Introduction: Anterior glenohumeral dislocations frequently result in injury to the glenoid labrum and capsule. The failure of these soft tissue restraints to sufficiently heal can lead to persistent shoulder instability. In order to study capsulolabral healing, our group has developed a novel rat model of shoulder instability. In previous work with this model, we found that immunohistochemical expression of the pro-inflammatory cytokines IL-1β and TGF-β1 were increased in the tissues of injured compared to uninjured animals. Therefore, we hypothesized that downregulating this initial inflammatory response may inhibit healing of the labrum and capsule to the glenoid. Although nonsteroidal anti-inflammatory medications (NSAIDs) have been shown to impair fracture, tendon, ligament, and enthesis healing, the effects on capsulolabral healing are unknown. The purpose of this study was to determine the effect of ibuprofen, a commonly used NSAID, on the healing glenoid labrum and capsule after glenohumeral dislocation in a rat model. Methods: Sixty-six rats had surgically induced anterior-inferior labral tears and anterior glenohumeral dislocation. The animals were assigned to either a control group with normal drinking water (n = 32) or an experimental group with ibuprofen drinking water (n = 34). The animals in the experimental group were given water mixed with an ibuprofen suspension and consumed an average 30 mg/kg per day. Animals were euthanized at two and four weeks postoperatively. Fourteen animals were excluded due to infection (n = 1) and persistent irreducible dislocation (n = 13). Three specimens from each group (total of 12 animals) underwent biomechanical testing on both the injured (right) and uninjured (left) limbs using a custom-designed tensile testing apparatus. The glenohumeral joint was fixed at 45° of abduction and neutral rotation. Prior to final clamping, the humerus was manually centered in the glenoid and a compressive axial load was placed. Anterior to posterior cyclic laxity fatigue was performed for 100 cycles at a frequency of 1 Hz and a load of 3.64% of the weight of the rat. Monotonic loading with anterior humeral translation was then performed until either failure or complete displacement of the humeral head anterior to the glenoid (7 mm). The data between experimental groups was tested for normality with the Kolmogorov-Smirnov test and the statistical analysis was performed with the two-tailed student’s t-test. The uninjured limb groups were compared with the Mann-Whitney U test. A matched comparison between the injured and uninjured limb was performed utilizing the Wilcoxon test. Results: Maximum Load: Within the NSAID groups, maximum load increased from 2 to 4 weeks post injury (5.70 ± 1.88 N and 8.43 ± 1.79 N, P < .01). At 2 weeks, the maximum load was lower in the NSAID compared to the control group (5.70 ± 1.88 N and 7.78 ± 2.23 N, P < .05). In the matched comparison between injured and uninjured limbs, the maximum load was significantly decreased in the injured limb of the 2 week NSAID group (5.70 ± 1.88 N, 7.47 ± 3.02 N, P < .01). There were no differences in maximum load within the control group (Fig. 2). Stiffness: Terminal capsular stiffness increased from 2 to 4 weeks in both the NSAID (1.30 ± 0.16 N/mm versus 0.96 ± 0.14 N/mm, P < .001) and the control groups (2.08 ± 0.42 N/mm versus 1.13 ± 0.49 N/mm, P < .01). At 4 weeks, the NSAID group had decreased stiffness as compared to the 4 week control group (1.30 ± 0.16 N/mm and 2.08 ± 0.42 N/mm, P < .001). When comparing the uninjured limbs in the NSAID and control groups, there were no significant differences in maximum load, initial stiffness, or terminal stiffness (Fig. 1). Discussion: In a novel rat model of glenohumeral instability, the post-injury administration of ibuprofen resulted in decreased biomechanical properties of the healing glenoid capsulolabral complex. Capsular stiffness and maximum load increased with time after injury indicating some healing of the capsule and labrum. However, statistically significant differences in maximum load and capsular stiffness were observed, with NSAID treated animals having decreased maximum load at 2 weeks and decreased capsular stiffness at 4 weeks post injury. A matched pair analysis of injured to uninjured limbs supported the findings of impaired healing in the NSAID treated animals. These findings demonstrate that the use of NSAIDs after glenohumeral dislocation may impair capsulolabral healing and should be limited or avoided to optimize glenohumeral stability.
Paper #2  PARP-1 KNOCK-OUT LEADS TO REGENERATION AND DECREASED FATTY INFILTRATION IN THE MUSCLE AFTER ARTIFICIAL ROTATOR CUFF TEAR IN A MOUSE MODEL
Michael Kuenzler, MD, Katja Nuss, DVM, Agnieszka Karol, DVM, Michael Schär, MD, Michael Hottiger, DVM, PhD, Michael Raniga, MD, David Kenkel, MD, Brigitte von Rechenberg, DVM, ECVS, Matthias A. Zumstein, MD, MD, Shoulder, Elbow and Orthopaedic Sports Medicine, Department of Orthopaedic Surgery and Traumatology, Inselspital, Bern University Hospital, Bern, Switzerland; Institute of Veterinary Biochemistry and Molecular Biology, University of Zurich, Zurich, Switzerland; Institute of Veterinary Biochemistry and Molecular Biology, University of Zurich, Zurich, Switzerland; Department of Diagnostic and Interventional Radiology, University Hospital of Zürich; Shoulder & Elbow Unit, SportsClinic#1 AG, Papiermühlestrasse 73, Wankdorf Center, Bern, Switzerland; Competence Center for Applied Biotechnology and Molecular Medicine (CABMM), Equipe Department, Vesuisse Faculty, University of Zurich, Zurich, Switzerland

