and related measures were identified, although more SQ-BTKR reported the procedure was excellent at increasing ability to perform regular activities than ST-BTKR, which trended toward significance. The adverse outcome variable was ICU admission; three ST-BTKR and 10 SQ-BTKR were admitted to the ICU. SQ-BTKR had 5.3 times the odds of going to the ICU compared to the ST-BTKR, a significant finding. For within group comparisons of SQ-BTKR in ICU admissions (n = 10) versus none (n = 96), lower pre-op hemoglobin, lower CCI probability scores, pulmonary embolism, and higher ASA scores were significant predictors of ICU admission.

Conclusion: Patient-reported outcome measures (Oxford Knee Score and satisfaction and related variables) were similar between surgical groups. Average length of stay was two days less for SQ-BTKR (reduced costs) with the benefit of one recovery period for patients. Risks of ICU admission for SQ-BTKR patients included lower CCI score, higher ASA score, chronic anemia, and pulmonary embolism. Sequential-bilateral TKR can be safe and effective for properly selected patients for whom the higher risk of complications has been carefully explained. The CCI may be a useful tool for determining patient appropriateness, and also predicting length of stay.

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Mid-term Evaluation of Oxford Unicompartmental Knee Arthroplasty in Patients with BMI of 40 or
Greater
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Purpose: The role of unicompartmental knee arthroplasty (UKA) for medial compartment osteoarthritis of the knee in patients with a high BMI continues to be controversial. An increasing body of literature outlines the results of UKA in obese patients but there has been little published on patients with class III obesity. In this prospectively followed database review, we present the survivorship of Oxford UKA in patients with BMI ≥ 40.

Method: Our prospectively monitored database was mined to capture consecutive patients with a BMI ≥ 40 who were treated with Oxford mobile bearing UKAs since February 2001. Each patient was reviewed for failure (defined as revision to a total knee arthroplasty for any reason) and clinical outcome as determined by the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and the Knee Injury and Osteoarthritis Outcome Score (KOOS). Univariate statistics were used to evaluate the roles of weight, gender and age as predictors of UKA revision.

Results: The review identified 124 UKAs in 101 patients (66 females and 35 males). Mean age was 57.6 years (range 42-75, SD 6.6), median BMI was 42 (range 40-65), and mean follow up was 5.7 years (range 0.9-12.6, SD 2.9). There were 13 failures (10.5%), 12 of which were in females. The mean time to revision was 3.44 years (range 1.25-7.6) and Kaplan-Meier survivorship analysis revealed survival rates of 99.2%, 95.6%, 87.9% and 83.6% at one, two, five and ten years, respectively. Female gender was a significant predictor of failure with an odds ratio of 7.6. Causes for revision included six for arthritis progression (three lateral compartment, three patellofemoral compartment), three for unexplained knee pain and four with tibial component subsidence (two with associated bearing dislocation). The cohort had significant improvement on all WOMAC (p < 0.001) and KOOS (p = 0.032 or less) subscores. Patients with failed UKAs had significantly worse pain (WOMAC p = 0.013, KOOS p = 0.006), stiffness (WOMAC p = 0.04) and function in sport/recreation (KOOS p < 0.001) than non-revised patients. Their ADL functional outcomes were worse but did not reach statistical significance.

Conclusion: This study includes the largest non-designer cohort of patients with a BMI ≥ 40 having undergone an Oxford UKA in the literature. UKA survivorship in this cohort is similar to the previously published survival rates for patients with BMI ≥ 30. Patients who underwent a revision had significantly worse pain, stiffness and sport/recreation function than non-revised patients. Female gender was a significant predictor of failure and was an unexpected finding. Female patients with BMI > 40 should be cautioned about an increased revision risk with this procedure.

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Simultaneous Bilateral Total Knee Arthroplasty: A Comparison of 30 Day Perioperative Complications Rates
Adam Hart, QC; Yaron Brin, QC; Laura Epure, QC; Olga Huk, QC; David Zukor, QC; John Antoniou, QC; Stephan Bergeron, QC

Purpose: Simultaneous rather than staged bilateral total knee arthroplasty (TKA) is an attractive and evermore popular treatment for patients with bilateral knee arthritis due to the shorter hospital stay, faster recovery, and single exposure to anesthesia. Unfortunately, enthusiasm for simultaneous bilateral TKA has been tempered by concerns of increased complication and mortality rates. The aim of this study was to query the American College of Surgeon’s National Surgical Quality Improvement Program (NSQIP), a high quality multicenter database, to compare the rate of 30-day major complications between simultaneous bilateral TKA and unilateral TKA. Re-admission rates were compared as secondary outcomes.
**Method:** We identified all simultaneous bilateral TKA and unilateral TKA procedures performed in 2011 and 2012 from the database. The bilateral cases were matched (1:4) with unilateral cases by age, sex, race, year of surgery, and American Society of Anesthesiologists class. Patient baseline characteristics as well as the rate of 30-day major complications and readmissions were compared between the two matched groups.

**Results:** There were 859 patients that underwent simultaneous bilateral TKA who were matched to 3468 patients that underwent unilateral TKA. No differences in baseline characteristics were found between groups except that the unilateral TKA patients had slightly higher body mass index and slightly more diabetics. The occurrence of major complications including wound infections, venous thromboembolism, and death were similar between groups. Furthermore, there was no difference in 30-day re-admission rates. The simultaneous TKA group had significantly more transfusions (44% versus 17%, \( P < 0.0001 \)).

**Conclusion:** In this study, the risk of major perioperative complications was similar between simultaneous bilateral and unilateral TKA suggesting the former is a viable option in carefully selected patients.

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**The Utility of Nucleated Cell Counts in Periprosthetic Fractures: A Retrospective Review**

Stephen Preston, ON; Lyndsay Somerville, ON; Brent A. Lanting, ON; James L. Howard, ON

**Purpose:** Excluding infection in the setting of periprosthetic fracture is important as it determines the course of treatment. However, fracture-related inflammation can make investigations used in the diagnosis of infection less reliable. The purpose of this study is to determine whether currently accepted nucleated cell counts used in the diagnosis of periprosthetic infection can be used for the same purpose in the setting of a periprosthetic fracture.

**Method:** Billing codes were used to identify all cases of periprosthetic hip and knee fracture at our institution dating back to 2005. A review of 2537 charts yielded 27 patients with periprosthetic fractures who had joint aspirates prior to surgical intervention. Nucleated cell counts from joint aspirates were recorded for all patients. Synovial fluid culture results were then used to calculate the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of an elevated nucleated cell count in the diagnosis of infection.

**Results:** Eleven of the 27 patients (41%) with joint aspirates had elevated nucleated cell counts. Only two of the 11 patients with elevated nucleated cell counts had positive synovial fluid cultures. One patient suffered a periprosthetic acetabular fracture and was culture positive for E. coli. The second suffered a distal femur fracture above a total knee arthroplasty and was culture positive for Staphylococcus epidermidis. Both patients suffered their fractures during a fall. None of the patients with normal nucleated cell counts had positive synovial fluid cultures. The specificity and PPV of an elevated nucleated cell count in the diagnosis of infection were and 64% and 18% respectively.

**Conclusion:** Although quite common, an elevated nucleated cell count has moderate specificity and poor PPV in the diagnosis of infection in the setting of periprosthetic fracture.

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**Outcome Following Subluxation of Mobile Articulating Spacers in Two-stage Revision Total Knee Arthroplasty**
Purpose: Infection after total knee arthroplasty (TKA) is a devastating complication. It is usually treated with two-stage revision and implantation of a cement spacer. Few studies describe the complications associated with a mobile articulating spacer. The purpose of this retrospective study was to examine coronal and sagittal subluxation of knees after stage one revision with a mobile articulating spacer, and correlate it with early outcome scores and level of constraint at stage two revision.

Method: All mobile articulating spacers performed for two-stage revision for infected primary TKA between 2004 and 2012 at a single institution were examined. Exclusion criteria were static spacers, multiple stage one revisions, multiple two stage revisions on the same knee, and previous revision TKA on the same knee. Level of constraint at stage two revision was recorded from an available database. Sagittal and coronal subluxation of mobile articulating spacers was measured using radiographs of the affected knee after stage one revision, and prior to second stage revision. Medical Outcomes Study Short Form-12 (SF-12), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and Knee Society Score (KSS) were obtained via patient administered questionnaire. Statistical analysis was carried out to look at the correlation between subluxation and outcome.

Results: There were 72 knees from 71 patients included in the study, with 40 right knees and 32 left knees. The mean age of the patients was 70.2 ± 10.8 years old, with 45 males and 26 females. There were four cases (5.6%) of spacer debonding from bone, three (4.2%) of which involved the femoral spacer, and one (1.4%) of which involved the tibial spacer. There was one case (1.4%) of posterior dislocation of the knee. In one case (1.4%), the femoral and tibial spacers bonded together during surgery. Median coronal subluxation was 4 mm (range, 0 to 15.5 mm). Median sagittal subluxation was 6 mm (range, 0 to 33.0 mm). No significant correlation was found between coronal or sagittal subluxation and SF-12, WOMAC, or KSS after stage two revision. There was also no significant association between subluxation and level of constraint at stage two revision.

Conclusion: Complications such as debonding and dislocation of the mobile articulating cement spacers were rare. While sagittal and coronal subluxation of the knee after stage one revision was common, it did not affect early outcomes or level of constraint following stage two revision.

Comparison of Health-related Quality of Life Between Patients with Unilateral and Bilateral End-stage Ankle Arthrosis

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Purpose: This review compared the extent of pain, loss of function, and health-related quality of life between patients with unilateral and bilateral end-stage ankle arthrosis (ESAA) registered in the Canadian Orthopaedic Foot and Ankle Society (COFAS) Prospective Longitudinal Ankle Reconstruction Database. Also, mid-term outcomes were compared between patients who have undergone unilateral and bilateral total ankle replacements (TAR).

Method: Fifty-three patients with bilateral end-stage ankle arthrosis who were waiting surgical management were matched with 106 patients with unilateral arthrosis. Pre-operative Short Form-36 (SF-36) outcome scores were compared. Mid-term outcomes in 37 patients who underwent bilateral TAR, and had minimum 2-year followup, were compared to 106 patients who underwent unilateral TAR.
Results: Patients with unilateral disease had a higher incidence of post-traumatic arthrosis, while bilateral patients mainly suffered from inflammatory arthritis (p < 0.001). The mean pre-operative SF-36 physical component summary score (PCS) in the unilateral group was higher than the bilateral group (p<0.001). Post-operatively, patients undergoing either unilateral or bilateral TARs demonstrated improved PCS scores (p<0.001). There were no differences in PCS scores between patients with unilateral or bilateral TAR at minimum 2-year followup (p=0.31), indicating greater pre-operative disability and greater overall improvement in the bilateral ESAA group. Six percent of patients underwent metal revision in the unilateral group, and 16% of patients in the bilateral group underwent metal revision in one or both TARs (p = 0.52). There was no difference in five-year survival for the bilateral group (4.5 years; 95% CI 4.2-4.8) or the unilateral group (4.2 years; 95% CI 3.9-4.5) (p=0.09).

Conclusion: Pre-operative SF-36 scores demonstrate that bilateral ESAA is a more debilitating condition than unilateral ESAA. Patients with bilateral TARs for bilateral ESAA have greater overall improvements in general health, pain and disability compared to patients with unilateral TARs. Overall metal revision rate and implant survival were similar between groups.

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Comparison of Outcome in Isolated Non-deformed End-stage Ankle Arthritis between Ankle Replacement, Arthroscopic Ankle Fusion, and Open Ankle Fusion
Andrea N. Veljkovic, BC; Timothy R. Daniels, ON; Mark A. Glazebrook, NS; Peter Dryden, BC; Murray J. Penner, BC; Kevin J. Wing, BC; Alastair Younger, BC

Purpose: End-stage ankle arthritis is a disabling condition with similar effect on morbidity, pain, and loss of function as hip arthritis. OAA has been considered the gold standard for the treatment of end-stage ankle arthritis. AAA has gained momentum with better outcomes than OAA. The outcomes of TAR and fusion may change with the involvement of the surrounding joints or with intra articular or extra articular deformity. Historically, treatment of ankle arthritis with TAR has had less reproducible results and longevity. With the advent of newer designs ankle replacement is gaining favour. The purpose of this study is to compare the outcomes of TAR, AAA, and OAA with the AOS in isolated, non-deformed ankle arthritis.

Method: 212 COFAS Type 1 isolated arthritic ankles with < 10° of intrarticular and extrarticular deformity without arthritis in the triple joint complex (ST, TN, or CC) were only included. Ankles with previous infection, hindfoot or ankle fusions, or arthroplasty were excluded. In total, 78 TAR (Hintegra), 42 AAA, and 92 OAA ankles followed for an average of 3.9 (+/−SD 1.7) yrs were analyzed in 55 females and 44 males above the age of 18. Mean age and BMI was 57.9 (+/−SD 11.4) yrs and 28.9 (+/−SD 4.9) kg/m² respectively. All procedures were preformed by 6 foot and ankle surgeons at 4 major centres across Canada. The primary outcome measure was the AOS total change score (AOS T△) and the secondary outcome measures were the MCS, PCS, and reoperations. Survivorship using removal of metal components for TAR or revision of the fusion were used as end points.

Results: There were no statistically significant differences in rates of diabetes, inflammatory arthropathy, smoking status, and follow up time between the three groups. There was a difference in mean patient age, p=0.002, with TAR 61.7[95%CI 59.5, 63.8]yrs, AAA 56.3[CI 53.2, 59.4]yrs, and OAA 55.4[CI 52.7, 58.0]yrs respectively. There was no significant difference in number of revisions, p=0.262. Revisions for TAR were 7.69[CI 0.64, 14.75]% and 5.43[CI 0.71, 10.16]% for OAA, with no revisions in the AAA group. Survival analysis is presented in table 1. PSC and MCS difference was not significantly different between the three
groups. AOS $T\Delta$ scores were significantly better for TAR and AAA, $p=0.002$, with OAA fairing worse in comparison. AOS $T\Delta$ scores were: TAR $32.2[CI 26.8, 37.5]$, AAA $40.5[CI 32.8, 48.3]$, and OAA $22.9[CI 17.5, 28.3]$. Separate analysis of AOS $T\Delta$ between TAR and AAA did not indicate significant difference, $p=0.077$, although AAA trended to be mildly better. However, AOS $T\Delta$ was significantly better for TAR when compared to OAA alone, $0.028$

**Conclusion:** Based on AOS $T\Delta$ scores, TAR and AAA had significantly higher outcomes than OAA, with a non-significant trend for AAA to fair better as compared to TAR. In addition, AAA had a trend toward less revision and reoperations, although this too was not significant. TAR and AAA are relatively equal options for the treatment of end-stage Type 1 ankle arthritis.

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**Effects of Right Lower Limb Fractures and Orthopaedic Immobilization on Driving Performance**

**Laurence Des Ormeaux, QC; Jon Armano, QC; Mathieu Hamel, QC; Frédéric Balg, QC; Hélène Corriveau, QC; François Cabana, QC**

**Purpose:** Research on the effects of right lower limb fractures and orthopaedic immobilization on driving performance has been limited. The Quebec's Highway Safety Code stipulates that limb immobilization is essentially inconsistent with driving a motor vehicle, but this part of the Code does not have any underlying scientific foundation. The aim of this study is to target the moment when injured patients with fractures of the right lower limb (ankle/foot) treated with an orthopaedic immobilization (walking cast/Aircast) can safely resume driving.

**Method:** In order to achieve this goal, an experimental design with repeated measures was used. Measurements of maximum braking force and different braking times with and without distraction were gathered on a previously validated computerized driving simulator. These variables were collected and compared in two groups of individuals: healthy volunteers over 75 years old tested twice to establish safe minimal braking parameters (group I); and patients over 18 years of age with a fracture of the right lower limb treated with an orthopaedic immobilization tested four times at ~five days, ~20 days, ~40 days, and ~60 weeks post-trauma (PT) (group II). All individuals had a valid driver’s license. A sample of healthy subjects over 75 years old allowed for us to establish safe minimal braking parameters inferior to those that would have been obtained with a sample of young healthy subjects. Therefore, these older subjects were carefully screened with specific selection criteria to make sure their standard driving practices were approximately as safe as younger drivers.

**Results:** Preliminary results reveal that injured subjects' results are significantly inferior to those of the healthy volunteers over 75 years old at ~five days PT for all measured variables. Both group performances seem to meet up at ~40 days PT, except for the braking times without distraction where they meet up at ~60 days PT. Finally, injured subjects' results are significantly better than those of the healthy volunteers over 75 years old regarding maximum braking force at ~60 days PT.

**Conclusion:** Current preliminary data suggest that patients should wait a minimum of 40-60 days following trauma for the safe resumption of driving after fracture of the right lower limb treated with an orthopaedic immobilization.

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Hallux Valgus Deformity: Should We Surgically Correct Most of Them? A Utility Scores Outcome Study

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**Purpose:** Hallux valgus is a common condition that affects about 28% of the population. Although it can rarely cause considerable disability and affect the quality of life of affected people, many patients seek medical attention due to the cosmetic concerns. The aim of this study was to objectify the health burden of hallux valgus using validated utility score tests to influence patient management decision analysis.

**Method:** An online survey hosted by McGill University was sent out. All prospective participants were healthy from the general population. They were asked to fill out anonymous demographic questionnaires, health state questionnaires and utility assessments for patients with hallux valgus. A picture of hallux valgus and clinical scenario were presented to all participants. To minimize any particular weakness of any individual tool, we used three utility measures: standard gambling (SG), visual analogue scale (VAS) and time trade-off (TTO) tests. To examine participants’ comprehension of the survey, we performed monocular and binocular blindness tests. Those who rated binocular blindness with higher utility scores (e.g. close to prefect health) than monocular blindness were excluded from the study. Student t test and liner regression analysis were used for statistical analysis.

**Results:** A total of 103 participants met the inclusion criteria and were retained for analysis. Females were the predominating gender among the study participants (71 %). The utility measures (VAS, SG, TTO) for hallux valgus were (86±16, 0.95±0.14 and 0.95±0.5 respectively). These were higher in values and differed significantly when compared to monocular and binocular blindness utility scores (P=0.0001). Liner regression analysis showed that Age, gender, race, income and education were not independent predicting factors of utility scores. The hallux valgus TTO (0.95±0.5) were significantly lower than self reported TTO (0.97±0.02) with P value =0.02.

**Conclusion:** This is the first study to objectively quantify the burden of hallux valgus. Theoretically, our population if faced with hallux valgus would be willing to trade 1.8 years of their lives to fix their hallux valgus surgically and accepting a mortality rate of 5%. These data can be used to guide patient’s management and allow us to think how patients perceive their hallux valgus deformity.

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Modification of the Distal Tibiofibular Relationship of the Normal Ankle in Plantar Flexion and Dorsiflexion Measured on MR Images

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**Purpose:** Classically, the position of the foot was thought to be important during reduction and fixation of a syndesmotic injury to avoid loss of dorsiflexion. Even if most cadaveric studies showed that the tibio fibular medio-lateral distance increase in dorsiflexion, Tornetta et al showed that the position of the foot did not impact ankle dorsiflexion as long as the syndesmosis was anatomically reduced. A validated measurement system was previously developed to describe the distal tibio-fibular joint on both MRI and CT scan. The purpose of this study was to evaluate the impact of the position of the foot in the sagittal plane (dorsiflexion (DF), plantar flexion (PF)) on the syndesmosis using this measurement system.
Method: Thirty-four volunteers were recruited and had a series of ankle MRIs in three different ankle positions: dorsiflexion, plantar flexion and neutral position. Inclusion criteria’s were: no previous ankle injuries and no contraindication to MR exam. Three different holders were designed to keep the ankle stable in the 3 positions. Measurements (6 translational measurements and 2 angles) were then taken on each of the three sets of MRIs. Paired t-tests were done to establish significant differences between measurements.

Results: The mean angle between the leg and the foot for the three positions were 152±8° for plantarflexion, 95±3° for neutral position and 80±5° for dorsiflexion, and this was statistically different. The first set of analyses was between PF and DF. The distance between the most anterior point of the incisura and the nearest most anterior point of the fibula varied from 2.5mm(PF) to 3.9mm(DF) (p<0.000). The same posterior measurement was not significant. The fibular angle also changed from 8.7°(PF) to 7.8°(DF) of internal rotation (p=0.046). The distance between the tibia and the fibula in the middle of the incisura was 1.5mm in PF and increased to 2.6mm in DF (p<0.000). In the anteroposterior plane, there was a significant anterior displacement of the fibular in the incisura of 0.4mm (p=0.007 and p=0.037). Those differences where essentially from PF to neutral position. The only parameter increasing of 0.4mm from neutral to DF was the anterior distance (p<0.002).

Conclusion: There are significant changes in normal anatomy of syndesmosis between dorsiflexion and plantar flexion. Specifically, there is an increase in external rotation and lateral translation of the fibula. These changes are visible with MR images using a validated measurement system and values are concordant with those reported on cadaveric studies. Taking ankle position in consideration will be important for future research studies that focus on syndesmosis imaging.

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Outcomes of Ankle Arthroplasty with Preoperative Coronal-plane Valgus Deformity
Matthew Adam Mann, ON; Hailey R. Banack, ON; Emma S. Green, ON; Timothy R. Daniels, ON

Purpose: Coronal plane mal-alignment of the tibiotalar joint increases the technical difficulty of total ankle replacement and is associated with an increased failure rate. Deformity greater than 15° has been reported to be a contraindication to arthroplasty. Varus deformities have been more closely examined in the literature. We examined whether clinical outcomes in patients with ankle arthritis and preoperative ankle joint valgus were comparable with those of patients with a neutral deformity of less than 5°.

Method: We prospectively followed 54 patients (58 ankles) with a preoperative coronal-plane valgus tibiotalar deformity and a matched “neutral” cohort who underwent ankle replacement. Clinical outcome measures included pre and post-operative Ankle Osteoarthritis Scale (AOS) score, the SF-36 general health score, and radiographic measurements of coronal–plane deformity.

Results: The cohorts were similar with respect to age, sex, and BMI. Mean follow up duration of the valgus mal-alignment group was 58 months. Thirty-four ankles were classified as valgus congruent joints, with a mean tibiotalar angle of 4.5°. Twenty-four ankles were classified as valgus incongruent with a mean tibiotalar angle of 16.8° (10-25 degrees). Patients in the valgus group had significantly more ancillary procedures at the time of primary arthroplasty and re-balancing procedures subsequent to arthroplasty to obtain a plantigrade foot. Ancillary procedures at time of arthroplasty in the valgus cohort included 18 lateral ankle ligament reconstructions; eight medial calcaneal translational osteotomies; four midfoot fusions and syndesmosis stabilizations; three triple arthrodesis, achilles tendon lengthening, and posterior tibial tendon debridement; two fibular osteotomies, tendon transfers, and first-ray osteotomies; and one subtalar fusion, deltoid imbrication, and plantar fascia release. Secondary ancillary procedures included five medial calcaneal translational
osteotomies; three midfoot fusions and lateral closing wedge calcaneal osteotomies; and one subtalar fusion and fibular osteotomy. There was one early infection and one withdrawal revised to fusion without data. There was one failure due to osteolysis converted to fusion, and one progression of deformity converted to fusion. There were three cases of aseptic loosening and one case of component malposition requiring revision ankle replacement. Revision rate of the valgus cohort was 13.3%. The neutral cohort had a revision rate of 8.3%. The valgus plane mal-alignment group had a 35-point improvement in the AOS pain and a 41-point improvement in the AOS disability score, whereas the neutral group had a 30-point improvement in both the AOS pain and disability score.

**Conclusion:** Satisfactory results can be obtained in patients with valgus plane mal-alignment of the tibiotalar joint and end stage arthritis. Balancing the ligamentous structures as well as obtaining a plantigrade foot is imperative if a satisfactory result is to be achieved.

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**Percutaneous Endoscopically-assisted Calcaneal Osteotomy: An Anatomic Study**

Andrea N. Veljkovic, BC; Joshua Tennant, NC; Phinit Phisitkul, IA

**Purpose:** Calcaneal osteotomies are performed to correct hindfoot malalignment and restore the correct weight-bearing axis of the ankle and hindfoot. Open surgery, rather than endoscopy, is traditionally used due to safety concerns. However, endoscopy is also associated with potential decreased morbidity, scarring and injury to surrounding tissues, and reduced hospital time, post-operative pain, infection rates and wound complications. This study investigated the safety of the percutaneous endoscopically-assisted calcaneal osteotomy (PECO) technique to correct hindfoot malalignment.

**Method:** Calcaneal displacement osteotomies were performed using the PECO technique on 8 fresh-frozen cadaver below-knee specimens. The closest perpendicular distances between surgical sites and the anatomical structures of the hindfoot were measured from the medial and lateral side of the foot. Damage to the lateral calcaneal nerve (LCN) was compared between PECO and open surgical techniques.

**Results:** PECO requires three portals- a distal and a proximal portals on the lateral side of the foot, and a proximal portal on the medial side of the foot. The surgical portals and osteotomy cuts were on average 13.7 mm (range: 4.71-21.63 mm) and 12.9 mm (range: 4.86-24.71 mm), respectively, from the hindfoot neurovascular structures. The structures at highest risk were the LCN and sural nerve (SN) branches from the proximal portal on the lateral side of the foot. Only 1/11 LCN branches in eight limbs was transected using PECO. In contrast, 8/10 LCN branches from six limbs would likely have been cut by the incision on the lateral side of the foot in open surgery.

**Conclusion:** These results suggest that percutaneous endoscopically-assisted calcaneal osteotomy (PECO) is a safe and effective means to treat calcaneal and ankle misalignment even in the narrow confines on the hindfoot, and that it poses fewer risks to the neurovasculature than open surgery with potential benefits of endoscopic/arthroscopic techniques.

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**The Effects of Ankle Brace use on a 3-step Volleyball Spike Jump Height**

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Purpose: Ankle injuries are the second most common injury in sports. Current ankle injury prevention includes several external ankle support methods. However, due to the perception amongst volleyball players that ankle braces inhibit performance, many athletes choose not to wear them. Previous research studying the effects of ankle braces on vertical jump height, have shown mixed results. There have been no studies examining the impact of ankle brace use on a 3-step volleyball spike jump. The purpose of our study was to determine if the use of ankle braces in volleyball players had a negative impact on the volleyball spike jump height. Secondary objectives included: 1) the relationship between anthropometric data and jump height 2) subjective functional outcomes of specific brace use 3) the reliability of the Vertec measuring device

Method: Anthropometric and demographic data was collected from nine University level volleyball players. Motion tracking markers were then attached to each participant and they were asked to complete four 3-step volleyball spike jumps while wearing bilateral ASO ankle braces, bilateral Active Ankle braces, as well as no braces. Vertical jump heights were measured using a Vertec jump measuring device and an optical motion tracking system. After the study, participants completed a functional outcome questionnaire regarding the specific brace use.

Results: Compared to the no brace condition, participants’ 3-step volleyball spike jumps were significantly lower in the ASO condition (75.1±5.6 vs. 77.4±6.1, p=0.001) and Active Ankle condition (75.7±6.2 vs. 77.4±6.1, p=0.003). Several positive correlations were found in the subjective functional outcome questionnaire: 1) participants who felt greater ankle restriction in dorsiflexion/plantarflexion (Q.1) also felt greater ankle restriction in inversion/eversion (Q.2). 2) Participants who felt greater ankle restriction in inversion/eversion (Q.2) also felt that the brace was more likely to protect them from injury (Q.4). 3) Participants who felt the brace was more uncomfortable (Q.3) felt that the brace had a greater negative impact on their vertical jump height (Q.5). Body fat percentage and jump height for the ASO condition (r=-.727, p=0.027) and no brace condition (r=-.739, p=0.023) was significantly correlated. The Vertec was determined to be a reliable method of measuring one’s true vertical jump height.

Conclusion: In our controlled laboratory trial, we found that ankle braces significantly decreased three-step volleyball spike jump heights. This finding can impact a volleyball player’s decision on whether or not the decrease in vertical jump height with brace use is worth the increased ankle protection. Furthermore, a negative correlation was found between increases in body fat percentage and vertical jump height. Lastly, the Vertec, the most commonly used jump height measuring device is a reliable method for measuring vertical jump height.

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The Lateral Distal Tibial Articular Angle and the Relationship to Talar Subluxation in Total Ankle Arthroplasty
Andrea N. Veljkovic, BC; Adam Norton, IA; Peter Salat, ON; Charles L. Saltzman, UT; John E. Femino, IA; Phinit Phisitkul, IA; Amendola Annunziato, IA

Purpose: The long-term success of Total Ankle Replacement (TAR) depends on correct coronal and sagittal tibiotalar joint alignment. The lateral talar station (LTS) classifies the talus position as anterior, posterior, or neutral. We hypothesize that the LTS and the distal tibial articular angle (DTAA) are related. If so, correcting the DTAA during TAR could anatomically realign the tibiotalar joint, reducing the risk of anterior or posterior subluxation and wear on the prosthesis.
Method: A retrospective cohort of total ankle replacements (TAR) at the University of Iowa Hospitals and Clinics between 2004-2011 was evaluated. Patient inclusion criteria were: primary ankle replacements with adequate weight-bearing imaging. Patient demographics such as age, gender, race, Body Mass index (BMI; weight (kg)/(height [m])2), limb side, and prosthesis type were collected. Weight bearing lateral ankle radiographs obtained pre (n=96) and post (n= 94) TAR were used to measure LTS (mm) and DTAA (degrees). LTS and DTAA measurements were completed twice by two blinded observers one month apart. The inter- and intra-observer reliability were excellent (correlation coefficient >0.9). Descriptive statistics and non-parametric analyses were used where applicable.

Results: The most common LTS pre-operatively was anterior (60.4%) followed by posterior (27.1%) and neutral (12.5%). There was a strong pre-operative correlation between LTS and DTAA (r = 0.81; p<0.0001). Post-operative results indicated that ankles with anterior and posterior subluxation moved towards neutral alignment. In those that were initially anterior and became less anterior post-operatively (anterior-less anterior group) the LTS decreased from an average 8.07 mm to 6.48 mm. In the group that was initially a posterior station LTS increased from an average of -5.05 mm to -2.81 mm. However, the correlation between LTS and DTAA was reduced post operatively (r= 0.62; p<0.0001) suggesting that additional factors might impact the LTS/DTAA relationship post-operatively. The LTS changed 1.12 mm per degree DTAA in the anterior-less anterior group (n= 41) and 0.61 mm per degree DTAA in ankles that were posterior initially and became less posterior post-operatively (n= 25).

Conclusion: We would suggest that the aim of TAR is to return the joint to a neutral alignment that will likely reduce wear on the prosthetic insert and improve TAR longevity. Our results suggest that 1.12 mm change in LTS is recommended per closing degree DTAA change to translate anterior ankles to a neutral position, while a 0.61 mm change in LTS is recommended per opening degree DTAA change to translate posterior ankles to a neutral position. This refutes the standard assumption that a global defined distal tibial cut of 2 degrees opening should be done for all ankles. Instead, we have shown that the distal tibial cut should be customized to the individual patient based on the pre-operative LTS presentation.

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Anterior Cruciate Ligament Quality of Life (ACL-QOL) Questionnaire: Responsiveness to Change up to 2-years Post ACL Reconstruction
Sarah Kerslake, AB; Mark R. Lafave, AB; Laurie A. Hiemstra, AB; S. Mark A. Heard, AB; Gregory M.L. Buchko, AB

Purpose: The ACL-QOL was originally published by Mohtadi in 1998, and has been cited in over 130 studies. The responsiveness to change of an instrument is one aspect of its validity. The purpose of this study was to further validate the ACL-QOL by assessing its responsiveness to change up to 2-years post anterior cruciate ligament (ACL) reconstruction surgery.

Method: Five hundred and seventy nine ACL-deficient patients were referred to an orthopaedic surgical practice for consultation. All patients completed the ACL-QOL questionnaire pre-operatively. To date, ACL-QOL data has been gathered prospectively from this patient cohort at 6-months post-operatively (n = 446), 12-months post-operatively (n = 280), and 24-months post-operatively (n= 100). Comparison of change in ACL-QOL scores was calculated using a one-way analysis of variance (ANOVA) for each time point.

Results: The mean ACL-QOL score for ACL-deficient patients presenting for an orthopaedic surgery consultation was 35.6/100, (n = 579). The mean post-operative ACL-QOL scores were 51.5/100 at 6-months (n
= 446), 67.3/100 at 12-months (n = 280) and 81.5/100 at 24-months (n = 100). There was a statistically significant difference in ACL-QOL scores from the initial orthopaedic consult, to the 6-month, 12-month and 24-month post-operative appointments, p < 0.001. There was a statistically significant difference between the mean ACL-QOL scores at 6, 12 and 24 months post-operatively p < 0.005.

**Conclusion:** This study provides further validation of the ACL-QOL by demonstrating the responsiveness to change of this disease-specific quality of life instrument. Patients demonstrated a statistically significant improvement in ACL-QOL score following ACL reconstruction surgery.

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**Clinical Laxity 2-years after Anatomic ACL Reconstruction is Associated with Reduced Disease-specific Quality of Life**

Greg M.L. Buchko, AB; S. Mark A. Heard, AB; Laurie A. Hiemstra, AB; Mark R. Lafave, AB; Sarah Kerslake, AB

**Purpose:** The purpose of this study was to assess the frequency of ACL laxity following primary anatomic hamstring autograft ACL reconstruction, and to determine whether patients with objective ACL laxity demonstrated a significant difference in scoring on the Anterior Cruciate Ligament Quality of Life (ACL-QOL) questionnaire.

**Method:** A prospective cohort study design (n = 1174) was used to gather data on clinical and quality of life outcomes. Post-operative ACL laxity assessment using the Lachman and Pivot-shift tests was completed independently on each patient by a physiotherapist and an orthopaedic surgeon at a minimum of 24-months post-operatively. Patients completed the ACL-QOL at the 24-month post-operative appointment. The degree and frequency of post-operative laxity was calculated. A comparison of ACL-QOL scores for patients presenting with no laxity, compared with positive laxity on the Lachman and/or Pivot-shift tests was performed to assess for between-group differences. A Pearson r correlation assessed the relationship between ACL graft laxity and ACL-QOL scores.

**Results:** Data was gathered for 831/1174 patients (71%). At clinical assessment two-years post-operatively, 14.7% of patients demonstrated a positive Lachman and/or Pivot-shift test. The mean ACL-QOL score for patients with no ACL laxity was 82.1/100, for patients with a positive Lachman or Pivot-shift test the mean score was 73.4/100, and for patients with both positive Lachman and Pivot-shift tests the score was 67.7/100. Pearson r correlation coefficient demonstrated a significant relationship between the presence of clinical ACL graft laxity and ACL-QOL score (0.61, p < 0.05).

**Conclusion:** Patients with clinically measurable ACL graft laxity demonstrate lower ACL-QOL scores. Further study is required to identify factors that are associated with the development of laxity.

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**Proximity of Lateral Critical Structures to Femoral Tunnels in All-epiphyseal Outside-in Drilling Technique for Pediatric ACL Reconstruction**

Kunal Kalra, MI; Mark K. Lane, MI; Jennifer A.J. Mutch, QC; Kaitlyn Ratkowiak, MI; Stephen E. Lemos, MI

**Purpose:** The incidence of Anterior Cruciate Ligament (ACL) tears in the pediatric population is on the rise due to increasing participation and intensity of competitive sports at an early age. When neglected, ACL deficiency leads to meniscal tears, chondral damage and poor outcomes. Therefore early anatomic ACL reconstruction is
recommended. However, ACL reconstruction in the skeletally immature athlete is challenging due to the presence of physes and all-epiphyseal techniques have been developed in consequence. These techniques lead to a horizontal femoral tunnel that exits more distally than in standard adult ACL reconstructions, which may put the lateral collateral ligament (LCL), Popliteus Tendon (PT), Articular Cartilage (AC), and Peroneal Nerve (PN) at risk. To our knowledge, this is the first study evaluating the proximity of the lateral structures to the femoral tunnel in an all-epiphyseal outside-in ACL reconstruction.

**Method:** Twelve all-epiphyseal ACL reconstructions were performed in human cadaveric knees using arthroscopy and outside-in drilling for anatomic femoral tunnel placement. Fluoroscopy was used to confirm tunnel position and reconstructions were performed with quadruple hamstring grafts and endobutton fixation on the femoral side. Following reconstruction, the lateral side of the knee was dissected and the LCL, PT, distal and posterior AC, and the PN were identified. The distances of these structures from the center of the exiting femoral tunnel were then measured using a digital caliper at 0°, 30°, 60°, 90°, and 120° of knee flexion. Any gross damage to these structures caused by the femoral drilling was also noted.

**Results:** Clear violation of the LCL was noted in 3 specimens and of the PT in 1 specimen. As the knee was progressively flexed, the distance between the LCL and the femoral tunnel decreased (P<0.001) with an average distance of 6.52mm at 0°, 6.26mm at 30°, 4.23mm at 60°, 2.38mm at 90°, and 0.4mm at 120°. The PT similarly approached the femoral tunnel with progressive knee flexion with an average distance of 8.07mm at 0°, 7.75mm at 30°, 6.33mm at 60°, 4.12mm at 90°, and 1.89mm at 120° (P<0.001). The PN was remote from the femoral tunnel at all flexion angles with an average distance of 42.83 to 59.22mm (P<0.001). The articular cartilage was respected in all specimens.

**Conclusion:** The LCL and PT are at significant risk during femoral drilling for all-epiphyseal anatomic ACL reconstruction using an outside-in technique. This risk was maximized at 120° and minimized in full extension. The posterior articular surface was preserved in all specimens and the PN was greater than 4.5cm from the femoral tunnel at all flexion angles. These findings suggest that the optimal position for femoral drilling in all-epiphyseal ACL reconstruction is full or near-full extension of the knee. This is important because it the opposite of the recommended knee flexion angles in adult ACL reconstructions using an anteromedial portal.

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**Rupture of the Anterior Cruciate ligamEntSurvey (RACES): What is the Impact of Being on a Surgical Wait List?**

**Devin Peterson, ON; Lauren Salci, ON; Olufemi R. Ayeni, ON; Forough Farrokhyar, ON; Dyda Dao, ON; Rick Ogilvie, ON**

**Purpose:** To determine the impact of ACL surgery wait times on the patient’s quality of life (QOL).

**Method:** A twelve question survey was administered to fifty patients on the wait list for ACL reconstruction surgery. Questions covered three main areas: disability, physical health, and emotional. Patient demographic and wait time data were collected and divided into two groups based on length of wait for surgery:< 182 days and > 182 days.

**Results:** Only two questions had significantly different answers between the two weight time groups. Thirty-seven percent of patients on the waitlist for >182 days either lost their job or had it significantly modified compared to only 3.6% of patients in the group that was on the waitlist for 182 days or less. Interestingly, the group that were on the waitlist for 182 days or less felt that their physical health has deteriorated significantly
due to their ACL injury compared to the group that were on the waitlist longer (38.7% vs 11.1%). It was found that a large number of respondents in both groups reported substantial disability, physical health issues, and emotional stress while on the wait list for ACL surgery. Only 4% of respondents were not affected in their day to day activities or non-pivoting activities due to their ACL injury. Sixty three percent of total respondents felt that their overall physical health had deteriorated significantly or somewhat due to their ACL injury. The following physical health issues were also noted: 70% of patients felt they had gained weight, 94% experienced instability to some degree and 96% experienced some degree of pain due to their injury. A majority of total respondents felt their emotional health had been affected while waiting for surgery. Thirty-three percent and 17% of patients felt their work and schoolwork, respectively, had suffered significantly or somewhat due to their emotional stress related to their injury. Additionally, over 50% of respondents felt sad or depressed all or most of the time because they were unable to participate in their main sport.

**Conclusion:** This study found that waiting any period of time for an ACL surgery can have negative impacts on patients’ disability, physical health and emotional health. Overall, patients waiting less than or more than 182 days for their surgery (the Weight Time 2 benchmark for arthroscopic knee surgery in Ontario) were similarly negatively affected. However, a significant finding suggests that as wait time increases there is a greater likelihood for losing a job or having it significantly modified. It would seem that decreasing the wait for ACL surgery or applying interventions that minimize ACL insufficiency symptoms would be beneficial to improve quality of life.

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**A Randomized Clinical Trial to Assess the Clinical Effectiveness of a Measured Objective Tensioning Device in Hamstring ACL Reconstruction**

**Peter Grunau, BC; Shalinder Arneja, BC; Patrick Chin, BC; Michael Gilbart, BC; Cheryl Davies, BC; Jordan Leith, BC**

**Purpose:** Soft tissue grafts (hamstring grafts) are commonly used in surgical reconstruction of the ACL. Applying the appropriate tension to the final graft reconstruction has traditionally been performed by the surgeon and is based on the surgeon experience and perception of applied tension. There are inherent problems with manual application of tension to the ACL reconstruction. These include under or over tightening the reconstruction, inconsistent tension application between subjects and variable load application to each of the strands. Commercially designed tensioning devices are available that offer a more objective and consistent application of tension to the final reconstruction construct. The objective of this study was to assess whether measured tensioning (SE™ Graft Tensioner, Linvatec corp.) of hamstring ACL grafts during fixation improves clinical outcome or knee laxity post-operatively when compared to conventional tensioning manoeuvres.

**Method:** This study is a prospective randomized control trial of consecutive primary ACL subjects. The treatment group included subjects where a measured tensioning device (SE™ Graft Tensioner, Linvatec corp.) was used for graft tensioning (80 N), and the control group did not use a tensioning device. The primary outcome was KT1000 differences between knees at 6, 12 and 18 months. The KT-1000 is an instrumented objective knee laxity testing device and has been shown to be useful in the clinical evaluation of subjects with ACL insufficiency and in following subjects undergoing ACL reconstruction. Secondary outcomes included The International Knee Documentation Committee Knee Evaluation Form (IKDC) score and ACL QOL scores at those intervals. Chi square and t tests were used for analysis. The study had 90% power to detect a difference of 1 mm between groups.
**Results:** A sample of 127 patients were randomized. Of those, 14 did not have follow up data and were excluded from this analysis resulting in a final sample of 113. There were 55 patients in the treatment group and 58 in the control group. No significant differences were found in baseline demographics or comorbidities between the groups. The KT1000 means for the device measured tension group versus the physician tension group were: 4.7 (SD=2.51) vs 4.6 (SD=2.34) at baseline; 1.3 (SD=1.10) vs 1.6 (SD=1.49) at 6 months; 1.3 (SD=1.20) vs 1.5 (SD=1.31) at 12 months; and 1.0 (SD=1.15) vs 1.1 (SD=1.05) at 18 months. There were no significant differences between the groups in KT1000, IKDC or ACL QOL scores at baseline or follow up.

**Conclusion:** Measured tensioning of hamstring ACL grafts during fixation does not improve clinical outcome or knee laxity post-operatively when compared to conventional tensioning manoeuvres.

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**Factors that Contribute to Laxity 2-years After Anatomic Anterior Cruciate Ligament (ACL) Reconstruction**

**Gregory M.L. Buchko, AB; S. Mark A. Heard, AB; Laurie A. Hiemstra, AB;; Mark R. Lafave, AB; Sarah Kerslake, AB**

**Purpose:** The purpose of this study was to assess factors that may contribute to ACL laxity 2-years after a primary anatomic hamstring autograft ACL reconstruction.

**Method:** A prospective cohort study design (n = 1174) was used to gather data on clinical and quality of life outcomes. Post-operative ACL laxity assessment using the Lachman and Pivot-shift tests was completed independently on each patient by a physiotherapist and an orthopaedic surgeon at 6, 12 and 24 months post-operative. Descriptive statistics were used to calculate the degree and frequency of post-operative laxity. Multiple regression analysis using Pearson r correlation coefficient examined the relationship between post-operative laxity and, gender, age, body mass index (BMI), operative limb, smoking, Beighton score, meniscal repair, meniscal resection and chondral lesions.