Introduction: Both muscular atrophy and fatty infiltration are still irreversible in chronic rotator cuff tears (RCT) and repairs. Poly[ADP-ribose]-polymerase 1 (PARP1), a nuclear factor for DNA damage repair has shown to be one key factor in the up-regulation of early muscle inflammation, muscle atrophy and fat deposition. We therefore hypothesized that the absence of PARP1 would lead to less early inflammation, muscle atrophy and fatty infiltration subsequent to combined tenotomy and neurotomy in a PARP1 knock-out mouse model.

Methods: PARP1 knock-out (KO group) and standard wild type C57BL/6 (WT group) mice were randomly allocated into three different time points (1, 6 and 12 weeks, total n = 72). In all the mice the supraspinatus (SSP) and infraspinatus (ISP) tendons of the left shoulder were detached and the SSP muscle was denervated according to a recently established model. Macrosopic muscle weight analysis, retraction which was documented using macroscopic suture, histology, immunohistochemistry gene expression analysis using real time qPCR (RTqPCR), were used to assess the differences of early inflammation, atrophy, and fatty infiltration between knock out and wild type mice in the supraspinatus muscle.

Results: In both groups the muscles retracted visually; however, the WT muscles retracted more than KO muscles. Tenotomy and denervation resulted in a significant loss of muscle mass in both groups compared to the contralateral side (KO group 62 ± 11% and WT group 52 ± 11%, P = .04) 6 weeks after surgery. 12 weeks postoperatively, the muscular mass increased significantly to almost normal in KO group compared to the WT group (14 ± 6% and 42 ± 7% lower muscle mass respectively; P < .0001). Gene expression levels of inflammatory and muscular atrophy genes 1 week as well as adipogenic genes 12 weeks after surgery revealed significantly decreased gene expression in KO group compared to WT group. Discussion: Our preliminary results show for the first time that PARP1 knock-out leads to decreased early inflammation after tenotomy of the rotator cuff muscle. Although PARP1 knock-out and wild type mice developed severe atrophy 6 weeks after surgery the muscles of the PARP1 knock out mice regrew to almost normal size after 12 weeks. These findings taken together with a lower expression of adipogenic genes, leads to the conclusion that PARP1 has a negative influence on the restoration of muscular integrity after RCT.

Introduction: Impingement, the major functional setback of Reverse Shoulder Arthroplasty (RSA), has been correlated with both implant design and surgical techniques. Studies have suggested the favorable effect of humeral component retroversion on reducing scapular impingement (contact of the humeral cup with the scapular inferior border) and increasing external rotation and abduction range of motion (ROM). However, limited data exist to show how humeral version affects impingement in activities of daily living (ADLs) and whether other impingement sites (besides the glenoid inferior border) may affect the functional outcome. We investigated the effect of humeral component version on the mechanism of impingement during ADLs.

Materials and Methods: A single surgeon performed virtual RSA on 30 arthritic shoulders that were reconstructed from pre-operative CT scans. For each subject, the humeral component was placed into 5 versions (−40°, −20°, 0°, 20°, and 40°; +) anteversion, (−)retroversion), while maintaining the height and 45° neck/shaft humeral resection. Incidence of both intra-articular impingement (contact of the scapula’s inferior border with the humeral prosthesis) and extra-articular impingement (acromion and/or coracoacromial contact to the humerus) was measured for a kinematic dataset that included 10 ADLs and 3 standard ROM (abduction, forward flexion, scaption) activities determined from 10 healthy subjects. The risk of impingement during the ADLs was assessed as the collective frequency of impingement across a cycle of motion. Frequent impingement sites on the scapula were also identified. For the standard activities, average ROM for each humeral version was calculated. Results: For the ADLs, 0° retroversion showed the least amount of impingement (Fig. 1). In contrast, 40° retroversion resulted in the largest ROM for the standard activities (94.5 ± 20.6° in abduction, 108.3 ± 8.6° in forward flexion, and 89.1 ± 13.0° in scaption). The most frequent site of impingement changed with the degree of version; retroverted fixation increased the extra-articular impingement, where the antverted alignment increased the contact between the inferior scapula border and the humeral cup (Fig. 2). Discussion: Our results showed that humeral version can significantly affect the impingement in RSA. Maximizing ROM in standard activities may not reduce the risk of impingement during ADLs. Our data indicate that 0° of humeral version should be preferred to reduce the overall impingement. However, the results are based on a small number of ADLs, and future studies should expand on a larger kinematic data set. It has also been shown that retroversion can increase tension on teres minor, which can result in increased pain and decreased function.

Figure 1  Average impingement (intra and extra-articular) for all 10 ADLs.

% Impingement in all ADLs

Degrees of humeral version

Paper #3  HUMERAL COMPONENT VERSION IN REVERSE SHOULDER ARTHROPLASTY AFFECTS IMPINGEMENT IN ACTIVITIES OF DAILY LIVING
Xiang Chen, MS, Andreas Kontaxis, MSc, PhD, Daniel Choi, MS, Julien Benhouet, MD, Timothy M. Wright, PhD, David M. Dines, MD, Edward V. Craig, MD, Russell F. Warren, MD, Lawrence V. Gulotta, MD, Hospital for Special Surgery, New York, New York, USA

Introduction: Impingement, the major functional setback of Reverse Shoulder Arthroplasty (RSA), has been correlated with both implant design and surgical techniques. Studies have suggested the favorable effect of humeral component retroversion on reducing scapular impingement (contact of the humeral cup with the scapular inferior border) and increasing external rotation and abduction range of motion (ROM). However, limited data exist to show how humeral version affects impingement in activities of daily living (ADLs) and whether other impingement sites (besides the glenoid inferior border) may affect the functional outcome. We investigated the effect of humeral component version on the mechanism of impingement during ADLs.

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Figure 1  Average impingement (intra and extra-articular) for all 10 ADLs.
increased active external rotation post-operatively. **Clinical Significance:** The results of this study inform surgeons as to how humeral version can affect the impingement in RSA and suggest ways of minimizing it. The data also serve as a resource for prosthetic design optimization and further improve the functional outcome of shoulder replacement.

**Paper #4** IMAGE-BASED 3D MORPHOMETRIC ANALYSIS OF THE CLAVICLE INTRAMEDULLARY CANAL

**Peter Simon, PhD, Jazmine Aira, BS, Geoffrey P. Stone, MD, Sergio Gutierrez, PhD, Brandon G. Santoni, PhD, Mark A. Frankle, MD, Foundation for Orthopaedic Research and Education, Tampa, Florida, USA**