**Results:** At 6-months post-operative 13.2% of patients demonstrated a positive Lachman and/or Pivot-shift test. This increased to 14.4% at one-year and 14.7% two years after ACL reconstruction. At two years post-operative 3.8% of patients demonstrated complete graft rupture. A statistically significant increased risk of post-operative laxity was determined for meniscal resection (p= 0.03) and age less than 19 years (p =0.05). There was some evidence of an association between laxity and, BMI (p=0.14), Beighton score (p=0.12) and intra-operative evidence of chondral lesions (p = 0.15) but none of these factors reached statistical significance. There was no evidence of a relationship between post-operative laxity and, gender, meniscal repair or smoking.

**Conclusion:** This study demonstrated up to 15% of patients had clinically measurable ACL graft laxity two-years after primary anatomic hamstring autograft ACL reconstruction. Meniscal resection and age were associated with an increased risk of laxity. Further assessment of the relationship between graft laxity and, BMI, Beighton score and chondral lesions is warranted in a larger cohort.

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**The Rate, Type, and Quantification of the Intraoperative Contamination of the Anterior Cruciate Ligament Autografts**

**Abdulaziz Z. Alomar, Saudi Arabia**
**Purpose:** Background: While inadvertent contamination of the anterior cruciate ligament (ACL) autografts during harvesting or by accident is infrequent, it can result in significant complications, and managing this contamination poses a challenging dilemma to orthopaedic surgeons. Published data on the rate of this mechanism of contamination are limited. Additionally, the quantification of the bacterial contamination during harvesting and preparation and compare to those accidentally dropped is unknown. Purpose: To quantitatively evaluate the rate of bacterial contamination of ACL autograft during harvesting and to compare it to the rate of contamination from accidently dropping the graft onto an operating room floor.

**Method:** Materials and methods: Fresh ACL specimens were sterilely recovered from 27 primary total knee arthroplasties (TKAs). All 27 total knee arthroplasties were performed for osteoarthritis. In all cases, the ACL was intact. None of the total knee arthroplasty patients developed a postoperative infection. For each TKA, the ACL was cut into identical six pieces (total of 162 specimens from 27 TKAs)—three specimens were used as the controls while the others three were dropped onto the operative room floor adjacent to the operating table. No changes were requested to the floor cleaning protocol prior to operation. Each dropped ACL specimen was placed on the operating room floor for 10 s before being collected for tissue culture using sterile forceps. Each retrieved specimen was immediately transported to the microbiology laboratory. All tissue samples were weighed using a digital balance. Each tissue sample was rolled on sheep blood agar (SBA) plates for at least 20 s to ensure that all sides contacted the culture plate. Then all the plates were incubated in 5% CO2 for 48–72 h for aerobic growth and for 7 days in sealed jars for anaerobic growth. After 72 h of incubation, the bacterial colonies were counted on each plate, and the colony-forming units (CFU) per gram were calculated from the total number of CFUs per plate for each sample. The tissue samples were then transferred to cooked meat medium, incubated at 36°C for 72 h. The tubes were placed in a vortex and 100-µL aliquots of the supernatant were streaked onto SBA plates for overnight incubation. If the plates or cooked meat medium showed growth, the organisms were identified using standard clinical microbiological methods. The bacterial isolates were identified on the basis of their morphology using the gram stain procedure. Cultural characteristics of the isolates were studied after 72 h of incubation. Identification was performed using an automated MicroScan WalkAway-96 System (Dade Behring, West Sacramento, CA, USA) with identification and susceptibility panels (Negative Combo 42 and Positive Combo 28).

**Results:** We assessed 81 control ACL specimens and 81 dropped ACL specimens. The bacterial contamination rates (positive cultures) for the control and dropped groups were 17.3% (14) and 27.2% (22), respectively. The difference in the contamination rate between the groups was not statistically significant (p = 0.131). The mean rank of the CFU for those dropped and control specimens with positive cultures were 24.25 and 9.46, respectively. ACL autograft specimens with positive cultures in the dropped group were significant higher CFU than that of the control group (p = 0.000). The most common organisms identified in the contaminated control group were Staphylococcus epidermidis (35.7%) and Staphylococcus aureus (21.4%). The other organisms were Kocuria Kristinae, Staphylococcus Saprophyticus, Staphylococcus Auricularis, Staphylococcus Haemolyticus, Micrococcus Luteus/Lylae and Staphylococcus Lentus, Micrococcus luteus, and Kocuria kristinae (7.1% each). In the dropped group, the most common organisms were Staphylococcus epidermidis (31.8%), Bacillus species (13.6%) and Escherichia coli (13.6%). Followed by Micrococcus luteus/Lylae and Staphylococcus Sciuri and Staphylococcus aureus (9.1% each). The other organisms were Staphylococcus Warneri, Sphingomonas paucimobilis and kocuria rosea (4.5% each).

**Conclusion:** A relatively high rate (17.3%) of ACL autografts contamination can be expected during harvesting and preparation. Quantification analysis showed that accidentally dropped autografts have a significantly higher CFU than those contaminated during harvesting. Therefore, mechanical or chemical decontamination of
ACL autografts after harvesting and preparation is strongly recommended, especially for grafts that have been accidently dropped onto the operating room floor.

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Femoral Tunnel Accuracy in Medial Patellofemoral Ligament Reconstruction: Relationship to Banff Patellofemoral Instability Instrument Score
Laurie A. Hiemstra, AB; Sarah Kerslake, AB; Mark R. Lafave, AB

Purpose: The purpose of this study was to assess the accuracy of femoral tunnel placement in a medial patellofemoral ligament reconstruction (MPFL-R) cohort from a high-volume sport-medicine surgery practice, and to compare tunnel accuracy to a validated disease-specific patient report quality of life outcome measure, the Banff Patellofemoral Instability Instrument (BPII).

Method: Data was prospectively gathered from 139 subjects who had undergone an MPFL-R. Lateral radiographs were measured to determine the accuracy of the femoral tunnel. Femoral tunnel accuracy was measured in relation to Schottle’s point. Rating categories and criteria for tunnel position were standardized and defined apriori as: ideal (0-6mm), good (>6-12mm) or poor (>12mm). The Banff Patella Instability Instrument (BPII) was collected at a minimum of one-year post operative.

Results: One hundred and thirty nine femoral tunnels were assessed. The mean duration of follow-up was 19.8 months (range 12-38 months). Measurement from the centre of the femoral tunnel to Schottle’s point resulted in 129/139 (92.8%) tunnels being categorized as ‘good’ or ‘excellent’. The mean distance was 6.15 mm (range 0.8-25.9) from the centre of the MPFL tunnel to the centre of Schottie’s point. The mean overall BPII score was 62.8/100 (range 13.1-98.9). The mean BPII scores by tunnel accuracy category were poor = 55.9/100 (range 33.5-98.9, n = 10), good = 66.7/100 (range 13.1-98.9, n = 46), and excellent 64.2/100 (range 17.4-97.6, n = 83). Pearson r correlation demonstrated no statistically significant relationship between accuracy of tunnel position and BPII score (r= -0.02).

Conclusion: In this prospective cohort, accurate femoral tunnels were placed greater than 92% of the time during MPFL-R. There was no evidence of a correlation between the accuracy of the femoral tunnel in relation to Schottle’s point, and post-operative disease-specific quality of life score. Accurate femoral tunnel placement during MPFL reconstruction may not correlate to patient-reported quality of life following surgery.

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Comparison of STG Tendon Harvest and ACL Reconstruction on Knee Flexor Strength in Two Hip Positions
Sheila McRae, MB; Matt Kulas, MB; Jeff Leiter, MB; Peter MacDonald, MB; Dean Kriellaars, MB

Purpose: The purpose of this study was to evaluate the impact of hip position on knee flexor strength following ACL reconstruction using STG semitendinosus/gracilis autograft.

Method: Men and women between the ages of 18 and 50 with a complete anterior cruciate ligament (ACL) tear awaiting surgical reconstruction and who had no other ligament injuries requiring surgical intervention were candidates for inclusion. Participants were randomized intraoperatively to one of two study groups: 1) Standard treatment group (Standard) who would undergo anterior cruciate ligament reconstruction using semitendinosus and gracilis (STG) tendon graft harvested from the patient’s own ACL-deficient leg; or 2) Contralateral harvest group (Contra) who would undergo ACL reconstruction using STG graft harvested from
the ACL-intact leg (i.e., leg contralateral to the torn ligament). From the two study groups, four treatment conditions were created based on whether the knee was reconstructed or not (represented by R or NR) combined with whether the limb was used as a graft donor for STG tendon or not (represented by D or ND). Pre-surgery and at 12-months post-surgery, knee flexor concentric and eccentric strength was measured through 90° (5 to 95° flexion) range of motion for five repetitions each at ±60, 150, and 270°/s, with a two-minute rest. This testing was performed in a seated position (85° hip flexion) and hip-neutral supine (5° hip flexion). Negative velocities represent eccentric and positive velocities represent concentric contraction of the prime movers.

Results: Fourteen males and four females took part in the study with a mean age of 29.2 (SD 7.1). No significant differences were identified between groups with respect to sex (p=0.141), age (p=0.529), height (p=0.588), body mass (p=0.686), body mass index (p=0.794) or time from injury to surgery (p=0.209). At pre-surgery, there was no significant difference between peak knee flexor torque based on donor limb in the seated (85° hip flexion; p=0.471) or supine position (5° hip flexion; p=0.195). At 12-months post-surgery, there was still no difference between limbs in the seated position (p=0.870); however, there was a significant difference based on donor limb in the hip-neutral position (p=0.005) with a mean difference between ND and D of 16.1 Nm. This relationship also holds true when examining change from pre- to 12-months post-surgery. This significant interaction effect between position and limb did not exist when comparing reconstruction and non-reconstructed sides at 12-months post-surgery.

Conclusion: STG tendon harvest had a negative impact on knee flexor strength while the ACL reconstruction itself did not. The decrease in strength was only significant in the hip-neutral position, not in a seated position. This finding has clear implications for patient outcome as the hip-neutral position is a more functional position than seated.

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Does Ligament Preservation in ACL Reconstruction Improve 2-year Outcomes? A Prospective Cohort Study
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Purpose: To compare disease-specific quality-of-life, clinical outcomes and re-injuries following ACL reconstructive surgery with ligament preservation, or a standard autograft ACL reconstruction.

Method: Two groups of ACL deficient patients undergoing ACL reconstruction were prospectively compared (n=44 in each): “Preserved” group – two-stranded semitendinosus autograft reconstruction with preservation of ACL tissue (20 males; mean 29.6 years; 20 acute); “Standard HT” group – had a four-stranded semitendinosus/gracilis autograft reconstruction (25 males; mean 29.8 years; 15 acute). ACL preservation was performed in ACL deficient patients with mild-moderate translation and rotational abnormalities under anesthesia, and arthroscopic evidence of robust ACL tissue. At the time of reconstruction, the two-stranded semitendinosus graft was placed alongside and/or through the remaining ACL tissue. Standard HT patients were matched based on age, gender and acuity. Fixation, pre- and post-surgical protocols were identical for all patients. Primary outcome: the disease-specific and patient-reported ACL Quality-of-Life score (ACL-QOL). Secondary outcomes: Subjective and Objective IKDC scores, KT Arthrometer (30lbs/134N). An independent trained assessor measured the clinical outcomes.

Results: Matching for age, gender and acuity was effective, with no statistically significant differences in demographic or baseline scores between groups. Mean ACL-QOL and Subjective IKDC scores increased
significantly from baseline to two years for both groups (p=0.000, both outcomes). Mean two year ACL-QOL scores were not different (p=0.719): Preserved=89.9 (SD=14.3; 95% CI=85.4-94.4); Standard HT=84.4 (SD=18.2; 95% CI=78.9-90.0). At two years, 88% (37/42) of Preserved and 73% (30/41) of Standard HT patients had (IKDC) Normal/Nearly Normal knees (p=0.074). Preserved patients had significantly less KT arthrometer side-to-side differences (2.2mm, SD=1.6mm; 95%CI=1.7-2.7mm) than Standard HT patients (3.1mm; SD=1.9mm; 95% CI=2.5-3.7mm), p=0.024. Two Preserved patients had a traumatic re-rupture. Three patients required arthroscopy for intra-articular scarring (n=two) and meniscal tear (n=one). One Standard HT patient had a traumatic re-rupture requiring revision. Four patients required arthroscopy for intra-articular scarring (n=one), meniscal tears (n=two), and posterolateral corner injury (n=one).

Conclusion: A two-stranded semitendinosus ACL preservation technique should be considered in a subset of ACL deficient patients with mild-moderate laxity and robust ACL tissue. ACL preservation using a two-stranded hamstring autograft results in comparable quality-of-life outcomes, improved knee stability (KT arthrometer) and more patients with Normal/Nearly Normal knees at two years, than a standard four-stranded hamstring reconstruction.

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A Mechanism of Muscle Atrophy in Osteosarcoma-induced Cachexia
Kurt R. Weiss, PA; Xiaodong Mu, PA; Adam Rothenberg, PA; Johnny Huard, PA

Purpose: Cachexia is characterized by skeletal muscle and adipose tissue loss due to chronic illness, and occurs in up to 50% of cancer patients. The mechanism of cancer cachexia may result from depressed protein synthesis or increased protein degradation. Cachexia could also be mediated by various tumour or host factors. A recent study of both tumour-bearing mice and patients with pancreatic cancer demonstrated that muscle atrophy in cancer cachexia might be mediated by the deregulation of muscle stem cells. In this study we have evaluated the effect of osteosarcoma tumour development on skeletal muscle stem cells, and the potential involvement of exosomes released from cancer cells to induce muscle atrophy.

Method: 1. Osteosarcoma Tumour Formation: 2.0 x 10^5 K7M2 (a highly metastatic murine osteosarcoma cell population) cells were injected into the right tibial intramedullary canal of 4-week old SCID/Beige mice in order to establish tumour formation. 2. Tissue Harvesting: Muscle tissue from the contralateral left limb was harvested for study six weeks after cell injection. 3. Exosome Isolation: K7M2 cells were plated at 60% confluence and cultured for 48 hours. 10mL culture medium was used for exosome isolation with the Total Exosome Isolation Reagent (Lifetechnologies). The isolated exosomes were added to 10mL of fresh culture medium for the treatment of muscle-derived stem cells (MDSCs).

Results: 1. Compared with control mice, both the size of hindlimb skeletal muscle and the volume of abdominal adipose tissue were found to be diminished in mice with tumours. 2. Hematoxylin and eosin, and Trichrome stains were performed on histologic slides of skeletal muscle tissue. Compared to control mice, the size of the myofibers in the skeletal muscle of tumour-bearing mice was smaller, and the fibrosis formation with concomitant collagen deposition was much greater than muscle from control animals. 3. To discern the influence of K7M2 cells on MDSCs, K7M2 cells and MDSCs isolated from 4-week old control mice were co-cultured in a transwell system. Compared with control MDSCs (MDSC/MDSC), K7M2 cells reduced the myogenic potential of MDSCs (K7M2/MDSC), as demonstrated by the diminished immune-staining of Myosin Heavy Chain (MHC)+ myotubes. 4. Exosomes are known to be released by cancer cells as a mediator of intracellular communication. Exosomes in the culture medium of K7M2 cells were isolated and added to the culture medium of MDSCs. K7M2 Exosome treatment of reduced the myogenic potential of MDSCs.
Conclusion: These data demonstrate that cancer cachexia, manifested by muscle and fat atrophy, occurs in mice with osteosarcoma. Muscle from osteosarcoma-bearing mice is both quantitatively (smaller) and qualitatively (more fibrotic) different. Exosomes released from tumour cells could represent an important mediator of cancer cachexia. Future investigations will attempt to determine which factors in the exosome actively potentiate cancer cachexia.

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A Systematic Approach to Evaluating Registration Error in Computer Assisted Orthopaedic Oncology Surgery
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Purpose: This study evaluates the principles of computer registration in CAOS using commercial software. To date this software has been used clinically for numerous applications but the accuracy of the software or the reported estimation of error of the software has not been independently assessed.

Method: A radiolucent high resolution commercially available Saw Bones model of the pelvis was imaged at varying resolutions on volumetric computed tomographic scanner. Before imaging the pelvis, 11 fiducial markers were placed at various positions throughout the pelvis to ensure a diffuse spread for assessment. Volumetric data was then uploaded onto the Stryker Orthomap 3D Software and the pelvic model was then registered to the different volumetric resolutions to determine the effect of resolution on registration error. Once the optimum resolution was determined, this volume was then used to assess the importance of paired points, distribution of paired points, number of points for surface matching, and position of the pelvic model in the field of view on the registration error. Root mean square errors were then calculated for the fiducial markers relative to their coordinates in the volumetric image volumes to determine target registration errors (TRE). These values were then compared to the system registration error (SRE). The data was then tested for normality and homogeneity of variance and the appropriate statistical analysis was completed using ANOVAs for parametric data and Kruskal-Wallis Tests for non-parametric data.

Results: Resolution of the volumetric data was found to play a statistically significant role in TRE. Extremely low or high resolutions were found to have significant effect. The number of paired points showed no significant difference in SRE but did show a trend for TRE. Choosing 4 or more paired points showed a trend for concordance between the SRE and TRE. Out of plane paired points showed a significant improvement in TRE versus in plane points. The importance of minimizing SRE in paired point registration was demonstrated in surface matching as no significant difference was found in the number of points used for surface matching. Rather the quality of the paired point registration played a more important role in determining TRE. Finally, the position of the pelvic model did not play a significant role in the TRE registration error. Variable concordance between SRE and TRE demonstrated the importance of visual inspection to determine the quality of registration.

Conclusion: The Stryker Orthomap 3D software is a robust and accurate method for registering a pelvic model and its volumetric data. High resolution scans, accurate paired point matching of at least 4 points, and using paired points that are out of plane are all important factors in reducing registration error. Users need to verify the registration accuracy by running the navigation probe on the bone surface near target resection planes to truly determine the quality of registrations.
Aldehyde Dehydrogenase (Aldh) Activity Correlates with Clinical Metastases in Human Bone Sarcomas
Kurt R. Weiss, PA; Nicholas Greco, PA; Xiaodong Mu, PA; Adel Mahjoub, PA; Trevor Schott, PA

Purpose: Primary sarcomas of bone are frequently complicated by metastatic disease. Patients with metastases continue to have high rates of mortality that have remained unchanged despite advancements in surgical and oncologic care [1]. The problem of metastatic disease remains unsolved, and novel approaches are required. Aldehyde Dehydrogenase (ALDH) is an enzyme that has been associated with a poor clinical prognosis in a variety of malignancies [2,3]. We have shown that highly metastatic murine osteosarcoma cells lines produce more ALDH than their less metastatic counterparts [4]. The purpose of this study was to establish whether ALDH could be a molecular marker of metastatic potential in various human musculoskeletal tumours originating in bone.

Method: After IRB approval, musculoskeletal tumour tissue samples were obtained from patients diagnosed with a variety of tumours originating in bone at the time of diagnostic biopsy or operative procedure. Diagnoses included Osteosarcoma, Chondrosarcoma, and Ewing's sarcoma. Flow cytometry was performed on the cell population isolated from each tissue sample in order to identify the percentage of cells that demonstrated high ALDH activity. These data were correlated with the patients' clinical histories: specifically the clinical event of metastatic disease.

Results: Tissue samples were attained from 10 consecutive bone sarcoma patients. Diagnoses included Chondrosarcoma (n=5), Osteosarcoma (n=3), and Ewing's Sarcoma (n=2). Metastatic disease was evident in 8 patients at the time that the sample was acquired. The patients with metastatic disease were found to have high ALDH activity ranging from 3.9% to 39.4% in the examined tumour tissue samples. The two patients without metastatic disease had high ALDH activity less than 1.2%. In this limited patient population, employing 3.9% as a threshold value, high ALDH activity assay was both 100% sensitive and specific at differentiating patients with metastatic disease from those without metastatic disease.


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Does Extended Curettage for the Treatment Giant Cell Tumour Offer Adequate Therapeutic Profile in the Era of Latest Adjuvant Options?
David Nikomarov, ON; Anthony Griffin, ON; Prakash Nayak, ON; Shaneel Deo, ON; Peter Ferguson, ON; Jay Wunder, ON

Purpose: Giant cell tumour (GCT), a locally aggressive benign condition of the musculoskeletal system, remains notorious for its stubborn tendency for local recurrence. The mainstay of primary treatment for this condition in the last decades is extended curettage. Recurrence risk ranges in literature from low as 5% to as high as 50%. Different adjuvant therapeutic methods have been described in the past, with effectiveness estimated usually as moderate at best. Lately data is accumulating about new therapeutic options, mainly Denosumab and bisphosphonates. The aim of this study is to evaluate the effectiveness of extended curettage as the sole primary treatment for GCT.
Method: Data was collected from our institute's prospectively collected registry. Two hundred and ninety nine patients were operated with extended curettage for the treatment of GCT between the years 1989 and 2012. Data for anatomical lesion site, presenting status regarding metastasis, pathological fractures and local recurrence, surgical reconstruction method, local recurrence during followup and metastasis during followup were analyzed. Local recurrence free survival and metastasis free survival were estimated according to the Kaplan-Meier method.

Results: Two hundred and ninety nine patients were found applicable. 147 (50.8%) were female. The most common site was around the knee, with 180 (60.2%) cases, followed in descending frequency rate, by the ankle/foot with 43 (14.4%), wrist/hand 33 (11%), hip 21 (7%), shoulder 12 (4%), elbow 7 (2.3%), pelvis 3 (1%). 203 patients (67.9%) were diagnosed with a local lesion without any associated fracture or metastasis, 76 patients (25.4%) presented with pathological fracture, 16 patients (5.4%) presented to our institute with local recurrence, and 4 patients (1.3%) presented with local recurrence and pathological fracture. None of the patients was diagnosed with metastasis at presentation. 247 patients (82.6%) underwent reconstruction with bone graft after completion of the extended curettage, and 52 patients (17.4%) underwent cement reconstruction. 53 patients (17.7%) were diagnosed with local recurrence during followup. 7 patients (2.3%) were diagnosed with metastasis during followup. Mean local recurrence free survival was estimated 203.18 month (95% CI 188.53–217.84 month). Mean metastasis free survival was estimated 286.77 month (95% CI 280-293.54 month).

Conclusion: GCT remains a challenging diagnosis with regards to local recurrence risk. Extended curettage offers a reasonable but sub-optimal option as a sole treatment. Further research into novel adjuvant treatment options is needed.

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Epigenetic Regulation of Osteosarcoma Metastatic Potential with Histone Deacetylase (HDAC) Inhibition

Kurt R. Weiss, PA; Xiaodong Mu, PA; Daniel Brynien, PA; Johnny Huard, PA

Purpose: The epigenetic modification of cancer cells regulates tumour development and metastasis. Epigenetic changes include DNA methylation and histone modification, both of which regulate gene expression but do not alter the genetic code. Our previous research has demonstrated differential DNA methylation of tumour suppressor genes between highly metastatic (K7M2) and less-metastatic (K12) murine osteosarcoma cells. The de-methylation of tumour suppressor genes was able to repress the metastatic phenotype of highly metastatic cells. Histone deacetylase inhibitors (HDAC inhibitors, HDACi's) have been evaluated for epigenetic regulation of various cancer cells, but the role of HDACi's in osteosarcoma is unclear. We have investigated the effect of the HDAC inhibitor, vorinostat (SAHA), on murine osteosarcoma cells.

Method: 1. Osteosarcoma cells: K7M2 and K12 are related murine OS cell populations with differing metastatic potentials: K7M2 is highly metastatic to the lung but K12 is much less metastatic. 2. Vorinostat treatment of cells: vorinostat (25, 50, or 100 µM) in proliferation medium (10% FBS in DMEM) was used to culture the K7M2 cells. Cells were incubated with vorinostat for 48 hours prior to fixation for observation, harvest for mRNA isolation, or plating for invasion assays.

Results: 1. A significantly lower number of cells was observed in vorinostat-treated K7M2 cells. Vorinostat treatment caused both apoptosis and decreased cell proliferation of K7M2 cells. 2. Phalloidin staining of the
actin cytoskeleton revealed significant structural differences in vorinostat-treated cells. Treated cells displayed fewer invadopodia, and their shape was more polygonal, resembling the less-metastatic K12 cells. 3. Semi-quantitative polymerase chain reaction (PCR) showed that the expressions of mammalian target of rapamycin (mTOR, a cancer stem cell marker), aldehyde dehydrogenase-1 (ALDH-1, a cancer stem cell marker), and peroxisome proliferator-activated receptor gamma coactivator 1 (PGC-1, a mediator of mitochondria biogenesis) were down-regulated in K7M2 cells treated with vorinostat (50 µM). Conversely, the expression of microtubule-associated protein 1A/1B-light chain (LC3, an autophagy maker) was up-regulated. 4. The in vitro invasion capacity of K7M2 cells through 2.5% matrigel was analyzed with the xCelligence system. Vorinostat treatment significantly reduced the cells’ invasion capacities.

**Conclusion:** Highly metastatic osteosarcoma cells can be epigenetically modified with HDAC inhibition. Vorinostat treatment of K7M2 cells in vitro reduced both the proliferation and migration of osteosarcoma cells, indicating HDAC inhibition may have the potential to reduce tumour development and metastasis in vivo. The effect of vorinostat on osteosarcoma cells could be related to diminished expression of some genes regulating tumour development and metastasis such as mTOR, ALDH and PGC-1. In the future we will test this hypothesis with an in vivo model of metastatic osteosarcoma.

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**Giant Cell Tumour of the Distal Radius**

Robert E. Turcotte, QC; Hasan Sawan, Saudi Arabia; Peter Ferguson, ON; Jay Wunder, ON; Marc Isler, QC; Sophie Mottard, QC; Joel Werier, ON; Hesham Abdelbarry, SK

**Purpose:** Giant cell tumour of bone (GCT) is a benign disease usually treated by extended curettage and cementing /bone grafting. There have been reports suggesting that GCTs involving the distal radius are more aggressive in their behavior, predicting higher rates of local recurrence and increased incidence of lung metastasis. For these reason some have favored en bloc resection of the distal radius over extended curettage. Although many treatment options exist their oncologic and functional outcome are still vaguely estimated. The aim of our study was to focus on GCT of the distal radius, comparing local control, metastatic rate and function between those who underwent curettage and those who underwent en bloc resection with wrist arthrodesis.

**Method:** Four Canadian institutions collaborated to this work. Cases were identified through prospective databases in existence in each center. 58 patients were recorded between 1989-2011 with giant cell tumours of the distal radius. Age ranged from 18 to 69 years old (mean 25). 57% were female. The mean follow-up was 86 months (range 1 to 280 mos). 15 were classified as Campanacci Gr 2 and 40 were Gr 3 (4 unknown). 16 had fractured. 35 patients underwent extended intralesional curettage. Bone cement was used in 23 of them and internal fixation was used in one. 11 were bone grafted among which 7 needed internal fixation. Wide resection and wrist arthrodesis using plate and screws for fixation where preformed on 23 patients from which 7 had free vascularized fibula transfer. All resection were performed for Gr 3 tumours.

**Results:** There were no deaths or lung metastases in both groups. 10 local recurrences occurred in the curettage group (29%). 9 of them where Campanacci grade 3. 9 of the 11 patients had PMMA insertion. This group had no other post-operative complications. Among these 10 recurrences, two had one more local recurrence. 3 of the 10 recurrences ultimately required resection. The primarily resected group sustained one local recurrence (4%) but 7 post-operative complications (30%) including 4 infections, 1 malunion, 1 nonunion and 1 fracture. Difference in local recurrence rates was significant (p= 021). Complications beside local recurrence were only reported in the resection group. The median Musculoskeletal Tumour Society score was
33 in the curettage group and 27 in the resection group (p= .103). The Toronto Extremity salvage Score in the curetted group displayed a median score of 94.7 compared to 85.1 for the resection group (p= .012)

**Conclusion:** Intraläsional curettage is an effective alternative to wide resection with the advantage of preserving the distal radius and wrist function but with indeed a notable local recurrence rate. Most local recurrence could be managed with iterative curettage. Wide excision showed significantly lower recurrence but was technically challenging and associated with many post-operative complications. Resection should probably be reserved for most severe Gr 3 tumours.

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Navigated Geometric Bone Tumour Resections: A Sawbones Study Assessing Accuracy and Reproducibility of Resection Planes
Aidin Kashigar, ON; Amir Sternheim, ON; Michael Daly, ON; Jimmy Qiu, ON; Robert Weersink, ON; Jonathan Irish, ON; Peter Ferguson, ON; Jay Wunder, ON

**Purpose:** To assess the accuracy and reproducibility of geometric bone tumour resection using a navigation system with novel real-time quantitative guidance.

**Method:** Using a novel navigation system and 3D planning tool, we navigated bone cuts to resect bone tumours. The system includes a prototype mobile C-Arm for intraoperative cone-beam CT, optical tool tracking (NDI Polaris), and 3D visualization software. A 3D virtual view and real-time guidance, in the form of colour-coded error scales, were utilized to guide the surgeon during navigation. We utilized three sawbone tumour models that replicated resected tumours in past patients. Three surgeons each completed 3 navigated resections and 3 non-navigated resections for each tumour model.

**Results:** There were 126 navigated cuts in sawbones which were compared to 126 non-navigated cuts. Non-navigated cuts went through tumour in 22% (6/27) of the resections compared to navigated cuts which did not go through tumours (0/27). In the navigated sawbone cuts, the mean entry was 1.6 mm (SD 1.4) from the plan compared to the non-navigated cuts which were 3.4 mm (SD 2.6) from the planned osteotomy site. Pitch and roll were 3.5° (SD 4.3) and 3.7° (SD 4.0) in the navigated cuts compared to 13.3° (SD 10.6) and 10.9° (SD 9.1) in the non-navigated cuts, respectively. The navigated cuts were significantly more accurate (P≤0.001). The variation between three different users using navigation was less than 0.6 mm on the entry cut and 1.5° on pitch and roll.

**Conclusion:** The use of real-time quantitative guidance and navigation to perform geometric resection of bone tumours is accurate and feasible. 3D visualization and real-time guidance should be used for improved accuracy. Navigated cuts were significantly more accurate than non-navigated cuts.

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Oncologic Outcome for Younger Patients with Chondrosarcoma
Prakash R. Nayak, ON; Anthony M. Griffin, ON; Prakash Nayak, ON; Shaneel Deo, ON; David Nikomarov, ON; Peter Ferguson, ON; Jay Wunder, ON

**Purpose:** To determine if there is a difference in oncologic outcome for patients 35 years or younger as compared to those over 35 years treated for chondrosarcoma.
Method: Three hundred ten patients treated surgically for a chondrosarcoma between 1989 and 2012 were identified from our prospectively collected database. Patient and tumour characteristics, treatment details, local recurrence-free, metastasis-free and overall survival were compared for patients 35 years or younger to those over 35 years. Means were compared with the t-test, proportions with the chi-square test and survival with the log rank test. Cox regression was employed for multivariate analysis.

Results: Ninety-four patients (30%) were ≤35 (range 14-35) years, of whom 56 (60%) were male. Fifty-five (58%) were in the lower extremity, 91 (97%) were primary presentations, 60 (64%) were grade 2 or 3, 4 (4%) had pathologic fractures and none had metastases at diagnosis. Mean tumour size was 8.7 (1.7-26.7) cm. Three patients (3%) required an amputation. Margins were negative in 72 patients (77%). There were 2 local recurrences (2%), 10 (10.6%) developed metastases and 86 (91%) are currently alive without disease. For the 216 patients over 35 (range 36-94) years: 132 (61%) were male, 149 (69%) were in the lower extremity, 202 (94%) were primary presentations, 173 (80%) were grade 2 or 3, mean tumour size was 10.5 (1.5-34.4) cm, 19 (9%) had pathologic fractures, 13 (6%) presented with metastases, 20 (9%) required an amputation, 164 (76%) had negative margins, 29 (13%) had a local recurrence, 46 (21%) developed metastases and 147 (68%) are currently alive without disease. The tumours were higher grade in the older group (p=0.004), while mean size was not significantly different (p=0.07). Five year local recurrence-free survival was 97.6% for those ≤35 and 86.3% for those over 35 years (p=0.002). Five year metastasis-free survival 89.5% and 80.8%, respectively (p=0.02). Five year overall survival was 93.4% and 82.6%, respectively (p=0.01). On multivariate analysis, age category and pathologic fracture were statistically significant (p=0.03 and p=0.0002, respectively) for local recurrence while pathologic fracture and tumour diameter were significant for metastasis-free survival (p=0.0002 and p=0.01, respectively).

Conclusion: Patients with chondrosarcoma who were 35 years or younger had better local recurrence-free and metastasis free survival than those over 35 years.

103 Oncologic Outcomes for Patients with Myxofibrosarcoma
Shaneel Deo, ON; Anthony M. Griffin, ON; Prakash Nayak, ON; David Nikomarov, ON; Jay Wunder, ON; Peter Ferguson, ON

Purpose: Due to the infiltrative growth pattern of myxofibrosarcoma, there are reports that the local recurrence rate for this subtype of soft tissue sarcoma is much higher than for other types. Our goal was to examine both local recurrence and overall outcomes for patients treated for myxofibrosarcoma.

Method: One hundred and forty five patients treated surgically for a myxofibrosarcoma between 1989 and 2012 were identified from our prospectively collected database. Patient and tumour characteristics, treatment details, local recurrence-free, metastasis-free and overall survival were determined. Survival was estimated with the method of Kaplan and Meier.

Results: Mean age of the patients was 61 years (range 18-97 years) and 79 (54%) were male. One hundred thirty five were primary presentations, 5 of whom had concurrent metastatic disease. Ten patients presented as local recurrences. Forty-six patients (32%) had an unplanned excision at an outside centre prior to referral. Ninety-two (63%) tumours were in the lower extremity, 72 (50%) were superficial, 36 (25%) were grade 1, 37 (25%) were grade 2 and 72 (50%) were grade 3. Mean tumour diameter was 9.2 cm (median 6.5 cm, range 1-36 cm). Preoperative radiotherapy was employed in 83 cases and postoperative in 9. Flap closure and/or skin grafting was necessary in 73 cases (50%); 1 patient required an amputation. Surgical margins were negative in
121 cases (83%). Ten patients (7%) developed a local recurrence and 35 (24%) developed metastases. One hundred and three (71%) are currently alive without disease.

Estimated 5-year local recurrence-free survival was 91.8%, 5-year metastasis-free survival was 73.1% and 5-year overall survival was 68.8%. Development of metastases was dependent on grade (estimated 5-year survival was 94.1%, 75.7% and 61.4% for Grade1, 2 and 3 respectively). There was no difference in local recurrence for those who had a prior inadvertent surgical excision (log rank 0.4).

**Conclusion:** Our experience suggests that when managed with a multidisciplinary approach at a specialist sarcoma centre, the local recurrence rate of appropriately treated myxofibrosarcoma is similar to those of other soft-tissue sarcomas treated at our institution.

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**Porous Tantalum Reconstruction in Periacetabular Metastatic Bone Disease**

**German A. Norambuena, MN;** Ahmet Salduz, MN; Matthew P. Abdel, MN; Peter S. Rose, MN; David G. Lewallen, MN; Franklin H. Sim, MN

**Purpose:** Acetabular reconstruction of periacetabular metastatic bone disease is challenging especially in the setting of large bone defects and history of local radiotherapy. Extended survival expectancy in patients with metastatic disease has inspired our group to seek for more durable reconstructions. Given the low failure rates of porous tantalum acetabular implants in other conditions such as large bone defects and irradiated bone, we have developed a technic to treat these patients utilizing these implants.

**Method:** Forty consecutive patients (22 women) with periacetabular metastatic bone disease were retrospectively analyzed from 2001 to 2013. All patients were treated with our previously described technic. The median age was 61 years (range, 22–84 years). The majority of the patients had either myeloma (15 patients) or metastatic carcinoma (15 patients). The mean follow-up was 48 months (range 20-101 months). We assessed for progressive radiolucent lines and component migration on follow-up radiographs, complications and overall survival using Kaplan-Meier estimate.

**Results:** We observed no cases of progressive radiolucent lines or component migration. Complications included one perioperative death, two superficial infections, three deep infections two deep vein thrombosis, and two dislocations. One patient was revised due to instability. Fifty percent of the patients were still alive at 4 years of follow-up.

**Conclusion:** Our experience has made tantalum reconstruction our chosen method for managing major periacetabular neoplastic bone loss. A durable reconstruction is required because of improved survival in patients with metastatic bone disease.

**2014 Nutter Award Presentation**

**The Health Economic Implications of Perioperative Delirium in Older Orthopaedic Surgery Patients with Low-energy Hip Fractures**

**Michael G. Zywiel, University of Toronto**

Rajiv Gandhi, ON; Rushil Chaudhary, ON; Nizar N. Mahomed, ON; Peter C. Coyte, ON; Y. Raja Rampersaud, ON
Purpose: In the present climate of modest economic growth, rising health care expenditures, and changing models of reimbursement, there is an increasing emphasis on improving the efficiency of health care delivery. The reduction of delirium in older patients has been recognized as an important goal for improving patient clinical outcomes. However, little is known about differences in health resource utilization associated with perioperative delirium in patients with low-energy hip fractures, despite this population being at high risk for this adverse event. The purpose of the present study was to determine the incidence of perioperative delirium in elderly patients who underwent surgical treatment of low-energy hip fractures, and to evaluate its impact on length of stay and episode of care costs from the hospital perspective.

Method: A prospectively-collected adverse events database was reviewed to identify all patients 65 years of age or older who were admitted to a single specialized orthopaedic center and underwent surgical treatment of a low-energy, non-pathologic hip fracture between January 2011 and December 2012. A total of 242 patients with a mean age of 82 years (range, 65 to 103 years) were studied. Demographic, clinical, surgical and adverse events data were extracted and analyzed. Perioperative delirium was assessed prospectively using the Confusion Assessment Method (CAM). Patient care data were linked with administrative patient level micro-case costing reports. A propensity matching technique was used to control for potential confounders. Sensitivity analysis was performed by estimation of alternate models using regression with generalized linear models.

Results: One hundred sixteen of 242 patients experienced perioperative delirium during admission to hospital (48%). While patients who developed perioperative delirium were significantly older and were more likely to have a higher ASA class, there were no significant differences in time between admission and surgery, or operative time between groups. Perioperative delirium was associated with a mean incremental total length of stay of 7.4 days (95% CI 3.7 to 11.2 days; p<0.001), mean incremental length of stay following surgery of 7.4 days (95% CI 3.8 to 11.1 days; p<0.001), and mean incremental episode of care cost of $8,286 (95% CI $3,690 to $12,881; p<0.001) when controlled for potential confounders. This represented an additional cost burden equivalent to 46% of the mean total episode of care cost for patients who did not develop delirium. The total incremental episode of care costs attributable to delirium over the study period were $961,131 in 2012 Canadian dollars. Comparable results were found on sensitivity analysis with alternative techniques.

Conclusion: Almost 50% of study patients developed perioperative delirium, which was associated with significant incremental in-hospital length of stay and episode of care costs. As reimbursement schemes evolve toward greater reliance on bundled episode of care payment, perioperative delirium may have a marked impact on the financial viability of hip fracture care. The findings of the present study highlight the importance of implementing cost-effective interventions to reduce the incidence of perioperative delirium in elderly patients with low-energy hip fractures.

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Bisphosphonate Associated Periprosthetic Fractures - A New Fracture Complication for this Previously Touted Benign Therapy
Juan de Dios Robinson, NS; Ross K. Leighton, NS; Kelly Trask, NS

Purpose: To redefine the characteristics of biphosphonate associated periprosthetic fractures in patients on long term (>2 years) treatment. This fracture association has NOT been included in the definition of biphosphonate related fractures to date.
Method: This was a retrospective review of patients who presented with femoral fractures to five centres in Canada and the USA. Hospital records were reviewed from January 1st 1999 to March 1, 2012. Patients with a periprosthetic femoral fracture and a history of bisphosphonate (BAPPF) use were included and these formed a special group of previously undefined bisphosphonate related fractures. Data was recorded including age, gender, BMI, prior history of fracture, prodromal pain, history of co-morbidities, frequent falls, dementia, pre-injury function, and history of smoking. Detailed medical records including bisphosphonate use, other medication use and general health issues were also recorded from the medical records.

Results: The study included 195 patients, 175 patients with atypical femoral fractures (AFF) and 20 patients with atypical periprosthetic fractures (BAPPF). The mean age of the atypical femoral fracture (AFF) was 73 which was slightly younger than the mean age of 80 in the periprosthetic fracture group. The gender ratio was similar. The groups did not differ greatly in history with all having a prodrome of pain in the leg prior to investigation or occurrence of the atypical fracture. Time to radiographic union in the AFF group was 5 months, while in the BAPPF group showed a delayed union of 8 months. Bone Scans proved to be the most effective early test to detect this bisphosphonate induced atypical fracture. Complications were similar in both groups. However, mortality was higher in the BAPPF group versus the AFF group (9% vs 2%) but interestingly the BAPPF group returned to previous function much more predictably when compared to previously published literature of non bisphosphonate periprosthetic fractures in the elderly. It is a very different fracture to diagnose and demands a different treatment strategy.

Conclusion: Patients with periprosthetic fractures (BAPPF) on long term bisphosphonates share the same radiographic and pain related characteristics as patients who present with atypical femoral fractures. Locked plates plus a cortical strut graft allograft seems to provide the best evidence based fixation in this slow healing fracture. This is the largest series of bisphosphonate related periprosthetic fractures reported to date and should alter the classification of these bisphosphonate fractures going forward.

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Injected versus Oral Deep Vein Thrombosis Prophylactic Therapy: A Patient Satisfaction Study
Michael Pickell, ON; Daniel Banaszek, ON; Gavin Wood, ON; Aaron Campbell, ON

Purpose: Post-operative deep vein thrombosis (DVT) is a potentially life threatening post-operative complication. Rates of pulmonary embolism (PE) without prophylaxis have been reported as high as 20% in total hip arthroplasty, and 8% in total knee arthroplasty. As such, the use of post-operative DVT prophylaxis has become standard of care in patients undergoing total joint arthroplasty. Recently, there has been resurgence in usage of oral Aspirin for post-operative DVT prophylaxis. Benefits include ease of delivery, no required monitoring, and long-term safety profile. Further benefits specific to TJA include decreased rate of hematoma formation, fewer issues with wound healing, and reduced serious bleeding complications. Current studies have proven that Aspirin is as effective as injectable DVT prophylactic agents in preventing post operative DVT. Despite the mounting evidence that Aspirin is an effective DVT prophylactic agent, no studies to date have evaluated patient satisfaction with oral or injectable agents. Our study aims to elucidate patient preference for Aspirin versus injectable agents for post-operative DVT prophylaxis in TJA.

Method: This was a prospective cohort study at a single surgical center. A total of 96 patients met inclusion criteria for the study. All patients underwent a standard TKA and were started on a 2-week course of DVT prophylaxis. Patients were randomly assigned to receive either low molecular weight heparin (injected) or oral high dose aspirin (oral). All patients were seen post operatively at 2 weeks and given the patient satisfaction survey. The survey evaluated the following parameters: satisfaction with treatment, confidence in treatment,
complications of treatment, and doses missed. Each question was rated on a 10-point numeric scale. No patients were lost to follow-up. Statistics were compared using Non-parametric Mann-Whitney and Chi-square tests.

**Results:** Patient satisfaction was significantly greater in patients treated with oral DVT prophylaxis (p<0.01). Patients rated satisfaction with oral medication at 9.4 and injected treatment at 7.3. Patient confidence in the treatment was equivalent between the 2 groups (p>0.05). Only 10 patients reported a missed dose; 8 in the injected group and 2 in the oral group. The most common complication was bruising which occurred significantly more frequently in the injected group than in the oral group, 57% versus 25% (p<0.01). No patients experienced a blood clot in either treatment group.

**Conclusion:** Post-operative DVT prophylaxis with oral Aspirin is becoming increasingly accepted as a safe alternative. Patient satisfaction with their treatment regimen is an important measure that is often over looked. This study clearly demonstrates that patients prefer an oral treatment option and have no less confidence in its ability to prevent blood clots. Complications such as bruising were also found less frequently in the oral Aspirin treatment group.