**Introduction:** Optimal treatment for clavicle fractures remains controversial. Conservative treatment is considered the gold standard, yet others advocate for surgical fixation. Superior and anterior plating systems represent the most common fixation strategies, however, the complexity of the clavicle’s three-dimensional (3D) shape poses a challenge for their design and utilization. In addition to lower patient satisfaction, plating systems are associated with post-surgical complications including infection, hardware malfunction, and fracture re-occurrence. Clavicular intramedullary (IM) fixation may be a feasible surgical alternative to external plate fixation as it allows faster functional recovery and is associated with higher patient satisfaction. Existing cadaveric and imaging studies on clavicle morphometry are often limited in the true assessment of clavicular canal geometry and curvature due to the use of the imaging technique, manual measurements or human factor bias. A normalized 3D automatic methodology to measure these morphologic parameters is necessary to determine the optimal design features of future IM devices. **Methods:** Clinical CT scans of 38 male and 37 female shoulders from the patient database of the affiliated hospital were included in this study. Exclusion criteria were incomplete scans, old or acute clavicle fractures, and congenital bone anomalies. Using a standard protocol, the clavicles were segmented in MIMICS (Materialise, Leuven, Belgium) and the 3D models of the clavicle and IM canal were generated. A custom-written automatic algorithm (MATLAB, MathWorks, Natick, MA) was utilized for the subsequent data analysis. First, a standardized coordinate system across all individuals was established (Fig. 1, A). Second, a tightest-fit box (length and size normalization) was calculated around every 3D clavicle model and subsequently every box was divided into 100 sections along its length at 1% increments (Fig. 1, B). Each clavicle slice section was then fitted with a circumscribed (Fig. 2, A, B) and an inscribed circle (Fig. 2B). Finally, the radii of curvature of the IM canal center-line were calculated (Fig. 3). **Results:**

**Figure 2** The version of the humeral fixation affected the site and the frequency of impingement.

**Figure 1** (A) Standardization of coordinate system. Blue is original position of the clavicle from CT. Red is the clavicle positioned at origin. (B) Normalization box in blue, and a highlighted cross-section (1% clavicle).

**Figure 2** (A) Clavicle in red, circumscribed circles in blue. (B) Inscribed and Circumscribed circles from the clavicle cross-section.

**Figure 3** Radius of curvature for medial and lateral sections of the IM canal.
Figure 4 Mean (±STD) clavicle and IM canal radius size for each slice as a function of clavicle length (%) along the longitudinal axis. Highlighted in blue are the smallest values.

Table 1 Average radius of curvature for both sections of the IM canal in males and females

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<thead>
<tr>
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<th>Medial Side Radius of Curvature (mm)</th>
<th>Lateral Side Radius of Curvature (mm)</th>
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<tbody>
<tr>
<td>Male</td>
<td>96.4 ± 12.9</td>
<td>36.5 ± 11.6</td>
</tr>
<tr>
<td>Female</td>
<td>86.0 ± 13.7</td>
<td>32.8 ± 12.7</td>
</tr>
<tr>
<td>Combined</td>
<td>91.3 ± 14.2</td>
<td>34.7 ± 12.3</td>
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clavicle and IM canal, respectively. The standard deviation was smallest at the normalized clavicle lengths corresponding to the smallest circumscibed and inscribed radii. The average medial side radius of curvature was 96.4 mm for males, and 86.0 mm for females; the average lateral side radius of curvature was 36.5 mm for males, and 32.8 mm for females (Table 1). Discussion: The data obtained in this study presents IM canal and clavicle radius parameterized as a function of clavicle length from a 3D model of the IM canal. Our 3D modeling approach to analyze clavicular IM morphometry provides an objective representation of clavicle spatial geometry. The smallest IM canal and clavicle cortex radii were seen at different clavicle lengths. This suggests that, on average, one may not estimate the location of the narrowest region of canal based on external visualization of the clavicle shape alone. The radii of curvature on both sides of the clavicle are similarly parameters dependent on the clavicle length and cortex diameter. Based on this data, an IM canal device with a maximum radius of 3.4 mm for males, 2.5 mm for females, and fabricated to match the curvature parameters reported here may serve as a viable alternative to external plate fixation of mid-shaft clavicle fractures. Since 3D morphometric analysis is a requisite for noting the different locations of clavicle cortex and IM canal narrowing, a pre-operative CT scan and canal analysis is necessary in pre-operative planning and implant selection for fracture treatment with an IM device.

References

Paper #5 OUTPATIENT TOTAL SHOULDER ARTHROPLASTY IN THE AMBULATORY SURGERY CENTER ENVIRONMENT IS A SAFE ALTERNATIVE TO THE INPATIENT HOSPITAL SETTING: A MATCHED COHORT STUDY

Tyler J. Brolin, MD, Ryan P. Mulligan, MD, Frederick M. Azar, MD, Thomas (Quin) Throckmorton, MD, Department of Orthopaedic Surgery, Campbell Clinic, University of Tennessee, Memphis, Tennessee, USA