**Clinical Outcome and Survival of Total Hip Arthroplasty after Acetabular Fracture: A Case-control Study**

Emil H. Schemitsch, ON; Zachary Morison, ON; Dirk Jan Moojen, Amsterdam; Aaron Nauth, ON; Jeremy Hall, ON; Michael Mckee, ON; James P. Waddell, ON

**Purpose:** The purpose of this study was to investigate the long-term clinical and radiographic results in patients who have undergone THA after an acetabular fracture as compared to patients who underwent THA for primary hip osteoarthritis.

**Method:** This retrospective case-control study compared findings of patients who underwent THA after acetabular fracture versus a matched cohort of patients who had received a primary THA for non-traumatic osteoarthritis. Eighty patients were identified from those who presented with an acetabular fracture between January 1, 1987 and March 31, 2011 at a level 1 Trauma Center and who subsequently underwent THA. The second cohort of patients was matched for date of operation, age, gender, and type of implant. The primary outcome measurements were revision and complication rates.

**Results:** The cohort of acetabular fracture patients included 55 male and 25 female patients with a mean age of 52 years (Range, 25-85 years) and mean follow up of 8.1 years (Range, 2-23 years). The majority of acetabular fractures were treated by ORIF (74%), while 23% were treated non-operatively and 3% had an acute total hip arthroplasty. The mean time between the initial treatment of the acetabular fracture and the THA was 6.2 years (SD, 5.5 years) for patients after ORIF and 5.8 years (SD, 12.9 years) for patients after non-operative treatment (p=0.941). The 10-year survival for the THA was 71.8% in those patients with a previous acetabular fracture as compared to 90.4 % for the matched cohort (p < 0.001). There was a significant difference in the time from the initial THA to the revision between patients with previous acetabular fracture (7.7 years; SD, 5.1 years) and the matched cohort (12.8 years; SD, 5.9 years; p=0.015). Patients with previous acetabular fracture had a 6.25% rate of infection and a 10% dislocation rate compared to no infections and a 2.5% dislocation rate in the matched group. The functional outcome was assessed using a standardized hip score and was found to be significantly higher in the matched cohort than the acetabular fracture group at one year post-operative and at the most recent follow-up (p< 0.01).
Conclusion: Patients with a prior acetabular fracture had a THA revision rate which was significantly higher than the matched cohort and also required a revision THA 5 years earlier than those without a prior acetabular fracture. This case-control study substantiates a higher complication rate and impaired function in patients who have undergone total hip arthroplasty after an acetabular fracture.

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Blood Conservation and Transfusion Rates in Total Joint Arthroplasty: A Ten-year Analysis
Rebecca M. Rock, AB; Doris Hawkins, AB; Diane Moser, AB; Jason Werle, AB; Charles MacAdams, AB

Purpose: The Perioperative Blood Conservation Program (PBCP) of Alberta Health Services (AHS), Calgary Zone has reported red cell transfusion rates and encouraged blood conservation measures in arthroplasty for 10 years. Transfusion reports were created to evaluate transfusion practice in the Calgary Zone and determine opportunities for improvement.

Method: Data analysts affiliated with the Quality Improvement and Health Information portfolio of AHS developed software to link Discharge Abstract Database information on surgical procedures and Laboratory Information System data on transfusion. This facilitated reporting on transfusion of red blood cells for all patients in 4 hospitals undergoing primary hip or knee arthroplasty. Tabular and graphical transfusion reports were produced quarterly, with results provided to all surgeons and anesthesiologists annually. In recent years, surgeon-specific reports have been provided to each surgeon. For 12 years, the PBCP has been responsible for autologous donation and preoperative anemia management. In 2011, the PBCP provided formal recommendations for blood conservation to the Alberta Bone and Joint Health Institute (ABJHI) which had become responsible for the arthroplasty program. These recommendations were formally adopted by the ABJHI into the provincial care pathway and include: 1) preoperative identification and treatment of low red blood cell mass 2) intraoperative use of tranexamic acid 3) application of the conservative transfusion criteria from the FOCUS Trial.

Results: Annual case volume has increased from 2260 to 3200 cases over 10 years. Representative data shows the rate of transfusion of at least one unit of red blood cells. Transfusion rates fell gradually over several years, despite near elimination of autologous collections, and most dramatically over the past two years since the adoption of the tranexamic acid protocol. Primary hip arthroplasty transfusion rates declined 20% to eight (8) %. Primary knee arthroplasty transfusion rates declined 19% to six (6) %. The very clear impact of gender on transfusion rates is consistent over the years; the rate of transfusion for females is consistently two times the transfusion rate for males.

Conclusion: Reporting on transfusion rates to surgeons and anesthesiologists, and formal adoption of blood conservation measures in the provincial care path for arthroplasty, have been associated with important reductions in transfusion rates. There is room for improvement in these results: London Health Science Centre and St. Michael's Hospital (Toronto, ON) have adopted universal application of tranexamic acid in primary hip and knee arthroplasty and report lower rates of transfusion (3.6%, 2%) and no increase embolus risk. This reporting can be improved by incorporation of data on postoperative hemoglobin levels, surgical complication rates and hospital length of stay to determine the overall impact of more conservative transfusion practice.

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A Systematic Review of the Evidence for Post-operative Antibiotic Prophylaxis in Primary Total Hip and Knee Arthroplasty
Patrick Thornley, ON; Nathan Evaniew, ON; Michael Riediger, ON; Mitchell Winemaker, ON; Mohit Bhandari, ON; Michelle Ghert, ON

**Purpose:** Consensus exists regarding the importance of antibiotic administration for infection prophylaxis perioperatively for primary total joint arthroplasty (TJA). However, controversy remains between practicing orthopaedic surgeons regarding the most efficacious choice of antibiotic agent, dose required, and postoperative duration of treatment. We aimed to conduct a systematic review to assess the best available evidence to support post-operative antibiotic prophylaxis for primary total hip arthroplasty (THA) and total knee arthroplasty (TKA). Our secondary objective was to review English-speaking orthopaedic association guidelines on TJA antibiotic prophylaxis.

**Method:** All studies reporting on intravenous perioperative antibiotic prophylaxis for the reduction of surgical site infections (SSIs) for primary THA/TKA from 1964-2014 were included. Two authors independently appraised each study for inclusion as well as assessed the level of evidence and risk of bias for all randomized controlled trials (RCTs). We conducted an additional search for antibiotic prophylaxis guidelines among the largest, primarily English-speaking orthopaedic associations.

**Results:** A total of 4,332 studies were eligible for review, with 61 studies meeting inclusion criteria. Of included studies, 26 were randomized in nature (22 RCTs, two systematic reviews and two meta-analyses of RCTs). There were four Level I RCTs and 18 level II RCTs. The majority of included RCTs were found to have an unclear risk of bias. Included RCTs demonstrated virtually unequivocal support for peri-operative antibiotic prophylaxis for primary TJA. However, the body of evidence does not support the efficacy of post-operative antibiotic regimens. Guidelines regarding antibiotic prophylaxis and post-operative duration for primary THA/TKA were available from the American Academy of Orthopaedic Surgeons (AAOS), the British Orthopaedic Association (BOA) and the New Zealand Orthopaedic Association (NZOA). The AAOS recommend antibiotic prophylaxis a minimum of one hour before skin incision, while the BOA and NZOA recommend antibiotic prophylaxis with anesthesia induction. Post-operative antibiotic prophylaxis should not exceed 24-hours (AAOS, BOA) or 24-36 hours (NZOA). The BOA and NZOA recommend no particular antibiotic agent or dose for post-operative prophylaxis.

**Conclusion:** The vast majority of RCTs addressing antibiotic prophylaxis in TJA are of unclear risk of bias. The AAOS, BOA and NZOA guidelines for post-operative antibiotic prophylaxis for primary TJA are consensus based without systematic grading of available evidence. Presently, no high level evidence exists to support the use of any post-operative antibiotic regimen, which presents inherent risks of antibiotic overuse. Strategies designed to mitigate this gap in the evidence will strengthen accepted clinical practice guidelines for TJA antibiotic prophylaxis. Continual revisions to current guidelines will respond to the emerging issue of global antibiotic resistance.

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**The Wagner Cone Stem for the Challenging Femur in Primary Total Hip Arthroplasty**

**Clive P. Duncan, BC; Michael C. Parry, BC; Mihai H. Vioreanu, BC; Nelson V. Greidanus, BC; Donald S. Garbuz, BC; Bas Masri, BC**

**Purpose:** Primary THA in the presence of proximal femoral deformity presents a challenge requiring careful pre-operative planning. We assessed the medium-term clinical and radiological survivorship of the Wagner cone femoral prosthesis when used to treat degenerative hip disease resulting from deformity of the proximal femur secondary to a variety of pathologies.
**Method:** The study population comprised 51 consecutive patients treated with the Wagner cone prosthesis, for degenerative hip disease secondary to proximal femoral deformity. Diagnoses included developmental dysplasia, Perthes disease, multiple/spondylo-epiphyseal dysplasia, take down of hip arthrodesis, post traumatic proximal femoral deformity, proximal femoral focal deficiency and the sequelae of septic arthritis. Radiographs at a minimum of 2-years (range 24-73 months) were assessed for loosening and subsidence. Clinical outcomes were assessed using the WOMAC, Oxford, SF-12, hip satisfaction scale and UCLA activity rating.

**Results:** The population comprised 31 females and 20 males with a mean age of 49 (range 15-79). No stem was revised for loosening or subsidence. Three patients (5.8%) demonstrated mild stress shielding affecting the greater and lesser trochanters only. One patient (1.9%) demonstrated stable radiolucent lines in zones 1 and 7 only which resolved over the 2-year period. Four patients (7.8%) required revision surgery for recurrent instability, 2 treated with a constrained liner, and 2 by upsizing the femoral head. One patient (1.9%) required revision for a pseudotumour secondary to a metal-on-metal articulation, and one required a subsequent trochanteric advancement for painful impingement. One patient (1.9%) developed a periprosthetic joint infection requiring two-stage revision. Clinical follow-up demonstrated a mean Oxford score of 82.5, WOMAC function score of 83.4 and pain score of 85.7, and excellent patient reported outcomes for pain relief (93.6), function (89.9), recreation (83.8) and satisfaction (91.7).

**Conclusion:** This is the first series demonstrating the use of the Wagner cone in the context of proximal femoral deformity due to a variety of conditions. The prosthesis demonstrated excellent survivorship with 100% survival of the stem for aseptic loosening and 98.1% 2-year survivorship with revision of the stem for any indication. At a minimum 2-year follow-up, patients reported good to excellent function and satisfaction. Revision for instability in this series was higher than that seen in primary osteoarthritis and may represent the complex nature of the underlying conditions.

**111 Universal Tranexamic Acid Therapy to Optimize Patient Blood Management for Major Joint Arthroplasty**

**Emil H. Schemitsch, ON; James E. Baker, ON; Katerina Pavenski, ON; Razak A. Pirani, ON; Alexander White, ON; Mark Kataoka, ON; James P. Waddell, ON; Alexander Ho, ON; Nick Lo, ON; Earl Bogoch, ON; Antoine Pronovost, ON; Katherine Luke, ON; Alanna Howell, ON; Anna Nassisi, ON; Albert K.Y. Tsui, ON; Rosemary Tanzini, ON; David Mazer, ON; John Freedman, ON; Gregory M.T. Hare, ON**

**Purpose:** Tranexamic acid (TXA) therapy reduces red blood cell (RBC) transfusion. However, this therapy remains underutilized in many surgical patient populations. We assessed whether a protocol to facilitate “universal” utilization of TXA in patients undergoing total hip and knee arthroplasty would improve the quality of patient care without increasing adverse clinical outcomes in a cost effective manner.

**Method:** We implemented a quality of care initiative to provide “universal” administration of intravenous TXA (20 mg/kg iv, preoperatively) in all eligible patients undergoing total hip and knee arthroplasty between January 1, 2012 and April 30, 2014. Analysis was performed comparing data from the 6 month universal treatment period to data from the prior period in which targeted TXA therapy was utilized to treat patients at increased risk for transfusion. Data was analyzed by adjusted logistic and linear regression analysis with Bonferroni correction (p<0.05 was taken to be significant). Adverse events were identified from the electronic records and a cost analysis was performed.
**Results:** An increase in TXA utilization from 37% to 95% resulted in a reduction in RBC transfusion rate from 9% to 5% (p=0.046); an increase in postoperative hemoglobin concentration (Hb) from 96 (14) to 101 (14) g/L (p<0.001) and a decrease in LOS (p=0.012). Universal TXA therapy had the greatest effect in primary hip arthroplasty. No increase in adverse events was observed and we estimated an overall cost reduction.

**Conclusion:** Initiation of a protocol for “universal” preoperative administration of TXA safely increased postoperative Hb and reduced RBC transfusion and LOS. Broader application of TXA therapy may increase quality of care and reduce cost to the health care system.

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**Hip Fracture Evaluation with Alternatives of Total Hip Arthroplasty versus Hemi-arthroplasty (HEALTH): Design, Rationale, and Execution of Global Trials**

**Mohit Bhandari, ON; HEALTH Investigators, ON**

**Purpose:** Hip fractures are a leading cause of mortality and disability worldwide and the number of hip fractures is expected to rise to over 6 million per year by 2050. The optimal procedure for the surgical management of displaced femoral neck fractures remains unknown. Current evidence suggests the use of arthroplasty; however, there is a lack of evidence regarding whether patients with displaced femoral neck fractures experience better outcomes with total hip arthroplasty (THA) or hemi-arthroplasty (HA). The HEALTH trial compares outcomes following THA versus HA in patients with displaced femoral neck fractures.

**Method:** HEALTH is a multi-centre, randomized controlled trial where 1,434 patients 50 years of age or older with displaced femoral neck fractures from international sites are randomized to receive either THA or HA. The primary outcome is unplanned secondary procedures and the secondary outcomes include functional outcomes, quality of life, mortality, and hip-related complications within two years of the initial surgery. We are using minimization to ensure balance between intervention groups for the following factors: age, pre-fracture living, pre-fracture functional status, American Society for Anesthesiologists class, and participating centre. Data analysts and the HEALTH Steering Committee are blinded to surgical allocation throughout the trial. Outcome analysis will be performed using Chi-square or Fisher’s exact tests and Cox proportional hazards modeling estimate.

**Results:** Enrollment for the HEALTH trial is currently ongoing. To date there are 33 active sites in Canada the United States, Norway, Australia, and Spain and 580 patients have been recruited. 28 additional sites are in various stages of start-up in Canada, the United States, the Netherlands, Spain, Finland, the United Kingdom, and New Zealand. The HEALTH trial has received local and McMaster University Research Ethics Board approval (#06-151). The HEALTH trial is registered with clinicaltrials.gov (NCT00556842).

**Conclusion:** The results of the HEALTH trial will make an important contribution to orthopaedic surgical literature and have the potential to change orthopaedic practice. Identifying the optimal arthroplasty procedure for the management of displaced femoral neck fractures has the potential to improve the lives of hundreds of thousands of patients and to reduce the economic burden associated with hip fractures. If this trial shows that one procedure is superior to the other, it will revolutionize the treatment of hip fractures globally, and may potentially lead to the establishment of new clinical guidelines for treatment of displaced femoral neck fractures. In addition to the clinical impact, the HEALTH trial also has the potential to impact orthopaedic trial conduct. With this trial we will build collaborative relationships among countries and between clinical centres.
This trial further demonstrates large scale, international multi-centre studies in orthopaedic surgery are certainly feasible.

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A Detailed Cost Analysis of Primary Joint Replacements at a Tertiary Care Centre: Show Me the Money?
Adrian Huang, ON; Geoffrey Dervin, ON; Paul E. Beaulé, ON

Purpose: Both total hip and total knee arthroplasty are included in health funding reforms and participate as quality based procedures. In this model, hospitals receive funding based on several factors, most importantly the resource intensity weights (RIW), a multiplier given to each case depending on several patient and hospital related factors. As this funding model comes into universal practice, the challenge remains to fall within funding limits for these procedures. The purpose of this study was to identify and analyze the total costs of inpatient primary total knee and total hip arthroplasty cases comprising those in the 95th percentile or higher for cost in order to provide a focused approach to cost-savings.

Method: Detailed inpatient primary total hip and total knee arthroplasty case costs were collected from our institutional database. These had been recorded as per the Ontario Case Costing Initiative (OCCI) guidelines. The costs were compiled and divided into two groups, outlier and non-outlier, where outlier costs were those above the 95th percentile for total cost and non-outlier comprised the cases below the 95th percentile for total cost. These cases were analyzed and compared both internally and externally, to provincial standards for cost, based on the quality based procedure methodology and funding.

Results: The preliminary cost analysis indicates that for total hip arthroplasty, the 95th percentile outlier cost was $15,565, while average cost for non-outlier cases (<95th percentile) was $9997. This represents a cost-minimization of approximately 36%. Similarly for total knee arthroplasty, the 95th percentile outlier cost was $13,440, while the average cost for non-outlier cases was $9470. This accounts for an approximately 30% cost-minimization. Major contributors to cost included operating room costs, implant expenses, and nursing and floor costs. Of these, only nursing and floor costs varied by group, rising from approximately 25% to 35% of total cost in the non-outlier and outlier groups, respectively.

Conclusion: Fixed costs such as operating room and implant expenses are set by hospital contract and represent approximately 55% of the total cost. The minimization of costs based on patient stay such as floor costs, medication and food expenses must be optimized in order to fall within the funding limits of the quality-based procedures. Alternative strategies such as introducing high efficiency rooms to increase the number of primary joints done within the same operating room allocation may also be utilized.

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Data Access and Measurement, Performance Reporting Central Role to Quality Improvement in Hip and Knee Arthroplasty
Christopher Smith, AB; Tanya Christiansen, AB; Don Dick, AB; Jane Squire Howden, AB; Tracy Wasylak, AB; Jason Werle, AB

Purpose: To promote adherence to the practices and protocols of an evidence-based integrated care path (ICP) for hip and knee arthroplasty.
Method: The ICP was shown in a pragmatic clinical trial to improve quality of care in the six dimensions comprising the Alberta Quality Matrix for Health – safety, effectiveness, appropriateness, efficiency, accessibility, acceptability. Working under the auspices of the Alberta Bone and Joint Health Strategic Clinical Network, we developed a multifaceted strategy to build support on the front lines for following the ICP. The strategy involved collecting and synthesizing data from multiple sources, and reporting results against evidence-based benchmarks for key performance indicators (KPI) in each quality dimension. As suggested by clinical trial results, quality of care would improve as adherence to the ICP increased. Frontline teams were formed in 2011 at Alberta’s 12 hip and knee arthroplasty sites. Central Intake Clinics were established in urban and rural areas to deliver and manage multidisciplinary frontline care. Alberta Bone and Joint Institute (ABJHI), an independent third party, collected data via individual agreements with 68 orthopaedic surgeons and Alberta Health Services (AHS). ABJHI analyzed data and reported performance results via three different mechanisms: 1) a confidential semi-annual Continuous Quality Improvement (CQI) Report to each surgeon, 2) a semi-annual CQI Report to AHS managers, 3) a quarterly Balanced Scorecard for each arthroplasty site team. Data were acquired from administrative and clinical databases and patient surveys.

Results: Results are reported from start of program in April 2010 to March 2014 (end of 2013-14 fiscal year). Mobilization on day of surgery increased to 85% from 48%. Risk-adjusted readmissions to hospital 30 days post-surgery declined to 3.60% from 3.84%. Average acute-care length of stay down to 4.0 days from 4.3 days (adds capacity patient satisfaction with in-hospital experience (8 or higher on a scale of 10) increased to 85% from 77%, based on patient surveys 6-weeks post-surgery.

Conclusion: Successful change in practice for the purpose of improving the quality of care requires: 1) ongoing access to health care performance data, 2) regular data measurement and analysis, 3) evidence-based benchmarks and performance reports using KPIs, and 4) collaboration among clinicians and administrators. An independent third party can be an effective broker of collaboration breaking down barriers to data. This strategy has produced adherence to the ICP across Alberta resulting in significant improvement in quality of care.

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Acute Proximal Pole Fractures of the Scaphoid: Natural History and Factors Associated with Union
Nina Suh, ON; Ruby Grewal, ON; Kristina Lutz, ON; Joy MacDermid, ON

Purpose: We hypothesize that by using serial computed tomography (CT) scans, we can more accurately predict the natural history of acute isolated proximal pole fractures treated non-operatively and identify risk factors which may lead to non-union and delayed union.

Method: A radiology database at a tertiary care centre was used to identify all proximal pole scaphoid fractures between 2006 and 2012. Inclusion criteria included acute fractures with CT scans performed within 6 weeks of injury. Exclusion criteria included associated perilunate dislocations or scapholunate ligament injuries and fractures treated with acute surgical management. A retrospective chart review was performed collecting demographics, injury mechanism and fixation method. CT images were reviewed to assess for fracture orientation, displacement (translation between fragments and/or humpback deformity), comminution, cysts, and sclerosis. The association between imaging and risk of non-union was determined using odds ratios and time to union using a student’s t-test.

Results: There were 40 patients identified with isolated acute proximal pole fractures treated non-operatively. Two patients were lost to follow-up, leaving 38 analyzable patients (mean age 27.3 years, 84.2% male). Based
on initial CT scan, there were 9/38 (23.7%) displaced fractures, 7/38 (18.4%) comminuted fractures, 3/38 (7.9%) with sclerosis present, and 10/38 (26.3%) with cystic changes present. All 38 patients were treated non-operatively with a short arm thumb spica cast. The overall union rate of proximal pole fractures in this cohort was 84.2% (32/38, SD 0.37) and the mean overall time to union (defined as 50% union based on CT scan) was 14.1 weeks. Of the 6 fractures that were considered non-unions, one patient was non-compliant with casting and is awaiting further management, 1 patient declined further intervention, and 4 patients healed successfully after ORIF with bone grafting. We were unable to identify any factors than increased the risk of non-union based on initial CT scan. However, presence of comminution and displacement were found to be significant factors contributing to delayed union.

**Conclusion:** In a cohort of isolated, acute proximal pole scaphoid fractures treated with casting, based on serial CT scans, we confirmed that the mean union time for casting was 14.1 weeks and the overall union rate was 84.2%. There were no radiographic characteristics identified that could be used to predict development of a non-union. However, comminuted and displaced fractures were found to significantly increase time to union. Future research is needed to determine the best treatment modality for proximal pole fractures.

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Laura Sims, SK; Geoffrey Johnston, SK

**Purpose:** The effect of distal ulna (DU) fracture on outcomes of distal radius (DR) fracture is not known. Previous studies have noted trends in outcomes but did not reach statistical significance at one year. These effects have not been examined in a large homogenous population. The purpose of this analysis was to determine the incidence of DU fractures associated with DR fractures in women 50 years and older; to classify and describe incidence DU fractures by their location; and to determine whether presence, location, and union of DU fracture impacts clinical, radiographic, and patient's self-reported outcome measures following treatment of the DR fracture.

**Method:** Data from 976 displaced DR fractures in women 50 years and older was collected prospectively. Grip strength, palmar flexion, dorsiflexion, pronation, and supination were measured at nine, 12, 26 and 52 weeks post fracture. Patient rated wrist scores (PRWE) were recorded at the same intervals. Radial inclination, palmar tilt, and ulnar variance were recorded up to 12 weeks post fracture. X-rays were then retrospectively reviewed to determine the frequency of ulnar fractures. Ulnar fractures were classified by location according to a classification system devised by the authors. Patients with pre-existing radiocarpal osteoarthritis, history of inflammatory arthritis, previous old fracture of the same wrist, multiply injured patients, and those unable to participate in clinical evaluation were excluded.

**Results:** Of the 976 distal radius fractures reviewed, 69% had associated DU fractures. Of these ulnar fractures they were categorized as to their location, those involving the styloid tip, the styloid base, those that transversed the head-styloid junction, those that oblique crossed the styloid-head junction, those involving the head, and those were proximal to the head. The prevalence of each was identified in this cohort. Non-union of the styloid fracture was commonplace. The most salient outcome feature was related to the ulnar fracture type. Fractures of the ulnar neck were associated with substantial and significant preservation of radial height or inclination, in contrast to the shortening generally seen in those with other DU fracture types.
Conclusion: The authors concluded that in this particular cohort of fractured radius, indeed the most common, an associated distal ulnar fracture occurred in 69%. A classification system deigned to capture the different types of distal ulnar fracture in this cohort was adopted. The presence of an associated ulnar fracture influenced the patient-rated wrist evaluation, and the timing of regaining grip strength. The presence of a Type 4 distal ulnar fracture was associated with preserved radial inclination.

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Biomechanical Comparison of Headless Compression Screws for Scaphoid Fixation
Adam Hart, QC; Edward Harvey, QC; Reza Rabiei, QC; Francois Barthelat, QC; Paul A. Martineau, QC

Purpose: To promote a quicker return to function, an increasing number of patients are treated with headless screws for acute displaced and even non-displaced scaphoid fractures. Therefore, it is imperative to understand and optimize the biomechanical characteristics of different implants to support the demands of early mobilization. The objective of this study was to evaluate the biomechanical fixation strength of four popular headless compression screws under distracting and bending forces.

Method: The Acutrak Standard, Acutrak Mini, Synthes 3.0, and Herbert-Whipple screws were tested using a polyurethane foam scaphoid model. Implants were inserted into the foam blocks across a linear osteotomy. Custom fixtures applied pull-apart and four-point bending forces until implant failure. Pull-apart testing was performed in three different foam densities in order to simulate osteoporotic, osteopenic, and normal bone.

Results: Pull-apart and four-point bending profiles were created for each implant type. The peak pull-apart forces, from greatest to least, were achieved by the Acutrak Standard (226N), Synthes 3.0 (186N), Herbert-Whipple (124N), and Acutrak Mini (122N) screws. The screws most resistant to bending, from greatest to least, were the Acutrak Standard, Acutrak Mini, Herbert-Whipple, and Synthes.

Conclusion: The pull-apart force is substantially reduced in osteopenic and osteoporotic bone, possibly warning against routine fixation in these patients. A crack displacement opening of more than 0.5 mm on post-operative imaging is highly suggestive of implant stripping, significant reduction in construct rigidity, and possible treatment failure. Overall, the fully threaded, conical design of the Acutrak has superior fixation strength compared to the shanked designs of the Synthes and Herbert-Whipple.

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Can Computerized Tomography be used to Predict Successful Non-operative Treatment of Scaphoid Wrist Fractures?
Ruby Grewal, ON; Nina Suh, ON; Joy MacDermid, ON

Purpose: The purpose of this study was to determine whether computerized tomography could be used to predict success with non-operative treatment of scaphoid fractures and to determine if any predictors for delayed union could be identified.

Method: A radiology data base (2004-2013) was searched to identify a cohort of simple acute scaphoid waist fractures. Simple waist fractures were identified by excluding cases presenting >6 weeks from injury, or those with CT findings associated with nonunion/delayed union (displacement, humpback deformity, comminution and/or a sclerotic border). Cases that were not given a trial of non-operative management (short arm thumb spica cast) were excluded. The x-rays, CT scans and health records for each patient were reviewed to extract data on the injury, treatment course and outcome.
**Results:** A sample of 172 patients met inclusion criteria (138 males, 34 females). The mean age was 30 ± 16 years. Nine patients had diabetes, 39 were smokers (22.7%), 82 were non-smokers (47.7%) and the smoking status was unknown in 51 patients (29.5%). Although all fractures were acute, 18 patients had evidence of cystic resorption along the fracture line on CT. The union rate for this cohort of simple non-operatively treated scaphoid fractures was 99.4% (1 nonunion/172 subjects). The mean time to union was approximately 7.5 weeks (53 ± 37 days). Smoking did not affect union rates (p=0.18) or time to union (p=0.94), nor did energy of injury, age or gender. Cysts did not affect the union rate (p=0.73) but patients with cystic resorption along the fracture line required approximately 10 weeks for union (69 ± 60 days) compared to 7 weeks (51 ± 34 days) for those without cysts (p=0.05). Diabetes did not affect the union rate (p=0.81) but was also found to increase the risk of delayed union (p=0.05). There was a weak but statistically significant correlation between the number of days before the fracture was casted and the length of time needed to achieve union (r=0.27, p=0.001).

**Conclusion:** Using CT to assess scaphoid fractures can help identify scaphoid fractures that can be expected to heal reliably (99.4%) within a short time frame (7 weeks). The presence of a treatment delay, cystic changes at initial assessment and a history of diabetes were found to be associated with delayed union. CT can be used to predict successful union of scaphoid waist fractures, allowing us to focus operative resources on those with a higher likelihood of delayed union or non-union.

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**Operative Treatment of Ulnar Impaction Syndrome: A Systematic Review**

**David J. Stockton, BC; Marie-Eve Pelletier, BC; Jeffrey M. Pike, BC**

**Purpose:** Three types of surgery exist for operative management of refractory ulnar impaction syndrome (UIS): ulna shortening osteotomy (USO), arthroscopic wafer procedure (AWP), and open wafer procedure (OWP). There is limited high-quality data available to suggest which intervention performs best with regards to subjective and/ or objective surgical outcomes. The purpose of this article is to critically and systematically review the surgical treatments for UIS.

**Method:** The electronic databases PubMed MEDLINE, Ovid MEDLINE, and Ovid EMBASE were searched. Articles were included that reported a subjective or objective outcome for adult patients who underwent USO, AWP, or OWP. Included studies were evaluated for quality using the Modified Detsky Score.

**Results:** The search yielded 479 articles. 34 articles were included in the final analysis. 13 articles had a Modified Detsky Score of 6/10 or higher. Average ulnar shortening was 3.68cm for USO, 3.13cm for OWP, and 1.11cm for AWP. Satisfaction rates were 83% for USO, 89% for OWP, and 100% for AWP. Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire scores improved from 51.4 to 14.5 for USO studies. Visual Analog Score (VAS) for pain improved from 6.7 to 2.0 for USO studies, and from 8.0 to 2.2 for OWP. The percentage of participants reporting an Excellent or Good outcome was 75.7% for USO, 87.1% for OWP, and 81.8% for AWP.

**Conclusion:** Available evidence does not support the endorsement of one surgical intervention over another. Current decisions are guided by surgeon preference and technical limitations of the interventions themselves. A common method does not exist for reporting objective outcomes for surgical treatment of UIS. Future research should focus on prospective cohort methods, and should report participant outcomes using validated subjective scoring methods such as the DASH questionnaire and VAS for pain.
Radiographic Analysis of the Wrist: How Does Distal Radius and Ulna Anatomy Correlate with Lunate Morphology?
Frédéric Charles Cloutier, BC; Parham Daneshvar, BC; Jeffrey M. Pike, BC; Thomas J. Goetz, BC

Purpose: The purpose of this study was to assess the correlation of different distal radius and ulna radiographic parameters with lunate morphology. In addition, the radiographic parameters of the wrist are compared in contralateral limbs to evaluate their similarities. We hypothesize that lunate and scaphoid facet inclinations are similar in contralateral wrists, and that increased inclination would correlate to more negative ulnar variance and type 2 lunate morphology.

Method: Posteroanterior radiographs of 50 bilateral and 40 unilateral wrists were evaluated. Radial inclination (RI), scaphoid (SFI) and lunate (LFI) facet inclinations, ulnar variance (UV), sigmoid notch angle (SNA), lunate uncovering index (LCI) and lunate type were assessed. The correlation between left and right for each parameter was analyzed. In addition, correlation between each measurement was performed to test our hypothesis. Pearson’s correlation test was used for parametric value and chi-square for nonparametric value.

Results: The distal radius scaphoid and lunate facet inclinations were 34° and 15° respectively. In contralateral limbs this correlation was strong with r=0.84 for both measurements. Contralateral radiograph also demonstrates strong correlations for RI (r=0.85), UV (r=0.78), SNA (r=0.76), and moderate correlation for LCI (r=0.66). No correlation was seen between the inclination of either scaphoid or lunate facet and UV, LCI, or lunate type. Type 2 lunates were found to have statistically significant increased obliquity of the sigmoid notch and more negative ulnar variance than type 1 lunates.

Conclusion: All parameters measured on a standard posteroanterior wrist radiograph in this study is reliable and predictive of the contralateral side. This information can be useful in the planning of reconstructive surgical procedure. No correlation was observed when scaphoid and lunate facet inclinations were correlated to ulnar variance. As demonstrated in previous studies, the sigmoid notch obliquity correlates inversely with ulnar variance. We also identified a trend that this obliquity as well as ulnar variance can also correlate with the type of lunate. Further measurements and studies will be required to correlate our findings in clinical and pathological conditions.

Rotational Anatomy of the Radius and Ulna: Surgical Implications
Parham Daneshvar, ON; Michael Lapner, AB; Ryan Willing, NY; Graham King, ON

Purpose: The purpose of this study is to provide the surgeon with some rotational landmarks for better understanding of the pathologies involving the radius and ulna. We hypothesize that the rotational anatomy of contralateral limbs are similar, and expect the location of the radial tuberosity to be opposite to the radial styloid.

Method: Computed tomography images of 98 cadaveric forearms were obtained. These included 29 bilateral arms and 40 unilateral arms. Specimens with previous bony injuries were excluded. Using MIMICS (Materialise), three dimensional models of the entire radius and ulna were obtained and analysed using Paraview (Kitware). The rotation of the ulna was analysed by assessing the location of the axis of the ulnar head and styloid with respect to the guiding ridge of the greater sigmoid notch. The rotation of the radius was
assessed by comparing the twist of the volar cortex of the distal radius, midshaft interosseous ridge, and biceps tuberosity with respect to the distal radius joint axis.

**Results:** The ulnar head had a variable internal rotation of $8.4 \pm 14.9^\circ$ with respect to the guiding ridge of the greater sigmoid notch (Range: $50.3^\circ$ internal rotation-$22.0^\circ$ external rotation) (Figure 1). The side to side difference in orientation of the ulnar heads in bilateral specimens is $8.2 \pm 8.5^\circ$ ($p=0.31$, pearson’s 0.78). The orientation of the volar cortex of the distal radius at the wrist joint line was $12.6 \pm 5.4^\circ$ in external rotation compared to the wrist joint axis (Figure 2). External rotation of the volar cortex decreased more proximally. The axis of the mid biceps tuberosity was located at $43.8 \pm 16.9^\circ$ in external rotation from the axis of the wrist joint (Range: $2.7^\circ - 86.5^\circ$) (Figure 3). The mean difference between contralateral biceps tuberosities was $7.0 \pm 7.1^\circ$ ($p=0.09$, pearson’s 0.75)

**Conclusion:** The rotational anatomy of the radius and ulna varies significantly between individuals. However, there are similarities amongst contralateral radius and ulna rotational anatomy which can be of guidance when dealing with segmental bone loss, fracture malunion, and joint reconstruction. The distal radius volar cortex has a consistent external rotation in relation to the wrist joint axis which can be of guidance during wrist arthroplasty procedures. The position of the biceps tuberosity is more anterior than previously thought. Understanding the rotational anatomy of the radius and ulna can play an important role in surgical planning.

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The Effect of Fracture Comminution on the Reliability and Accuracy of Radial Head Sizing

Irfan N Abdulla, ON; G. Daniel G. Langohr, ON; Michael Gladwell, ON; Celine Yeung, ON; Kenneth J. Faber, ON; Graham King, ON; George S. Athwal, ON

**Purpose:** Radial head arthroplasty is frequently performed for un-reconstructible comminuted fractures. Implant size is often determined using the reassembled radial head fragments. Radial head implant sizing can be based on a variety of radial head features: The maximum head diameter (D-MAX), minimum head diameter (D-MIN) and the articular dish diameter (D-DISH). The purpose of this study was to assess the reliability of different radial head sizing techniques and investigate the effect of fracture comminution on radial head measurement accuracy.

**Method:** Ten observers were asked to measure 11 intact cadaveric radial heads using three different radial head features (D-MAX, D-MIN and D-DISH diameter). All radial heads were then fractured into 2-parts and the measurements were repeated by all observers in a blinded manner. This process was then repeated for 3 and 4-part fractures. Variability was then assessed for each fracture state using intra-class correlations. The measurements of the fractured radial heads were then compared to the intact state to assess the effect of radial head fracture comminution on sizing accuracy.

**Results:** When the reliability of the three measurement techniques were compared for the intact radial head, both D-MAX and D-MIN were consistent amongst all observers (ICC: 0.980 and 0.973, respectively). D-DISH was found to be less reliable (ICC: 0.643). As comminution increased, no significant differences were detected in the reliability of any measurement (MAX, MIN, DISH, $p>0.2$). In terms of accuracy, D-MAX underestimated the diameter when the radial head was fractured (-0.4 ±0.3mm, $p<0.001$), and increasing the number of fractures, or degree of comminution, further exaggerated these findings. Introducing comminution did not significantly affect D-MIN (-0.1 ±0.3mm, $p=0.13$), while D-DISH overestimated radial head size (+0.5 ±0.4mm, $p<0.001$).
Conclusion: The D-MAX and D-MIN measurement techniques were more reliable than using the D-DISH technique. Comminution did not significantly affect the reliability of any measurement technique in this study but did compromise the accuracy. Increasing radial head fracture comminution resulted in the D-MAX measurement under-predicting radial head size, and the D-DISH technique over-predicting radial head size, both by approximately 0.5mm compared to the intact measurements. The results of the current study demonstrate that D-MAX and D-MIN measurement techniques are more reliable than the D-DISH technique when sizing fractured radial heads. Furthermore, the accuracy of the D-MIN technique was least affected by radial head comminution. Measurement technique is an important factor when selecting RH implant size particularly for comminuted fractures. The D-MIN technique of measuring radial head size was both reliable and accurate, even in the presence of fracture comminution.

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The Osseous Anatomy of the Distal Ulna: Considerations for Fracture Fixation and Implant Design
Nathan Sacevich, ON; Parham Daneshvar, ON; Graham King, ON

Purpose: To assess the osseous anatomy of the distal ulna using three dimensional modelling of 100 cadaveric specimens.

Method: 100 cadaveric arms (30 matched pair, 40 unilateral specimens) with no evidence of previous bony injury or significant arthritic change were used. Three dimensional models of the ulna were created using MIMICS (Materialize) software. The coronal plane was established as the perpendicular plane to the guiding ridge of the greater sigmoid notch of the proximal ulna. Paraview (Kitware) software was used to perform sectional analysis of ulna. Measurements of ulnar head radius, ulnar head offset, and ulnar head height were taken. Coronal plane angulation of the distal ulna was also assessed.

Results: Analysis of 70 unilateral ulna revealed a mean ulnar head radius of 9.2mm (range 6.6 - 11.8, SD 1.2). The mean ulnar head offset was 1.1 mm in a medial direction (range 3.4 mm medial to 1.5 mm lateral, SD 1.0) and 1.0 mm in an anterior direction (range 2.5 mm anterior to 0.9 mm posterior, SD 0.7). The mean ulnar head length measured 6.8 mm (range 3.9 mm - 9.9 mm, SD 1.2). The mean distal ulna coronal plane angulation measured 6.72 degrees of valgus (range 0.7 - 12.2 degrees, SD 2.8) with an apex located at a mean distance of 52.5 mm proximal to the fovea (range 32.4 mm - 76.1 mm, SD 7.8)

Conclusion: We have demonstrated considerable variability in the anatomy of the ulnar head, highlighting the challenges of anatomic restoration using ulnar head hemiarthroplasty. Furthermore, we have identified a consistent valgus angulation of the distal ulna not previously described. This angulation may have implications in distal ulna fracture fixation, arthroplasty design, and in ulnar shortening osteotomies.

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Continuous Femoral Nerve Block is not Superior to Periarticular Injection for Primary Knee Arthroplasty Analgesia
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Purpose: In Total Knee Arthroplasty (TKA), multimodal analgesia is commonly used with Periarticular Injection (PI) or Femoral Nerve Block (FNB) depending on institutional preference. This study is a prospective double-blinded randomized controlled trial comparing PI with combined Continuous Femoral Nerve Block and Posterior Capsular Injection (CFNB+PCI) with postoperative follow-up for 1 year.
Method: All patients in both groups had preoperative oral analgesia with Controlled Release Hydromorphone (CRHM), Celecoxib & Acetaminophen; FNB catheter placed under guidance; standardized spinal anesthesia; IV patient controlled analgesia; Oral analgesia with CRHM, Hydromorphone, Celecoxib and Acetaminophen from POD-1 onwards. Patients were randomized to CFNB+PCI or PI. Randomized patients received either Ropivacaine through the FNB catheter or saline as a loading dose in the OR in the CFNB+PCI & PI groups, respectively. The FNB catheter was infused with either Ropivacaine or saline until POD-2 morning and it was then discontinued. Either Ropivacaine or periarticular solution was injected in the posterior capsule of the knee and a sham periarticular injection with saline or a solution containing Ropivacaine, Morphine, Ketorolac and Epinephrine was infiltrated around the joint and skin in the CFNB+PCI & PI groups, respectively. Surgeons, anaesthetists, patients and assessors were blinded to the group assignment. Pain was measured by 10-point Likert scale twice daily on days one and two and was assessed at rest and with motion. Total pain was also assessed. ROM, walking tolerance, narcotic usage, length of stay, patient satisfaction and one year patient satisfaction, Oxford Knee Score and ROM were assessed. The study was powered for a 2-point pain difference at rest and with motion between groups (p=0.05, beta=0.2).

Results: Seventy three ASA 1-3 patients were recruited. Thirty nine were randomized to the CFNB+PCI group and 34 to the PI group. There were no differences between the groups for baseline characteristics. A non-significant trend towards reduced pain on post-op day 2 both at rest and with movement for PI versus CFNB+PCI by approximately 1-point was seen. There were no statistical differences in time in OR, length of stay, nausea, mobilization, quadriceps strength and knee range of motion at discharge. There was a small difference in quantity of hydromorphone delivered by PCA with the PI patients requiring only 3.0 versus 4.5 mg for CFNB+PCI (p=0.03). Patient reported satisfaction did not differ during the hospital stay nor at one year from surgery. At one year, knee flexion was slightly better in the CFNB+PCI group (120 versus 110 degrees, p=0.01).

Conclusion: There was no demonstrated pain control improvement with the use of a CFNB+PCI versus PI when accompanied by multimodal oral analgesics. Surgeons and anaesthetists should select whichever modality works best in their hands with the least impact to the patients and OR workflow.

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Periarticular Multimodal Drug Injection is Better than Single Anaesthetic Drug in Controlling Pain after TKA: A Double Blinded RCT
Nattapol Tammachote, Thailand; Supakit Kanitnate, Thailand; Sudsayam Manuwong, Thailand; Phonthakorn Panichku, Thailand

Purpose: Periarticular multimodal drug injection has been shown effectively reduced postoperative pain after total knee arthroplasty (TKA). But there was gap of knowledge about the efficacy of each drug and whether we need multiple drugs or only single anesthetic agent for the injection. The aim was to compare the efficacy between multimodal drug injection (group M) and single anesthetic drug injection (group S) in controlling pain after TKA

Method: In a double blinded, randomized controlled trial we randomized 64 osteoarthritic patients who underwent TKA into two groups. Spinal anesthesia was induced before surgery and periarticular injection was given to all patients. Group M received levobupivacaine 150 mg, ketorolac 30 mg, morphine 5 mg and epinephrine 0.6 mg while group S received only levobupivacaine and epinephrine. The primary outcomes were
pain level (VAS), the amount of opioid consumption (mg) and time to acquire first dose of analgesic drug (min). All patients were followed up to three months.

**Results:** Patient received multimodal drug injection had less pain level at rest and motion in the first 4 hours after surgery (VAS rest; 30 vs 46, p< 0.05, VAS motion; 45 vs 66, p< 0.05). More over they consumed less morphine in first 8 hours after surgery (5.3 mg VS 11.6 mg, p< 0.05) and had approximately two hours longer time to acquire the first dose (254 min vs 148 min, p< 0.05). There were no difference in side effects, knee motion, length of stay and knee functional score between both groups.

**Conclusion:** Multimodal drug injection provides better pain control than single anesthetic drug injection in the early recovery period. It is worthwhile to add morphine and ketorolac in periarticular injection to decrease pain level, morphine consumption and prolong analgesic effect after TKA.

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**Results of Arthroplasty in Obese versus Non-obese Patients in Alberta**

**Jason Werle, AB; Hoa Khong, AB; Chris Smith, AB; Tanya Christiansen, AB**

**Purpose:** Total hip and knee arthroplasty is one of the most successful orthopaedic interventions with significant improvements in patient quality of life and pain reduction. There is controversy in the literature regarding complication rates and outcomes in obese patients. This study assesses the risk profile and outcomes for patients with obesity (Body Max Index (BMI) >= 30) vs non-obese patients (BMI < 30) undergoing elective hip or knee arthroplasty in Alberta.

**Method:** 9265 arthroplasty patient records from Calgary, Edmonton, and Red Deer were assessed from September, 2010 to April, 2014. These records included age, gender, procedure type, BMI, co-morbidities, pre- and 3 months post-op WOMAC and EQ5D scores, and in-hospital data including adverse events. Adverse events assessed included deep infection, pulmonary embolism (PE), other medical adverse events, and mechanical adverse events related to the arthroplasty. Thirty-day readmission and 2-year revision rates were also determined based on Discharge Abstract Database (DAD) data. Risk-adjusted comparison of obese and non-obese patient cohorts was performed. Statistical methods included logistic regression and calculation of Odds Ratios (OR) and 2-year Cumulative Revision Rate (CRR).

**Results:** Of the 9265 patients, 5207 patients (56.2%) were obese (BMI >= 30). Thirty-five percent of patients underwent THR , 59% underwent TKR, and 5% had a partial knee replacement or hip resurfacing. All data was risk-adjusted based on age, gender, procedure, and co-morbidities. Obesity was a multiplicative risk factor for readmission within 30 days and medical adverse events. Obese patients with no history of prior thromboembolic disease had a 70% higher risk of PE (OR 1.7) than non-obese patients. Obese patients had a 170%(OR 2.7) higher risk of deep infection than non-obese patients. There were no differences in mechanical adverse events during the hospital stay between the cohorts. Obese patients were less likely to achieve a WOMAC score of 90 or higher at 3 months post surgery compared to non-obese patients. Obese and non-obese patients had the same quality of life at 3 months post surgery as measured by the EQ5D. Two-year cumulative revision rates were significantly higher in the obese patient cohort, with a rate of 2.70% versus the non-obese cohort rate of 1.79% (p-value <0.05).

**Conclusion:** Obese patients undergoing lower extremity arthroplasty surgery are at a higher risk of medical adverse events, especially PE and deep infection, readmission within 30 days, and revision within 2 years compared to non-obese patients. Quality of life improves to a similar level in all patients post-operatively as
measured by EQ5D but WOMAC scores are less likely to achieve a value of 90 or higher. This may have implications for patient functional outcomes. This data is important to provide to patients as part of the informed consent process and reinforces the importance of weight reduction strategies prior to surgery.

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Relationship of the Posterior Axis of the Femur with the Transepicondylar and Whiteside Line: A Guide for Rotational Alignment of Distal Segmental Femoral Prosthesis
Paul Voorhoeve, ON; Alexis Marshall, ON; David Backstein, ON

**Purpose:** Revision arthroplasty in the setting of extensive distal femoral bone loss can be challenging. In particular, determination of appropriate femoral component rotation in the absence of boney landmarks such as the epicondyles, can be difficult.

**Method:** In this retrospective study we examined 117 MRI’s of the normal knee in order to establish if a relationship exists between the transepicondylar axis and Whiteside line to the posterior axis of the femur at 9 cm above the joint line (a common resection level for distal femur replacement prostheses.)

**Results:** This study demonstrates that the posterior axis of the femur is 10 degrees (SD 3.0) externally rotated relative to the a line perpendicular to the Whiteside line or eight degrees (SD 3.2) externally rotated relative to the transepicondylar axis. This is consistent with accepted error when using either the transepicondylar axis or Whiteside line in primary knee arthroplasty where standard deviation can be as high as 4.7 degrees.

**Conclusion:** Our study shows that the posterior axis of the femur can be used as a useful landmark for femoral rotation. Because of the standard deviation found for this measurement, it should always be used in conjunction with acceptable intra-operative patellar tracking.

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External Tibial Torsion and Proximal De-rotational Tibial Osteotomy in Patients with Cerebral Palsy and Other Neuromuscular Disorders
Sebastian S. Tomescu, ON; James Donaldson, ON; William Chu Kwan, QC; John Cameron, ON

**Purpose:** External tibial torsion (ETT) is an under-reported phenomenon that affects leg biomechanics, limb alignment, and gait. Its aetiology is multifactorial with genetics, intrauterine position, and mechanical forces all playing a role. Patients with ETT often present with an apparent valgus deformity as they try to improve their foot progression angle by internal rotation and adduction of their hips. Consequently, the knee is driven medially relative to the foot causing abnormal pressure across the knee, as well as gait abnormalities, patellofemoral instability, and pain. This study investigates the outcomes of tibial de-rotational osteotomies in patients with ETT and concomitant neuromuscular disorders.

**Method:** We retrospectively reviewed 11 patients with neuromuscular conditions and excessive ETT (over 45 degrees) that underwent a proximal tibial de-rotation osteotomy. All patients presented with worsening lower limb dysfunction. The posture of the leg mimicked a crouch deformity typical of spastic conditions, such as cerebral palsy.

**Results:** The average age was 53 years (range 20 – 59 years). Mean rotational correction was 37.5 degrees. No further episodes of instability occurred in patients with pre-operative patellar instability. All but one patient
were ‘extremely satisfied’ at an average 4.2 years follow-up. Oxford knee scores improved on average from 13.4 pre-operatively to 36.9 post-operatively (p <0.05). There were no complications.

**Conclusion:** Whilst ETT is known to be associated with neuromuscular disorders, we believe this to be the first report of a cohort of patients where lower extremity function has have been significantly improved with an isolated proximal tibial de-rotation osteotomy.

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**Assessing Safety of Site Marking at the Surgical Site versus Distant Limb Sites**

James L. Howard, ON; William Moores, NL; Abigail Korczak, ON; Douglas D. Naudie, ON

**Purpose:** Previous research presents conflicting evidence on the safety of marking a limb at the surgical site. The objectives of the present study were two-fold 1) to assess colonization of a reusable skin marker following use on hip and knee arthroplasty patients and 2) to evaluate for differences in bacterial growth from primary surgical sites following skin marking within or away from the surgical site, specifically at the hip and knee.

**Method:** Patients were selected from the outpatient arthroplasty clinic at a single institution. Patients were considered arthroplasty patients if they had previously had or were currently awaiting knee or hip arthroplasty. Exclusion criteria included prior confirmed MRSA or have any current active infection. Patients were assigned to either the surgical site or distant site marking arms of the study. All utilized sites were native tissue site (ie. No local surgical scars). Three markers were used in each study arm. Each marker was used on a total of eight patients, up to four being collected in a single clinic day. Each marker was passed across an agar plate prior to each patient marking to assess for colonization of the marker tip. After site marking, either at or away from the surgical site, the surgical area was prepped using chlorhexidine and a swab taken and passed on an agar plate. Standard incubation periods were used and all bacterial colonies were evaluated for identification.

**Results:** Marker tip controls, assessing for colonization of the reusable markers, showed growth of a single bacterial colony in both study arms. The distant site control showed a single growth following the eighth patient marked which was not reproduced when that marker was re-cultured. At site control showed a single growth with one marker following the third patient marked but no growth was recorded when marker was cultured following the fourth through eighth patient. No growth was recorded in any of the 24 patients swabbed following marking at the surgical and chlorhexidine preparation. Distant site marking showed a single growth of staph epi. This growth was recorded from the first hip swabbed following marking at the ankle and standard hip preparation. No growth of staph epi was recorded in subsequent controls or test swabs of the marker used on this subject.

**Conclusion:** The current study illustrates that standard reusable site markers do not become colonized with bacteria for transfer to future patients. In addition it illustrates that bacterial growth following surgical site marking within the surgical field does not increase compared to marking the limb at a distant site. The ability to view the site marking within the surgical field following draping infers a decreased risk of wrong site surgery and its safety is supported by the current study.

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**Contribution of Surface Polishing and Sterilization Method to Backside Wear in Total Knee Replacement**

Edward M. Vasarhelyi, ON; Brent A. Lanting, ON; Kush Shrestha, ON; James L. Howard, ON; Matthew G.
Teeter, ON

**Purpose:** Polyethylene wear is a well-established detriment to the longevity of total knee replacement. While most wear occurs at the condylar surface of the polyethylene tibial insert, the backside surface has also been identified as a potential source of debris. Modern gas-plasma polyethylene sterilization is known to reduce polyethylene wear compared to historical gamma-air sterilization. The purpose of this study was to compare the relative contributions of backside wear from polished and roughened tibial baseplates and the difference between sterilization methods.

**Method:** Three groups of tibial inserts of the same design were identified based on tibial baseplate design and polyethylene sterilization: roughened gamma-air, polished gamma-air, and polished gas-plasma (n = 18). The groups were matched on implantation time, patient age, body mass index, gender, revision number (primary or first revision), and reason for revision. The magnitude of seven damage features on the backside surface of each insert was scored from zero to three, with a lower score corresponding to less damage. Each insert was also scanned with micro-CT, and deviation maps between the retrieved inserts and never-implanted reference inserts were created. Maximum penetration was measured from each deviation map. Wear rates were determined by dividing maximum penetration by implantation time.

**Results:** Total backside damage was higher (p = 0.045) in the roughened gamma-air group (13.8 ± 3.4) compared to the polished gamma-air group (8.7 ± 3.4) and the polished gas-plasma group (8.2 ± 4.8). There was no difference between groups in the prevalence of different damage modes. Maximum penetration was similarly greatest (p = 0.02) in the roughened gamma-air group (0.33 ± 0.25 mm) compared to the polished gamma-air group (0.12 ± 0.04 mm) and the polished gas-plasma group (0.07 ± 0.05 mm). Backside wear rates in the roughened gamma-air group (0.038 mm/year) was three times higher than the polished gamma-air group (0.012 mm/year) and four times higher than the polished gas-plasma group (0.009 mm/year).

**Conclusion:** Sterilization with gas plasma improved wear resistance compared to sterilization with gamma air, consistent with previous findings. With this knee system, use of a roughened tibial baseplate over a polished tibial baseplate had an even greater effect on wear magnitude than sterilization method. Tibial inserts sterilized using gas plasma implanted with a polished tibial baseplate resulted in the least amount of wear. The effect of implant locking mechanisms was not investigated but could also contribute to wear.

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**The Impact of Frontal Plane Alignment on Polyethylene Damage in Total Knee Replacement**

Matthew Teeter, ON; Pieter-Jan Vanderkerckhove, Belgium; Douglas D. Naudie, ON; Steven J. MacDonald, ON; James L. Howard, ON; Brent A. Lanting, ON

**Purpose:** Coronal plane alignment is one of the contributing factors to polyethylene wear in total knee arthroplasty (TKA). The goal of this study was to evaluate the damage patterns of retrieved tibial polyethylene inserts in relationship to the overall mechanical alignment and to the position of the tibial component in a long-term in-vivo TKA population.

**Method:** Based on full-length radiographs, ninety-five polyethylene inserts retrieved from primary TKA’s with a minimum in-vivo time of five years were analysed. Four alignment groups were compared: valgus, neutral, mild varus and moderate varus. Varus and valgus positioning of the tibial component was analysed for damage score for the neutral and varus aligned groups.
**Results:** A progression in the angle of wear was observed with progressively mechanical varus alignment (p < 0.01). The valgus group was thinner laterally and the neutral, mild varus, and moderate varus groups were progressively thinner medially. The lateral compartment had greater damage in the mild and moderate varus group compared to the valgus group (p = 0.01). There was a progression of increased lateral damage with increasingly varus alignment. No difference in damage was seen between groups for tibial component positioning.

**Conclusion:** While greater wear of the lateral compartment in valgus aligned implants and progressively greater medial compartment wear in varus aligned implants was observed, greater damage scores were observed in the lateral compartment in the mild and moderate varus aligned TKA’s compared to the valgus group. This observation is unique and might be explained by lateral condylar lift-off inducing impact and shear loading in the varus group.

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**Topical Tranexamic Acid in Simultaneous Bilateral Total Knee Arthroplasty**

Christopher Kim, MB; Herman Singh Dhotar, ON; Nizar Mahomed, ON; J. Rod Davey, ON

**Purpose:** There are numerous blood conservation strategies utilized in total knee arthroplasty (TKA) aimed at reducing the need for blood transfusion. Recently, topical tranexamic acid has been reported in studies to be an effective and inexpensive method to reduce postoperative bleeding after unilateral joint replacement. Blood management in simultaneous bilateral TKA is considered more challenging than unilateral joint replacement. The main objective of this study was to assess the effectiveness and safety of topical TA administration of patients undergoing simultaneous bilateral TKA compared with a matched control group.

**Method:** Retrospective chart review of patients undergoing simultaneous bilateral TKA was conducted at our institution. Twenty-seven patients that received tranexamic acid were age and gender matched to twenty-seven patients from a similar time frame, prior to routine tranexamic acid administration. A topical concentration of two grams of tranexamic acid per 30mL normal saline was used in each knee. Data was analyzed using a two-tailed paired t-test and Fisher’s exact test.

**Results:** There were no statistical differences in patient demographics between the groups. The rate of transfusion in tranexamic acid patients was 7.4%, compared to 74% in non-tranexamic acid patients (p<0.001). The net hemoglobin loss in tranexamic acid patients was 44g/L versus 65 g/L non-tranexamic acid patients (p<0.001). The use of tranexamic acid was found to be associated with 88% relative risk reduction (RR: 0.116, 95% CI: 0.031, 0.442) and 97% reduced odds (OR:0.028, 95% CI: 0.005, 0.150) of requiring a transfusion. There were no thromboembolic events in tranexamic acid patients, and one pulmonary embolus in the non-tranexamic acid group. Postoperative length of stay was significantly reduced in the tranexamic acid group by a mean difference of 1.037 days (p=0.005).

**Conclusion:** Topical administration of tranexamic acid in simultaneous bilateral TKA compared to age and gender matched controls, displayed significantly reduced transfusion requirements, blood loss and postoperative length of stay with no increased risk of thromboembolic events.

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**Personalized Tourniquet Systems: A New Technique for Measuring Limb Occlusion Pressure**

Bas Masri, BC; Brian Day, BC; Alastair S.E. Younger, BC; James A. McEwen, BC
**Purpose:** It is well established that the optimal surgical tourniquet pressure setting for each patient is based on the Limb Occlusion Pressure (LOP). Evidence shows that higher tourniquet pressures are associated with higher probabilities of injuries, and lower tourniquet pressures can lead to breakthrough bleeding and other complications. LOP is defined as the minimum pressure required to stop arterial bloodflow past a specific type of tourniquet cuff applied to an individual patient’s limb at a specific limb location and shape. The use of personalized tourniquet settings based on LOP has been limited by practical difficulties of manual LOP determination using Doppler ultrasound, and by limitations of the current technique of automatic LOP measurement. A new technique for measuring LOP has been developed to overcome these limitations, using a tourniquet cuff as a dual-purpose patient sensor and pneumatic effector, and no distal sensor. This initial study compares the accuracy of LOP measurements made using the new technique to LOP measurements made using the gold standard Doppler technique.

**Method:** The study was conducted on 38 surgical patients. Tourniquet cuffs with sleeves were applied to upper arms and thighs of the non-surgical limbs of each patient. Four randomized LOP measurements were taken using the Doppler technique and new technique. For the Doppler technique, LOP was measured by increasing the cuff pressure until the distal pulse could no longer be detected by a Doppler ultrasound probe. For the new technique, LOP was automatically determined using a modified tourniquet instrument that incremented cuff pressure and detected pressure pulsations in the patient’s limb using the cuff as a sensor. Blood pressures were measured before and after the LOP measurements sequence using a standard portable blood pressure monitor.

**Results:** Data was collected from 65 limbs consisting of 33 arms and 32 thighs. Error was defined as the new technique reading minus the Doppler technique reading. The mean error ± SD mmHg was +1.3 ± 12.5 for all limbs, +5.9 ± 9.0 for the arms, and -3.4 ± 14.0 for the thighs.

**Conclusion:** Initial results indicate that the new LOP measurement technique has accuracy comparable to LOP measurement by Doppler ultrasound, and that it is feasible to incorporate it into an improved personalized tourniquet system. With this, many limitations of the present technique of LOP measurement may be overcome, such as the need for a distal bloodflow sensor, which is awkward and not always responsive, particularly in the lower extremity of elderly patients. Also, the new device would save time when the tourniquet is being applied because pausing for sensor attachment and an LOP measurement would not be required. Data from additional arthroscopy, TKR and foot and ankle procedures is being collected and analyzed to further evaluate and improve the accuracy of the new technique in personalized tourniquet systems.

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**From "Surgical Gatekeepers" to "Patient Navigators": Examining Perceptions and Practices of Hip and Knee Osteoarthritis Management Among Primary Health Care Physicians**

Darren De SA, ON; Justin de Beer, ON; Danielle Petruccelli, ON; Stephen Patton, ON; Mitchell Winemaker, ON

**Purpose:** While total joint replacement (TJR) is reserved for end-stage osteoarthritis (OA), a much greater proportion of OA sufferers require non-surgical treatment. Primary health care physicians (PHCP) generally assume non-surgical OA management, referring potential TJR candidates to orthopaedic surgeons. Given the importance of PHCPs in the management of OA patients, we surveyed local PHCPs to ascertain their perceptions of/and practice patterns regarding conservative management of hip/knee OA.
Method: A cross-sectional survey was developed to determine OA management practice among PHCPs within our region. Items included conservative management, comfort level in discussing TJR, use of a regional joint assessment program (RJAP), OA diagnostic tools, and value/utility of allied healthcare, physician specialists, diagnostics, and non-surgical treatments within own practice. PHCPs were identified via the College of Physicians and Surgeons of Ontario (CPSO). VAS responses were analysed using descriptive statistics. Response variance by practice duration <10 years vs. ≥10 years was explored.

Results: Surveys were mailed to 856 active CPSO PHCPs, 85 were returned no longer in practice, and 265 completed surveys received yielding a 34% response rate. While this appears low, precision of the 95% confidence interval around the response estimate was narrow, providing a good sample of the overall PHCP frame in the region. Though the majority of respondents were in practice ≥10 years (75%), practices less than 10 years comprised a significantly greater portion of patients with hip/knee OA (24% vs. 17%, p<0.0001). PHCPs agreed x-rays play a crucial role in decision for specialist referral (7/10), placing a higher value/utility on non-weight-bearing x-ray for knee OA diagnosis (87%). Mean comfort level with discussing indications and contraindications of TJR was 6/10, and was lower for discussing TJR postoperative course (5.7/10). There was higher agreement among <10 year PHCPs regarding usefulness of RJAP to manage OA patients (<10 years=7.7/10 vs. ≥10 years=6.8/10, p=0.033), however referral is not routine (5.6/10). Top treatment modalities were weight loss, low impact exercise and oral NSAIDs, with <10 year PHCPs assigning higher value/utility to more holistic treatments.

Conclusion: Amongst PHCPs there is discordance in the conservative management of hip/knee OA, variability in comfort level of non-surgical management, and a knowledge gap in the value/utility of plain radiographs within the OA management algorithm. While PHCPs in practice <10 years are in favor of earlier intervention and practice a more holistic approach to symptom management, more senior physicians stressed greater importance of direct surgeon referral. With the role of the PHCP shifting from surgical gatekeeper to patient navigator, future efforts aimed at helping facilitate this role are needed.

Intra-operative Culture Positive Allograft Bone and Subsequent Post-operative Infections: A Retrospective Review
Laura A. Sims, SK; Allan Woo, SK

Purpose: Obtaining intra-operative culture of allograft bone prior to its use in orthopaedic procedures is standard practice in Canada. Studies examining the relationship between positive intra-operative cultures and subsequent infections are limited, with mixed results. No study has been performed in Canada or assessed the involved costs. Objectives of this study are to describe the prevalence of intra-operative culture positive allograft bone and associated post-operative infection, to determine if the organism isolated in cases of post-operative infection is the same as primary allograft culture, and to perform a cost assessment.

Method: Data was obtained from the Saskatoon Health Region Laboratory Information System Database on all patients receiving bone allograft from Jan 1 2009 to Dec 31 2012. Those who received intra-operative culture positive allograft bone were identified and a retrospective chart review was completed, identifying cases of significant surgical site infection (requiring intravenous antibiotics or re-operation in the first post-operative year). In cases where post-operative infection occurred and new post-operative cultures were obtained at the time of reoperation, the organisms isolated were compared to the original intra-operative allograft culture. Patients with ongoing infection at the time of graft implantation and those receiving tendon and soft tissue grafts were excluded. An assessment of costs associated with performing intra-operative allograft bone
cultures, prescribing prophylactic antibiotic treatment for positive results, and treatment of post-operative infection was carried out.

**Results:** From 2009-2012, 996 allograft bone grafts were used in the Saskatoon Health Region. Of these, 43 (4.3%) had a positive intraoperative culture. Five were excluded based on predefined criteria leaving 37 subjects for final analysis. Men represented 46% of subjects. Prophylactic antibiotics were prescribed in 24%. Thirteen different organisms were isolated from initial allograft cultures, with Staphylococcus Epidermidis isolated most commonly (22% of cases). Two subjects developed significant post-operative infections that required re-operation. In each case, cultures taken at the time of reoperation differed from the original allograft culture. Neither patient received specific prophylactic antibiotic therapy; however, one patient was on IV antibiotics during the entire post-operative period for a separate infection. The cost of performing 996 allograft bone cultures was $169,320.

**Conclusion:** Rates of positive intra-operative bone allograft culture are low and rates of subsequent infection in this group are rare. Further, in cases where post-operative infection occurred, primary allograft culture and secondary tissue cultures isolated different organisms. The utility of allograft culture for infection in this series was low. Costs associated with performing intra-operative allograft cultures are high, raising questions about the value of this test.

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*Not all Total Joint Replacement Patients are Created Equal: Preoperative Factors and Hospital Length of Stay*  
Justin V. de Beer, ON; Danielle Petruccelli, ON; Conrad Kabali, ON; Mitchell Winemaker, ON

**Purpose:** Despite ample support for total joint replacement (TJR) being a highly cost-effective intervention, the large burden of care and measurable costs associated with it has led to cost containment efforts. In Ontario, Canada TJR has been targeted as one of the first to be funded outside the global hospital budget as a quality-based procedure (QBP). Standardization of implants, materials and reducing hospital length of stay (LOS) are key cost saving methods that many centres have employed. The current mean LOS benchmark in Ontario is 4 days and some centres have reduced this to between 2 and 3 days. The TJR population typically represents an aged one with multiple comorbidities which has been linked to a longer hospital stay and higher in-hospital costs. To identify patient characteristics that may inform resource allocation, specifically in terms of accounting for patient complexity, a cross-sectional study of primary TJR patients was conducted to determine predictors for prolonged hospital LOS.

**Method:** Preoperative demographics, medical comorbidities and acute hospital LOS for a consecutive series of primary TJR patients from one academic arthroplasty centre in fiscal year 2011/12 were abstracted. Acute hospital LOS was categorized according to: ≤3 days, =4 days, and ≥5 days to align results with varying LOS benchmarks. Statistical analysis included descriptive statistics and regression modelling. To identify predictors for LOS, a generalized logistic regression model was fitted on a LOS ternary outcome using LOS ≤3 days as a reference category. A receiver operating characteristic (ROC) curve was used to assess the classification power of the model.

**Results:** The sample included 1459 patients comprising 61.7% total knee and 38.3% total hip, of which 57.6% were female and 42.4% male. Median age was 67 years (IQR 52-82), with 26.7% aged ≥75 years. Male gender was highly predictive of LOS ≤3 days (4 days; OR 0.48, 95%CI 0.364-0.631, ≥5 days; OR=0.57, 95%CI 0.435-0.758), as was current smoking status (4 days; OR 0.425, 95%CI 0.274-0.659, ≥5 days; OR 0.489
95%CI 0.314-0.762). Strong predictors of prolonged LOS included total hip versus total knee, age ≥75 years, ASA 3 and ASA 4 classifications, and number of cardiovascular comorbidities. The model performance was good with LOS ≤3 days, =4 days, and ≥5 days having an area under the curve of 0.73, 0.63, and 0.73 respectively.

**Conclusion:** Given the current culture to provide more care, albeit, with fewer resources there is a constant pressure to discharge patients quickly from hospital. Most would agree that aggressive discharge of patients must be balanced against concern regarding risk of complications and hospital readmission. As our data has shown, not all patients presenting for TJR are equal and the ultimate goal should be on individual patient-focused care rather than on a predetermined LOS which is not achievable for all. Hospital resource planning must account for patient complexity when planning future bed management.

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**Orthopaedic Surgical Trainees Retain Knowledge Following a Short Partner Abuse Course**

**Kim Madden, ON; Sheila Sprague, ON; Brad Petrisor, ON; Forough Farrokhyar, ON; Michelle Ghert, ON; Marium Kirmani, ON; Mohit Bhandari, ON**

**Purpose:** Intimate Partner Violence (IPV) is a serious global issue that plays a large role in the preventable morbidity and mortality rate in women. Educating clinicians about IPV can overcome barriers through actively engaging healthcare workers ultimately improving care for victims of abuse. This prospective study aimed to determine the impact of a half-day educational course on IPV for orthopaedic surgical trainees’ on knowledge and attitudes.

**Method:** Using the published literature and previous research conducted to date on IPV in patients with musculoskeletal injuries, we developed a half-day educational course. The curriculum included lectures and discussion about the basics of IPV, the current state of IPV research, what to do when a patient is a victim or perpetrator, and the orthopaedic surgeon’s role in preventing and assisting with IPV. Course participants completed a questionnaire that included general questions about their IPV knowledge, attitudes, and practices in the musculoskeletal setting and it also included a knowledge test of 25 questions. The questionnaire was administered immediately prior to, immediately after, and 3 months following the course. The scores were compared across the three different time points to determine the course’s impact.

**Results:** Thirty-three trainees (30 males and 3 females) attended the course. The mean percentage of correct answers before the course was 57% and increased to 73% after the course and was 68% three months later (F=9.505, p<0.05). 93.8% of participants agreed that IPV is an important issue, which rose to 100% immediately after the course. The largest improvement in attitude was in the question “I am skeptical that the health care system has the resources to screen for IPV.” 53.1% of trainees endorsed this statement before the course, but this dropped to 36.0% following the course and remained low at 33.3% at the 3 month follow up test.

**Conclusion:** Our findings demonstrate that a short course on IPV in patients with musculoskeletal injuries led to an improvement and retention of knowledge three months following the course. IPV education should be integrated into training programs for orthopaedic surgeons. Future projects should focus on developing and implementing a sustainable and impactful education program for health care professionals and trainees in multiple hospitals and academic centres.

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Osteoporosis Canada Needs Survey for Orthopaedic Surgeons Treating Osteoporotic Patients with a Hip Fracture

Ted V. Tufescu, MB; Heather Frame, MB; Mohit Bhandari, ON

**Purpose:** Hip fracture patients are at high risk of a subsequent fragility fracture and are almost always under the care of an Orthopaedic surgeon. This presents Orthopaedic surgeons with the opportunity to initiate osteoporosis management to prevent the next fracture. A survey was constructed by Orthopaedic surgeons and Osteoporosis Canada and administered to members of the Canadian Orthopaedic Association. The purpose of the survey was to establish Orthopaedic surgeons’ attitude and knowledge toward osteoporosis treatment in patients with a hip fracture.

**Method:** An electronic survey was constructed through consultation with Osteoporosis Canada’s Scientific Advisory Council’s Knowledge Translation Committee. Ethics board approval was acquired through the University of Manitoba. The survey was administered by the Canadian Orthopaedic Association to 841 active members practicing in Canada. Descriptive statistics were used for data analysis.

**Results:** 130 surgeons participated. Respondents were approximately evenly distributed by level of experience and academic (58%) versus community practice (42%). All subspecialties were represented, but many respondents had an arthroplasty (39.8%), general (28%), or trauma practice (27%). The majority of respondents reside in Ontario (35%), Quebec (20%), Alberta (14%), and BC (14%). 90% (n=113) of respondents currently treat hip fractures, 89% (n=102) of whom feel there is a benefit to initiating osteoporosis management in order to prevent a subsequent fragility fracture. 25% (n=29) incorrectly believe a bone mineral density scan is required prior to treatment. 42% (n=47) opt to ask the patient’s GP to initiate treatment, which has been demonstrated not to work, while 14% (n=16) take no action at all. Furthermore, 41% did not feel up to date on current osteoporosis treatment guidelines, and 35% felt they currently do not have a pathway in their institution for the care of patients with fragility fractures. 38% felt unsure of the concept of a fracture liaison service and 43% were not aware of a fall prevention program in their area. Many respondents welcomed additional education or resources to begin osteoporosis management in high-risk patients, and 80% felt a fracture liaison service specifically would be useful.

**Conclusion:** This survey identifies that while the overwhelming majority of respondents agreed there is benefit to initiation of osteoporosis treatment in post hip fracture patients, there are multiple gaps in knowledge, as well as the resources available to Orthopaedic surgeons. A principal support resource for Orthopaedic surgeons is the Fracture Liaison Service. This study supports increasing access for Orthopaedic surgeon to the Fracture Liaison Service.

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Predicting Early Clinical Function after Hip or Knee Arthroplasty

Kristi Wood, ON; Stephane Poitras, ON; Jacinthe Savard, ON; Geoffrey Dervin, ON; Paul E. Beaulé, ON

**Purpose:** Significant costs associated with arthroplasty are due to hospitalization. To reduce length of hospitalization, a clinical goal is to quickly improve functional capacities of patients following surgery. However, the validity of tools to assess function shortly after surgery has not been studied. Also, preoperative factors predictive of short-term function have not been studied. The objective of this study was to identify preoperative and postoperative factors predictive of short-term function after hospital discharge in patients undergoing hip or knee arthroplasty.
**Method:** 108 patients undergoing hip or knee arthroplasty were assessed preoperatively and one, two and three days postoperatively with the Timed Up and Go (TUG), Iowa Level of Assistance Scale (ILAS), Postoperative Quality of Recovery Scale (PQRS), and Readiness for Hospital Discharge Scale (RHDS). The Western Ontario and McMaster Osteoarthritis Index (WOMAC) was also assessed preoperatively. The Older Americans Resources and Services ADL questionnaire (OARS) was used to assess function two weeks after discharge. Stepwise multiple regressions analyses were used to assess the relationship between the preoperative/postoperative assessments and the OARS scores. Receiver Operating Characteristic curves were performed to identify cut-off points of tools significantly related to the OARS with the regressions.

**Results:** Preoperatively, the TUG and WOMAC function subscale were significantly related to the OARS score. A cut-off TUG time of 10.3 seconds yielded a sensitivity of 74% and a specificity of 62%, while a cut-off WOMAC function subscale score of 48.5/100 yielded a sensitivity of 75% and a specificity of 59%. Postoperatively, the TUG on day two was significantly related to the OARS score. A cut-off TUG time of 30.9 seconds yielded a sensitivity of 75% and a specificity of 58%.

**Conclusion:** The TUG and WOMAC function subscale assessed before surgery, and the TUG assessed two days after surgery, can predict the short-term functional capacities of patients after hospital discharge.

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**Prosthetic Joint Infections: Patterns of Practice for Diagnosis, Management and Outcome**

Mitchell Winemaker, ON; Dominik Mertz, ON; David Harris, ON; Danielle Petruccelli, ON; Tim O'Shea, ON; Justin de Beer, ON

**Purpose:** Current data demonstrate an overall prosthetic joint infection (PJI) incidence of 1.4% (1.6% hip, 1.2% knee). Although these rates are low, the absolute number is significant and continues to grow with the increased number of total joint replacements (TJR) being performed. The relative lack of well accepted guidelines in the field may result in inconsistent approaches in how PJI is diagnosed and managed.

**Method:** A retrospective cohort study of a consecutive series of hip and knee arthroplasty patients diagnosed with subsequent deep or organ/space PJI (NHSN/CDC criteria) at one tertiary care arthroplasty centre over a 5 year period was conducted to determine diagnostic strategies, infecting organism, clinical management strategies, and outcomes.

**Results:** Of 8,505 hip and knee arthroplasty cases completed over the study period, 288 (3.4%) were diagnosed with subsequent PJI including 63 (0.7%) deep infections. Of deep PJIs, 22 (35%; PJI rate of 0.2%) were knees and 41 (65%; PJI rate of 0.5%) hips, with 67% occurring after primary TJR. Infectious diseases (ID) was involved in 47 deep PJI cases (57%). S. aureus or coagulase-negative staphylococcus were the infecting organisms in 82% of deep PJI knees and 78% of hips. Preoperative or intraoperative deep specimen for culture was obtained in 24/63 (38.1%) patients. With inclusion of joint aspirates, cultures were obtained in 58/63 (92.1%) patients. Nine patients (14.3%) underwent bone scan. Cefazolin was the first line antibiotic in 52% of patients (33/63), followed by ciprofloxacin (17.5%, 13/63) and oral cephalexin (12.7%, 8/63). Fifty-three patients (84%) underwent revision surgery (20 knees, 33 hips). Hereof, 24 (38%) patients underwent irrigation and debridement (I&D) with/out liner exchange, 18 (29%) underwent one stage revision, and 11 (18%) two stage revision. Total antibiotic duration was 99.7 (±97.4) days for knees and 106.4 (±110.6) for hips, and 119.8 (±121) for I&D, 80.6 (±87.7) for one stage and 110.5 (±116) days for two stage revision. Despite large variance, we could not demonstrate any statistical differences in terms of antibiotic treatment duration, duration by treatment route, or total PJI time to clearance by joint or infecting organism.
Conclusion: We found significant variability in how PJI were diagnosed and managed, which likely reflects the relative lack of a gold standard approach for this type of recommendation and the large number of health care providers involved. Furthermore, the highly individualized nature of each PJI case presents with a unique set of circumstances. While variability could be reduced by treatment guidelines it also limits the uniform application of such guidelines in all cases.

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Similar Efficacy and Safety of Prophylactic Rivaroxaban Compared to Low Molecular Weight Heparin after TJA

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Purpose: Thromboprophylaxis following total joint arthroplasty (TJA) is the standard of care to reduce the incidence of symptomatic venous thrombolic events (VTE). While new factor Xa inhibitors have recently become available, current guidelines from the American Academy of Orthopaedic Surgeons and the American College of Chest Physicians do not favor any particular medication. As a result, some controversy remains in the orthopaedic community concerning the optimal agent. Thus, the purpose of the present study was to compare the effectiveness and safety of one factor Xa inhibitor (rivaroxaban) to two different LMWHs (dalteparin and enoxaparin) in open-label use for the prevention of VTE following TJA.

Method: The medical records of 1,643 consecutive adult patients who underwent primary TJA between March 2008 and December 2009 at a single institution were reviewed. After application of exclusion criteria, 1,496 patients (636 primary total hip arthroplasty (THA) and 860 primary total knee arthroplasty (TKA)) who had a mean age of 64 years (range, 24 to 89 years) remained in the study cohort. Initially, dalteparin was used by 515 consecutive patients, followed by rivaroxaban by the next 318 consecutive patients as part of a phase IV post-market surveillance study, and finally enoxaparin by the remaining 663 patients. All patients received thromboprophylaxis for either 10 (TKA) or 21 (THA) days, starting on post-operative day one. Demographic, clinical, and surgical information was extracted. Effectiveness was assessed in terms of differences in the rate of symptomatic deep vein thrombosis (DVT) and/or pulmonary embolism (PE). Safety was evaluated in terms of post-operative bleeding-related complications, cardiac events, and death. Backward stepwise two-stage binary logistic models were developed to compare odds of developing the efficacy and safety outcomes of interest, when controlled for potentially confounding demographic, clinical and surgical factors.

Results: The incidence of symptomatic VTE with rivaroxaban was 2.5%, which was similar to dalteparin (OR=0.56 [0.19-1.59]; p=0.272) and enoxaparin (OR=0.77 [0.31-1.92]; p=0.571). Rivaroxaban was associated with a 0.6% incidence of clinically important wound blistering and/or hematoma, which was significantly lower when compared to dalteparin (OR=7.27 [1.70-31.04]; p=0.007) but similar to enoxaparin (OR=0.46 [0.06-3.29]; p=0.460). Twenty percent of patients treated with rivaroxaban required blood transfusion post-operatively, with significantly lower odds of transfusion compared to dalteparin (OR=1.50 [1.04-2.17]; p=0.031) but no difference compared to enoxaparin (OR=0.85 [0.58-1.24]; p=0.849). No differences in adjusted cardiac complication rates or death were seen between the three groups, and no significant differences in findings were identified when stratified by procedure type.

Conclusion: No significant differences in clinical effectiveness or safety of rivaroxaban were detected compared to enoxaparin in open label, non-randomized use for the prevention of symptomatic VTE following TJA. However, dalteparin was associated with increased bleeding-related complications compared to the other
agents. This is in contrast to differences in the rate of asymptomatic DVT identified in phase III randomized controlled trials reported to date. Surgeons and patients should select between the studied classes of agents based on accessibility and ease of use, rather than differences in effectiveness and safety. Larger post-market surveillance studies are needed to confirm these findings.

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Early Surgery for Proximal Femoral Fractures is Associated with Lower Mortality: Report of 12,654 Patients from Alberta, Canada

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Purpose: Hip fracture is a common injury with associated high mortality. Early operative treatment remains a contentious issue as some studies show no clear advantage. The purpose of this study was to compare the mortality rates in patients who had operative treatment for proximal femoral fractures within 48 hours of presentation to the emergency department and those that did not. We hypothesised that the mortality rate will be significantly higher in the latter.

Method: This is a retrospective study in which administrative data were collected from multiple centres on all patients that underwent operative treatment for proximal femoral fractures, from April 2009 to 2013 in the province of Alberta, Canada. The primary outcome was the in-hospital mortality rate; hospital stay was truncated at 30 days postoperatively. Cox regression analysis was used to assess whether age, gender, Charlson Co-morbidity index as well as timing of surgery had an effect on mortality rate.

Results: Of the 12,654 patients admitted with hip fracture during the study time period, 8,503 (67.3%) were female and the average age was 77.2±14.5 years. Almost half (5,960 [47.1%]) had a Charlson Comorbidity Score of at least 1. Overall 380 (3.7%) patients died in hospital. Of the overall cohort, 4,676 (37%) received surgery within 24 hours, 2,833 (22.4%) had surgery between 24 and 36 hours, 2,959 (17.3%) had surgery between 36 and 48 hours and 2,959 (23.4%) had surgery after 48 hours of admission. After adjusting for age, sex, comorbidity (via the Charlson score), those patients who went to the operating room at >48 hours post fracture were significantly more likely to die in hospital than those who received surgery within 48 hours (Hazard Ratio 1.60; 95% Confidence Intervals 1.33, 1.92)

Conclusion: The results from this large cohort encompassing the province of Alberta, Canada from 2009-2013 demonstrate that delay in surgery by more than 48 hours has an adverse effect on in-hospital mortality. Patients presenting with proximal femoral fractures should be adequately resuscitated, medically optimised and prioritised to undergo surgery on the next available trauma list.

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Frequency of Non-accidental Mechanisms in Femur Fractures in Children Below the Age of Three Years

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Purpose: To determine the age at which femoral shaft fractures are more commonly caused by non-accidental trauma.

Method: At our institution, all femoral shaft fractures in patients below the age of three years require a work-up for possible non-accidental trauma. A retrospective chart review was performed at a Level I Pediatric Trauma
Center for all femoral shaft fractures in this age group treated within the time period from 2009-2013. The outcome of the non-accidental trauma work-up, along with standard demographic information and reported mechanism of injury, was recorded.

Results: A total of 89 patients presented to the emergency department during the study period. Of these, 24 were in the less than one-year age group versus 65 in the one to three-year age group. Non-accidental trauma was identified in 75% (18 out of 24) femoral shaft fractures in the less than one-year age group versus 15% in the one to three-year age group.

Conclusion: Non-accidental trauma is dramatically more prevalent in femoral shaft fractures in the less than one-year age group compared to the one to three-year age group. A non-accidental trauma work-up requires time and resources and often exposes families to substantial amounts of psychological stress. A standardized protocol that dictates non-accidental trauma work-up for all femoral shaft fractures under the age of three years may not be warranted, since the frequency of non-accidental trauma drops to significantly lower values after the child turns one year of age. Children older than one year of age with suspected non-accidental trauma should be referred to Child Protective Services on a case-by-case basis and research should be focused on more objective criteria with which to diagnose possible abuse in older children. Non-accidental trauma work-up should continue to be the standard of care for all femoral shaft fractures occurring in children younger than one year of age.

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Staged Double-level Limb Lengthening: A Novel Technique Resulting in Decreased Healing Index
Matthew Abbott, MI; John G. Birch, TX; Mikhail L. Samchukov, TX; Alex M. Cherkashin, TX

Purpose: Single-level limb lengthening has known problems in terms of quality of bone regenerate, long consolidation time and complications including regenerate fracture and stiffness. Attempts have been made to speed up the lengthening process using simultaneous double-level limb lengthening; however this technique has resulted in increased complications due to overstretching of soft tissues. As a result, we have proposed a technique of staged double-level limb lengthening. The purpose of this study was to compare a novel technique of staged double-level limb lengthening to standard single-level limb lengthening.

Method: We retrospectively reviewed 10 patients treated since 2006 that completed staged double-level lower extremity lengthening using circular external fixation. All patients initially underwent a single level limb lengthening of an average of 4 cm, at which point the distraction was stopped and allowed to consolidate for 6 to 8 weeks. This was followed by second osteotomy and lengthening was progressed until the desired total amount was achieved. A control group of 10 patients previously lengthened using circular external fixation with single-level osteotomy was matched primarily by diagnosis, sex, and leg length discrepancy, and the treatment and control groups were compared in terms healing index (total frame time per centimeter lengthened) and complications.

Results: Among our outcome measures, the healing index was significantly lower in the staged double-level lengthening group compared to the matched control group (1.0 month/cm vs. 1.3 month/cm; p=0.037). There was no difference in complications between the two groups.

Conclusion: In this study, staged double-level limb lengthening using circular external fixation resulted in lower healing index while not increasing the risk of complication when compared to single-level lengthening. On average, staged double-level lengthening resulted in 2.4 months less time in the frame per patient than if
the patient underwent single-level limb lengthening. Staged double-level limb lengthening offers a comparably safe technique that may result in decreased total frame time in limb lengthening patients.

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A Comparison of Femoral Lengthening in Congenital Femoral Deficiency by Circular External Fixation or Motorized Intramedullary Nail
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Purpose: Circular external fixation for limb lengthening is associated with frequent and numerous complications. Intramedullary lengthening devices represent a recent advance, but only limited experience with these devices has been published. The purpose of this study was to compare outcomes of femoral lengthening in a pediatric population treated by either circular external fixation or a motorized intramedullary nail.

Method: All patients with a diagnosis of congenital femoral deficiency who underwent femoral lengthening with either circular external fixation or a motorized intramedullary nail treated between January 1, 1990 and October 31, 2013 were identified. The intramedullary nail (FitboneTM, Wittenstein Intens, Igersheim, Germany) was used on individual FDA compassionate-use approval. Patients so treated are restricted to standard-of-care treatment and investigations; hence, this study is a strictly retrospective chart and radiographic review.

Results: Thirty-nine patients underwent forty-eight femoral lengthenings using circular external fixation and thirteen patients underwent fifteen lengthenings using the motorized nail in a retrograde femoral fashion. The amount lengthened was similar, averaging 4.7 cm (range, 1.0–9.0 cm) in the circular fixation group and 4.4 cm (range, 1.5–7.0 cm) in the motorized nail group. The overall complication rate was 94% in the circular fixation group and 120% in the motorized nail group. A subset of eight patients had undergone one or more lengthenings with circular external fixation and subsequent lengthening with the motorized nail. These patients had overall complication rates of 264% during femoral lengthening by circular fixation, compared to 160% during subsequent femoral lengthening using a motorized nail. 37% of the circular fixation group failed to achieve a lengthening goal of at least four centimeters, compared to 26% of the motorized nail group.

Conclusion: Decreased complications and improved outcomes were noted with use of a motorized intramedullary nail compared to circular external fixation in pediatric patients undergoing femoral lengthening for congenital femoral deficiency in this study.