Background: Total shoulder arthroplasty (TSA) is a well-recognized treatment for glenohumeral arthritis. As the health care policy environment continues to evolve, increasing emphasis has been placed on high quality healthcare that can be delivered in a safe, efficient and cost-effective way. To that end, there has been recent increased interest in outpatient total joint arthroplasty. We proposed to compare a matched cohort of outpatient total shoulder arthroplasties with those performed in the inpatient hospital setting to evaluate episode-of-care complications. Methods: Twenty five patients underwent outpatient TSA at a freestanding ambulatory surgery center (ASC). An age and co-morbidities matched cohort consisted of 25 patients undergoing TSA in the traditional inpatient hospital setting. Ninety day episode-of-care measures included hospital (re)admissions, reoperations, and complications. Cost of care was evaluated by total facility charges in the ASC cohort. Two-tailed t-tests were used to evaluate differences between ASC and inpatient groups. Differences with P < .05 were considered statistically significant. Results: No statistically significant differences were seen between the ASC and hospital cohorts regarding average age (51.0 vs. 53.2), pre-operative American Society of Anesthesiologists (ASA) score (2.1 vs. 2.3), operative indication, and body mass index (32.0 vs. 32.1). None of the patients required re-operation. And there were no hospital admissions from the ASC cohort and no re-admissions from the hospital cohort. There were 5 minor complications in the ASC cohort including 2 stitch abscesses/superficial infections, 2 cases of arthrofibrosis and 1 patient with mild asymptomatic anterior subluxation. There were 4 minor complications in the hospital cohort including stitch abscess/superficial infection, mild asymptomatic anterior subluxation, transient superficial radial nerve neuritis, and superficial vein thrombosis. There were no cardiopulmonary complications in either group. The average total charge for the ASC cohort was $45639.77. Conclusions: This study demonstrates that TSA performed in the outpatient ASC setting is a safe alternative to hospital admission in appropriately selected patients. Further, outpatient TSA results in an average total charge that compares favorably with inpatient TSA charges reported in the literature. Further investigation is warranted to evaluate the longer term outcomes and cost-effectiveness of TSA performed on an outpatient basis.

Paper #6 TRANEXAMIC ACID DECREASES BLOOD LOSS IN TOTAL SHOULDER ARTHROPLASTY AND REVERSE TOTAL SHOULDER ARTHROPLASTY

Jeffrey T. Abdiggaard, MD, Ryan McLemore, PhD, Steven J. Hattrup, MD, Department of Orthopedics, Mayo Clinic Arizona, Phoenix, Arizona, USA; Department of Health Science Research, Mayo Clinic Arizona, Scottsdale, Arizona, USA

Introduction: Tranexamic acid (TXA) has been shown to significantly reduce perioperative blood loss after total hip arthroplasty (THA) and total knee arthroplasty (TKA). The efficacy of TXA remains unproven in the setting of total shoulder arthroplasty (TSA) and reverse total shoulder arthroplasty (RTSA). This study examines the effects of TXA on perioperative blood loss and drain output in patients undergoing primary TSA and primary RTSA.

Materials and Methods: We performed a retrospective comparison of 77 TSA and 94 RTSA performed in 168 patients. Thirty-five TSA and
42 RTSA received intravenous TXA at the initiation of the surgical procedure. The changes in hemoglobin (Hgb) and hematocrit (Hct), drain output, and total blood loss were reviewed with univariate analysis and additional multivariate regression examined the cofactors of age, Body Mass Index (BMI), American Society of Anesthesiology (ASA) status, and gender of each patient. Results: Patients that underwent TSA and received TXA were found to have significantly less total blood loss (679 mL versus 910 mL, \( P < .001 \)), less change in Hgb (1.8 mg/dL versus 2.6 mg/dL, \( P < .001 \)), and drop in Hct (5.2 versus 7, \( P < .001 \)) (Table 1). Similarly, RTSA also had significantly less total blood loss with the use of TXA (791 mL versus 959 mL, \( P < .001 \)), change in Hgb (2.3 mg/dL versus 2.9 mg/dL, \( P < .001 \)), and change in Hct (6.4 versus 8.3, \( P < .001 \)). Total blood loss was decreased by 25% in TSA and 18% in RTSA with the use of TXA. TXA also significantly decreased drain output in both TSA (100 mL versus 235 mL, \( P < .001 \)) and RTSA (180 mL versus 370 mL, \( P < .001 \)), representing a decrease of 58% in TSA and 51% in RTSA. Conclusions: Use of intravenous TXA perioperatively among patients undergoing primary TSA and primary RTSA can decrease perioperative blood loss, change in hemoglobin and hematocrit, and postoperative drain output.