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Detection and Non-operative Management of Paediatric Developmental Dysplasia of the Hip in Infants up to Six Months of Age: an Evidence-based Clinical Practice Guideline
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Purpose: Developmental Dysplasia of the Hip (DDH) is a spectrum of abnormalities that may not be detectable at birth. In 2000 the American Academy of Paediatrics (AAP) developed a technical report guideline of screening recommendations for detecting DDH in children with the goal of decreasing the incidence of dislocated hips diagnosed later in infancy and childhood. Using the AAOS methodology, a multi-society group has developed a new Clinical Practice Guideline (CPG) for DDH. The purpose of this report is to compare the AAOS CPG to the AAP guideline from 2000.
Method: The 2000 AAP guideline had equally weighted recommendations derived from literature review and expert opinion to provide a process of care for all typically developing infants up to walking age. The AAOS CPG, developed using standard AAOS methodology, created recommendations based upon the highest quality evidence from a systematic literature review. Recommendations included both “strength” and a rationale. This CPG focused on typically developing infants from birth to six months of age.

Results: The AAOS CPG had nine recommendations. The AAP guideline had eight. Both support clinical screening. The AAOS CPG had moderate evidence that did not support universal ultrasound screening, but did support an imaging study before six months of age for an infant with prescribed risk factors: breech presentation, family history and history of clinical instability. Limited evidence supported imaging and hip surveillance strategies to guide treatment and referral. The AAP guideline included recommendations of referral for persistent instability after two weeks of age, serial examinations at well child checks and US for infants with risk factors (breech presentation, sex, family history) and normal examination.

Conclusion: The AAOS CPG provides recommendations weighted by research evidence strength. Compared to the 2000 guideline, this CPG provides early treatment and surveillance guidance, but did not find evidence to guide decisions on referral criteria. Both guidelines had very little high quality evidence for early detection or treatment of infants with DDH. Both found evidence of risk factors that should alert the screening practitioner, but there were differences between the two. Despite an abundance of studies related to early detection and management of DDH, there is relatively little high strength research to guide practitioners. There is moderate evidence to guide screening strategies, allowing more specific recommendations to be made now compared to 2000. However, accumulation of stronger evidence will be necessary to produce a comprehensive set of sufficiently-backed recommendations.

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How Successful is Closed Reduction of the Dislocated Hip after Failed Pavlik Harness or Ring Splint Treatment?
David James Spence, Northern Ireland; David James Spence, Northern Ireland; Elaine Robinson, Northern Ireland; Aidan Cosgrove, Northern Ireland

Purpose: The aim of this study was to determine the success rate of closed hip reduction under general anaesthetic following a failed trial of Pavlik harness or ring splints in children with developmental dysplasia of the hip (DDH).

Method: This is a retrospective review of all children with a dislocated hip undergoing closed reduction in the years 2007 to 2012 in Northern Ireland. Data was obtained from the Northern Ireland DDH database, hospital notes and electronic care records. Children included in the study were those with a dislocated hip who failed a trial of Pavlik harness or ring splint treatment. Exclusion criteria included children with neuromuscular disorders and children that proceeded directly to closed reduction without any preceding splintage. All radiographs of successful reductions were reviewed and the presence of AVN was recorded.

Results: There were 1362 hips in 1073 children treated in Pavlik harness or ring splints. Forty-seven hips in 42 children failed to stabilise in Pavlik harness or splint and proceeded to arthrogram and closed reduction under anaesthesia with adductor tenotomy, if required. Mean age at time of procedure was 182 days. Eleven hips in 10 children failed to reduce under anaesthetic and later underwent open reduction. The remaining 36 hips in 32 children had successful closed reductions in theatre with application of hip spica in the human position of Salter. Of the 36 deemed successfully reduced on arthrogram, 8 hips in 6 children were found to be
dislocated or subluxed on post operative CT scan or on follow up, for these children treatment in spica was abandoned, mostly within the first few days. Therefore out of the initial group of 47 hips, 28 hips in 26 children (60%) had successful closed reductions. At an average of 2.9 years radiographic follow up 66% (18) of these hips had no evidence of AVN and 26% (seven) type I AVN with one type II and one type IV AVN changes. One patient has had a pelvic osteotomy for residual dysplasia.

**Conclusion:** For hips that failed to stabilise in Pavlik harness or ring splints, we had a 60% success rate for arthrogram and closed reduction. Therefore following failed Pavlik harness or ring splint treatment, we continue to advocate, proceeding to arthrogram with the potential for closed reduction before considering open reduction.

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**The Effectiveness of Pavlik Harness Treatment for Fixed Congenital Dislocations of the Hip**
**Alexander Aarvold, BC; Simon P. Kelley, ON; Jose Herrera-Soto, FL; Charles Price, FL; Nick Clarke, Enlgand; Kishore Mulpuri, BC**

**Purpose:** To compare treatment methods and outcomes for infants less than six months of age with dislocated but irreducible hips, in order to optimize management of this difficult patient cohort.

**Method:** A multi-center prospective hip dysplasia study database was analyzed from 2010 to 2014. All infants aged <six months with dislocated but irreducible hips were included in the study.

**Results:** Thirty six hips in 32 patients aged <six months were included. All hips were clinically and radiologically dislocated and have ≥two year follow up or remain under review. Mean age at diagnosis was 1.6 months (range 0.3 – 5.9 months). There were 24 left hips and 12 right hips. Four patients had bilateral dislocated but irreducible hips (eight hips). Pavlik treatment failed in all eight hips (one patient due to femoral nerve palsy; in the remaining six hips due to failure to achieve reduction). All required closed or open reductions. Fourteen of 24 unilateral dislocated but irreducible hips (58%), achieved successful reduction with Pavlik harness treatment alone, within 11-42 days (mean age 1.6 months, range 0.3-4.0). Pavlik treatment failed in 10 of 24 unilateral hips (42%), which required a subsequent procedure to achieve reduction (mean age 1.4 months, range 0.6 – 2.7 months). No statistical difference in age at diagnosis was demonstrated between these two groups (p=0.62). Four of 36 hips had alternatives to Pavlik treatment. Three had primary open / closed reductions (aged 3.2, 3.9 and 5.9 months at diagnosis). One patient was started in a Von Rosen splint aged 0.4 months which failed, then closed reduction, which also failed, leading to open reduction. Three complications occurred. Two patients developed femoral nerve palsy in Pavlik harness, but had subsequent successful closed reductions. One patient developed avascular necrosis at 18 months of age, having had three weeks of unsuccessful Pavlik harness treatment aged three months and a closed reduction aged 11 months.

**Conclusion:** Pavlik harness treatment has been demonstrated to be a safe and sensible first line treatment for infants with unilateral dislocated but irreducible hips up to the age of four months. Age is not a predictor of success / failure in this group. This study has not identified any success in Pavlik treatment for patients with bilateral dislocated but irreducible hips.

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**Does Isolated Gastrocnemius Tightness Predispose Children to Lower Extremity Injury?**
**Raymond W Liu, OH; Katherine K. Xie, OH**
Purpose: Gastrocnemius tightness is known to exacerbate a variety of pediatric orthopaedic foot and ankle conditions. It is unclear whether isolated gastrocnemius tightness can increase the risk of lower extremity injury in an otherwise healthy child.

Method: We prospectively studied 207 consecutive walking age children presenting to a county orthopaedic clinic with new upper or lower extremity complaints. Exclusion criteria included neuromuscular conditions such as cerebral palsy, children with combined upper and lower extremity complaints, children with spine complaints, or children previously seen by the orthopaedic clinic for any other problem. Passive ankle dorsiflexion was measured based on the lateral border of the foot versus the lower leg with the knee fully extended and the foot in inversion. In the case of lower extremity injuries contralateral ankle dorsiflexion was utilized; otherwise the two sides were averaged.

Results: Average age was 10 ± 5 years. Ninety patients presenting with lower extremity complaints had ankle dorsiflexion of 9° ± 13°, while 117 patients presenting with upper extremity complaints had ankle dorsiflexion of 15° ± 12° (P=0.0006). Of the lower extremity patients 49 presented with trauma, with dorsiflexion of 7° ± 12°, while 41 presented with no trauma with dorsiflexion of 12° ± 14° (P=0.05). 12% of upper extremity patients had 0° or less of dorsiflexion, as compared to 24% of lower extremity non-trauma patients and 41% of lower extremity trauma patients (overall Chi Squared P<0.0005).

Conclusion: Patients presenting with lower extremity complaints had more gastrocnemius tightness than patients presenting with upper extremity complaints, and within the lower extremity group patients with trauma had more tightness than patients without trauma. Isolated gastrocnemius tightness correlates with lower extremity complaints in general, and with lower extremity trauma in particular. Preventative stretching programs may be beneficial towards reducing lower extremity issues and merit further study.

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The Epidemiology and Demographics of Pediatric Supracondylar Humerus Fractures in New York State
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Purpose: Supracondylar humerus fractures (SCHF) are the most common elbow fractures in children, although the true incidence is not known. The purpose of this study was to define the incidence of complications and reoperation following the surgical treatment of SCHF in children. We hypothesized that surgeons who treat a higher volume of pediatric SCHF may have lower reoperation and complication rates.

Method: The SPARCS database (a census of New York State hospital admissions and ambulatory surgical procedures) was used to identify all SCHF in patients less than 16 years old treated in New York State between 1997 and 2009. The first admission for each patient with a SCHF was considered the index procedure. The surgeon’s license number for the primary attending surgeon is also recorded allowing calculation of surgeon volume. Patient complication and reoperation records were identified. These included Volkmann’s contracture, compartment syndrome, peripheral nerve injury, claw hand, wrist drop, cellulitis, osteomyelitis, median nerve palsy, radial nerve palsy and ulnar nerve palsy. Multivariate logistic regression analysis was used to evaluate the association of surgeon volume with the likelihood of complications and reoperation.

Results: 25,872 patients were admitted for SCHF between 1997 and 2010. The mean age was 6.6 ±4.1y. 57.4% were male and 43% were female. Within one year of initial diagnosis 71(0.3%) were admitted for a
Volkmann’s ischemic contracture, 43 (0.2%) for cellulitis or osteomyelitis, 10 (0.1%) for a nerve palsy and 923 (3.6%) underwent a reoperation. Of the 923 patients who underwent reoperation within 1 year, 773 (83.8%) were treated by a low volume surgeons (<6 cases/year) and 150 (16.3%) by a high volume surgeons (>6 cases/year). Patients treated by high volume surgeons had a lower risk of reoperation than patients treated by low volume surgeons (OR 0.61; 95%CI [0.51, 0.73]; p<0.001).

**Conclusion:** Patients treated by high volume surgeons have a lower risk of reoperation compared to those treated by a lower volume surgeon. Despite limitations inherent in the database model, the overall rate of complications and reoperations is comparable to the current literature. Further study is required to identify the specific factors that contribute to the higher reoperation rates such as patient co-morbidities, fracture complexity and surgeon characteristics (e.g. fellowship training, years in practice, practice setting, etc.).

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**Non-operative Treatment of Type IIA Supracondylar Humerus Fractures: Comparing Two Modalities**

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**Purpose:** Although the recommended treatment for Gartland Type I and Type III Supracondylar humeral fractures is well established, the treatment for type II minimally displaced fractures remains controversial. Treatment traditionally involves circumferential casting or closed reduction and pinning. At BC Children’s Hospital (BCCH), we employ hyperpronated-flexion taping for Gartland type IIA fractures, an approach that theoretically removes the external pressure caused by circumferential casting and decreases the risk of compartment syndrome while mitigating the potential loss of reduction into extension due to its flexed position. These modalities have not yet been compared.

**Method:** A retrospective chart review at BCCH was performed to compare flexion taping and cuff and collar immobilization versus traditional above elbow casting at 90-100 degrees. It was hypothesized that flexion taping of type IIA supracondylar fractures will result in comparable if not superior maintenance of reduction measured radiographically using Bauman’s angle and the anterior humeral line. Charts from 2010 to present at BC Children’s Hospital are being reviewed for all patients between the age of 2 and 8 years with a Gartland Type II fracture treated with either cast or taping.

**Results:** Preliminary findings at this point show that the casting group (n=11) and taping group (n=18) were split fairly evenly by gender and slightly more left arms compared to right. Mean age was 4.1 +/- 2.0 years across both groups. Post reduction films showed a reduction of Baumann’s angle of 6.2°± 4.8 and 3.5°± 3.1 in the taping and casting groups respectively (p=0.1684). Post reduction LHCA was 11.5°± 7.2 and 8.12°± 3.6 in taping and cast groups respectively (p=0.1492). No significant change in either measure was seen at termination of immobilization (3-4weeks post reduction): Baumann’s angle p=0.3611 and LHCA p=0.3136. The only complication was a self limiting rash experienced by one patient in the taping group.

**Conclusion:** Preliminary data has shown no significant difference in either measure at pre reduction, post reduction or at termination of immobilization. Both immobilization techniques were able to achieve and maintain an adequate reduction and improvement in measures in all cases. There were no major complications and no cases were converted to surgical treatment. Taping allows for adequate reduction and safe immobilization for Gartland Type IIA fractures comparable to that seen with traditional casting. Further research will involve further clinical/radiographic reassessment on these patients to assess remodelling and function.
Results of Operatively Treated Non-unions and Symptomatic Mal-unions of Adolescent Diaphyseal Clavicle Fractures
Sasha Carsen, BC; Donald S. Bae, MA; Mininder S. Kocher, MA; Peter M. Waters, MA; Kyna Donohue, MA; Benton E. Heyworth, MA

Purpose: The purpose of this study was to review the results of adolescents treated surgically for non-unions, impending non-unions, and symptomatic mal-unions of diaphyseal clavicle fractures, which are rare complications of primary non-operative treatment.

Method: Records of all patients 10-18 years-old who underwent surgery at a single tertiary-care children’s hospital between 2003-2013 for a symptomatic mal-union, non-union (> 6 months from fracture), or impending non-union (1-6 months post-fracture) of a diaphyseal clavicle fracture were reviewed. Demographic data, radiographic features (e.g. fracture pattern), operative details, and post-treatment course were analyzed and compared to an age-matched, sex-matched, and fracture pattern-matched control group of adolescents who underwent plate fixation as primary fracture treatment.

Results: Sixteen patients (56.3% male; mean age 15.4 years, range 12.4-17.7 years) met inclusion/exclusion criteria. Most (87.5%) were initially treated at an outside hospital. Plate fixation with or without osteotomy was performed in 14 cases (87.5%), with bone grafting pursued in 13 cases (81.3%), which included either iliac crest autograft (n=4; 30.8%), local bone graft (n=4, 30.8%), cancellous allograft (n=1; 7.7%), or local graft + cancellous allograft (n=4; 30.8%). Two mal-union patients (12.5%) underwent ostectomy only. Comparative analysis showed time from injury to surgery was 9.4 months in the non-union (NU) group (n=6), 2.2 months in the impending non-union (IN) group (n=6), 19.8 months in the mal-union (MU) group (n=4), and 0.4 months in the control (C) group (n=15) (p<0.001). Time from surgery to union was 4.1 months for NU, 2.7 months for IN, 2.9 months for MU, and 2.9 months for C (p=0.99). Time from surgery to a return to sports was 4.3 months for NU, 3.6 months for IN, 2.6 months for MU, and unavailable for C. Removal of hardware was performed in 3 of the 14 cases (21%) where it was implanted, and in 3 of 15 (20%) control subjects.

Conclusion: Adolescents who underwent surgery for diaphyseal clavicle fracture non-union, impending non-union or symptomatic mal-union demonstrated bony healing and returned to sports within 2-4 months, with a comparable post-operative course and rate of subsequent hardware removal as those patients treated with plate fixation for their primary clavicle fracture. For the rare instance of slow, failed, or painful healing following non-operative treatment of diaphyseal clavicle fracture in adolescents, surgery may represent a viable treatment option, with a similar post-operative course and safety profile to primary plate fixation.

Outcomes of Operative and Non-operative Treatment of Adolescent Mid-diaphyseal Clavicle Fractures
Sasha Carsen, BC; Benton E. Heyworth, MA; Collin May, MA; Kyna Donohue, MA; Patricia Miller, BC; Dennis Kramer, MA; Mininder S. Kocher, MA; Donald S. Bae, MA

Purpose: The optimal treatment approach to mid-shaft clavicle fractures in adolescents remains an area of significant controversy. The purpose of this study was to review the demographic characteristics, treatment approaches, and complications reported in a large series of clavicle fractures treated with surgical and non-surgical treatment in an exclusively adolescent population.
Method: Radiographic and chart review was conducted for all cases of patients ages 10-18 years-old who presented to a single tertiary care children's hospital between 2003-2012 with a mid-diaphyseal clavicle fracture. Demographic data, clinical and radiographic features, such as fracture pattern, operative details when applicable, and post-treatment clinical course was analyzed, including any known complications.

Results: Out of 641 cases reviewed (79% male; mean age 14.6 years, range 10-18 years), 408 (64%) fractures were sustained during sports, most frequently football (25%), hockey (18%), soccer (12%), snowboarding (12%) and skiing (9%). Other common mechanisms of injury were falls sustained outside of athletic activity (19%) and motor vehicle accidents (5%), with similar distribution of mechanism of injury and similar rates of associated injuries seen within the operative (5%) and non-operative (6%) treatment groups. Among the overall cohort, 82% were treated non-operatively, while 18% were treated surgically, with increasing annual percentage of patients undergoing surgery over the course of the study period. The mean age was higher in the operative group (15.8 years) than the non-operative group (14.3 years)(p<0.001). Documented complications occurred in 46 patients (7.2%), were significantly more common in the operative (16.2%) group than the non-operative (5.2%) group (p<0.001), and were more common in older patients (p<0.001). One case of non-union occurred in both the non-operative group (0.2%) and operative group (1%). The rate of symptomatic malunion was 2% in the non-operative group, with older patients being more likely to have a symptomatic malunion (p=0.03). The rate of symptomatic hardware was 13% in the operative group, leading to plate removal in 9% cases. Rates of re-fracture were 3% and 2% and in the non-operative and operative groups, respectively. No infections were reported in either group.

Conclusion: Greater numbers of clavicle fractures are being seen in the adolescent population, with over 60% of cases occurring during sports, and an increasing trend towards operative treatment in recent years. Complication rates appear to be more common following operative management, the most common of which is symptomatic hardware. Prospective clavicle fracture research is needed to better understand optimal treatment selection in the adolescent population.

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Purpose: To study how the systematic use of intraoperative skull-femoral traction (IOSFT) in posterior arthrodesis for Adolescent Idiopathic Scoliosis (AIS) impacts perioperative outcomes and health resource utilization.

Method: Retrospective, single-center cohort study. Seventy-three consecutive patients with AIS who underwent single stage posterior spinal arthrodesis from 2008 to 2012 at a tertiary children’s hospital were identified. Forty-five patients were operated with IOSFT (traction group) and twenty-eight patients were operated without IOSFT (non-traction group). Outcome measures included operative time, calculated blood loss, blood transfusion requirement, traction related complications and cost comparisons.

Results: Operative time was 375.6 min for the traction group (p=0.0001) and 447.6 min for the non-traction group. Calculated blood loss was significantly less in the traction group (p=0.027). Thirty-three percent of patients in the traction group required blood transfusion, as compared to 64% of patients in the non-traction group (p=0.01, absolute risk reduction of 31%). There was no significant difference in curve magnitude
correction (p=0.49). There were no significant complications with the use of traction. There was a significant reduction in cost per surgical procedure in the traction group (p=0.0003).

**Conclusion:** The systematic use of intraoperative skull-femoral traction in posterior arthrodesis for adolescent idiopathic scoliosis contributed to significant reductions in operative time, calculated blood loss, and blood transfusion requirement, thus resulting in lower perioperative costs and improved health resource utilization. There were no significant complications or added morbidities associated with the use of IOSFT. Thus, the systematic use of IOSFT resulted in significantly improved perioperative outcomes with no added morbidity supporting the use of IOSFT as an adjunct to posterior arthrodesis in AIS. Improved health resource utilization resulted in improved access to surgical care for children. This is a hypothesis generating study, which offers a starting point for multicenter prospective observational studies including centers where the systematic use of IOSFT is not routine practice, and where posterior arthrodesis for scoliosis is performed with an otherwise similar process. Further research is required to investigate the generalizability of our findings and to study the effect of IOSFT on patient based outcomes.

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**An Updated Algorithm for Radiographic Screening of Upper Cervical Instability in Patients with Down Syndrome**

Maryse Bouchard, WA; Walter F. Krengel III, WA

**Purpose:** There is scant evidence in the literature regarding the best approach for radiographic screening of upper cervical instability in patients with Down syndrome. There is also controversy as to what a “normal” radiographic measurement should be considered in this population, as many have slightly “abnormal” findings without evidence of myelopathy or instability. The purposes of this paper are to determine the best radiographic studies for screening of upper cervical instability in patients with Down syndrome; and to establish normal radiographic measurements in this population.

**Method:** This study is a retrospective evaluation of 187 lateral cervical spine radiographs in children with Down syndrome that compares the effectiveness of a neutral lateral upright x-ray (NUL) to a full series of cervical spine views in identifying patients at risk of upper cervical instability. On neutral upright lateral x-rays, we measured the atlantodental interval (ADI), space available for cord at C1 (SAC), and basion axial interval (BAI). On flexion/extension lateral x-rays, the same measurements were performed on all images, as well as the Wiesel-Rothman (WR) measure.

**Results:** SAC measurements obtained in NUL, flexion and extension films were not significantly different (NUL vs flexion, p=0.900; NUL vs extension p=1.000). ADI measurements were not significantly different between NUL and flexion films (p=0.501). ADI was significantly different between NUL and extension films (p=0.000), however the difference mean ADIs between the two views is not clinically significant (3.13±3.03mm in neutral and 2.33±2.45mm in extension). Normal ranges for measurements (mean +/- 2SD) were 0-6mm for ADI, 14-24mm for SAC, -12-5mm for BAI, and <7mm for WR.

**Conclusion:** Our data suggest that obtaining a neutral upright lateral cervical spine x-ray is the most effective method of performing radiographic screening, and we provide “normal” values for the common radiographic measurements used in assessing risk of atlanto-axial and atlanto-occipital instability in patients with Down syndrome.

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Pelvic Incidence is Associated with Proximal Junctional Kyphosis in Patients Treated with Growing Rods

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Purpose: Pelvic incidence is considered a constant parameter in the child, and abnormal pelvic incidence has been associated with increased risk of failure in scoliosis surgery. We investigated whether pelvic incidence can vary during growing rod treatment, and if it is associated with failure in children with growing rods.

Method: We studied 48 patients treated for early onset scoliosis who underwent growing rod treatment with at least two year follow up from our prospective database. Age, gender, type of scoliosis (idiopathic, neuromuscular, congenital), and duration of follow up were recorded. Pelvic incidence was measured on 25 preoperative, 40 first upright and 48 final postop radiographs which included visible hip joints. Proximal junctional kyphosis and lordosis was defined based as a 10° or greater increase in the proximal junctional angle on final postop images compared to preoperative images. Failures included rod fracture, pedicle screw pullout, hook dislodgement, hook erosion, and proximal junctional kyphosis.

Results: Average age at initial treatment was 7±3 years, with 35 females and 13 males. Thirteen patients were idiopathic, 30 were neuromuscular and 5 were congenital. Mean follow up was 97 months (range: 24 – 264 months). Mean pelvic incidence was 48°±17° preop, 49°±14° at first upright, and 51°±19° at final follow up. Repeated measures ANOVA on 22 patients with all three values found no statistical difference in pelvic incidence throughout the three films (P=0.66). Twenty-two patients had an average of 2 failures. Of 22 patients with measureable preop and final postop images, eight fulfilled criteria for proximal junctional kyphosis. Multiple regression analysis with Bonferroni correction found that: younger age (P<0.0005) was associated with increased overall failure and congenital etiology (P=0.022) was associated with decreased overall failure rate. Younger age (P=0.017), female gender (P=0.001) and lower pelvic incidence (P=0.021) were all associated with increased proximal junctional kyphosis.

Conclusion: Pelvic incidence remained constant throughout the course of growing rod treatment. Lower pelvic incidence was associated with increased proximal junctional kyphosis. When treating growing rod patients with decreased pelvic incidence, increased attention should be paid to sagittal plane balance to avoid proximal junctional kyphosis.

The Impact of Living with Adolescent Idiopathic Scoliosis (AIS): A Utility Scores Assessment

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Purpose: Minimal information exists on the health burden of living with AIS. Utility scores represent the health burden of a disease and can be used to help advocate for and appropriately allocate health care resources towards the disease. The authors set out to quantify the perceived health state utility of living with AIS.

Method: Adult subjects were approached to participate in this study and were recruited from the general population. One hundred and seventeen subjects completed a survey consisting of validated utility outcome measures including the visual analog scale (VAS), time trade-off (TTO), and standard gamble (SG) tests for a scenario of living with AIS. Monocular and binocular blindness were used as controls. Demographic information was collected to assess for any socioeconomic predictors of health utility. Linear regression and Student t tests were used for statistical analysis.
Results: Age, gender, income, and education as independent predictors of each of the utility scores for AIS showed no statistically significant difference (p>0.05). All measures (VAS, TTO, and SG) for AIS (77±16.4, 0.90±0.11, and 0.91±0.13, respectively) showed a significant deviation (p<0.001) from healthy state values (100,1, and 1 respectively). They were significantly less severe (p <0.001) than the corresponding scores for monocular blindness (62.2±19.9, 0.85±0.16, and 0.83±0.9, respectively) and binocular blindness (35.2±19.5, 0.63±0.27, and 0.63±0.28, respectively). The TTO and SG revealed that patients were willing to trade off 3.6 years of their remaining life and to accept a theoretical 9% chance of mortality to not have to live with scoliosis.

Conclusion: Utility scores revealed that AIS patients live with a significant health burden and are willing to trade off 3.6 years of their life and take a 9% chance of mortality to not have to live with AIS. This and future studies quantifying the health burden of AIS will allow for improved advocacy for health care resources towards the treatment of scoliosis.

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Internet-administered Health Related Quality of Life Questionnaires Compared to Pen and Paper in an Adolescent Scoliosis Population: A Randomized Crossover Study
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Purpose: Modern technology puts into question the effectiveness of using pen and paper as a means of collecting information from web-enabled patients. This study aimed to validate and test the reliability of using the internet as a method of administering health related quality of life (HRQoL) questionnaires in a pediatric spine population.

Method: A prospective randomized crossover study was conducted. Patients aged 11-18 with idiopathic scoliosis were invited to participate and informed consent was obtained from a scoliosis outpatient clinic setting. Participants were randomized to one of four groups determining the method of questionnaire administration (SRS-30 and Pediatric Outcomes Data Collection Instrument (PODCI)). Both questionnaires were completed at two separate time points, two weeks apart to prevent recall bias. Participants were given an additional two weeks to return the second group of questionnaires. Groups included: Paper/Paper, Paper/Internet, Internet/Paper, and Internet/Internet. Paired sample T-tests were used to determine the test-retest reliability of each group. Analysis was stratified for surveys returned within or outside of the allotted four week time frame following enrollment.

Results: Ninety-six participants completed and returned both sets of questionnaires. Twenty-six participants were allocated to the Paper/Paper group (27%), 20 to the Paper/Internet group (21%), 26 to the Internet/Paper group (27%), and 24 to the Internet/Internet group (25%). Sixty-nine of the participants (71.2%) returned the second set of questionnaires on time. Of the late questionnaires, 18 (67%) were paper forms. Overall, no differences were observed between internet-administered compared to pen and paper administered questionnaires (p = 0.206). No differences were observed within any group individually for either the SRS-30 or PODCI questionnaire. Additionally, no significant differences were observed within groups for surveys returned within or outside of the four week time frame. 84% of the participants who completed both paper and internet versions of the questionnaires reported a preference of the internet.

Conclusion: Internet-administration of both the SRS-30 and PODCI questionnaires is a valid and reliable method of acquiring health related quality of life information in this population. The ability to use the internet as a method of questionnaire administration can increase the efficiency of data collection, and reduce any
problems associated with pen and paper questionnaires, including; postage and stationary costs, and time required for data input and analysis. Among a technology enabled population, consideration should be given to internet-administered questionnaires instead of the traditional pen and paper method.

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Vertebral Fractures in Duchene's Muscular Dystrophy Patients Managed with Deflazacort
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Purpose: We sought to establish the relationship between deflazacort use and vertebral fractures in patients with Duchene’s Muscular Dystrophy (DMD).

Method: We retrospectively reviewed 49 boys with DMD on long term deflazacort therapy for incidence of vertebral fractures (VF) and its association with age at start of deflazacort treatment, duration of deflazacort treatment, Bone Mineral Density Z-score (BMD Z) and whether the patient was ambulatory at the time of fracture.

Results: Twenty-six out of 49 boys on long-term deflazacort treatment had VF. Out of 26 patients who had VF, 15% showed evidence of VF in their third year of therapy, 50% within five years of starting therapy, 73% within seven years of starting therapy, and within nine years 100% had VF. The first evidence of VF was observed at a mean BMD Z score of, lumbar (L) = -2.2 and whole body (B) = -3.1. Eighty-five percent of these had more than three collapsed vertebrae. Mean BMD Z-score at the time of or prior to when multiple fractures were noted was -2.4 (L) and -3.4 (B). The patients who started deflazacort at age three to five years developed a VF after a mean of 59.6 months, those who started at age five to seven years after a mean of 67.8 months, and at an age greater than seven years after a mean of 62.8 months. Sixty-two percent of patients had VF by 12 years of age and 91% of patients by 15 years of age. Sixteen out of 26 patients were ambulatory at the time of VF.

Conclusion: Our findings suggest that there is a high risk of VF associated with deflazacort use in DMD patients. Additional therapy, such as pamidronate, should be considered in patients on long term Deflazacort.

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Health-related Quality of Life Outcomes in Paediatric Literature
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Purpose: Assessment of health-related quality of life (HRQoL) is being increasingly utilized and recognized as a primary measure of success and impact of health care services. At present, there is no consensus on HRQoL evaluation in pediatric orthopaedic surgery. The purpose of this study is to quantify the use of HRQoL outcome measures among original articles in prominent journals used by pediatric orthopaedic surgeons and to determine how the frequency has changed over time.

Results: A total of 117 (2%) original articles were identified from the six selected journals, during the specified time points, which used HRQoL assessment tools in pediatric populations. We included both generic and disease-specific HRQoL tools, all of which were self-administered by patient or proxy. The number of articles utilizing HRQoL tools has increased from two in the year 2000 to 49 in the year 2013. Spine published the highest number of original articles 47/117 (40%) using HRQoL measures; primarily due to the use of the SRS HRQoL questionnaires. The most frequently used HRQoL outcome measures were SRS, PODCI, SF-36, CHQ, and AOFAS Hind-foot. Only 50% of the HRQoL outcome tools identified were developed or validated for use in pediatric populations.

Conclusion: The use of HRQoL outcome measures in pediatric orthopaedic literature is evolving. Over the past 13 years there has been an increase in the use of HRQoL outcome measures in pediatric orthopaedic literature. The overall proportion remains low amongst original clinical publications at 2%. The most commonly used HRQoL tool was the SRS tool, followed by the PODCI. There is still widespread use of non-pediatric designed or validated measures. Further efforts are necessary to develop, validate and utilize pediatric-specific HRQoL tools to determine the effect of clinical intervention on all aspects of quality of life in children.

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Is Acetabular Rim Trimming Safe and Effective for Idiopathic Femoroacetabular Impingement in the Adolescent Patient?
Kevin Smit, TX; Daniel Sucato, TX; David Podeszwa, TX; Adriana DeLaRocha, TX

Purpose: Femoroacetabular impingement (FAI) has been most commonly treated with a femoral osteochondroplasty to address the cam-type impingement with overall good results. There is a paucity of published results in the pediatric population evaluating the effectiveness of acetabular rim trimming and labral reattachment to improving clinical and radiographic outcomes for pincer impingement

Method: This is a prospective analysis of consecutive patients with symptomatic idiopathic FAI treated with SHD from 2004-2013 at a single institution. Pre-operative and post-operative radiographs and functional scores (modified Harris Hip Score (HHS) and the Hip disability and Osteoarthritis Outcome Score (HOOS)) were compared for SHD combined with acetabular rim trimming to those who underwent femoral head/neck osteoplasty alone.

Results: There were 50 hips in 45 patients with idiopathic FAI (13 male, 32 female) at an average age of 16.4 years (range 11.8-19.6 years) and BMI of 24.4 (17.1-40.2). All subjects presented with anterior groin and/or lateral hip pain and all had a positive impingement sign. There were 14 patients in the acetabular rim trimming group (ART) and 36 in the femoral osteoplasty group (FOC). All patients in the ART had labral reattachment. There were no differences in age or gender. Preoperatively, there were no differences between the ART and FOC groups in hip flexion (96.4 vs 99.3 º) or internal rotation (30.0 vs 30.7º), however, the ART group had a larger LCEA (33.1 vs 28.5º, p=0.002), without difference in acetabular index (5.1 vs 5.7º) or alpha angle (64.2 vs 64.1º). The ART group demonstrated a significant improvement in the LCEA (-3.0 vs 1.2º, p<0.05) while the FOC group demonstrated greater improvement in the alpha angle (-10.8 vs -14.0 º, p<0.05).

The HHS and HOOS scores improved at follow-up in the ART (71.6 to 90.9, p=0.006) (69.5 to 79.3, p=0.002) and FOC groups (64.3 to 82.9, p<0.001) (57.6 to 79.3, p<0.001), respectively. There weren’t any reoperations in the ART group. In the FOC group, 3 patients required reoperation. These procedures included removal of screws for implant irritation (1), labral repair for an acute tear (1) and arthroscopic labral debridement for a degenerative tear.
Conclusion: Acetabular rim trimming improves the radiographic parameters of pincer impingement and, when added to a femoral osteochondroplasty leads to significant improvement in clinical scores without additional complications. An acetabular rim trimming is safe and effective when it is deemed appropriate in the adolescent patient with symptomatic femoroacetabular impingement.

Gastrocnemius Recession Compared to Tendo-achilles Lengthening for Surgical Correction of Equinus Deformity in Children with Cerebral Palsy: Are we Under or Over Correcting Based on Gait Analysis?
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Purpose: Equinus is a common deformity in children with cerebral palsy (CP). There is significant concern of iatrogenic weakening of the gastrocsoleus complex with surgical correction of equinus deformity. Weakening of the gastrocsoleus complex secondary to over lengthening can lead to calcaneus deformity and crouch gait. The current standard of care is single-event multi-level surgery with a focus on cautious lengthening of the of the gastrocsoleus complex to preserve its integrity and ankle plantar flexion power. The goal of this study was to compare pre-operative and post-operative gait analysis data in patients with CP who had either a gastrocnemius recession (GR) or tendo-achilles lengthening (TAL) for correction of equinus deformity to identify differences in outcome between these two interventions and assess for evidence of over or under-correction.

Method: Patients with a diagnosis of CP who presented for pre-operative and post-operative computerized gait analysis were retrospectively identified from a gait analysis database. A chart review was completed to identify patients who had undergone surgical correction for an equinus deformity with either a GR or TAL. Pre-operative and post-operative sagittal plane kinetic and kinematic gait analysis data was analyzed. Bilateral procedures were considered individually for analysis.

Results: Forty-one patients with 55 procedures were identified. Twenty-five GR and 30 TAL were performed. In the GR group 81% of patients were diplegic, compared to only 24% of patients in the TAL group. The average pre-operative maximum ankle flexion angle during stance phase was 4.4 and 1.5 degrees of DF respectively in the GR and TAL groups. Post surgical intervention gait analysis was performed on average 1.5 years post operatively (range 0.4-4.1 years). The average post-operative maximum ankle flexion angle during stance phase was 8.9 and 10.3 degrees of DF respectively in the GR and TAL groups. The average difference in maximum ankle flexion angle during stance phase was 4.5 degrees of increased DF with GR and 8.6 degrees of increased DF with TAL (p=0.17). The maximum ankle power generated during stance phase decreased by 0.26 W/kg after GR and increased by 0.24 W/kg after TAL (p<0.001).

Conclusion: Both TAL and GR can successfully correct equinus deformity in patients with CP without evidence of overcorrection at medium term follow-up. A trend towards a larger average increase in maximum ankle DF during stance phase post operatively was seen with TAL compared to GR. Despite the larger increase in ankle DF post operatively with TAL, this group of patients also showed a significantly larger improvement in maximum ankle power during stance phase. This suggests that a closer return to normal sagittal plane kinematics at the ankle may improve ankle power. However, this conclusion is made with caution since a larger proportion of patients in the TAL group were hemiplegic compared to those in the GR group.

The Effect of Orientation of Stemless Implants on Proximal Humerus Bone Stresses: A Finite Element
Study
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Purpose: Partial joint resurfacing implants (PRJs) are becoming increasingly popular as an alternative to traditional arthroplasty. Accordingly, there is a need to investigate properties of joints subjected to PJR. This study compared the effect of varying PJR position on the contact area and stress of articular cartilage, and contrasts these against the intact joint, using the glenohumeral joint as a model.

Method: CT data was used to develop three-dimensional models from three cadaveric joints. Each was oriented (75° abduction) such that the joint reaction force ran between the centers of the humeral head and glenoid articular surface. A generic PJR (15mm diameter, 3mm deep, 22mm radius of curvature) was placed in the humeral surface such that its center was in-line with the joint reaction force. The PJR position was then varied so its face was flush with, 0.5mm proud of, and 0.5mm subsided compared to the humeral cartilage. Material stiffness was assigned to bone based on CT data, and a stiffness of 210GPa was assigned to the PJR to represent CoCr. Cartilage was modeled as a non-linear elastic material. A load of 400N compressed the articulation. Results were compared on the basis of contact area and peak contact stress in both the glenoid and humeral cartilage, with all results presented as percentages of the intact joint values. Statistical significance was assessed using a one-way RM ANOVA (α = 0.05).

Results: Joint contact area was found to differ significantly (p ≤ 0.018) between all configurations except the subsided vs. intact models (Intact = 100%; Flush = 91±5%; Proud = 81±6%; Subsided = 100±5%). All PJR positions were found to vary significantly from the intact joint (p ≤ 0.039) in terms of both peak stresses in the glenoid (Intact = 100%; Flush = 137±24%; Proud = 146±28%; Subsided = 134±28%) and humeral cartilage (Intact = 100%; Flush = 26±12%; Proud = 13±7%; Subsided = 45±22%). Moreover, peak humeral stresses in the subsided models were significantly higher than either the flush or proud configurations (p ≤ 0.045), though still lower than the intact joint.

Conclusion: Overall, none of the resurfaced joints achieved the same peak contact stresses observed in the intact joint. This is perhaps since the implants were stiffer than cartilage. Accordingly, proud and flush configurations prevented the surrounding cartilage from compressing similar to the intact joint, while subsided implants engaged after the surrounding cartilage, leading to a contact area that matched the intact joint. In general, the trend towards recreating the intact state with subsiding the implant demonstrates that PJR positioning is an important surgical parameter that may have implications for joint wear and ultimately PJR longevity. Accordingly, softer and further subsided implants require investigation. Regardless, differences between intact and resurfaced joints suggests perhaps that other implant parameters (e.g., geometry) may play a role in recreating the contact mechanics of the native joint.

Elbow Strength and Endurance Testing after Distal Biceps Reconstruction with Allograft
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Purpose: The purpose of the current study is to investigate the functional strength outcomes of late distal biceps tendon reconstruction using allograft tissue.

Method: Patients who underwent distal biceps tendon reconstruction with allograft tissue between May 2007 and May 2013 at our institution were identified. Charts were retrospectively reviewed for postoperative complications, gross flexion and supination strength, and range of motion (ROM). Isokinetic strength and
endurance in elbow flexion and forearm supination were measured in both arms. Tests were conducted using a Biodex System 4 dynamometer at 60 degrees per second for isokinetic strength assessment, and at 240 degrees per second for endurance assessment. Isometric strength testing was also measured for elbow flexion and forearm supination. Paired t tests were used for statistical analysis.

**Results:** Ten patients with a mean age of 48 years (range 42 - 61 years) were included in the study. Distal biceps tendon reconstruction was performed using an achilles tendon allograft in nine patients, and a combination of tibialis anterior allograft and gracilis allograft was used in one patient. Of the reconstructions, 50% involved the dominant arm. No ROM deficit was observed in any patient at the time of final follow-up assessment. The mean follow-up for dynamometer strength testing was 34 months (range 13-81 months). No statistical differences were noted between data obtained from the involved and uninvolved extremity. The average peak torque of the involved limb (38.5± 5.9 Nm) was 91.7% of that of the uninvolved limb (41.8±4.9 Nm) in flexion and 93.4% (involved, 5.7±1.3 Nm; uninvolved, 6.1± 1.0 Nm) in supination. No significant differences were found in fatigue index between involved or uninvolved limbs for flexion (involved, 34.1±17.1%; uninvolved, 30.8±17.1%; p = 0.29) or supination (involved, 38.2±16.5%; uninvolved, 42.1±11.9%; p = 0.65). A single case of transient posterior interosseous nerve palsy was the only complication identified. All patients recognized postoperative cosmetic deformity, although this appearance was reported as acceptable.

**Conclusion:** Late reconstruction for chronic distal biceps tendon rupture using allograft tissue is a safe and effective solution for symptomatic patients who have functional demands requiring forearm supination and elbow flexion. Dynamometer testing shows near normal return of strength and endurance of both elbow flexion and supination following this procedure.

### 165 Outcomes for Fractures of the Greater Tuberosity Associated with Anterior Shoulder Dislocation

**Jonah Hébert-Davies, QC; Jennifer A. Mutch, QC; Dominique M. Rouleau, QC; G-Yves Laflamme, QC**

**Purpose:** Isolated fractures of the greater tuberosity occurring during anterior shoulder dislocation represent a challenging clinical problem. Treatment generally consists of initial closed reduction of the shoulder followed by evaluation of the tuberosity fracture. Undisplaced fractures are treated conservatively while displaced fractures are treated by a number of different internal fixation options. Our hypothesis is that many initially undisplaced fractures eventually migrate during follow-up. Furthermore, these displacements are often seen in a delayed fashion making optimal treatment more difficult. The primary goal of this study is to evaluate radiological outcomes and the need for surgery in patients with combined fractures of the greater tuberosity and anterior shoulder dislocations.

**Method:** A prospective trauma database was reviewed to identify all patients with both anterior shoulder dislocation and greater tuberosity fractures. A retrospective review of patients’ charts and radiological history was done. Two observers evaluated all X-rays to determine initial displacement, quality of reduction, presence of a Hill-Sachs lesion and subsequent displacement. Patients were asked to answer a validated functional outcome questionnaire and also their general satisfaction with their outcome.

**Results:** There were 54 patients including 28 women, with an average age of 63.8 years. A majority of patients (46) received initial treatment with closed reduction under sedation, with acceptable (<5mm of displacement) reduction of the tuberosity in 36 patients (78.2%). Patients with unacceptable reduction were treated with open reduction with or without internal fixation in 8 cases or conservatively in 2 patients who refused surgery. In patients treated only with closed reduction, migration of the greater tuberosity was seen in 11 patients (24%).
When looking at patients younger than 65 years old, the rate of failure increased to 32%. Patients with loss of reduction were operated in only 36% of cases, mostly due to late presentation. There were no cases of redislocation.

Conclusion: Treatment of anterior gleno-humeral dislocations with associated greater tuberosity fractures is complex. Most patients will do relatively well with conservation treatment after initial closed reduction. However, a significant portion of these patients will have tuberosity migration, leading to a potential impact on function. Unfortunately, no specific patient related factors were identified to predict loss of reduction. Nevertheless, identifying these patients early with tight follow-up is key to allow for optimal surgical treatment.

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Radial Head Fractures Treated with Modular Metallic Radial Head Arthroplasty: Outcomes at a Mean Follow-up of 8 Years
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Purpose: Radial head arthroplasty (RHA) is commonly used to treat acute unreconstructable radial head fractures. The purpose of this study is to report on the clinical and radiographic outcomes at a minimum of 5 years follow-up for patients that underwent modular metallic radial head arthroplasty for acute radial head fractures.

Method: Fifty-five patients with unreconstructable radial head fractures treated acutely with a smooth stem modular metallic RHA were retrospectively reviewed. All patients returned for an interview, physical examination and radiographic evaluation (range 5-14 years). Elbow and forearm motion, elbow strength and grip strength were measured. Radiographs were evaluated and validated self-administered patient-rated outcome questionnaires were completed. A longitudinal subgroup analysis was performed with 33 patients who were previously evaluated at 2 years follow-up.

Results: At a mean of 8.2±2.9 years, the mean arc of motion of the affected elbow was 11±14° to 137±15°. Elbow strength and motion were significantly diminished compared to the unaffected elbow (p<0.05). The mean Mayo Elbow Performance Index (MEPI) was 91±13. Twenty-one patients (38%) had ulnohumeral arthritis, 25 (45%) had stem lucencies and 20 (36%) had heterotopic ossification with one case of radio-ulnar synostosis. Two patients underwent secondary elbow surgery, but no patients required implant removal or revision. In the subgroup evaluated longitudinally, there was a statistically significant improvement in MEPI scores from 2 years to 8 years follow-up (p=0.012), with no statistically significant loss of motion or strength (p>0.05).

Conclusion: The mid-term outcomes of smooth stem modular metallic RHA are comparable to previously reported short-term outcomes with no evidence of functional deterioration. Although the strength and range of motion of the elbow were diminished as compared to the contralateral limb, most patients were satisfied with minimal pain and good function of the elbow. The implant survivorship was 100% at a mean of 8.2 years. Post-traumatic arthritis, stem lucencies and heterotopic ossification were common, but most cases were mild causing minimal functional impairment.

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Optimal Approaches to the Management of Acute Displaced Midshaft Clavicle Fractures: A Meta-analysis of Randomized Controlled Trials
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Purpose: The popularity of acute displaced midshaft clavicle fracture fixation has largely been fueled by randomized controlled trials (RCTs) demonstrating improved union rates and functional benefits over time. Increased focus and recent RCTs provide an opportunity to evaluate the efficacy of surgical fixation of these injuries on other patient-focused outcomes. The objectives of this meta-analysis were to determine the relative effects of nonoperative and operative interventions in treating acute displaced midshaft clavicle fractures with respect to rates of secondary operations, all complications, and long-term function (1 year or longer).

Method: A systematic review of the literature and meta-analysis was conducted. RCTs comparing any form of treatment (operative or nonoperative) of acute displaced midshaft clavicle fractures were included. Methodological quality was evaluated using the Cochrane Risk of Bias Tool. The Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach was used to summarize the quality of evidence for all outcomes and make a final health care recommendation.

Results: Fifteen RCTs (n=1343) were included (9 RCTs comparing operative versus nonoperative, 5 comparing implants for operative treatment, and 1 comparing alternative approaches to nonoperative treatment). Nonoperative treatment did not confer a greater risk of secondary operations (risk ratio (RR) 1.16, 95% confidence interval (CI) 0.58 to 2.35, p=0.67, I²=50%) or all complications (RR 0.90, 95% CI 0.55 to 1.50, p=0.70, I²=67%); functional outcome at 1 year slightly favoured operatively treated patients but did not reach statistical significance (standardized mean difference 0.38, 95% CI 0 to 0.75, p=0.05, I²=79%). Between trial heterogeneity was not explained by subgroup analyses for type of operative implant or risk of bias. Evidence for type of implant or approach to nonoperative treatment remained inconclusive with few high quality trials and small sample sizes.

Conclusion: Current evidence does not support routine internal fixation for acute displaced midshaft clavicle fractures. Non-significant differences in all complications and reoperations with operative treatment suggest additional exploration of prognostic factors for outcomes are needed. High degree of heterogeneity in functional gains with operative treatment lessens the confidence in the pooled treatment effect.

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Topographic Analysis of the Capitellum and Distal Femoral Condyle: Finding the Best Match for Treating Osteochondral Defects of the Humeral Capitellum
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Purpose: Osteochondral autograft transplantation has been performed as a treatment option for osteochondritis dissecans of the humeral capitellum. Ideal reconstruction would allow for accurate matching of the shape of the articular surfaces of the donor and recipient sites to reconstruct the original articular surface of the elbow. The purpose of this study was to determine the donor zone of most congruent topographic match by comparing four donor sites from the femur to four potential recipient sites onof osteochondritis dissecans at the capitellum. Our hypothesis was that all four selected donor regions of distal femoral donor sites would provide equally appropriate match to the capitellar surface.

Method: Computed tomography (CT) was performed on 5 right elbows, 6 right medial and 6 right lateral distal femoral hemicondyles-which included the femoral notch. Three-dimensional CT models were created and
exported into point-cloud models. A local coordinate map of the distal humerus and distal femoral articular surfaces was created. The capitellum was compared with medial and lateral distal femoral condyles with two donor zones in each condyle (medial trochlea and medial intercondylar notch; lateral trochlea and lateral intercondylar notch). In each capitellum, four combinations of 10 mm defects were simulated (central and lateral; 30° and 45° anterior to shaft of humerus), resulting in 480 capitellum-femur comparative combinations being tested. The capitellum surfaces were virtually placed on a point on the femoral articular surface in 3D space. The least distances between the point-clouds on the distal humerus and distal femoral articular surfaces were calculated.

**Results:** There was less than 0.1-mm difference in the topographic articular surface match between the four commonly used donor sites of distal femur and four recipient sites of the capitellum. However, the best match for any given 10 mm capitellar defect (central 30°, central 45°, lateral 30° and lateral 45°) were the same such that the lateral trochlea on the femur always yielded the best fit compared to the three other graft locations (P < 0.005).

**Conclusion:** The findings suggest that all four donor sites provide close articular matching for the capitellum articular surface with the lateral trochlea articular surface providing the best match.

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**Reverse Shoulder Arthroplasty for Treatment of Acute Proximal Humeral Fracture**

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**Purpose:** Proximal humeral fractures occurring in older patients often lead to significant functional disability. Treatment of displaced fractures is often associated with tuberosity nonunion and poor function. Reverse shoulder arthroplasty (RSA) is an appealing alternative because of the ability of the prosthesis to compensate for tuberosity complications. The optimal treatment remains controversial. The purpose of this study was to review the satisfaction and quality of life in patients who underwent RSA for proximal humerus fractures compared with hemiarthroplasty.

**Method:** Between 2008 and 2013, 53 RSA for proximal humerus fractures were performed at one institution. Patient demographics, comorbidities, time to surgery, peri-operative clinical and radiographic findings were recorded. The outcomes of each patient was measured based on range of motion, strength, and standardized patient rated pain and disability scores (ASES, Constant, SF-12 and DASH). Dual-energy x-ray absorptiometry (DEXA) scan evaluated bone mineral density (BMD). Neuromuscular control was assessed by quantifying their ability to maintain dynamic bilateral postural stability on a static and unstable surface using the Biodex balance system SD (13935E/R08073, Shirley, NY, USA). Independent Student t-tests and Pearson's correlation coefficients were used where appropriate (p < 0.05).

**Results:** Fifty-two patients (51 females) with RSA, with an average age at fracture of 78 years, were able to return for evaluation at an average of 30 months post-surgery. The mean BMI was 33 (19-61). A significant decrease in active external rotation range (23° vs 40°) and in internal rotation strength compared to non-affected side was recorded. We report outcomes for VAS 2 (0-7), ASES 22 (10-30), DASH 21 (0-48), SF-12 physical 41 (24-63) and mental 55 (36-70). The Constant score was 53 compared to sex and age adjusted 64-69 with no difference seen when fracture type or dominant side affected analyzed. Survivorship was 96% at 68 months. Complications were two infections, fracture of glenoid and fracture of humerus.
Conclusion: Comparison of clinical results from this study correlate with results published in most recent literature. RSA scores are not affected by hand dominance. Reverse shoulder arthroplasty for proximal humerus fracture in older patients rendered good outcomes and with a low complication rate.

An Analysis of Intra-operative Findings in Acute Varus Posteromedial Rotatory Instability of the Elbow - Comparison to Pre-operative Radiographic Classification
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Purpose: Background: Acute varus posteromedial rotatory instability (VPMRI) of the elbow is rare. Instability is thought to be driven by an incompetent lateral ulnar collateral ligament (LUCL). With an acute injury, VPMRI is commonly associated with a Type II O’Driscoll anteromedial coronoid fracture fragment. O’Driscoll classified coronoid fractures and postulated a pathomechanical cause for VPMRI injury patterns. Our aim was to compare pre-operative radiographic classifications with our findings at open surgery (ligamentous disruptions, chondral damage and fracture pattern). Our hypothesis was that there is no difference between our radiographic classification and predicted intra-operative findings.

Method: 17 consecutive patients with an acute, traumatic anteromedial coronoid process fracture with a suspected VPMRI mechanism, were managed between Nov 2004 and Jan 2013. Patients were assessed with plain radiographs, CT and 3-D CT. Coronoid process fractures were classified from the available imaging according to O’Driscoll et al. Patients that required further stability assessment underwent EUA and intra-operative fluoroscopic assessment. Intra-operative findings were compared to the expected injury pattern described for VPMRI. Patients were followed up clinically and radiographically at 6/52, 3/12 and then as required. Functional scores were recorded at most recent follow-up using Mayo Elbow Score, SF-12, Patient-Rated Elbow Scale and Visual Analogue Scale.

Results: 16 patients were classified pre-operatively as O’Driscoll Type 2 coronoid fractures (12 Subtype II (anteromedial rim + tip); 4 Subtype III (anteromedial rim + sublime tubercle)). One patient was classified as O’Driscoll Type 3 (Coronoid body and base). 14 patients had a LUCL tear (12 humeral avulsions; 2 midsubstance tears); 2 patients had a preserved LUCL. 10 patients had a complete MCL tear (6 anterior bundle only; 4 anterior and posterior bundles); 6 patients had a preserved MCL. No difference was found between fracture type, ligamentous disruption, type of fixation and clinical scores at latest follow-up. Average follow-up has reached 5 years (Range: 2 to 9).

Conclusion: Intra-operative findings did not always correlate with the expected findings at surgery. A Type II O’Driscoll anteromedial coronoid fracture fragment is not always associated with an LUCL disruption. O’Driscoll Type II anteromedial coronoid fractures are not pathognomonic for VPMRI. Careful intra-operative dynamic assessment is recommended to ensure the goals of surgery are met.

Sutures Cutting Through Bone Can be Affected by Knotless Suture Anchor Design
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Purpose: A variety of knotless suture anchors have been developed with different methods of managing the sutures in relation to the anchor body. The purpose of the study was to evaluate the mechanical performance
of knotless anchors with different locations of sutures with respect to the anchor body: sutures external to the anchor body and adjacent to bone (PushLock, SwiveLock), sutures completely internal to the anchor body (SpeedScrew) and a combination of the two (MultiFIX P, Footprint PK).

**Method:** Five types of anchors (4.5mm PushLock, MultiFIX P and 5.5mm SwiveLock, SpeedScrew, Footprint PK; eight anchors for each) were tested in cadaveric humeral heads and subsequently MultiFIX P and SpeedScrew were tested for further analysis in foam blocks representing normal and osteopenic bone. Mechanical loading was applied through standard suture loops at ~60° from anchor axis to simulate rotator cuff loading. Constructs were subjected to a standardized protocol including a 10N preload, cyclic testing from 10-60N for 500 cycles, and then returned to 10N. The parameters evaluated were displacement A (from preload to peak of first cycle), displacement B (from the peak of first cycle to the peak of 500th cycle), and displacement C (from preload to return to 10N after cyclic loading). Data were analyzed using ANOVA with linear contrasts or Kruskal-Wallis test with Conover post-hoc analysis. Video analysis was also performed.

**Results:** In cadaveric bone, none of the MultiFIX P or SpeedScrew anchors failed, whereas some of the other three types failed during testing. Displacement A was less for SpeedScrew than the other four types with significance for MultiFIX P and Footprint PK (p<0.05). In addition, there was significantly less displacement B and C for SpeedScrew when compared to MultiFIX P (p<0.05). Video observation demonstrated that sutures cutting through bone was the predominant factor resulting in increased displacement particularly in the initial stage of testing (preload and early cyclic loading). To focus on the effect of sutures cutting through bone, the MultiFIX P and SpeedScrew, were tested in foam blocks and represented sutures either external or internal to the anchor body, respectively. In osteopenic foam, only one MultiFIX P anchor survived throughout cyclic testing whereas no SpeedScrew anchor failed. Displacement A was greater for MultiFIX P than SpeedScrew (p<0.05). In normal foam, all anchors survived the loading protocol. All three displacement parameters were greater for MultiFIX P than SpeedScrew (p<0.05). Video analysis demonstrated early and more extensive sutures cutting through the foam block for MultiFIX P, even from the first cycle and throughout the testing.

**Conclusion:** Greater displacement was seen for the anchors with sutures external to the anchor body. Those anchors could be at higher risk for sutures cutting through bone due to abrasion against the edge of the bone socket during cyclic loading. This may be particularly relevant in weak osteopenic bone.

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**Functional Outcome and Health-related Quality of Life After Surgical Repair of Full-thickness Rotator Cuff Tear Using Mini-open Technique: A 10 Year Follow-up**

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**Purpose:** To determine whether functional and health-related quality of life outcomes were maintained at 10 years after mini-open rotator cuff (RC) repair.

**Method:** Subjects with a confirmed full-thickness RC tear who underwent a mini-open repair between April 1997 and July 2000 were evaluated preoperatively and at 1 year postoperatively for (1) active shoulder range of motion (ROM); (2) functional outcome and health-related quality of life (HRQL); and (3) satisfaction with the outcome. Subjects were re-evaluated at 10 years postoperatively. A physical therapist not involved in subjects’ clinical care conducted all evaluations. Pain, function and HRQL were assessed by administration of the American Shoulder and Elbow Surgeons (ASES) score and Western Ontario Rotator Cuff (WORC) Index. Shoulder ROM was assessed using goniometry.
Results: Eighty-four subjects were enrolled preoperatively, of which 61 (73%) were men and the average age was 53 (±9.9) years. Sixty subjects (71%) were evaluated at one year postoperatively. At 10 years, four subjects were deceased; 59 subjects (74%) underwent the 10-year evaluation. Four subjects had re-tears, one of whom elected not to participate in the 10-year evaluation. The remaining cohort of 59 subjects consisted of 43 males (73%) and had an average age of 63 (±8.5) years. At one year, the mean ASES score had improved from 58.1 (±19.3) preoperatively to 91.1 (±12.0) and the mean WORC score improved from 57.1 (±18.0) preoperatively to 88.4 (±13.6) (p<0.001). At 10 years, the mean ASES score was 89.3 (±19.8) and the mean WORC index score was 87.1 (±19.7); paired t-test analysis showed no difference between 1-year and 10-year HRQL scores (p=0.83). Shoulder ROM showed significant improvement over time (p<0.03). Flexion improved significantly from before surgery to one year after surgery (p<0.002); the improvement in external rotation in 90 degrees abduction was marginally significant over this period (p=0.07). Comparison of the 1-year and 10-year ROM using a paired t-test yielded mixed results. Flexion in standing and supine did not change significantly (p≥0.30). External rotation ROM in both 0 and 90 degrees abduction significantly increased from 49.4 (±13.8) at 0 degrees and 69.6 (±14.5) at 90 degrees at 1-year to 56.2 (±16.9) at 0 degrees and 83.0 (±15.8) at 90 degrees at 10 years (p<0.01). Fifty-three subjects (90%) were satisfied or very satisfied with their results. Subject tear size, WCB status, gender and smoking status did not influence HRQL or shoulder ROM (p>0.06).

Conclusion: Long term results of functional and health-related quality of life outcomes after RC repair are infrequently reported. This study found that patients who underwent mini-open RC repair retained excellent postoperative results in terms of both HRQL and shoulder ROM at 10 years postoperatively.

173 Clinical Outcomes of Subpectoral Long Head of Biceps Tenodesis with Cortical Button Fixation

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Purpose: This study was conducted to evaluate the clinical outcomes following subpectoral long head of biceps tenodesis performed using cortical button fixation.

Method: All patients who underwent open subpectoral long head of biceps tenodesis with cortical button fixation at our institution with a minimum of 6 months follow-up were identified. Cases were reviewed for indications, operative details, and postoperative complications. Patients were evaluated with preoperative and postoperative clinical outcome measures, including physical examination, pain assessment, and patient satisfaction scores. The validated questionnaires used consisted of the American Shoulder and Elbow Society (ASES), the Oxford Shoulder Score, and the Disabilities of the Arm, Shoulder, and Hand (DASH) score.

Results: A total of 64 patients (46 M, 18 F) underwent subpectoral long head of biceps tenodesis with cortical button fixation with a mean follow-up of 14 months (range 9-18 months). The mean age was 53.8 years (range 31-74 years). Intraoperatively, all patients were found to have long head of biceps pathology, which included extensive tenosynovitis and/or partial thickness tearing. Additional pathology was identified in all patients, including subacromial impingement (n = 52), labral tear (n = 43), and rotator cuff tear (n = 46). The mean tendon diameter was 5.5 ± 0.7 mm (range 4 to 7mm) and the mean transossseous tunnel was 5.9 ± 0.8 mm (range 4.5 to 7.5mm). No intraoperative complications were documented. Two patients developed transient sensory neuropathy in the sensory distribution of the musculocutaneous nerve, both of which resolved within three months postoperatively. Full elbow range of motion was restored for all patients. All clinical outcome measures demonstrated statistically significant improvement from the preoperative baseline to the time of final
follow-up. The mean Oxford Shoulder Score increased from 28.1 ± 11.8 to 42.4 ± 10.7 (p <0.01). The mean ASES increased from 39.6 ± 20.5 to 78.3 ± 26.3 (p <0.01) and the mean DASH score decreased from 43.5 ± 25.3 to 17.9 ± 24.2 (p<0.01). Patients with coexisting labral or rotator cuff tear were found to have lower preoperative and postoperative scores for all measured outcome parameters. A high level of patient satisfaction following the procedure was found to be present in 60 of 64 patients (93.9%), indicating that they would choose to undergo the procedure again.

**Conclusion:** Subpectoral long head of biceps tenodesis with cortical button fixation is a safe and effective approach to relieve pain and restore function in patients with symptomatic long head of biceps pathology. This technique minimizes the drill hole diameter needed when transosseous fixation is used, potentially lowering the risk for intraoperative and postoperative humeral fracture. In addition, this technique reduces trauma to the tendon with the use of a tension-slide shuttling method.

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**Morbid Obesity: A Significant Risk Factor for Failure of Revision Total Hip Replacement**

**Sammy Hanna, ON; Lyndsay Somerville, ON; Richard W. McCalden, ON; Steven J. MacDonald, ON; Douglas D. Naudie, ON; James L. Howard, ON**

**Purpose:** Previous published work from our institution has shown that a high body mass index (BMI) is associated with a good clinical result although a significant increase in post-operative complications following primary THR. However, there is a paucity of data concerning the outcome of revision THR in patients with a significantly high BMI. The purpose of this study was to examine the complications and outcomes of revision THR in patients with a BMI < 40 kg/m2 compared with patients with a BMI > 40 kg/m2 at our institution.

**Method:** A total of 56 living patients with a BMI > 40 kg/m2 who had undergone revision THA were identified by searching our prospectively kept database. Mean age in this group was 66.4 years and mean BMI was 45.7 kg/m2. Follow-up was 11.7 years (5-21). This group was matched with a second cohort of patients with a BMI <40 kg/m2 (according to age, gender and date of index procedure). Mean age in this group was 66.6 years and mean BMI was 33.6 kg/m2. Mean follow-up was 12 years (5-19). Outcomes included subsequent revision and functional scores (Harris Hip Score – HHS). Minimum follow-up in both groups was 5 years.

**Results:** Patients with a BMI > 40 kg/m2 had a significantly increased risk for revision surgery (29% compared with 16%; p<0.05). Major complications in the higher BMI group included (instability: 4, infection: 4, prosthetic fracture: 3, loosening: 4) compared with (instability: 2, infection: 2, prosthetic fracture: 2, loosening: 2 and periprosthetic fracture: 1) in the lower BMI group. HHS increased significantly following surgery in both groups (BMI < 40 kg/m2: 26.3 to 79.3) and (BMI > 40kg/m2: 37.6 to 69.9) (p<0.05). However, HHS at last follow-up was significantly higher in the lower BMI group (79.3) than in the higher BMI group (69.9) (p<0.05).

**Conclusion:** This study demonstrates that a significantly high BMI is associated with increased risk of failure of revision THR and lower satisfaction/functional outcome scores. Caution should therefore be used when proceeding with revision THA in patients with a BMI greater than 40 Kg/m2.

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**The Changing Bacteriology in Infected Total Hip Replacements: An International Collaborative Study**

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Purpose: Published studies report Coagulase negative staphylococcus (CNS) as the most common organism in an infected total hip replacement (THR). A gradual shift in the organisms isolated from samples obtained at the time of first stage revision has been observed in our practices. The aim of this study was to evaluate and compare the bacteriology in patients undergoing revision hip surgery for infection at two high volume arthroplasty units.

Method: An international multi-centre collaborative study where a retrospective review of prospectively collected data was obtained from two large lower limb arthroplasty units (LLAU) in Canada and in the UK from 1999 to 2012. Patients who underwent two stage revision for an infected primary THR were identified from local arthroplasty databases. Data collected included dates of primary and revision surgery, and microbiology results.

Results: 166 patients were identified from the LLAU in Canada, and 232 patients from the unit in the UK. Staphylococcus aureus was identified as the most common causative organism in infected primary THRs at both centres: 36% of infections in the unit in Canada and 30% from the unit in the UK. This was closely followed by CNS in both the units in Canada (35%) and the UK (26%). In both units, MRSA accounted for 22% of the total Staphylococcus aureus infections. There is no statistical difference between the results from the two units (p > 0.05). One unit also reported an increase in polymicrobial infections.

Conclusion: Deep infection remains as one of the most feared complications following THRs. The risk of deep infection following THR stands at < 1% in most large centres. Literature reports that up to 67% of infected THRs are caused by CNS, making it the most common causative organism. Any future changes in antibiotic prophylaxis should take this into account. The reason for the increase in isolation of Staphylococcus aureus warrants further investigations. Staphylococcus aureus infection is now the commonest organism in revision hip arthroplasty for infection.

Wear Rates of Highly Crosslinked and Conventional Polyethylene in Total Hip Arthroplasty at 13 Years
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Purpose: Highly crosslinked polyethylene was introduced for total hip arthroplasty (THA) with the goal of increasing wear resistance and improving implant longevity. The purpose of this study was to report the radiographic wear rates of first-generation highly crosslinked and conventional polyethylene in THA at long-term follow up.

Method: Patients who had previously been enrolled in a prospective, randomized controlled trial to receive either a first-generation highly crosslinked or conventional polyethylene liner in THA were reviewed after a minimum of 13 years (range, 13 to 14 years). Sixteen patients with an average age of 81.1 ± 6.9 years returned for radiographic and radiostereometric analysis (RSA). Radiographs were reviewed for the presence of osteolysis or component loosening. Femoral head penetration (which includes both wear and creep) was measured with RSA using the center index method. Wear rate was calculated by dividing total penetration by the implantation time.
**Results:** There was no difference in demographics between the crosslinked (n=8) and conventional (n=8) groups. Mean implantation time was 13.6 ± 0.5 years, mean age at surgery was 67.5 ± 6.9 years, and mean BMI was 28.4 ± 3.5 kg/m2. Wear rate was lower (p = 0.007) with crosslinked polyethylene (0.04 ± 0.02 mm/year) than conventional polyethylene (0.08 ± 0.03 mm/year). Total penetration was 0.36-1.04 mm in the crosslinked group and 0.55-1.43 mm in the conventional group (p = 0.013).

**Conclusion:** First generation crosslinked polyethylene demonstrates greater wear resistance than conventional polyethylene after 13 years of implantation. The steady state wear rate (after the initial bedding-in period) may be even lower than reported here, due to total penetration including both creep and wear. Crosslinked polyethylene continues to outperform conventional polyethylene into the second decade of implantation.

**The Accuracy of Joint Aspiration Lavage for the Diagnosis of Infections in Hip Arthroplasty**

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**Purpose:** The diagnosis of infection regarding hip arthroplasty is based on clinical suspicion, joint aspiration and laboratory investigations. A positive joint aspirate implies a periprosthetic infection and may direct subsequent surgical intervention. Therefore, it is imperative that joint aspirates provide accurate results. If no fluid can be aspirated from an arthroplasty hip with the suspicion of infection, current practice is to inject sterile fluid into the hip joint and attempt to reaspirate the fluid for analysis. There is currently no strong evidence to date that this practice yields accurate results in determining whether an arthroplasty hip is infected or not. The goal of this study was to determine whether aspiration lavage laboratory results can accurately identify infected hip arthroplasties by: 1) comparing aspiration lavage culture results to the operative culture results (utilized as the gold standard in diagnosing infection) and 2) determining the usefulness of cell count and differentiation in aspirated lavaged hip arthroplasties.

**Method:** Review of our institutional arthroplasty database was completed to identify all revision total hip arthroplasties performed from 2005 – 2013. Retrospective chart review was completed to identify all patients who had joint aspiration lavage to exclude infection. Patients whose aspirate was greater than 6 months before surgery and those that did not have intraoperative cultures at the time of revision were excluded. Charts were retrospectively reviewed to record gender, fluid used for lavage, volume of substance injected into the hip joint (mL), volume of fluid aspirated after lavage (mL), CRP, ESR, synovial fluid cell count, synovial fluid percentage neutrophils, synovial fluid culture, operative culture, antibiotic use, and time to revision surgery after aspiration lavage.

**Results:** Fifty nine cases received aspiration lavage to diagnose infection during the study period. There were 47 hip arthroplasties (total hip arthroplasty, bipolar, or hip resurfacing) and 12 antibiotic spacers. Of the 47 arthroplasties, 17 (36.1%) had positive bacterial operative cultures, while only 5 (10.6%) had positive bacterial aspiration lavage cultures. The lavage aspiration correctly identified the presence of a periprosthetic infection in only 2 of the 17 cases which were positive intra-operatively (11.8%). Of the 12 antibiotic spacers, 0 had positive bacterial operative cultures, while 1 (8.3%) had a positive bacterial aspiration lavage culture. Of the 59 cases that underwent lavage aspiration, synovial fluid cell count could only be determined in 10 aspirates (16.9%) and synovial fluid percentage neutrophils in 1 aspirate (1.7%)
Conclusion: The method of attempting to reaspirate an arthroplasty hip with non-bacteriostatic saline when a dry aspirate occurs is not an accurate or effective means of diagnosing infection in hip arthroplasty.

Highly Cross-linked Polyethylene Decreases the Revision Rate of Total Hip Arthroplasty Compared to Conventional Polyethylene at 13 Years Follow-up

Sammy A. Hanna, ON; Lyndsay Somerville, ON; Richard W. McCalden, ON; Steven J. MacDonald, ON; Douglas D. Naudie, ON

Purpose: Although highly cross-linked polyethylene (XLPE) has been shown to have decreased wear in-vivo compared to conventional polyethylene (CPE), it remains unknown whether this is associated with a decrease in wear-related THA revision rates. The aim of this study was to compare the clinical outcomes, incidence of osteolysis and rate of wear-related revision for young patients with long-term follow-up after a primary THA with either a CPE or XLPE liner.

Method: We reviewed all THA patients followed prospectively in our institutional database who received either a CPE or XLPE liner. The inclusion criteria in this study included: primary THA performed between January 2000 and December 2001 for osteoarthritis, age between 45-65, THA with a 28mm cobalt-chrome femoral head, no previous surgery to the hip and no coexisting musculoskeletal or neurological problems affecting mobility. A total of 203 patients (out of a total of 700) met the inclusion criteria, of which 19 were lost to follow-up. This left 184 patients available for review (95 – CPE, 89 – XLPE). Mean age, BMI and follow-up in each group were: (CPE: 56.9 years, 30.6 kg/m2, 13.3 years) – (XLPE: 54.8 years, BMI: 30 kg/m2, 13.1 years) (p>0.05, Unpaired t-test). Patient records were reviewed to identify wear-related failures/revisions. Pelvic/hip radiographs were assessed for osteolysis defined as punched out lesions with sclerotic margins and/or calcar resorption. Functional outcome was assessed using the Harris Hip Score (HHS).

Results: There were 17 revision THAs in total in the CPE group, of which 16 (17%) were related directly to polyethylene wear and/or osteolysis at a mean of 11.4 years (9.4 – 13.8). All 16 cases had a liner exchange and 12 required bone grafting. Two of these cases required revision of the femoral stem but none required revision of the acetabular shell. Three revisions occurred in the XLPE group, none of which were directly related to polyethylene wear and/or osteolysis. One femoral stem required revision but no acetabular shells were revised in this group. Osteolysis was present in 37% (acetabular) and 32% (femoral) of the CPE patients compared to 8% (acetabular) and 6% (femoral) of the XLPE patients at last follow-up (p<0.05, Mann Whitney U test). Mean HHS at last follow-up was 88.4 (CPE) and 91 (XLPE) – (p>0.05, Mann Whitney U test).

Conclusion: This study demonstrates that XLPE liners are associated with significantly less osteolysis and wear related revision rates than CPE liners following primary THA in young and active patients at long-term follow-up.

Comparison of Canadian and American Perioperative Outcomes in Primary Total Hip and Knee Arthroplasty

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Purpose: Over the last decade, the combination of an aging population, growing number of medical interventions, and surging economic burden of healthcare have renewed interest in reevaluating and exploring
new healthcare models. The aim of the present study was to compare predominantly public (Canadian) and private (American) healthcare systems by assessing perioperative outcomes following primary total hip (THA) and knee (TKA) arthroplasties.

**Method:** We queried the National Surgical Quality Improvement Program database to identify all Canadian and American patients who underwent primary, elective, total hip or knee replacement surgery in 2011 and 2012. Patients were grouped according to the country where they received their surgery and differences in patient demographics as well as the rate of 30-day major complications, readmission rates, and length of stay were compared between patients treated in either country.

**Results:** We identified 21,578 (19,535 American, 2,043 Canadian) THA and 33,933 (31,092 American, 2,841 Canadian) TKA patients from the database. Univariate analysis identified the following significant differences in demographics and comorbidities between groups: American patients were slightly younger (by 2.2 years for THA, 1.9 years for TKA), heavier (by 1.1 more in BMI for THA, 0.9 for TKA), had a higher prevalence of hypertension (11% more for THA, 10% more for TKA) and COPD (1.2% more for THA, 0.9% more for TKA), greater rate of preoperative transfusion (9% more for THA, 6.4% more for TKA), and tended to have a higher ASA. The majority of Americans underwent general anesthesia (62% for THA, 59% for TKA) while Canadian patients underwent more regional anesthesia (79% for THA, 81% for TKA). Length of surgery was also significantly longer for American patients (by 21 minutes in THA, 18 minutes in TKA). Americans had shorter hospitalizations (1.4 days less for THAs and 1.3 days less for TKAs) with a greater proportion of patients discharged to rehabilitation facilities (21.6% more for THA, 26.6% more for TKA). After adjusting for all other variables, risk factors, and adverse outcomes, having surgery in Canada increases the post-operative length of stay by 57% for THAs and 49% for TKAs; however, the rate of major complications and readmissions was similar between countries.

**Conclusion:** In this study, we found that patient baseline characteristics and complication rates were very similar between both countries. While American hospitals champion shorter length of stay following surgery, Canadian centers provide a very comparable level of care in the context of a publicly insured system.

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**Minimally Invasive Anterior Approach vs Posterior Approach in Total Hip Arthroplasty: A Prospective Randomized Study**
**Pascale Derome, QC; Henry-Servantes Gaspard, QC; Benoit Benoit, QC**

**Purpose:** The aim of this study is to compare two minimally invasive approaches in total hip arthroplasty: the anterior and posterior approaches. Recovery rate, length of hospital stay, surgical time, complications and implant position were analyzed.

**Method:** In this prospective randomized multicenter study, 55 patients (28 anterior, 27 posterior) were enrolled between February 2011 and July 2013 for an average follow-up of 25 months. Follow-up was sampled 2 weeks, 1 month, 3 months, 6 months, 1 year and 2 years postoperatively. Harris Hip Score (HHS) and Visual Analog Scale (VAS) were used to monitor functional outcome. Hospital stay, surgical time and complications were documented. Radiological analysis was used to assess implants position.

**Results:** According to the HHS, there is a trend towards faster recovery at 2 weeks (67 vs 59 p=0.07) and 4 weeks (76 vs 67 p=0.08) postoperatively for the anterior approach group. When compared to the posterior
approach, the average surgical time for the anterior approach is slightly increased (59.9 vs 45.7 p=0.001). The long-term results showed no difference in both groups.

**Conclusion:** The minimally invasive anterior approach for total hip arthroplasty appears to be a safe and effective option, potentially offering short term advantages in the early postoperative recovery.

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**The Impact of Surgical Approach on Short-term Patient Outcomes in Total Hip Arthroplasty**

Stephen Petis, ON; James L. Howard, ON; Brent A. Lanting, ON; Lyndsay Somerville, ON; Edward Vasarhelyi, ON

**Purpose:** The impact of surgical approach on clinical outcomes following total hip arthroplasty (THA) has been under scrutiny over the past decade. Few studies have used validated clinical outcomes in their comparisons, and to our knowledge, none of the studies have standardized the implants used at the time of the index procedure. The purpose of this study was determine the impact of the anterior, posterior, and lateral approach for THA on validated clinical outcome measures. Complication rates were also compared between the three cohorts.

**Method:** We recruited 118 patients undergoing a THA using either an anterior, posterior, or lateral approach. Each patient had a cementless femoral stem (Corail TM stem, DePuy Orthopaedics Inc., Warsaw, IN), cementless acetabular cup (Pinnacle Sector II TM, DePuy Orthopaedics Inc., Warsaw, IN), cobalt chrome femoral head (Articul/eze TM, DePuy Orthopaedics Inc., Warsaw, IN), and cross-linked polyethylene liner (AltrX TM, DePuy Orthopaedics Inc., Warsaw, IN) at the time of the operation. Demographics including sex, body mass index (BMI), age, and primary diagnosis were collected. Each patient completed a WOMAC, Harris hip score (HHS), SF-12, EQ-5D, and Timed Up-and-go (TUG) test pre-operatively, and at 6-weeks and 3-months following THA. We recorded postoperative complications for each approach. Group comparisons were performed using a Pearson Chi-square and one-way Analysis of variance (ANOVA), with post-hoc testing when necessary.

**Results:** The three groups were similar with respect to age (p=0.79), sex (p=0.97), BMI (p=0.54), and primary diagnosis (p=0.42). At 6-weeks, the anterior group had higher WOMAC function scores compared to the lateral group (p=0.036). The posterior group achieved higher functional component scores on the HHS at 6-weeks compared to the lateral group (p=0.037). Significantly more patients were performing “Usual Activities” at 6-weeks in the anterior versus lateral or posterior cohort as rated on the EQ-5D (p=0.017). There were no statistically significant outcome comparisons at 3-months. There were more nerve palsies in the anterior group (p=0.001), however, no group differences were noted in the number of dislocations, peri-prosthetic infections or dislocations, or wound complications.

**Conclusion:** Both the anterior and posterior approaches had higher functional component scores compared to the lateral approach at 6-weeks post-operatively. There was a higher complication rate of lateral femoral cutaneous nerve sensory deficits in the anterior group. Future research should correlate surgical approach and functional analyses such as gait analysis to explain functional differences between the groups.

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**Up to Five Year Follow-up of a Focal Constrained Acetabular Liner used for Revision Total Hip Arthroplasty**

Paul R.T. Kuzyk, ON; Oleg Safir, ON; Wael Abdelrahman, ON; Tomas Amnnebar, ON; Bander Hetaimish,
Purpose: Hip dislocation is a devastating complication of total hip arthroplasty (THA) and occurs much more frequently after revision THA as compared to primary THA. Constrained acetabular liners are designed to reduce the incidence of dislocation. However, constrained liners may result in restricted range of motion causing impingement and dislocation, as well as greater mechanical forces on the acetabular component/bone interface leading to aseptic loosening. The purpose of this study was to examine the survivorship of a focal constrained liner used for revision THA.

Method: We retrospectively reviewed the records of 98 patients (64 female, 34 male) that had revision THA between January 2009 and December 2012, and received either a cemented or modular Trilogy Longevity Constrained Liner (Zimmer, Warsaw, IN). Failure was defined as aseptic loosening of the acetabular component or hip dislocation. Two subgroups were identified within the cohort: 1) revisions performed for management of recurrent dislocation (N= 23); and 2) revisions with significant abductor muscle deficiency that were performed for any indication other than recurrent dislocation (N = 75). Kaplan-Meier survival curves were constructed and log-rank test was used to test for difference in survivorship between the two revision groups. Preoperative and postoperative Harris Hip Scores (HHS) were compared using a paired student’s t test. A p value <0.05 was considered significant and all statistical analysis was conducted using SPSS version 22 (Armonk, NY).

Results: The average age of the patients was 69.4 years ± 12.3 SD (range, 37-97 years) and patients had a mean of 2.1 ± 0.8 SD (range, 1-5) hip arthroplasty surgeries prior to the index revision THA. Average follow-up was 38 months ± 11.2 SD (range, 12-66). The mean HHS for the cohort significantly improved from 69.8 ± 7.4 SD (range, 50-83) preoperatively to 85.4 ± 4.7 SD (range, 58-93) postoperatively (p<0.01). There were 10 failures (10.2%) in the cohort: five dislocations (5.1%) and five aseptic loosening of the acetabular component (5.1%). The overall survival was 90.8% (95% CI: 85.1%-96.5%) at two years and 84.3% (95%CI: 71.0-97.6%) at five years. There was no significant difference in survivorship between revisions performed for recurrent dislocation as compared to revisions performed for any other diagnosis (p=0.79). There were seven complications not including failures: four deep infections requiring surgery, one foot drop, one non-union of a proximal femoral allograft requiring surgery, and one non-union of an extended trochanteric osteotomy requiring surgery.

Conclusion: Overall survival up to 5 years was good for this design of focal constrained liner when used in revision THA for patients at high risk of dislocation. Survival was similar when used in patients undergoing revision for recurrent dislocation as compared to patients having revision for other reasons.

The Mid- and Long-term Wear Rates Between Conventional and Highly Cross-linked Polyethylene in Bilateral Total Hip Arthroplasty

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Purpose: Studies indicate that wear rates are decreased with highly cross-linked polyethylene (HXLPE) compared to conventional polyethylene (CPE). However, most in vivo wear studies do not account for confounding patient and implant factors. The purpose of the present study was to compare the mid- and long-term polyethylene wear rates in patients that have undergone bilateral THA, with implants of the same design, one CPE and one HXLPE liner.
Method: A cohort of patients was identified who had undergone bilateral THA between 1998 and 2004. Patients were included in the study if they had one CPE and one HXLPE, with the same implant type (uncemented Synergy stem and Reflection acetabular shell (Smith & Nephew, Memphis, TN) and a 28 mm cobalt-chromium head. Radiographs were reviewed at 5 ± 1 years and at 10 ± 1 years post-operatively. Wear, defined as linear penetration of the femoral head, was measured using the ROMAN method. The student's paired t-test was used to statistically compare the wear between the CPE and HXLPE groups.

Results: There were 22 patients (13 females and 9 males) identified as having imaging available for analysis at the mid-term point, and 19 patients identified for analysis at the long-term point. Four patients in the CPE group had undergone revision, three for painful osteolysis secondary to polyethylene wear and the other for aseptic loosening of the femoral stem. There were no revisions in the HXLPE group. At mid-term follow-up, the average wear rate for the CPE group was 0.3mm/year and for HXLPE was 0.1mm/year (p < 0.0001). At long-term follow-up, the average wear rate for the CPE group was 0.3mm/year, and for HXLPE was 0.1mm/year (p < 0.0001). Femoral head penetration was not significantly greater at long-term versus mid-term for the CPE group or the HXLPE group.

Conclusion: By examining those patients with identical bilateral THAs except for the type of polyethylene, therefore controlling for patient and implant factors, wear rates were significantly higher at mid and long-term follow-up with the CPE compared with HXLPE THA. There were no revisions or evidence of osteolysis in the HXLPE group, while there were four revisions including three for osteolysis with the CPE liners.

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Activities Performed and Treatments Conducted Prior to Consultation with a Spine Surgeon: Are Patients and Clinicians Following Evidence-based Clinical Practice Guidelines?
Eugene K. Wai, ON; Elliot Layne, ON; Darren Roffey, ON; Courtney Wilson, ON; Stephen Kingwell, ON

Purpose: Clinical practice guidelines (CPGs) are designed to ensure that evidence-based care is easily put into action. Whether patients and clinicians follow these guidelines is equivocal. What is clear though is: a) Canadian spine surgeons receive a large amount of referrals and; b) there is no indication to suggest patients are adequately undertaking conservative treatments that can manage – and even diminish – their condition. We examined how many patients complaining of low back pain (LBP) underwent evidence-based treatment in line with CPG recommendations prior to consultation with a spine surgeon.

Method: Sub-analysis of a prospective randomized controlled trial. Eligible adult lumbar spine patients aged 18-80 years with no defective conditions (e.g. scoliosis) were restricted to those triaged as P2 (“routine”) or P3 (“non-urgent”); P1 (“urgent”) patients were excluded. Questionnaires were sent immediately after their referral from a primary physician was received in the office of one of two spine surgeons at The Ottawa Hospital. Data collected included health care utilization, exercise specifics, medication usage and general demographics.

Results: Out of 210 patients analyzed, 65% reported exercising, for an average of 3.72 hours/week. Walking/running (59%), stretching/yoga (19%) and cycling (14%) were the most common exercise modalities. The main reason among the 35% of patients who did not exercise was “Too painful”. Out of 220 patients analyzed, 52% underwent active rehabilitation (i.e. physiotherapy), 28% massage therapy, and 23% spinal manipulation (i.e. chiropractor). Pain medications for LBP were taken by 75% of the 230 patients (over-the-counter medications: n=36; exclusively prescription medications: n=71).
Conclusion: Evidence-based treatments are not being taken advantage of prior to consultation. If more patients were to undertake CPG-endorsed conservative activities, it may result in fewer unnecessary referrals, and patients might not degrade as much while on wait lists. Further studies incorporating principles of knowledge translation to patients and clinicians are necessary.

185 Are Post-operative Pelvic Parameters and Sagittal Balance Predictive of Further Lumbar Surgery in Patients with Spinal Stenosis?
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Purpose: Surgical treatment of spinal stenosis has been reported to have an early success rate of up to 85%. Despite this, recurrent surgical rates remain substantial in this population. Sagittal balance, pelvic incidence, pelvic tilt, sacral slope and lumbar lordosis are all measurements that could potentially play a role in predicting success or failure of surgically treated lumbar spinal stenosis. This study examined whether post-operative pelvic parameters as well as sagittal balance were predictive of the need for further lumbar surgery in the spinal stenosis patient population.

Method: A retrospective review of 212 patients with surgically managed spinal stenosis at our institution between February 1 2006 and June 1 2010 was performed. Post-operative upright radiographs were examined and measurements of pelvic parameters, lumbar lordosis and sagittal alignment were made. Modes of failure included instability or recurrent neural element compression at the operative level, adjacent-level, or non-adjacent lumbar level. Secondary surgery for a wound infection was not included.

Results: A total of 199 patients were included in this study with an average follow-up of 5.0 ± 1.5 years. 14% of patients failed surgical treatment and required revision surgery. The majority of patient’s index procedure was a decompression and fusion (83% vs. 17% decompression only). The second surgery rate was similar for those who underwent fusion versus decompression only (12% vs. 18%, p = 0.406). The most common reasons for further surgery were adjacent level instability (30%) and/or adjacent level compression (54%). Sagittal vertical axis did not differ between patients who required further surgery and those who did not (66.9 ± 34.4° vs. 59.3 ± 40.5°, p = 0.547). However, lumbar lordosis differed significantly between the two groups (41.9 ± 13.7° vs. 49.3 ± 15.7°, p = 0.022, respectively).