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Paper #7  PATIENT ACTIVITY LEVELS AFTER REVERSE TOTAL SHOULDER ARTHROPLASTY: WHAT ARE PATIENTS DOING?
Grant H. Garcia, MD\(^a\), Samuel A. Taylor, MD\(^a\), Brian DePalma, BA\(^b\), Gregory T. Mahony, BA\(^b\), Joshua S. Dines, MD\(^a\), David M. Dines, MD\(^a\), Russell F. Warren, MD\(^a\), Edward V. Craig, MD\(^a\), Lawrence V. Gulotta, MD\(^a\); \(^a\)Hospital for Special Surgery, New York, New York, USA; \(^b\)Robert Wood Johnson School of Medicine, Newark, New Jersey, USA

Introduction: Indications for reverse total shoulder arthroplasty (RTSA) are expanding, resulting in younger patients who wish to remain active following the procedure. Little information is available to help manage expectations of both physicians and patients for return to sporting activities. The purpose of this study was to determine the rate of return of sports activities, assess average time to return to sports for patients having undergone RTSA. Methods: A prospectively collected registry was queried for consecutive patients who underwent RTSA at our institution between 2007 and 2013. Patients with played sports preoperatively and a minimum of 1-year
follow-up were included. All patients were asked to complete a questionnaire regarding their physical fitness, sporting activities. Each patient also completed an ASES and VAS assessment. **Results:** 76 patients played a sport preoperatively and met inclusion/exclusion criteria. The average follow-up was 31.6 months (12-65 months) and average age was 74.84 years (49.9-92.6 yrs). Average VAS pain scores improved from 6.57 to 0.63 (P < .001). Average ASES scores improved from 34.30 to 81.45 (P < .001). 85.5% of patients who participated in sports preoperatively returned to at least one sport following RTSA. Average time to full return to sport was 5.3 months. Fitness sports had the highest direct rate of return (81.5%), followed by swimming (66.7%), running (57.1%), cycling (50.0%) and golf (50%). 41.1% reported improved physical fitness following RTSA. 88.2% felt their sports outcome was good to excellent and 93.4% felt their surgical outcome was good to excellent. **Conclusion:** Patients undergoing RTSA had an 85% rate of return to one or more sporting activities at an average of 5.3 months following surgery. Non-contact high demand activities (swimming, skiing, golf, and tennis) had lower return rates than lower demand activities. Age greater than 70 years old was a significant predictor of decreased return to activities. The present study offers valuable information to help manage patient and surgeon expectations.

**Paper #9** IMMEDIATE VS. DELAYED PASSIVE RANGE OF MOTION FOLLOWING TOTAL SHOULDER ARTHROPLASTY

**Patrick J. Denard, MD**, Alexandre Lädermann, MD, Southern Oregon Orthopedics, Medford, Oregon, USA, and the Department of Orthopaedics and Rehabilitation, Oregon Health & Science University, Portland, Oregon, USA; "Division of Orthopedics and Trauma Surgery, La Tour Hospital, Meyrin, Switzerland

**Introduction:** The number of total shoulder arthroplasties (TSA) in rapidly growing and expected to continue to increase in the years to come. Despite this common use, the ideal rehabilitation protocol following TSA has not been well-studied. The goal of this study was to compare delayed to immediate passive range of motion following TSA. The hypothesis was that range of motion gains would occur earlier with immediate range of motion but that there would be no difference in ultimate range of motion (ROM) or functional outcome. **Methods:** Sixty patients were randomized to two different rehabilitation protocols following TSA for primary glenohumeral arthritis with an intact rotator cuff. A lesser tuberosity osteotomy was performed in all cases. In the immediate motion (IM) group patients were a sling for 4 weeks but performed immediate passive forward flexion as tolerated and external rotation to 30 degrees. In the delayed motion (DM) group patients were a sling and were not allowed any shoulder range of motion until 4 weeks postoperative. ROM and functional outcome were compared at 4 weeks, 8 weeks, 3 months, 6 months, and 1 year postoperatively. Osteotomy healing was assessed with plain radiographs. **Results:** Compared to preoperative values, in the IM group forward flexion improved from 105° to 146° at one year postoperative, external rotation improved from 22° to 62°, and internal rotation improved by 4 spinal levels (P < .05). In the DM group forward flexion improved from 105° to 134°, external rotation improved from 25° to 54°, and internal rotation improved by 4 spinal levels (P < .05). There was no significant differences in final ROM or functional outcome scores between the 2 groups. The IM group had greater ROM and higher functional outcome scores at 4 weeks and 8 weeks postoperative, but by 3 months postoperative there was difference in ROM between the 2 groups. Osteotomy healing was 77% in the IM group compared to 95% in the DM group. **Conclusion:** Immediate passive range of motion provides more rapid ROM and functional outcome improved compared to a delayed range of motion protocol following TSA. However, there are no differences in ultimate ROM or functional outcome between the 2 groups. Moreover, immediate range of motion may lower the healing rate of a lesser tuberosity osteotomy.