Conclusion: The results show that only decreased lumbar lordosis was associated with further surgery following initial surgical treatment of lumbar spinal stenosis. Other measurements of sagittal alignment as well as pelvic parameters did not predict need for revision. However, further follow-up is required of this patient cohort. Thus, more accurate measurement of intra-operative lumbar lordosis could improve outcomes in surgically treated spinal stenosis. Also, post-operative measurement of lumbar lordosis may provide the highest yield in predicting future surgery in spinal stenosis.

186 Does a Simple 3-item Pain Questionnaire Reduce Wait Times for Consultations for Patients Who Would Benefit from Lumbar Spinal Surgery?
Matt Coyle, ON; Darren Roffey, ON; Stephen Kingwell, ON; Eugene Wai, ON

Purpose: We have developed a 3-item back-versus-leg pain questionnaire (“3-Item-Q”) that has previously identified optimal surgical candidates from non-specific low back pain (LBP) referrals. However, questions
remain over its capacity to: a) reduce wait-times for surgical patients and; b) accurately quantify patient symptomology between referral and spinal surgery consultation.

**Method:** Sub-analysis of data collected via a prospective randomized controlled trial comparing two groups: (i) Control – triage via referral letter and radiology report; (ii) Study – triage via referral letter, radiology report and 3-Item-Q responses. Eligible adult lumbar spine patients aged 18-80 years were restricted to those triaged as P2 (“routine”) or P3 (“non-urgent”); P1 (“urgent”) patients were excluded. Study group patients had their wait-list position upgraded if they indicated consistent leg-dominant pain on the 3-Item-Q. Quality of life questionnaires were completed at referral and again at consultation.

**Results:** Study group patients had a mean wait-time of 122 ± 88 days, while Control group patients waited 131 ± 60 days. Study group patients upgraded to P1 from P2 experienced the shortest wait-times (78 ± 33 days); the largest percentage of surgical candidates was extracted from this cohort (21%). Upgraded Study group patients (i.e. P2 to P1) also had an improved quality of life at consultation, as reported by responses to the EuroQol-5D. Overall, 39% of patients from both groups worsened from referral to consultation, as per responses from numerical pain scales and the Oswestry Disability Index. Contributing factors to worsening conditions were an unhealthy BMI (≥25 kg/m2), low physical activity levels, depression/anxiety and back dominant pain.

**Conclusion:** This study highlights the potential for patients to experience worsened symptoms while on the wait-list for spinal surgery consultation. By employing our 3-Item-Q and analyzing its responses, patients may experience shorter wait times and surgeons can more effectively identify surgical candidates from the abundance of non-specific LBP referrals.

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**Effectiveness and Safety of Transforaminal Lumbar Interbody Fusion in Revision Lumbar Surgery Patients with Previous Laminectomy**

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**Purpose:** To determine the efficacy and safety of transforaminal lumbar interbody fusion (TLIF) for revision lumbar spine surgery in patients with previous laminectomy. The secondary objective was to evaluate the clinical and radiological outcome after such a procedure.

**Method:** Retrospective case series study. Eighty-two patients were included. There were 48 women (58.5%) and 34 men (41.5%) with a mean age of 51 years (range 26-84) at the time of index procedure. The outpatient and inpatient charts were reviewed to identify patients’ demographic data, preoperative, perioperative, and postoperative data. An independent spine surgeon and musculoskeletal radiologist reviewed the imaging studies. Fusion within the intervertebral disc space was classified according to the criteria described by Brantigan and Steffee. Posterolateral fusions were evaluated according to the method popularized by Lenke et al. The outcome Measures were assessed by Oswestry Disability Index and visual analog scale for back and leg pain.

**Results:** The average operative time was 160 minutes (range 131-250). The average estimated blood loss (EBL) was 652 cc (100-1400 cc). Nineteen patients (23.1%) required blood transfusion. Five patients (6%) had dural tear. One patient (1.2%) had a surgical site infection. Tow patients (2.4%) had thromboembolic events. The average hospital stay was 3.8 days (2-5 days). At a mean follow up of 28 months, there were statically significant improvement in the ODI and VAS for back and leg pain. The mean preoperative ODI score was
142%
(range, 26–78), mean postoperative score was 26.4 (range, 0–60), and final follow-up score was 25.7
(range, 0–54) (P<0.05), with a mean final improvement of 51.6% (range, 12–100%) (P<0.05). The mean leg
pain VAS decreased from a preoperative score of 65.6 (range, 31–100) to a mean postoperative score of 39.2
(range, 2–90) and 42.6 (range, 4–90) at the last follow-up (P<0.05), with a mean final improvement of 51.5%
(range, 11–96.2%) (P<0.05). The mean back pain VAS decreased from a preoperative score of 65.6 (range,
31–100) to a postoperative score of 32.1 (range, 2–73) and 33.6 (range, 2–77) at the last follow-up (P<0.05),
with a mean final improvement of 57.4% (range, 21–97.0%) (P<0.05). None of the patients’ radiographs
showed hardware failure or pedicle screw loosening and no patient returned to the operating room for
pseudarthrosis.

Conclusion: The current study confirmed that TLIF approach in patients with previous laminectomy is effective
in achieving sound fusion and correction of alignment imbalance, safe with less complications than previously
reported and associated with good functional outcomes. The debate continues, on the optimal approach for
revision lumbar spine surgery, front, back, lateral or combined. What to do still strongly depends on the
surgeons’ preference as informed by training, expertise, and the past experience of what works best in their
hands.

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Wait Times for Spinal Surgery Across Canada: Data from the Canadian Spine Registry
Alexandra C.R. Stratton, AB; Ken C. Thomas, AB; Greg McIntosh, AB; Lauren Hirsch, AB

Purpose: The primary objective was to determine the wait times for elective spine surgery across Canada for
T1, T2, T3 and total wait time. Specifically, the primary aim was to identify which Canadian centres have higher
and lower wait times than the national medians. The secondary aims were to compare the three waiting
periods to determine which is most lengthy, and to investigate whether patients with motor deficit have shorter
wait times than those without.

Method: Wait time data collected between October 2008 and October 2014 from 11 participating sites were
used to determine the national median. Eight sites with >10 patients were used to compare the four wait time
periods, in patients with and without motor deficit. Nonparametric tests were used given the data was,
appropriately, heavily right skewed.

Results: The median national wait time (days) for T1=56, T2=1, T3=54 with a total median wait time of 213
days. Comparison of individual sites’ median wait times to the national median revealed: for T1 and T2, one
site was below and four above the national median; T3, one site was below and five were above. The median
wait times of patients with motor deficit were T1=33.5, T2=0, T3=30 and total=114 days which were all
significantly shorter than the national medians for patients without motor deficits (p<0.01).

Conclusion: The time from the first appointment with a spine surgeon to the date of surgical booking (T2) is
where spine surgery candidates spend the least time. There is considerable regional variation for all waiting
periods. Patients with motor deficit have significantly shorter wait times than the national median suggesting
that these patients may be given relative priority.

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Radiological and Clinical Outcomes Following Anterior Cervical Discectomy and Fusion (ACDF) Using
Trabecular Metal Cervical Interbody Cage with Minimum One Year Clinical Follow-up
Melissa Nadeau, ON; Aleksander Splawinski, BC; Jan Splawinski, BC

Purpose: To assess fusion rate and clinical outcomes following Anterior Cervical Discectomy and Fusion (ACDF) procedure using Trabecular Metal cage without bone graft at single and multiple levels.

Method: Eighty-three consecutive patients from one clinical site who had an ACDF procedure performed between 2006 and 2012 were identified. In all patients a Trabecular Metal cervical inter-body cage without bone was used as the fusion device. Operative details were obtained from patient charts then clinical and radiologic follow-up carried out prospectively. Radiologic assessment of fusion failure included motion on flexion/extension lateral C-spine x-ray, evidence of cage subsidence or migration, and the presence of radiolucency around implant. Clinical outcome measures included the Neck Disability Index (NDI), neck and arm pain severity Visual Analog Score (VAS 10 point scale), and Odom's Criteria. Adverse events were recorded.

Results: Eighty-three patients (45 men, 38 women) with mean age of 53 years participated in the study. Mean follow-up time was 3.6 years (range one to 6.6 years). Indications for surgery included trauma in two patients, radiculopathy in 58, myelopathy in 12, and myelo-radiculopathy in 11. Fifty-five patients had single level surgery, 25 had two level, two had three level and one had four level. The ACDF procedure was performed at C3-C4 (9%), C4-C5 (14%), C5-C6 (44%) and C6-C7 levels (33%). A total of 116 segmental levels were fused. 107 levels in 76 patients were plated anteriorly. Nine levels in eight patients were not plated (seven single-level and one two-level). Four patients required re-operation: one for adjacent level degeneration, one for postoperative hematoma and two for symptomatic screw back-out. No patients required cage revision. Based on radiologic criteria fusion rate was 89%. Odom's Criteria showed excellent outcome in 50% (37/74) of patients who showed fusion and 11% (1/9) of patients who did not fuse. Good outcomes were seen by Odom's Criteria in 35% (25/74) of fused patients and 78% (7/9) of unfused group. NDI and VAS clinical scores showed no significant difference between fused and non-fused groups.

Conclusion: This study shows that Trabecular Metal cage implants achieve a fusion rate comparable to that of autograft and allograft. The Trabecular Metal based fusion technique in cervical spine yields good early clinical and radiologic outcomes with minimal complication rates.

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Spinal Dural Arteriovenous Fistula: A Case Series and Review of Imaging Findings
Shandy Lynn Fox, SK; Luke Hnenny, SK; Michael Kelly, SK

Purpose: Spinal dural arteriovenous fistulae (AVF’s) are rare lesions. Patients typically present with slowly progressive myelopathy that is often mistaken for degenerative cervical or lumbar stenosis. On MRI, multisegmental T2 hyperintensities within the spinal cord and associated flow voids are pathognomonic, although these signs are frequently missed. Definitive diagnosis and localization is achieved with spinal angiography. Treatment consists of open surgical ligation, endovascular embolization, or multimodality treatment. The purpose of this study is to present a series of cases to aid in the assessment, diagnosis, and treatment of this unusual pathology.

Method: We present 10 cases of spinal dural AVF’s treated at our center over an 8-year period. The clinical presentation, radiographic findings, lesion classification, treatment undertaken, and neurologic outcome are reviewed. Two atypical cases are highlighted.
Results: The patients in our series were predominantly male (70%), the mean age was 62.6 years, and the most common type of lesion was the dorsal dural AVF with single feeder (type IA). All patients underwent surgical ligation, with some undergoing pre-operative coil embolization. Eight patients showed improvement in their myelopathy following treatment as graded by the Nurick system. Two patients failed to improve. None of the patients worsened.

Conclusion: The successful treatment of spinal dural AVFs requires a detailed understanding of the specific lesion type and its angioarchitecture. This helps ensure successful endovascular or surgical treatment.

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The Effect of Prolonged Post-operative Antibiotic Administration on the Rate of Infection in Patients Undergoing Posterior Spine Surgery Requiring a Hemovac Drain
Darryl Collings, ON; Lori Nutt, ON; Jennifer Urquhart, ON; Fawaz Siddiqi, ON; Kevin Gurr, ON; Christopher S. Bailey, ON

Purpose: Post-operative infection remains a significant concern for all patients undergoing elective orthopaedic procedure. Postoperative prophylactic antibiotics for 24 hours following an elective procedure are routinely given to most orthopaedic surgery patients as the standard of care. However, a spinal wound drain is often maintained for 48 hours following surgery to prevent compressive hematoma formation. It is hypothesized that maintaining the prophylactic antibiotics for 24 hours after drain removal may decrease infection rates. The purpose of this study is to compare the rate of deep infection in patients receiving prophylactic antibiotics for 24 or 72 hours, and to provide more advanced practice guidelines on the management of wound infections in postoperative spine surgery.

Method: All patients undergoing elective posterior spine surgery were screened. 500 patients met the inclusion criteria, with 450 patients computer randomized to either 24 or 72 hours of antibiotics. A stratified block randomization design was utilized to ensure equal numbers of patients with diabetes in each group. For this interim analysis Chi Square tests were used to compare the rate of superficial and deep infection between the two groups. Secondary outcomes, such as length of stay, were compared using simple two-tailed t-tests.

Results: There were 17 superficial infections in the 24hour group, compared with 5 in the 72 hour group (p = 0.008). There were 7 deep infections in the 24 hour group, compared to 8 in the 72 hour group (p = 0.801). The most commonly isolated organism was staphylococcus aureus. The mean length of stay was 4.0 ± 2.4 days in the 24 hour group and 4.3 ± 1.7 days in the 72 hour group (p = 0.162).

Conclusion: These preliminary results would suggest that a prolonged course of postoperative antibiotics may decrease the rate of superficial infection, but is not associated with a statistically significant difference in the rate of deep infection requiring irrigation and debridement.

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The Efficacy & Accuracy of Cone Beam CT (O-Arm®) Navigation (StealthStation®) on Screw Position in Adult Scoliosis Surgery
Jason Strelzow, BC; Nicolas Dea, BC; Charles Fisher, BC; Marcel Dvorak, BC; John Street, BC

Purpose: Intra-operative CT and navigation systems may provide an opportunity to improve precision and accuracy of pedicle screw placement, and in so doing, improve patient outcomes. Adult spinal deformity provides unique anatomical challenges potentially amenable to spinal navigation. Our study aimed to examine
the efficacy and safety of intra-operative cone beam CT navigation for pedicle screw placement in complex spinal deformity cases.

**Method:** We identified all patients treated at our institution with spinal fusion for the primary diagnosis of major adult deformity between January 2008 and December 2012 in whom O-arm® and StealthStation® navigation was used (NAV). A historic control cohort (NonNAV) was matched based on age, number of levels, curve type and size, previous fusion. The number and timing (intra-operative, early symptomatic post-operative, late symptomatic post-operative and incidental) of screw malposition and the need for revision screw placement was recorded. All patients had a minimum of one year follow-up. Any screw with pedicle breach greater than 0mm was recorded as misplaced. The direction and anatomical level of misplaced screws was also determined. Quantitative statistical analysis compared screw placement between NAV and NonNAV cases.

**Results:** Fifty-six patients met inclusion criteria in both cohorts (112 patients). The mean number of screws placed in each group was not significantly different. (17.29 NAV and 17.71 NonNAV, p=0.75) Thirty-eight (34%) patients in the NonNAV group had misplaced screws compared to 21 (19%) in the NAV group (p=0.002). The detection of incidental screw malposition was significantly higher in the NonNAV cases (44.6% vs. 23.2%, p<0.05) and the need for intra-operative screw revision favoured navigation (p<0.03). Six cervical screws, 16 cervicothoracic, 90 thoracic and 112 lumbar screws were placed. Early post-operative screw revision rates approached significance (p<0.06) favouring navigation. The number of adverse events and length of stay (mean 17 vs. 20.4 days in NAV and NonNAV groups respectively) were not significantly different. The mean number of post-operative CT scans was significantly fewer in the NAV group (9 vs. 22 in NonNAV group, p=0.004) while mean OR time was statistically different between groups (492 mins in NAV Group vs. 408 mins in NonNAV, p=0.002).

**Conclusion:** Our results demonstrate that intra-operative CT-guided navigation provides an equally safe, and more accurate and precise tool for pedicle screw placement than traditional techniques in adult spinal deformity surgery. There were more intra-operative screws adjusted and fewer post-operative screws revised with NAV. Far fewer patients required post-operative CT examination with the use of NAV.

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**Metabolic Syndrome is not Independently Associated With Complications Following Lumbar Spine Fusion**

**Michael G. Zywiel, ON; Rushil Chaudhary, ON; Timothy Jackson, ON; Y. Raja Rampersaud, ON; Rajiv Gandhi, ON**

**Purpose:** Metabolic syndrome (MetS) is associated with an increased prevalence of spine osteoarthritis (OA). Furthermore, MetS has been shown to increase the risk of post-operative complications following a number of non-spinal surgical procedures, although the risk following spine surgery specifically is unknown. Thus, the purpose of the present study was to determine whether Metabolic Syndrome (MetS) is associated with an increased risk of post-operative complications following instrumented spine surgery in patients with spinal OA.

**Method:** The National Surgical Quality Improvement Project (NSQIP) database was reviewed to identify patients who underwent lumbar spine fusion for OA, defined as a diagnosis of stenosis (n=2,477) or spondylosis (n=997), between 2005 and 2012. Patient demographics, comorbidities, smoking status, chronic steroid use, and 30-day complications including mortality were extracted. MetS was defined as patients who had a BMI ≥30 kg/m2 coupled with diabetes and hypertension. Univariate analysis was performed using chi-
Results: Overall, 11% of the cohort met the study criteria for MetS (n=370), while 24.6% of patients experienced a post-operative complication (n=854). The most commonly reported complications included: return to the OR (3.9%), superficial surgical site infection (1.5%) and sepsis (1.32%). Patients with MetS had a greater, though marginally non-significant, likelihood of experiencing at least one complication within 30 days of surgery (28.6% vs 24.1%; p=0.055). On multivariable analysis, significantly higher odds of developing post-operative complications were found in patients with Class III obesity (OR 1.469; 95% CI [1.050-2.054]) even after adjusting for age, smoking, steroid use, ASA class and the presence of concomitant neurologic symptoms. However, hypertension, diabetes and the presence of MetS were not found to significantly influence the odds of developing a complication.

Conclusion: Patients with MetS had a higher incidence of 30-day complications following instrumented lumbar spine surgery for OA. However, these differences appear to be the result of variability in demographic characteristics and other risk factors between groups, most notably class III obesity, rather than MetS itself. Thus, MetS does not appear to be independently associated with increased overall 30-day complication rates following instrumented spine surgery for OA.

Pre-operative Femoral Nerve Block for Hip Arthroscopy: A Randomized Controlled Trial
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Purpose: Arthroscopy has become a standard method of treatment for a variety of intra-articular hip pathologies. While most arthroscopic hip procedures are performed as day-surgeries, patients can still experience significant post-operative pain and opioid-associated side-effects. Our group has shown the potential benefits of preoperative femoral nerve block (FNB) in a previous retrospective review. It was our objective to confirm these findings in a prospective study.

Method: Fifty patients undergoing hip arthroscopy were included in this prospective, single centre, double-blinded, randomized controlled trial. All patients received a pre-operative ultrasound-guided femoral nerve block with either 20 mL of 0.5% bupivacaine (treatment group, n=27) or normal saline (control group, n=23). Nerve blockade was confirmed via standardized sensory testing prior to the induction of general anaesthesia. Groups were compared with respect to patient sex, age, body mass index (BMI), physical status classification according to the American Society of Anaesthesiologists (ASA); procedure performed; and opioid requirements. The primary endpoint was total oral morphine equivalent consumption in 24 hours. Secondary endpoints included visual analog pain scores; Quality of Recovery (QoR-27) score at 24 hours; incidence of nausea and vomiting; patient satisfaction; and block-related complications.

Results: There were no significant differences between groups with respect to sex, age, weight, height, BMI, ASA classification, or type of procedures performed. Total oral morphine consumption at 24 hours was similar between groups. Patient-reported pain scores were lower at all times points in the femoral nerve block group compared to the placebo group with statistical significance reached at 30 minutes, 1 hour, 2 hour, 4 hour, and 6 hours post-operatively. There was no difference in the rates of nausea and vomiting after surgery, Quality of Recovery score at 24 hours, time to discharge, or symptoms of itching, weakness, and injection site bruising and pain. The placebo group had a significantly higher rate of reported constipation at 48 hours. 6 out of 27
patients in the femoral nerve block reported falls (without injury) at 24 hours compared to 0 out of 23 patients in the placebo group. The satisfaction score, however, was similarly high in both groups at all time-points.

**Conclusion:** Pre-operatively administered femoral nerve blocks lead to decreased pain scores in the early post-operative phase without affecting opioid consumption or opioid-related side effects. Patient satisfaction with pain control was similarly high between groups. Given the rate of falls observed in this study, however, we cannot recommend the routine use of femoral nerve blocks for outpatient hip arthroscopy.

**195 Reliability of the Arthroscopic International Cartilage Repair Society (ICRS) Grading System: Correlation with Histopathology Assessment**

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**Purpose:** The International Cartilage Repair Society (ICRS) cartilage grading system lacks validity and reliability data. Video is commonly used to assess the reliability of arthroscopic cartilage assessment tools; however, it is unclear how video relates to real-time arthroscopy. The current study examined: (i) the interobserver reliability of the ICRS grading system, (ii) a comparison of arthroscopic grading with histopathology assessment, (iii) the correlation between real-time arthroscopy and video analysis assessment.

**Method:** Eighteen lesions in 5 cadaveric knee specimens were arthroscopically graded by 7 fellowship-trained arthroscopic surgeons. Lesions were biopsied and depth and cartilage quality were assessed using the (Osteoarthritis Research Society International) OARSI and ICRS-II scoring systems. Arthroscopic video of each lesion was sent to the surgeons > 6 weeks later for repeat grading. Multi-rater Interclass Correlation (ICC) statistics were used to measure agreement.

**Results:** There was substantial inter-observer agreement between surgeons when grading lesions using real-time arthroscopy ICC 0.614. The average OARSI grade was 2.15 (SD 1.23) and ICRS-II scoring was 77.6 (SD 18.5). The histopathology and live arthroscopic assessments only correlated 34% (15-46) of the time with 95% of the discrepancy being arthroscopic over assessment. Live and video assessment showed substantial intra-observer agreement ICC 0.662.

**Conclusion:** The arthroscopic ICRS grading system has substantial inter-observer agreement but the correlation with histopathology assessment was low with arthroscopy often overestimating depth. Assessments made using video were in high agreement with live arthroscopic assessments.

**196 Subpectoral Biceps Tenodesis with PEEK Interference Screw: A Biomechanical Analysis of Fracture Risk**

**Jason J. Shin, SK; Chris Mellano, CA; Randy Mascarenhas, TX; Elizabeth Shewman, IL; Vincent Wang, IL; Brian J. Cole, IL; Anthony A. Romeo, IL; Nikhil Verma, IL; Brian Forsythe, IL**

**Purpose:** The purpose of this study was to determine the amount of torsional strength reduction in the humerus resulting from an unicortically drilled hole, and to evaluate the effect of inserting a tenodesis screw into the drilled defect. We hypothesized that unicortical drilling would weaken the humerus and that the use of tenodesis screws would restore strength to the humerus.
**Method:** Twenty (10 matched pairs) of fresh frozen full length humeri (mean age 55.3 years, range 37-70 years) were used to perform this study. All humeral specimens were stripped of all soft tissue, except for the pectoralis major tendon, which was used to determine location of the tenodesis. Specimens were allocated to either Screw (n=5) or Empty Ream Group (n=5) and the matching contralateral pairs remained intact. In the Empty Ream specimens, an 8 mm unicortical hole was placed into the bicipital groove 1 cm proximal to the inferior border of the pectoralis major tendon. The humeri in the Screw Group were prepared in the same manner and filled with a 8mm x 12 mm polyetheretherketone (PEEK) screw. All specimens were tested until failure under torsional loading at a rate of 1 degree/second. Peak torque, angular deformation at peak, total energy to failure and linear stiffness were recorded. A paired t-test was used to compare data from left and right humeri for each of the two groups. Data were also evaluated as the ratio of the intervention humerus to its contralateral intact humerus in order to compare Tenodesis Screw and Empty Ream groups via a 2-tailed, unpaired t-test. Statistical significance was assumed for P < 0.05.

**Results:** When compared with intact group, both Screw and Empty Ream groups showed a significant reduction in peak torque, energy and angular displacement (P < 0.05), but there was no significant difference in stiffness (P > 0.05). No statistical differences were noted between Screw and Empty Ream group for all measured values (Table 1).

**Conclusion:** Drilling an 8mm unicortical hole for subpectoral biceps tenodesis reduces the torsional load to failure of the proximal humerus at time zero. Placing a PEEK tenodesis screw alone does not appear to increase the strength of the humerus.

**Predictors of Return to Work in Workers Compensation Patients Undergoing Hip Arthroscopy: A Matched Case-control Study**

**Randy Mascarenhas, TX; Simon X. Lee, IL; Thomas Wuerz, MN; Richard C. Mather III, NC; Charles Bush-Joseph, IL; Shane J. Nho, IL**

**Purpose:** To compare outcome differences within a WC population undergoing hip arthroscopy in order to identify prognostic factors predicting return to work.

**Method:** Prospectively collected data on 29 WC patients who underwent hip arthroscopy was retrospectively reviewed and compared to an age and gender-matched control group. WC patients were then stratified into either a good outcome group (WC-GOOD; returned to previous work level without restrictions) or a poor outcome group (WC-POOR; failure to return to work or return to work with permanent restrictions) and compared to each other. Finally, these subgroups were compared to age- and gender-matched controls. Primary outcomes included return-to-work (RTW), time to maximum medical improvement (MMI), work level at MMI, the Hip Outcome Score Activities of Daily Living (HOS-ADL) and Sports-Specific (HOS-SS) subscales, and the modified Harris Hip Score (mHHS).

**Results:** Twenty WC patients were able to RTW (69%) while 9 were unable to RTW or returned with permanent restrictions (31%). All patient-reported outcomes at MMI increased significantly for WC patients and matched controls compared to pre-operative levels. Controls performed better than WC patients on the HOS-ADL (P=0.0001), HOS-SS (P=0.0001), and mHHS (P=0.0038). When compared to WC-GOOD patients at the time of MMI, the WC-POOR group had significantly lower HOS-ADL (P=0.0008), HOS-SS P=0.039), and mHHS scores (P=0.0042). WC patients had more associated injuries (P=0.0195) and increased tobacco use.
Compared to WC-GOOD, WC-POOR had more time between initial clinical presentation and surgery (P=0.0079), more associated injuries (P<0.0001), lower baseline mHHS (P=0.0163), and required more time to reach MMI (P=0.004). There was a significant difference in BMI between controls and WC-POOR (P=0.0389).

**Conclusion:** Workers compensation patients demonstrated a high likelihood of return to full-duty. Prognostic factors suggestive of poor outcomes include prolonged time to surgical treatment, associated injuries, high BMI, and lower pre-operative hip-specific outcome scores.

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**Is the Contralateral Hip at Risk in Patients with Unilateral Symptomatic Cam FAI? A Quantitative T1ρ MRI Study**

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**Purpose:** Cam-type femoroacetabular impingement represents a leading cause of early cartilaginous damage in the nondysplastic hip and is a risk factor for hip arthritis. T1ρ (rho) magnetic resonance imaging (MRI) is a promising quantitative cartilage mapping technique which can identify patients at risk of arthritis. This technique reveals hyaline cartilage degeneration by detecting changes in the proteoglycan (PG) content of the extracellular matrix. However there is a lack of understanding when and where the cartilage matrix changes occur in patients with pre-arthritic hip deformities. The goals of this study are to (1) assess the T1ρ MRI profile of weight-bearing cartilage of hips with a cam deformity (2) evaluate for a side-to-side difference in T1ρ profile in patients that have only unilateral hip pain in the context of bilateral cam morphology.

**Method:** 19 patients (17 males; 2 females; mean age 37.1 years) with bilateral cam morphology undergoing osteochondroplasty for unilateral hip pain were prospectively recruited. The alpha angle was measured at both the 1:30 and 3:00 positions using multi-planar computer tomography. All patients underwent bilateral 1.5T T1ρ MRI with the symptomatic hip being done pre-operatively. The weight-bearing hyaline cartilage bilayer of the acetabulum and femoral head was evaluated on 7 sagittal images and the mean T1ρ relaxation value was calculated for each sagittal slice. The weight-bearing area was divided into four quadrants and the mean T1ρ value calculated for each quadrant: anterolateral (AL), anteromedial (AM), posterolateral (PL) and posteromedial (PM).

**Results:** There was no significant difference in mean alpha angles between the symptomatic and asymptomatic sides at the 3:00 position (54.2 vs 56.0 degrees; p=0.382) and at the 1:30 position (65.1 vs 65.2 degrees; p=0.971). There was loss of the normative gradient in PG content with the mean T1ρ relaxation times being not significantly different when each quadrant (AL, AM, PL, or PM) was compared to the rest of the weight-bearing surface of the symptomatic (p=0.07) and asymptomatic hips (p=0.102). There was also no significant side-to-side difference in mean T1ρ values between the same quadrants of symptomatic and asymptomatic hips: AL 31.7ms vs 29.1ms (p=0.09); AM 34.0ms vs 32.0ms (p=0.24); PL 31.9ms vs 30.7ms (p=0.45); PM 32.9ms vs 31.5ms (p=0.40). No correlation was detected between severity of alpha angle and the mean T1ρ relaxation time value in each of the four quadrants.

**Conclusion:** In morphologically normal hips, the anterolateral quadrant displays a higher PG content than the rest of the weight-bearing surface. This study confirms that this normal regional variation in PG content is lost in both symptomatic and asymptomatic patients with cam morphology manifest by a decrease in the PG content in the anterolateral quadrant. Therefore, regardless of the presence of hip pain, a cam deformity suggests ongoing hip joint cartilage degradation and increased risk of hip osteoarthritis.
Prospective Evaluation of the Incidence of Deep Vein Thrombosis After Elective Hip Arthroscopy
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**Purpose:** To prospectively determine the incidence of deep vein thrombosis (DVT), using Doppler Ultrasound, following elective hip arthroscopy without pharmacologic or mechanical prophylaxis.

**Method:** One-hundred-and-fifteen consecutive patients (55 males) aged >18 years (mean: 34.9) underwent elective hip arthroscopy with one of two surgeons as a day surgery procedure. Patients with a previous thromboembolic event, known prothrombotic condition, systemic symptomatic medical disease, septic arthritis, or with third party compensation were not eligible. Eligible patients did not receive pharmacologic or mechanical thromboembolic prophylaxis and were encouraged to mobilize post-operatively depending on their specific procedure. At two weeks post-op patients were assessed for signs and symptoms of DVT and PE, including calf erythema and swelling, calf pain, shortness of breath and pleuritic chest pain. A bilateral Duplex color Ultrasonography with assessment of compressibility of the proximal deep venous system was performed between 10-21 days on all patients. The primary outcome was the frequency of DVT, as diagnosed by Doppler. The following risk factors were compared between patients: Demographic information, family history of DVT or blood dyscrasia, smoking status, surgical details i.e. traction time, patient positioning, specific surgical procedures (peripheral compartment arthroscopy, bony surgery, microfracture, labral repair, etc.).

**Results:** Five patients (mean age: 43.8; range 27-58) were diagnosed with a DVT (2 males / 3 females) between two-22 days post-operatively. Four patients were symptomatic. Three patients were diagnosed because of symptoms requiring an emergency assessment and evaluation confirming a DVT. One patient was suspected to have a DVT at their first post-op visit and then confirmed by Ultrasound. The asymptomatic patient was without signs of a DVT on clinical examination. Four patients had a DVT restricted to the calf veins and one patient had involvement of the popliteal vein. No patients had proximal extension into the thigh or pelvis. The arthroscopy for these 5 patients was performed in the supine position. The average age of the 110 patients (53 males/57 females) without a DVT was 34.5 (range 18-58). The average traction time was 38 and 61 minutes for those patients with and without a DVT, respectively. All other potential risk factors including surgical procedure, post-op weight bearing status, mobilization and use of NSAIDs were similar.

**Conclusion:** The incidence of DVT following elective hip arthroscopy is low. Routine screening for DVT is not recommended. Mechanical or pharmacologic DVT prophylaxis for patients without known DVT risk factors is also not recommended.

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Fixation of a Collagen Patch in the Porcine Knee: Implications for Matrix-assisted Chondrocyte Implantation (MACI) and Second-generation Autologous Chondrocyte Implantation (ACI)
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**Purpose:** To evaluate the integrity of fixation of a type I/III collagen patch secured to a chondral defect in the porcine knee using fixation methods typically used in autologous chondrocyte implantation (ACI) and matrix-assisted chondrocyte implantation (MACI).
Method: A total of 24 fresh cadaveric porcine knee specimens underwent a medial parapatellar arthrotomy. A prefabricated template was used to create standardized chondral defects of 2 cm² in the medial femoral condyle. A template was used to fashion a 2 cm² type I/III collagen patch. Four methods of fixation of the patch were analyzed: Group I – saline alone, Group II – fibrin glue around edge of collagen patch, Group III – fibrin glue in base of defect and around edge of collagen patch, Group IV – circumferential 6-0 vicryl suture and glue around edge of collagen patch. Each knee underwent 1200 cycles from full extension to 90 degrees flexion. Patch fixation was assessed at intervals of 60, 300, 600, 900, and 1200 cycles. Peripheral patch detachment, area of defect uncovering, and patch deformation were scored by two independent observers blinded to the fixation method.

Results: There were no complete failures of collagen patch fixation after 1200 cycles in the control or experimental groups. Mean peripheral detachment of the patch and chondral defect uncovering remained < 25% for all fixation methods, including saline, past 600 cycles. Addition of suture or fibrin glue at base of defect reduced patch deformation significantly after 900 cycles. Near-complete failure of patch fixation occurred in one specimen secured with fibrin glue alone.

Conclusion: Addition of suture increases the stability of a type I/III collagen patch to a chondral defect better than fibrin glue alone in the porcine knee after repetitive cycling. Fibrin glue at base of defect or suturing of the patch reduces the likelihood of patch deformation. For the surgeon who performs ACI or MACI, these findings should be strongly considered, particularly in cases where an arthroscopic MACI procedure is undertaken.

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Quantification Analysis of the Intraoperative Bacterial Contamination Rate of Osteochondral Autograft
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Purpose: While inadvertent contamination of osteochondral (OC) autografts during harvesting or by accident is infrequent, it can result in significant complications, and managing this contamination poses a challenging dilemma to orthopaedic surgeons. Subsequently, the operative team must weigh the risk of an infectious complication following reimplantation against that of discarding the OC fragment. The most commonly reported mechanism of contamination is accidentally dropping an OC fragment. Published data on the rate of this mechanism of contamination are limited. Additionally, the rate of contamination during harvesting and preparation is still unknown, and to our knowledge, it has not been reported in the English literature. Purpose: To quantitatively evaluate the rate of bacterial contamination of OC autograft during harvesting and to compare it to the rate of contamination from accidentally dropping the graft onto an operating room floor.

Method: Fresh OC specimens were steriley recovered from 23 primary total knee arthroplasties (TKAs). All 23 total knee arthroplasties were performed for osteoarthritis. None of the total knee arthroplasty patients developed a postoperative infection. Each specimen was prepared carefully and was cut into 1 cm² by an osteotome using a meticulous sterile technique. We obtained 138 fragments from 23 TKAs. Six OC fragments were harvested and retrieved from every TKA—Three specimens were used as the controls while the others were dropped onto the operative room floor adjacent to the operating table. No changes were requested to the floor cleaning protocol prior to operation. Each dropped OC fragment was placed on the operating room floor for 10 s before being collected for tissue culture using sterile forceps. Each retrieved specimen was immediately transported to the microbiology laboratory. All tissue samples were weighed using a digital balance. Each tissue sample was rolled on sheep blood agar (SBA) plates for at least 20 s to ensure that all sides contacted the culture plate. Then all the plates were incubated in 5% CO2 for 48–72 h for aerobic growth
and for 7 days in sealed jars for anaerobic growth. After 72 h of incubation, the bacterial colonies were counted on each plate, and the colony-forming units (CFU) per gram were calculated from the total number of CFUs per plate for each sample. The tissue samples were then transferred to cooked meat medium, incubated at 36°C for 72 h. The tubes were placed in a vortex and 100-µL aliquots of the supernatant were streaked onto SBA plates for overnight incubation. If the plates or cooked meat medium showed growth, the organisms were identified using standard clinical microbiological methods. The bacterial isolates were identified on the basis of their morphology using the gram stain procedure. Cultural characteristics of the isolates were studied after 72 h of incubation. Identification was performed using an automated MicroScan WalkAway-96 System (Dade Behring, West Sacramento, CA, USA) with identification and susceptibility panels (Negative Combo 42 and Positive Combo 28).

 Results: We assessed 69 control OC specimens and 69 dropped OC specimens. The contamination rates (positive cultures) for the control and dropped groups were 29% (20) and 42% (29), respectively. The difference in the contamination rate between the groups was not statistically significant (p = 0.109). The mean rank of the CFU for those dropped and control specimens with positive cultures were 31.24 and 15.95, respectively. Specimens with positive cultures in the dropped group have a significantly higher CFU than that of the control group (p = 0.000). The most common organisms identified in the control group were Staphylococcus aureus (35%), Staphylococcus epidermidis (25%), and Escherichia coli (10%). The other organisms were Sphingomonas paucimobilis, Staphylococcus lentus, Staphylococcus simulans, Gardnerella Vaginalis, Micrococcus luteus, and Kocuria kristinae (5% each). In the dropped group, the most common organisms were Staphylococcus epidermidis (24.1%), Bacillus species (20.7%), Escherichia coli (17.2%), Staphylococcus haemolyticus (13.8%), and Kocuria kristinae (10.3%). The other organisms were Staphylococcus auricularis, Micrococcus luteus, Staphylococcus intermedius, and Enterococcus casseliflavus (3.4% each).

 Conclusion: A high rate (29%) of OC autograft contamination can be expected during harvesting and preparation. Quantification analysis showed that accidentally dropped autografts have a significantly higher CFU than those contaminated during harvesting. Therefore, mechanical or chemical decontamination of OC autografts after harvesting and preparation is strongly recommended, especially for grafts that have been accidentally dropped onto the operating room floor.

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Patient Reported Outcomes Following Revision Anterior Shoulder Arthroscopic Capsulolabral Stabilization
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Purpose: The purpose of this study was to assess patient reported outcomes in patients following revision shoulder arthroscopic anterior capsulolabral stabilization.

Method: Sixty-two patients (63 shoulders) with failure of primary instability repairs were treated with revision arthroscopic anterior shoulder stabilization at a mean follow-up of 46.9 ± 16.8 months (range, 15-78). Forty-six male patients and 16 females with a mean age of 23.2 ± 6.9 years (range, 14.7 – 47.2) were identified and analyzed. Revision arthroscopic stabilization was indicated in patients with recurrent instability with limited glenoid bone loss(< 25%). Clinical outcomes were evaluated using validated patient reported outcome questionnaires including the American Shoulder and Elbow Surgeons score, Simple Shoulder Test, visual
analog pain scale and Western Ontario Shoulder Instability Index. In addition, patients were queried for recurrent instability events (subluxation or dislocation) or revision surgery.

Results: At final follow-up, the mean post-operative Western Ontario Shoulder Instability normalized score was 80.1 ± 18.7 (range, 15.0 - 100). There were clinically significant improvements in American Shoulder and Elbow Surgeons scores from 63.7 pre-operatively to 85.1 post-operatively (P < 0.001), Simple Shoulder Test normalized scores from 61.8 pre-operatively to 90.9 post-operatively (P < 0.001), and ten-point visual analogue scale for pain from 2.89 pre-operatively to 0.81 post-operatively (P < 0.001). Recurrent instability occurred in 12 shoulders (19.0 %), with number of prior surgeries and hyperlaxity found to be significant risk factor for failure (P < 0.001 and P = 0.04, respectively).

Conclusion: Revision arthroscopic anterior stabilization of the shoulder can result in satisfactory outcomes in appropriately selected patients who have failed previous capsulolabral repair. Increased number of prior surgeries and hyperlaxity are predictive of poor outcome. Longer-term studies are required to determine whether similar results are maintained over time, and to provide guidance on focused clinical indications.

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Cam Deformity not Associated with Conventionally Held Risk Factors for Femoroacetabular Impingement
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Purpose: Conventionally held risk factors for Femoroacetabular Impingement (FAI) include femoral and acetabular retroversion with the theory that relative retroversion leads to impingement and secondary cam deformity. We hypothesized that cam deformity is mostly primary in etiology and not associated with these risk factors. The purpose of this study was to utilize multiple regression to assess the relationship between femoral and acetabular version with two markers of cam deformity: alpha angle and anterior offset.

Method: We randomly selected 1013 cadaveric hips from a historical osteologic collection. Hemipelvies were reassembled with sacra to reproduce the pelvic ring. Acetabular version was then directly measured from specimens in a standardized fashion. Digital images were obtained of each femur from an axial view perpendicular to the femoral neck in order to measure alpha angle and anterior offset. Cam deformity was defined as alpha angle greater than 60 degrees. A direct axial view of the femur was also obtained in order to measure femoral version. Multiple regression analysis was performed to determine whether alpha angle or femoral offset are related to age, femoral version, and acetabular version.

Results: The mean alpha angle and anterior offsets for the sample population were 48.1±10.4 degrees and 0.76±0.18 cm, respectively. Twenty-two percent (223/1013) specimens demonstrated cam deformity (alpha angle >60 degrees). Multiple regression analysis did not demonstrate any statistically significant association between femoral version, acetabular version, and alpha angle. However, multiple regression analysis demonstrated a small, but significant association between increasing femoral and acetabular version with decreased anterior offset (both p<0.01). While this relationship was statistically significant, its clinical relevance was mild as all factors combined only explained 9% of the variance in anterior offset.

Conclusion: Conventionally accepted risk factors for development of cam deformity include relative femoral and/or acetabular retroversion. Our study did not observe these associations in a large and random population. Our data suggests cam deformity is generally a primary lesion rather than a contre coup lesion secondary to
impingement. It is important to note that our population presumably did not have any increased FAI symptomatology as compared to any random sampling. Given this, we propose that relative acetabular or femoral retroversion do not lead directly to cam deformity, but may instead increase the risk for a symptomatic hip by mechanically increasing the risk for impingement. An evolving understanding of the etiology of FAI may lead to changes in evaluation and management of adolescents and young adults with this pathology.

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An Alternative Site for Pin Placement in External Fixation of Pelvic Fractures: The Lateral Posterior Pelvic External Fixator Surgical Technique
Pierre Navarre, QC; Matthias Russ, Australia; Jarrad Stevens, Australia

Purpose: The application of an external fixator for unstable pelvic fractures is an important component of resuscitation protocols in a large portion of trauma hospitals. Moreover, certain pelvic fractures may be treated with an external fixator without requiring further internal fixation. The described techniques of pelvic external fixation include the anterosuperior (iliac wing), anteroinferior (supra-acetabular) and subcristal (anterior superior iliac spines) insertion sites. The reported infection rates in definitive pelvic fracture treatment are up to 50% in the first two techniques and 20% for the third technique. Due to the localization of the insertion site, the lateral femoral cutaneous nerve is potentially at risk with the last two techniques. We report our clinical results with an alternate pelvic external fixator site, the lateral posterior external fixator (LPEF), and describe the surgical technique.

Method: From 2010 à 2013, we identified 27 consecutive patients (mean 46 years of age, 18-80) treated by the same surgeon (MR) with a LPEF in a level-1 trauma center. We proceeded to a retrospective data collection relating to mechanism of injury, surgical interventions and complications including: infection, cutaneous complications, iatrogenic fracture, malposition of the external fixator, loss of fixation, neurological injury.

Results: The LPEF was used in 16 patients as acute pelvic stabilization and converted at a mean of 2,75 days (1-11) to internal fixation, whereas in 10 patients it was used as definitive treatment and removed at an average of 50.4 days (36-71). 1 patient deceased on day 14 secondary to his severe closed head injury. The only surgical complications were 2 wound infections (20% in the group of definitive LPEFs) which resolved without sequellae following the removal of the LPEF (at 36 and 50 days) and antibiotics, 1 case of loss of fixation leading to the removal of the LPEF at 71 days and 1 patient who had hypergranulating external fixator sites and eventually healed without any cutaneous sequellae. All fractures consolidated in good position.

Conclusion: The LPEF insertion site is anatomically far from any nerves as well as the inguinal region, possibly explaining the low risk of complications. Furthermore, the LPEF insertion site is as far as possible from the abdomen, permitting easy access for laparotomy. The lateral posterior pelvic external fixator technique has a low risk of infection and other complications and is a useful adjunct in the treatment of pelvic fractures.

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Exploring Variation in Hip Fracture Care Across Ontario
Tammy L. Cosman, ON; PJ Devereaux, ON; Kim Alvarado, ON

Purpose: Purpose: Worldwide the number of patients experiencing hip fracture is expected rise to 2.6 million by 2025. The 2010/2011 provincial orthopaedic scorecard identified variability in hospital length of stay (LOS)
across Ontario. International research suggests variations in patient outcomes, including LOS, are likely related to differences in patient care. This study examined differences in processes, systems and clinical care of hip fracture patients across 14 Ontario hospitals. The purpose was to explore the relationship between practice patterns and hospital LOS in surgical hip fracture patients.