**Paper #10** THE EFFECT OF PUBLIC DISCLOSURE OF SURGEON’S OPERATING ROOM COSTS

**Luke S. Austin, MD, Nicholas J. Lombardi, BS, Alvin C. Ong, MD; Fotios P. Tjoumakaris, MD; Rothman Institute, Thomas Jefferson University, Philadelphia, Pennsylvania, USA

**Introduction:** Affordable care organizations (ACO’s) have been developed in an attempt to combat the rising costs of health care in the United States. The purpose of our investigation is to evaluate if public cost disclosure throughout an ACO orthopaedic department motivates surgeons to reduce operating room expenses. **Methods:** On April 1st 2012, a regional health care system began distributing a “scorecard” to each orthopaedic surgeon in the ACO. The scorecard reported the average direct supply cost per-case of certain procedures and compared the surgeon’s data to that of other surgeons in the same sub-specialty. All surgeons within the ACO had access to the data for full disclosure. Rotator cuff repair (RCR) was chosen for analysis based on high volume and low case-case fluctuations in cost. Average supply cost per case was calculated quarterly and collected over a two-year period (1/2012-1/2014). **Results:** The average direct supply cost per case for RCR procedures decreased $269 during the study period. After an increase of $141 per case observed during Q2 of 2012, the average supply cost per RCR case either reduced, or stayed constant (within $25) over the remaining year and a half study period. Using the case-volume and average cost per case for each quarter, we calculated that $39,831 was saved during the study period. There was a very strong correlation (R2 = .77) between cost containment and time during the study period. **Discussion:** In our analysis, public disclosure of direct supply cost for RCR had a positive correlation with cost containment in a regional ACO. Surgeons can affect cost of RCR by varying exposure (open vs. arthroscopic) and technique (single row vs. double row vs. anchorless repair). As the healthcare environment shifts to value based care, there will be increasing pressure placed on providers to provide quality care at a cost premium. Our study is the first to evaluate what effect department wide disclosure of direct supply costs has on the episode of care for rotator cuff repair.

**Paper #11** THE EFFECT OF NECK-SHAFT ANGLE, GLONSPHERE SIZE, AND CUP DEPTH ON CONTACT MECHANICS IN REVERSE SHOULDER ARTHROPLASTY

**G. Daniel G. Langhoft, MASc, Ryan Willing, PhD; John B. Medley, PhD; James A. Johnson, PhD; George S. Athwal, MD, FRCSC; "The Roth|McFarlane Hand and Upper Limb Centre, London, Ontario, Canada; "The University of Waterloo, Waterloo, Ontario, Canada; "Binghamton University, SUNY, Binghamton, New York, USA