**Method:** Methods: Concurrent mixed methods design was used, including a cross sectional descriptive survey and qualitative interviews. Hospitals were selected based on surgical volume and hospital LOS. The survey and interview guide were based on practice guidelines and interprofessional team input. Ethics approval was obtained for this study. Semi-structured interviews were completed with 70 key informants in hip fracture care. Common themes were identified using content analysis with an iterative approach to data collection and analysis.

**Results:** Results: Fourteen Ontario hospitals participated in this study with survey and interviews completed between December 2013 and April 2014. Eight community and 6 tertiary hospitals across 9 LHINs were included. Patients were cared for on 8 orthopaedic and 6 mixed surgical wards with the orthopaedic surgeon as the MRP. Survey results found that hospitals meeting the provincial home to home LOS (H-H LOS) target (i.e., < 11 days) were more likely to have: 1. dedicated discharge personnel; 2. MRP support postoperatively; 3. communication techniques including bullet rounds and white boards; and 4. transfer patients to rehab on weekends. There was no difference in the use of standardized processes (preprinted orders, clinical pathway), nursing skill mix, nursing model of care or nurse patient ratio. Qualitative analysis revealed common features among the hip fracture population including multiple comorbidities, cognitive decline and financial and social issues. Four themes, with positive and negative attributes, were identified across hospitals including: collaborative culture, mobilization, quality patient care and creative structures. Mixed methods results identified team collaboration, communication, discharge planning and clinical care (i.e. postop weight bearing status, mobilization, catheter removal) as significant features in hospitals meeting H-H LOS target.

**Conclusion:** Conclusion: This study found interprofessional collaboration and communication impacted H-H LOS with hip fracture patients. Further research examining the impact of clinical care on patient outcomes is required as quality care practices identified in practice guidelines are not routinely monitored. Examining our existing processes, systems and clinical care standards will inform how to improve H-H LOS while maintaining overall quality.

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**Hospital Administrative Data Significantly Underestimate the Costs Associated with Perioperative Delirium in Patients with Hip Fractures**

**Michael G. Zywiel, ON; Anthony V. Perruccio, ON; Rajiv Gandhi, ON; Peter C. Coyte, ON; Y Raja Rampersaud, ON**

**Purpose:** Using clinical data, studies have identified a high rate of in-hospital delirium and significant associated incremental health resource utilization among older patients with hip fractures. However, there is limited knowledge of the extent to which delirium identified in administrative databases corresponds with clinical data. Thus, the present study sought to 1) determine the sensitivity and specificity of administrative data in identifying the occurrence of perioperative delirium among patients with low energy hip fractures, and 2) determine whether the choice of data source (administrative versus clinical) influences estimates of incremental episode of care costs and length of stay attributed to this adverse event.
Method: All patients 65 years of age or older who underwent surgical treatment of a low energy hip fracture at a single institution between January 2011 and December 2012 were reviewed. A total of 242 patients who had a mean age of 82 years (range, 65 to 103 years) were included. Delirium was identified using the Confusion Assessment Method (CAM), performed prospectively at the end of each nursing shift as a routine part of clinical care. Previous economic evaluation of this cohort revealed that 48% of patients experienced delirium, which was associated with an incremental episode of care cost of $8,515 and incremental length of stay (LOS) of 6.9 days. Health-related administrative data for each patient was obtained from the Discharge Abstract Database (DAD), which is part of the holdings of the two largest health services data repositories in Canada. These data were reviewed to identify delirium as indicated by the presence of an ICD-10 F05 group code. The sensitivity and specificity of ICD-10 coding in identifying delirium was determined compared to use of the CAM tool (considered the gold standard). We estimated the incremental and annualized episode of care costs and length of stay associated with administratively-identified delirium using a propensity matching approach to control for potential confounders, and compared these to findings obtained using clinical data for the same patient cohort.

Results: Thirty-three patients were identified as having delirium in the DAD (13.6%; 95% CI 9.9% to 18.5%), as compared to 117 patients using the CAM tool (47.9%; 95% CI 41.7% to 54.2%). Agreement between sources was poor as reflected by a kappa statistic of 0.17. Against identification by the CAM tool, administrative data yielded a sensitivity of 22.4% (95% CI 15.4% to 31.2%) and specificity of 99.2% (95% CI 94.7% to 99.9%). The annualized incremental total costs attributable to delirium were underestimated by 67% ($165,462 vs $502,395) and the annualized incremental number of bed-days was underestimated by 66% (137 bed-days vs 400 bed-days). Similarly, the proportion of hospital expenditure and bed utilization for patients with hip fractures attributed to delirium was markedly underestimated (6.3% vs 19.0% of expenditure; 7.7% vs 22.4% of bed utilization).

Conclusion: Compared to clinical data, administrative data failed to capture approximately two thirds of costs and bed utilization associated with delirium in patients with hip fractures. This may have substantial implications in terms of justifying the cost-effectiveness of implementation of strategies to reduce peri-operative delirium, as well as obtaining appropriate reimbursement from payors. Further work is needed to develop strategies to improve the sensitivity of administrative coding practices in identifying delirium. In the interim, health services analyses of administratively coded delirium should be interpreted with caution, and validated against representative clinical data sources.

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Predictors of Fixation Failure of Pertrochanteric Fractures: Fracture Reduction is More Important than Tip-apex-distance
Mike Millar, Australia; Sam Joseph, Australia

Purpose: Since the landmark paper of Baumgaertner in 1995 it is commonly believed that tip-apex distance is the most important parameter in successful treatment of pertrochanteric fractures. As current literature suggests that this may be multifactorial, the overall aim of this study was to assess the predictors of fixation failure and their relationship to each other.

Method: A retrospective review of 796 patients with peritrochanteric fractures treated at a tertiary referral trauma centre between 2008 and 2012 was undertaken. Radiographs were analyzed for fracture classification, reduction quality, Cleveland zone, tip-apex distance (TAD), implant type (DHS versus short and long Gamma
nails), and fixation points in Gamma nails, specifically the lateral cortex, greater trochanter, and fit of the nail in the intramedullary canal at its narrowest point.

Results: Unstable fractures had a 7.6 (OR 3.0-19.6) times increased risk of fixation failure (p <0.001), while fractures with a ‘poor’ grade of reduction had an 11.5 (OR 4.0-33.4) times increased risk of failure (p <0.001). There was a direct relationship between fracture stability and grade of reduction (P < 0.001). While A TAD > 20 mm incurred a 4.4 (OR (1.90-6.73) increased risk of failure (p=0.001), it was not powerful enough to mitigate against fixation failure in the event of poor fracture reduction (p<0.004). There was 10.3 (OR 8.1-28.4) times increased risk of fixation failure if the nail filled < 70% of the intramedullary canal (p<0.001).

Conclusion: Unstable fracture type, poor fracture reduction, non optimal cephalomedullary screw positioning, and inadequate fit of IM recon nails in the intramedullary canal were predictors of fixation failure. Fracture reduction was noted to be more important than tip-apex distance in ensuring successful fracture union.

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Comparison of Arthroplasty to Cephalomedullary Nailing for Pertrochanteric Hip Fractures
Simcha Gil Fichman, ON; Oleg Safir, ON; Tatu Mäkinen, ON; Alex Vincent, ON; Benjamin Lozano, ON; Aidin Kashigar, ON; Paul Kuzyk, ON

Purpose: Hip arthroplasty is seldom used in the treatment of pertrochanteric fractures, although it might offer some benefits over internal fixation. The purpose of this study was to compare arthroplasty and cephalomedullary (CM) nailing for the treatment of pertrochanteric hip fractures.

Method: We retrospectively reviewed 149 consecutive patients that were treated with either arthroplasty or CM nailing for their pertrochanteric fracture (31 in the arthroplasty group and 118 in the CM nailing group). The mean follow-up was 182 days. Patient records were reviewed for gender, age at the time of operation, duration of surgery, pre-operative and post-operative haemoglobin values, need for blood transfusion. Post-operative complications were classified as major or minor complications. In both groups any complication necessitating second surgery was defined as a major complication. In both groups death during the primary admission was defined as major complication regardless of the cause. Nonunion of the GT, heterotrophic ossification and subsidence of the femoral component were defined as minor complications in the arthroplasty group, provided that they did not require a reoperation. In the CM nail group, nonunion, varus malunion, cut-out, and painful prominent hardware were considered as minor complications if further surgery was not required.

Results: Overall there were no differences in major and minor complication rates between the patients treated with CM nailing or arthroplasty. In the arthroplasty group, two (6.4%) patients needed secondary surgery as compared to ten (8.5%) patients in the CM nail group. Interestingly, there were no major or minor complications in AO/OTA type 31.A3 fractures treated with arthroplasty, whereas CM nailing of 31.A3 fracture was associated significantly more complications and the need for further surgery (P=0.02). There were no significant difference in operative time for the arthroplasty group (115 min, range 50-273 ) as compared to the CM nail group (104 min, range 41-420))((P=0.28). Also, the need for blood transfusion during hospitalization was similar between the arthroplasty (1.6 units, range 0-3) and the CM nail (1.6 units, range 0-6) groups (P=0.99). There was no difference in the hospitalization period between the groups (12 days for the arthroplasty group range 2-61 and 15.5 days for the CM nailing group range 2-110; P=0.28).

Conclusion: In conclusion, we found no significant differences between the two treatment groups in terms of hospital stay and need for rehabilitation. Furthermore, compared to treatment with CM nailing, arthroplasty did
not require a longer operating time, had similar blood loss and did not increase mortality rate. Overall rates of major and minor complications were similar between the two treatment groups. However, patients with AO/OTA type 31.A3 fractures had fewer complications when treated with arthroplasty. A randomized study is warranted to further assess arthroplasty as an option for AO/OTA type 31.A3 fractures.

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Is "Delayed" Early Total Care Dangerous when Nailing Femur Fractures?
Jonah Hébert-Davies, QC; David P. Barei, WA; Daphne M. Beingessner, WA

Purpose: Timing of definitive fixation of femur fractures in the polytraumatized patient remains an area of certain controversy. The concept of Damage Control Orthopaedics (DCO) was designed to treat unstable patients with temporary stabilization using external fixation. Recently, improved resuscitative methods have allowed for the return of early appropriate total care. Recent studies have shown that definitive fixation within 24 hours of injury resulted in lower complication rates then delayed treatment. The purpose of this study was first to review the tendencies at our level 1 trauma center and second evaluate complications associated with timing of femoral nailing.

Method: Timing of definitive fixation of femur fractures in the polytraumatized patient remains an area of certain controversy. The concept of Damage Control Orthopaedics (DCO) was designed to treat unstable patients with temporary stabilization using external fixation. Recently, improved resuscitative methods have allowed for the return of early appropriate total care. Recent studies have shown that definitive fixation within 24 hours of injury resulted in lower complication rates then delayed treatment. The purpose of this study was first to review the tendencies at our level 1 trauma center and second evaluate complications associated with timing of femoral nailing.

Results: A total of 822 patients presenting with femur fractures were identified over a 5 year period. Of these patients, 610 were treated with intramedullary statically locked nailing. Nine patients died in the immediate post-operative period. The average age was 33.6 years and mean ISS was 22.3. The mean time from admission to operation was 23.1 hours, with 70.9 % being treated <24h, 15.2% between 24-48h, 9.3% between 48-120h and 4.6% >120h. The total rate of complications was 22%. ARDS and pneumonia were statistically more likely in patients nailed within 24h (p>0.05.) ARDS was also significantly increased in patients undergoing fixation after 120h. All other complications were not different among the groups.

Conclusion: Early total care for femur fractures is safe although not without complications. Modern resuscitation has likely allowed for earlier fixation time, however it does not eliminate complications. Current literature supports primary definitive fixation and this is reflected in our practice. Special attention should be given to patients at risk for respiratory complications. When there is a delay, intramedullary nailing can still be safely undertaken between injury days 2-4 without increased complications.

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Risk Factors for Exchange Nailing in Femoral Fractures
Pierre Navarre, QC; Mike J Millar, Australia; Elton R. Edwards, Australia

Purpose: Although locked intramedullary nailing is the treatment of choice for fixation of fractures of the femoral shaft, nonunion rates are reported to be 4.1-12.5%. Despite the very high success rate of exchange nailing, the degree of under-sizing of a nail as a risk factor for nonunion has not previously been investigated.
The aim of this study was to evaluate patient independent risk factors of aseptic femoral hypertrophic nonunion cases requiring exchange nailing.

**Method:** This retrospective case-control study included 211 femoral fractures, without any patient dependent risk factors for nonunion, treated with a locked reamed intramedullary nail between 2008-2012 at a tertiary referral trauma facility. 23 cases went on to hypertrophic nonunion requiring exchange nailing (treatment group) and 188 cases went on to union (control group). Analysis was undertaken investigating (1) open or closed fracture, (2) degree of comminution based on the Winquist classification, (3) antegrade or retrograde nail, (4) quality of reduction, (5) location of the fracture, and (6) the nail fit percentage, measured as the ratio between the nail diameter and the narrowest point of the intramedullary canal on the AP and lateral views combined.

**Results:** Patient demographics were statistically similar in both groups. Implant choice (p=0.106) and fracture location (p=0.350) were not statistically significantly different. The fracture-related factors associated with an increased risk of nonunion requiring exchange nailing were: poor fracture reduction (OR 11.5, 95% CI 4.0-33.4, p<0.001), open fracture (OR 7.6, 95% CI 3.0-19.6, p=0.004), Winquist classification of 4 (OR 4.4, 95% CI 1.9-6.7, p=0.016). Poor nail fit was also significantly associated with nonunion requiring exchange nailing, with those cases with successful healing having a nail occupying 88 ± 6 % of the canal, compared to 69% ± 6% (p <0.001) for those that required exchange nailing. Multivariate analysis, controlling for the fracture-related predictors, revealed that the nail fit ratio is an independent predictor of femoral nonunion requiring exchange nailing (OR 11.4, 95% CI 6.9-15.2, p <0.001). Moreover, we found a direct relationship between increasingly poor nail fit and increased risk of exchange nailing and the criterion for a significantly increased risk was a nail fit ratio of less than 70% (sensitivity 96%, specificity 91%).

**Conclusion:** The patient independent risk factors for nonunion requiring exchange nailing in this study were: poor fracture reduction, high degree of comminution, open fracture, poor nail fit (less than 70%). There is a direct relationship between increasingly poor nail fit and increased risk of exchange nailing. When proceeding to femoral fracture reamed intramedullary nailing, we recommend a minimum nail fit of 70%, and ideally 90% or more, in order to avoid surgical reintervention.
Periarticular Plating System) 4. Intramedullary fibular strut allograft plus polyaxial locked plate (Zimmer NCB Periprosthetic Femur Plate System). Following instrumentation, a metaphyseal diaphyseal defect was created using an oscillating saw, simulating an AO/OTA 33-A3 fracture pattern. The specimens were mounted on an Intron ElectroPulse E10000 universal mechanical testing machine. In non-destructive cyclic loading, each specimen experienced 10 cycles of 200N-500N axial load. This was followed by 10 cycles of torque between +8Nm and -8Nm superimposed on 200N of static axial load. Following cyclic loading, each specimen was quasi-statically loaded axially at 10mm/min deformation rate until specimen failure.

**Results:** No differences were found in the cyclic axial loading between the groups. However, in cyclic torsional loading the intramedullary nail (group 1) had the lowest torsional rigidity (1.03Nm/deg), while the intramedullary fibular strut allograft plus polyaxial locked plate (group 4) showed the highest rigidity (2.20Nm/deg). During quasi-static loading to failure, the intramedullary nail achieved the highest axial stiffness (0.616 kN/mm) while the non-locked plate (group 3) showed the lowest (0.46 kN/mm). The non-locked plate and the locked plate both displayed similar yield strengths (2.87kN and 2.93kN, respectively; p>0.05).

**Conclusion:** This current report is the first to examine fixation methods in a periprosthetic fracture proximal to a well-fixed femoral prosthesis in an osteoporotic bone model. Based on the results, the intramedullary fibular strut allograft plus polyaxial locked plate yielded the highest torsional stiffness. The non-locked plate showed the lowest strength and therefore should be avoided especially in comminuted fracture patterns.

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The Hyperextension Varus Bicondylar Tibial Plateau Fracture

**Benjamin Hamilton, WA; Daphne Beingessner, WA; Reza Firoozabadi, WA; Jason Schneidkraut, IL; Robert Dunbar, WA; David Barei, WA**

**Purpose:** Classification systems used to identify tibial plateau fracture have been developed to help recognize common injury patterns and help guide treatment as well provide a means to perform research. The authors have identified a certain subset of tibial plateau fractures- hyperextension varus bicondylar tibial plateau fractures. The purpose of this study is to describe this fracture pattern, to delineate its associated injuries & to suggest treatment strategies that may allow for improved reduction and stabilization.

**Method:** A retrospective review of prospectively gathered data at a regional Level I orthopaedic trauma center was performed to identify patients that had bicondylar tibial plateau fractures (OTA 41C). Preoperative radiographs and CT scans were reviewed to identify patients sustaining bicondylar tibial plateau fractures with combined hyperextension and varus displacement patterns. Specifically, sagittal plane imaging was assessed for osseous compression failure of the proximal tibia anteriorly and tension failure posteriorly, with loss of normal posterior slope of the proximal tibial articular surface. Coronal plane imaging was assessed for a medial articular injury and an apex lateral or varus coronal plane deformity. Patients were included if they had the above stated deformity on both planes.

**Results:** 212 bicondylar tibial plateau fractures were identified in 208 patients during the study period (5/2000-8/2010). Twenty-five fractures in 23 patients satisfied the radiographic criteria described above and formed the study population, with an average age of 58 years. The remaining185 patients with 187 fractures who had non-varus hyperextension bicondylar tibial plateau fractures had an average age of 41 years old. Mechanisms of injury included: 6 falls from standing, 5 falls from height, 11 involved motorized vehicles. Three patients were lost to follow up. Thirty-two percent of the fractures (8/25) demonstrated significant associated injuries. Three patients (12%) had a popliteal artery disruption that required repair. Four patients (16%) had an either partial or
complete peroneal nerve injury. Three patients (12%) developed leg compartmental syndrome which required emergent four-compartment fasciotomies.

**Conclusion:** The hyperextension varus bicondylar tibial plateau is a unique fracture. Low energy trauma can cause this fracture pattern and the associated injuries can be devastating. Specifically, the relatively high rate of popliteal artery disruption which can result in limb loss if not identified.

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**Infra-syndesmotic Fractures of the Fibula: Non-operative Management Outcomes**

**Ashlee M. Dobbe, AB;** Khaled Almansoori, AB; Lauren Beaupre, AB; Angela Scharfenberger, AB

**Purpose:** The purpose of this study was to examine the functional outcomes of conservatively [non-operatively] managed Denis-Weber Type-A (DW-A) distal fibular fractures.

**Method:** Observational, retrospective cohort study. Subjects included patients over the age of 17 years who sustained a unilateral isolated infra-syndesmotic distal fibula fracture that was managed non-operatively. Primary outcome measures were the American Association of Orthopaedic Surgeons Foot & Ankle Score (AAOS-FAS) survey results, which were compared to available normative population data. Secondary outcome measurements included the presence of radiographic signs of instability, fragment size, and degree of displacement to provide further sub-group analysis. All patients were located by visually reviewing all ankle radiographs uploaded to a provincial electronic radiology database-portal over the 2010 year period. All patients with radiographic evidence of an infra-syndesmotic isolated fibula fracture were contacted by mail or telephone to complete an AAOS-FAS survey. Results were statistically analyzed for significance and prognostic values.

**Results:** Over 8,000 radiographic images were reviewed which identified 104 patients that met the inclusion criteria and of which 68 patients [65%] agreed to participate. Forty-five of the patients were found to have less than or equal to two millimeters of displacement vs. nine with greater than two millimeters. Those with less than or equal to two millimeters of displacement had a normative score of 52 on the AAOS Foot and Ankle Score vs. 42 with greater than two millimeters of displacement (p<0.001). Twenty-two patients were found to have a fracture fragment size of <10mm vs. 29 with ≥10mm. On the shoe comfort scale patients with a fracture fragment < 10mm scored 46 vs. 55 with a fragment ≥10mm (P < 0.01).

**Conclusion:** Patients sustaining an isolated infra-syndesmotic distal fibula fracture report good to excellent functional outcomes at three year follow-up. While not statistically significant, a sub-group analysis demonstrated a trend for poorer outcomes with fractures that are greater than two millimeters displaced and <10mm in size, suggesting that patients who sustain more displaced avulsion-type injuries tend to have poorer functional and shoe-comfort outcomes than large minimally displaced fragments. Based on these interim results, additional participants have been enrolled to further explore this injury subgroup.

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**Are Patients Willing to Pay for Total Shoulder Arthroplasty?**

**Nathan O’Hara, BC;** Gerard P. Slobogean, BC; Carlo Marra, NL; Michael D. McKee, ON

**Purpose:** Shoulder arthritis has a significant impact on patients’ health related quality of life. The efficacy of total shoulder arthroplasty (TSA) to decrease pain and improve shoulder function is well established. Unfortunately, patients in a publicly funded health care system often must wait a year or more for this surgery.
The objective of this study was to determine patient preferences related to accessing TSA surgery in Ontario, Canada. Specifically, we sought to determine preferences towards paying out-of-pocket for surgery, travelling increased distances, or being treated by surgeons with varying levels of experience in exchange for a shorter waitlist for TSA.

**Method:** Patients currently on a single surgeon’s TSA surgery waitlist with end stage shoulder arthritis were recruited to complete a discrete choice experiment. Respondents were presented with 14 different choice-sets and were asked to choose one of three options: two different hypothetical scenarios or a status quo option. For each hypothetical scenario, we varied the levels of the following attributes: travel time, wait time, surgeon’s experience level and cost. Respondents’ relative preference weights for each attribute were determined based on selection proportions and reported on a scale of 0 – 1.00.

**Results:** Sixty-two respondents completed the questionnaire. The mean age (SD) of participants was 70.9 (9.62) years. Fifty-five percent (n=33) of participants were female, 37.1% (n=23) resided in Toronto, 26% (n=16) completed post-secondary education, 47% (n=29) were currently retired and 17.7% (n=11) had an annual household income of over $100,000. The most preferred attribute levels are: no cost (mean utility [SD]: 0.53, [0.30]), surgery by an experienced surgeon (0.39, [0.27]) and a half hour travel time (0.32, [0.22]). The least preferred attributes are: surgery by a surgeon with limited experience (0.03, [0.07]) and paying either $5000 (0.04, [0.09]) or $2500 (0.08, [0.12]) for the procedure. Respondents are relatively indifferent between waiting one month (0.22, [0.13]) to 24 months (0.23, [0.23]) for their surgery. They are willing to pay $1000 (0.23, [0.26]) for surgery by a surgeon with average (0.26, [0.20]) or above average experience. Most interestingly, respondents would rather drive six hours (0.10, [0.11]) or wait 24 months (0.23, [0.23]) than pay $2500 (0.08, [0.12]) for their surgery.

**Conclusion:** Patients waiting for elective shoulder surgery in Ontario have a stronger preference for surgery at no cost and an operation performed by a surgeon with average experience or above average experience. Reducing the wait time for surgery was ranked relatively lower compared to cost and experience attributes.

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**An in vitro Study of the Effect of Humeral Cup Constraint in Reverse Shoulder Arthroplasty**

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**Purpose:** Reverse shoulder arthroplasty (RSA) is a common and effective treatment option for rotator cuff tear arthropathy and as a salvage procedure for failed primary shoulder arthroplasty. Computer based studies have suggested that the level of polyethylene insert constraint influences range of motion (ROM) and joint stability. However, there is a paucity of information regarding the effects of constraint on joint load and resultant load angle. The purpose of this in-vitro biomechanical study was to investigate the effects of increasing humeral cup constraint on joint load, load angle, deltoid force, and range of motion in reverse shoulder arthroplasty. We hypothesized that loading parameters would not be significantly different, however, that range of motion would decrease with increased constraint.

**Method:** A custom RSA implant construct capable of measuring forces across the joint with varying humeral cup constraint (standard, retentive) was implanted in 7 fresh-frozen cadaveric shoulders (age: 71 ± 9 yrs). A shoulder simulator capable of independently loading musculature to produce active glenohumeral and scapulothoracic motion was then used to simulate active and passive motion. Both standard and retentive humeral cup constraint configurations were tested and joint kinematics and loads were recorded.
Results: When cup constraint was increased (standard to retentive), joint load during active abduction showed no significant differences (P=0.15). However, we did note that joint load trended downwards as we increased constraint for all angles of abduction (mean reduction: 3.3 ±1.9% of body weight). Similarly, joint load angle was not significantly affected by increasing cup constraint (P=0.42). Increasing cup constraint, however, did significantly increase the angle between the resultant joint load and cup edge (mean increase: 12±1°, P<0.001). Additionally, cup constraint did not significantly affect the required deltoid force for active abduction (P=0.125). Interestingly, range of motion was not significantly affected by increased cup constraint in both internal/external rotation (P=0.276) and abduction (P=0.282).

Conclusion: Our findings suggest that if increased cup constraint is required to enhance shoulder stability, the resultant joint loads and required deltoid forces are not substantially altered. The results support our hypothesis and are logical since the centre of rotation is unchanged in a highly-constrained articulation when this implant variable is altered. Range of motion, however, was not significantly different with increased cup constraint. This unexpected result occurred because impingement and terminal motion was limited by bone and soft tissue, rather than implant-related restriction. We did, however, find that the joint load migrated further from the edge of the cup (was more centrally located in the polyethylene) when cup constraint was increased, which may have a positive impact on wear characteristics and long term RSA performance.

The Influence of Reverse Shoulder Arthroplasty Implant Variables on Muscle Force and Joint Load
Joshua W. Giles, ON; G. Daniel G. Langohr, ON; James A. Johnson, ON; George S. Athwal, ON

Purpose: Reverse shoulder arthroplasty (RSA) has become widely accepted for treating a number of shoulder pathologies. However, the effect of RSA design parameters on muscle and joint loading is poorly understood. Therefore, our objective was to evaluate the effect of multiple humeral lateralization, humeral polyethylene cup thickness, and glenosphere lateralization configurations on the deltoid muscle forces required to produce active abduction and the resulting joint loads and angles.

Method: Seven cadaveric shoulders were tested using a validated in-vitro shoulder simulator that produces motion driven by muscle loading. Five muscle groups were independently loaded and the scapula was actively rotated to replicate its in-vivo motion. Measurement of the joint loads during these motions was achieved by developing a custom adjustable, modular load-sensing RSA implant system. Load sensing was accomplished by fitting a six degree-of-freedom load cell within the 38mm glenosphere/baseplate construct. Three RSA geometric parameters were tested at three levels – humeral lateralization: 0,5,10mm; humeral polyethylene thickness: +3,+6,+9mm; glenosphere lateralization: 0,5,10mm – with all 27 combinations examined.

Results: Increasing humeral lateralization significantly decreased deltoid muscle forces required for active abduction (0mm: 67.8±3.3 % Body Weight (%BW) vs 10mm: 64.9±2.9%BW, p=0.022), and had no adverse effect on joint loading (p=0.275). In contrast, increasing glenosphere lateralization significantly increased joint loads (0mm: 53.4±3.0%BW vs 10mm: 69.7±3.7%BW, p<0.001) and the required deltoid muscle loads to achieve active abduction (0mm: 61.4±2.8%BW vs 10mm: 70.4±4.2%BW, p=0.007). Additionally, increasing humeral polyethylene cup thickness significantly increased joint load (3mm: 60.0±2.8%BW vs 9mm: 64.0±3.3%BW, p=0.034) and deltoid load (3mm: 64.8±3.4%BW vs 9mm: 67.7±2.9%BW, p=0.03). Humeral lateralization produced a significantly more central compressive joint load as offset increased (0mm humeral offset: 37±4°; 0mm vs 5mm: mean decrease 3±1°, p=0.002; 0mm vs 10mm: mean decrease 6±1°, p<0.001).
Conclusion: Humeral lateralization is the only variable tested that positively affected joint and muscle loading, while glenosphere lateralization produced a marked increase. As such, lateralizing the humerus may be useful in countering the negative effects of glenosphere lateralization, but this must be considered cautiously. Overstuffing the articulation with increasingly thicker humeral polyethylene cups negatively affected deltoid muscle and joint loading. Therefore, the smallest insert required to passively tension the joint to obtain stability should be used. These findings have provided new insight into the effects of three commonly varied RSA implant parameters in a systematic manner, which was not limited by the values attainable using commercially available implants and thus can be used to provide a basis for future implant designs.

A Comparison of Augmented Glenoid Component Designs for Type B2 Erosions: Evaluation by Volume of Bone Removal, and Quality of Remaining Bone
Nikolas K. Knowles, ON; Louis M Ferreira, ON; George S. Athwal, ON

Purpose: Posterior glenoid erosion (Type B2) in glenohumeral osteoarthritis presents a challenging surgical problem. To account for the eroded bone and to preserve remaining bone, implant manufacturers have released, or are releasing, augmented glenoid components that use a step/wedge that is symmetric about the centerline of the implant. However, it has been suggested that posterior bone loss does not occur purely in the posterior aspect, in which these implants are designed. The purpose of this study was to determine the volume of bone removal required to optimally place three augmented glenoid component designs. Additionally, the quality of underlying bone was quantified as a measure of early implant stability and fixation.

Method: Three augmented glenoid component designs – full-wedge, posterior-wedge, and posterior-step were virtually implanted using the CT scans of 16 patients (8 male) with B2 glenoid erosion. Two clinically relevant scenarios of correction to 0° version and 10° retroversion were completed in each patient scan. The volume of bone removal was quantified for all three implant designs and two version angles, resulting in 96 testing conditions. Additionally, the quality of underlying bone supporting the implant was assessed in anterior and posterior regions in terms of its density and porosity.

Results: When correcting to an ideal 0° version, the posterior-wedged implant removed a mean 1347 mm3 less total bone than the posterior-step implant (p<0.001) and a mean 1010 mm3 less than the full-wedged implant (p=0.004). There was no significant difference between the posterior-step and full-wedge implants (p=0.509). Correcting to 10° of retroversion, the posterior-wedge implant removed significantly less total bone (mean 790 mm3, p=0.029) than the posterior-step implant. There was no significant difference in total bone removed between the posterior-wedge and full-wedge implants (p=0.143) or between the posterior-step and full-wedge implants (p=0.766). Comparing bone density in anterior and posterior regions of the glenoid by implant type, the full-wedge was a mean 196 HU more dense (p<0.001), the posterior-wedge a mean 177 HU (p<0.001), and the posterior-step a mean 100 HU (p=0.005) more dense posterior as compared anterior regions. When correcting to 10° retroversion, there was also a significant difference in underlying bone density posterior and anterior (p<0.001), but no significant differences between implants (p=0.370).

Conclusion: For patients with posterior erosion, augmented glenoid components can improve a bone preservation option as compared to eccentric reaming. The degree of benefit, however, depends largely on the augmented design. Design of the augment shape can also significantly impact the average density of remaining bone that supports the implant. Augmented glenoid component designs should be chosen on an individual basis to match the various geometries of osteoarthritic glenoids, in order to minimize bone removal and preserve underlying bone.
Synovial Biopsy: A Pilot Feasibility Study of a New Diagnostic Test for the Diagnosis of Infection in Shoulder Arthroplasty
Kelly Hynes, ON; Adnan Sheikh, ON; Peter Lapner, ON

Purpose: The diagnosis of infection following shoulder arthroplasty is notoriously difficult. The prevalence of prosthetic shoulder infection after arthroplasty ranges from 3.9 – 15.4% and the most common infective organism is Propionibacterium acnes. Current pre-operative diagnostic tests fail to provide a reliable means of diagnosis including WBC, ESR, CRP and joint aspiration. Fluoroscopic synovial biopsy, to our knowledge, has not been described in the literature. The purpose of the pilot feasibility study was to 1) develop a technique to perform synovial biopsy in the shoulder, 2) to determine if the technique consistently yields tissue, 3) to compare culture results of synovial biopsy to those of open tissue cultures and 4) to carry out a qualitative assessment of serum indices of infection where a positive culture was present.

Method: Fourteen patients, four females and 10 males with a mean age of 58 years (range 38-81) underwent synovial biopsy during the workup of suspected chronic glenohumeral infection. The synovial biopsies were conducted between 2010 and 2013. One musculoskeletal radiologist performed all synovial biopsies and all surgical interventions were by a single surgeon. Intraoperative tissue samples were taken from a minimum of three regions of the joint capsule during revision surgery. Serum indices were obtained in all patients including ESR, CRP and WBC.

Results: Of 14 patients who underwent revision surgery for suspected infection, four had confirmed culture positive infections based on intra-operative tissue sampling. Of these four patients, three (75%) had positive cultures from fluoroscopic synovial biopsy, with matching cultures. There were no false positive results. There were no complications associated with the procedure. Only one patient had elevated ESR. No patients had elevated CRP. Two patients had marginally elevated WBCs.

Conclusion: The technique for fluoroscopic synovial biopsy is feasible and has been found to consistently yield synovial tissue. Preliminary results for this novel technique appear promising, with a sensitivity of 75%, and specificity of 100%. Further research is required in order to fully validate this new diagnostic test.

Quantification of the Position, Orientation and Surface Area of Posterior Bone Loss in Type B2 Glenoids
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Purpose: Asymmetric posterior glenoid erosion (Walch type B2) in osteoarthritis with resultant acquired retroversion presents a challenge for surgical reconstruction. The surgical options in these cases include asymmetric reaming, bone grafting, augmented polyethylene implants or reverse shoulder arthroplasty. Augmented polyethylene implants consist of a step or wedge that is symmetric about the implant’s superoinferior axis, typically occupying the entire posterior hemisphere. Although these implants are intended to minimize eccentric reaming and therefore bone removal, it is assumed that posterior wear is directed towards the 9 o’clock position (right glenoid). The purpose of this CT-based imaging study was to quantify the orientation and position of wear in B2 glenoids. Additionally, we compared the curvature of the neoglenoid and paleoglenoid to the corresponding humeral head. We hypothesized that posterior glenoid erosion does not occur symmetrically, but does have a predictable orientation.
Method: This study evaluated 55 consecutive patients with type B2 glenoid erosions. Computed tomography imaging data was uploaded to imaging software and three-dimensional models were created. Point coordinates were extracted from each reconstruction for analysis of the orientation, position and articular curvature of the glenoid erosion. The ridge of bone between the neoglenoid and paleoglenoid was referred to as the line-of-erosion and was used as a landmark for measurements.

Results: There was a significant difference between the mean orientation angle (28±11°) of the posterior glenoid erosion and the superoinferior axis (p<0.001). Additionally, the line-of-erosion, which indicated the start of the erosion, was located 1.6±3.4 mm posterior to the center of the glenoid (p<0.001). The radius of the osteoarthritic humeral head was significantly less than the neoglenoid (p<0.001) and the paleoglenoid (p=0.009). Additionally, the radius of the neoglenoid was significantly greater than the paleoglenoid (p=0.012).

Conclusion: The results of this study indicate that posterior glenoid bone loss does not occur symmetrically about the glenoid superoinferior axis. This information is important to surgeons managing patients with commercially available symmetric posterior augmented implants. When using symmetric posterior augmented implants, extra bone removal may be required in the posterosuperior quadrant in order to accommodate the augment, given that it is not aligned with the line-of-erosion. Additionally, the orientation of the line-of-erosion causes the neoglenoid to partly occupy the anteroinferior region, which is not accounted for by superoinferior aligned augments. The results of this study will aid surgeons who use structural bonegrafting or commercially available augmented polyethylene implants to manage bone loss associated with Walch type B2 glenoid erosions.

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Rates of Return to Work in Claimants Receiving Shoulder Surgery in the Workers’ Compensation Board System in Alberta
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Purpose: Worker’s Compensation Board (WCB) claims have been shown to negatively impact outcomes following orthopaedic surgical procedures. Shoulder pathology, specifically rotator cuff tears, are a frequent cause for musculoskeletal pain in WCB patients behind back and neck pain. Many patients suffering from work-related shoulder disability proceed to surgical management prior to returning to work. The literature suggests that WCB patients have worse outcomes and take longer to return to work than non-WCB patients. We sought to determine the work fitness level and actual return to work level of patients undergoing shoulder surgery for a WCB-related claim compared to their pre-injury work level.

Method: We retrospectively evaluated the final work fitness level and actual return to work level at one year in consecutive patients undergoing shoulder surgery with an active WCB claim. Surgical management included one or more of the following: rotator cuff repair (open and arthroscopic), labral repair, bicep tenotomy/tenodesis, distal clavicle excision, subacromial decompression, and/or debridement. Work fitness level and actual return to work level at 365 days post-surgery was obtained from the WCB Alberta administrative database.

Results: 686 surgeries were performed with 624 (91%) patients deemed fit for work by 365 days while 524 (76%) patients actually returned to work. Fitness levels for work showed 258 (38%) patients at the pre-injury level, 359 (52%) at a lower fitness level, and 7 (1%) at a higher fitness level. 263 (38%) patients returned to
work at the pre-injury level, 253 (37%) at a lower level, and 8 (1%) at a higher level. At the 365-day period 91 (13%) were still receiving benefits while 9 (1%) had retired and 27 (4%) were not working.

**Conclusion:** Following surgical management of shoulder disorders in workers compensation patients, 75% return to work by 365 days. However only 38% return to work at their pre-injury fitness level. The results of this review can assist in evaluating the likelihood of individuals returning to their pre-injury level of work following surgery for occupational shoulder injuries. It also suggests that further investigation into the factors that lead to the above described rates should be undertaken.

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**Arthroscopic versus Open Lateral Release for the Treatment of Lateral Epicondylitis: A Prospective Randomized Controlled Trial**

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**Purpose:** The primary objective of this study was to determine if quality of life and function are different following arthroscopic versus open tennis elbow release surgery. Based on retrospective studies, both approaches have been found to be beneficial, but no prospective randomized comparison has been conducted to date.

**Method:** Following a minimum six-months of conservative treatment, seventy-one patients (>16 yrs old) were randomized intraoperatively to undergo either arthroscopic or open lateral release. Outcome measures were the Disabilities of the Arm, Shoulder and Hand questionnaire (DASH), a 5-question VAS Pain Scale, and grip strength. Study assessments took place pre-, and 6-week, 3-, 6-, and 12-months post-surgery. Comparisons between groups and within groups over time were conducted with p<0.05.

**Results:** Fifteen women and 19 men underwent the open procedure with a mean age of 47.1 years (6.7) and 13 women and 21 men were in the arthroscopic group with a mean age of 45.0 (6.9). No pre-surgery differences were found between groups based on age, sex, DASH or VAS scores. Both groups demonstrated a significant improvement in subjective measures and grip strength by 12-months post-surgery, and no significant differences were found between groups at any time point. The DASH, our primary outcome, decreased from a mean (SD) of 47.5 (14.5) pre-surgery to 21.9 (21.8) at 12-months post-surgery in the Open group and from 52.7 (16.0) to 22.6 (21.1) in the Arthroscopic group. VAS-pain scores (%) decreased in the Open group from 62.5 (17.2) pre-operatively to 30.0 (26.5) at 12-months. In the arthroscopic group, scores decreased from 63.7 (15.9) to 26.2 (24.6). Grip strength (kg) increased on the affected side from 23.6 (14.9) to 29.3 (16.3) and 21.4 (15.4) to 29.8 (15.4) for Open and Arthroscopic groups, respectively.

**Conclusion:** Based on this study, there is no difference in patient quality of life and function between arthroscopic and open tennis elbow release surgery at 12-months post-operative. Factors such as sex, age, smoking status, third party claims (WCB) may also influence patient outcome, but this study was not adequately powered to draw any specific conclusions.

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**Early Mobilization Following Mini-open Rotator Cuff Repair: A Randomized Clinical Trial**

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Purpose: Mini-open rotator cuff repair (MORCR) is a common treatment for rotator cuff (RC) disease. Traditional shoulder rehabilitation supports immobilization for the initial 6 postoperative weeks to promote tendon healing. However, delayed range of motion (ROM) may slow the return of shoulder ROM, increase the risk of stiffness, and disrupt patients' quality of life. The effect of early motion and the subsequent effect on clinical outcomes are unknown in humans. The objective of this study was to evaluate clinical outcomes following MORCR in patients treated with early range of motion compared to those who follow the standard 6-week postoperative immobilization protocol. In addition, we compared healing at 24 months postoperatively.

Method: 189 patients with radiographically-confirmed full-thickness rotator cuff tear underwent a MORCR performed by fellowship-trained surgeons (n=6). Subjects were randomized to one of two treatment groups following preoperative assessment of shoulder pain, ROM, abduction strength and health related quality of life (HRQL) using a disease-specific measure. Subjects randomized to early mobilization (n=97) self-weaned from the shoulder immobilizer as pain allowed and were allowed to perform pain-free active ROM for activities of daily living (ADLs) while the standard immobilization group (n=92) wore a sling. Both groups performed a self-assisted, passive ROM exercise program for the first 6 weeks and completed identical rehabilitation protocols after 6 weeks. Shoulder ROM and pain were assessed at 6-weeks and 3-months postoperatively. At 6, 12 and 24 months, subjects had their abduction strength and HRQL assessed in addition to shoulder pain and ROM. Ultrasound imaging was conducted after 24 months on a subset of patients (n=72; 36 early mobilization, 36 standard mobilization) to compare healing between groups.

Results: 165 (87%) patients completed the 24 month follow-up. The two groups were similar preoperatively in all clinical measures (p>0.06). Six week ROM comparisons demonstrated increased abduction (p=0.002), flexion (p=0.03) and scaption (p=0.006) in the early mobilization group, but these differences disappeared by 3 months (p>0.51). There were no differences between groups at 3, 6, 12 and 24 months on all clinical measures (p>0.21). At 24 months, 23 of 72 (32%) patients had full-thickness tears on postoperative ultrasounds, with no difference in healing seen between groups (p=0.31).

Conclusion: Patients who performed pain-free active ROM for ADLs showed no difference in clinical outcomes at 24 months compared to those who were immobilized for 6 weeks. Early ROM did not have any significant benefits for minimizing long-term stiffness and pain; however, postoperative shoulder power and HRQL were not compromised. In addition, there was no difference in healing at 24 months postoperatively between groups. Consideration should be given to allow patients to start actively using their shoulder within the first 6 weeks following a MORCR.

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Biomechanical Evaluation of Two Suturing Techniques for Distal Biceps Tendon Rupture Repair
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Purpose: To compare the biomechanical performance and residual bone-tendon contact area of two distal biceps tendon rupture repair techniques, the modified Krackow and the reduction knot.

Method: Twelve fresh frozen cadaveric full thickness distal biceps tendon ruptures were randomized into two repair groups: the modified Krackow or the reduction knot. Two 2.9mm suture anchors were anatomically placed in the bicipital tuberosity. The distal biceps tendon was repaired using the modified Krackow technique or the reduction knot technique. Cyclic loading was performed at 70N and 125N for 50 cycles, followed by load to failure. The bone-tendon insertion contact area was measured with digital image overlays after 1, 25, and 50 cycles, and the final load to failure and stiffness was recorded.
**Results:** The residual bone-tendon contact area at both 70N and 125N after 1, 25, and 50 cycles was significantly higher in the reduction knot repair compared to the modified Krackow (P <0.05). After 50 cycles at 70 N there was 40% contact area with reduction knot compared to 14% with the modified Krackow. After 50 cycles at 125N there was 27% contact area with the reduction knot compared to 0.5% with the modified Krackow. There was no significant difference in the repair stiffness between groups (43.3N/mm and 53.8N/mm respectively). There was no significant difference in ultimate tensile strength between the reduction knot and modified Krackow(168N and 170N respectively).

**Conclusion:** The reduction knot technique demonstrated equivalent strength and stiffness to the Krakow technique while resulting in a greater bone tendon contact area. This increased contact area may improve healing rates in clinical practice while allowing early mobilization.