**Background:** Reverse shoulder arthroplasty (RSA) implants incorporate a reduced coverage ball-in-socket articulation to accommodate the range of motion required of the shoulder. Implant
parameters can be changed during RSA to improve range-of-motion and stability, however, little is known regarding their impact on articulating contact mechanics. The purpose of this finite element study was to investigate RSA contact mechanics during abduction for different neck-shaft angles, glenosphere sizes, and polyethylene cup constraints. **Methods:** Finite element RSA models were developed in ABAQUS with varying neck-shaft angles (155°, 145°, 135°), sizes (38 mm, 42 mm), and cup depths (deep, normal, shallow) representing current clinically available options (Fig. 1). The RSA models were then loaded using physiologic joint load angles representative of those occurring throughout shoulder abduction (1.5°-120°). Contact area and maximum contact stress were computed for all 18 implant configurations during abduction. **Results:** The contact patch and location of maximum contact stress was typically located inferomedially in the polyethylene cup, except at low abduction angles (Fig. 2). In general, the adverse effects of reducing H-N angle on contact area and peak contact stress increased at higher abduction angles (Table 1). On average, reducing neck-shaft angle reduced contact area by 29% for 155°→145° and 39% for 155°→135°, and increased maximum contact stress by 71% for 155°→145° and 286% for 155°→135° (Fig. 3). Increasing size increased contact area by 12%, but only decreased maximum contact stress by 2%. Decreasing cup depth reduced contact area by 40% and increased maximum contact stress by 81%, while increasing depth produced the opposite effect (+52% & −36% respectively, Fig. 3). The 155° H-N angle provided the highest contact areas and lowest peak contact stresses throughout all abduction angles investigated (Table 1). **Conclusions:** The inferomedial location of the contact patch and maximum contact stress in this study matches the area of damage seen frequently on clinical retrievals, and was generated by the vertically oriented joint reaction forces which required the cup to resist vertical translation. This suggests that damage to the inferior cup due to notching may be potentiated by contact stresses. Increasing glenosphere size improved joint contact area and did not affect maximum contact stress. However, while reducing neck-shaft angle and cup depth can improve ROM, there is an associated negative consequence on joint contact area and peak contact stress, both of which may affect the long-term wear performance of RSA.

**Clinical Relevance:** The results of this study show that while reducing RSA H-N angle and polyethylene cup depth may improve range of motion, there is an associated negative consequence on joint contact area and peak contact stress, both of which may affect the long-term wear performance of RSA.
Additionally, the location of peak contact stress coincides with damage most commonly found on clinical retrievals, which may contribute to intermedial cup wear and potentially interact with damage due to scapular notching.

Paper #11  REOPERATION RATE FOLLOWING ISOLATED ARTHROSCOPIC ROTATOR CUFF REPAIR
Siddharth A. Mahure, MD, Brent Mollon, MD, FRCSC, Steven D. Shamah, BA, Joseph D. Zuckerman, MD, Young W. Kwon, MD, PhD, Andrew S. Rokito, MD
Department of Orthopaedic Surgery, NYU Hospital for Joint Diseases, New York University Langone Medical Center, New York, New York, USA

Introduction: Recent studies have questioned the association between tendon healing and clinical outcomes following arthroscopic rotator cuff repair (RCR). As need for subsequent shoulder surgery is expected to reflect poorer outcomes following RCR, understanding risk factors for additional surgery may help predict failure of RCR. The purpose of this study was to identify the rate and risk factors of subsequent shoulder procedures in individuals undergoing arthroscopic RCR. Based on previous literature, we hypothesized that older age, workers compensation and limited surgeon experience would be associated with reoperation. Methods: We examined the New York State Department of Health’s Statewide Planning and Research Cooperative Systems (SPARCS) database from 2003 to 2011 to identify all patients undergoing arthroscopic RCR (CPT code 29827). With the exception of subacromial decompression (CPT code 29826), patients coded as undergoing any other additional shoulder procedure were excluded. Baseline demographics and all subsequent ipsilateral outpatient shoulder procedures were collected for analysis. High-volume surgeons and high-volume surgical facilities were identified and defined as being in the upper quartile of arthroscopic RCR performed over the nine-year period. Patients were longitudinally followed for a minimum of two years to determine the incidence of subsequent ipsilateral shoulder surgery. SAS version 9.3 (Cary, NC) was used for data collection and statistical analysis. Results: We identified 22,535 patients who met the inclusion criteria. Mean patient age was 57.1 years (+/− 12.0), and 54.7% of the sample was male. A total of 1344 (6.0%) patients underwent subsequent ipsilateral shoulder surgery during the follow-up time period. Mean time between initial RCR and re-operation was 21.6 + /− 36.3 months, with 53% and 74% of patients having additional shoulder surgery within one or two years of the initial procedure, respectively. The most frequently performed subsequent procedures included: arthroscopic RCR (45.8%), subacromial decompression (43.4%), and open rotator cuff repair (13.5). Patients undergoing additional surgery were significantly younger (53.6 + /− 11.2 vs. 57.3 + /− 12.0 years, \( P < .0001 \)), more likely to be male (58.0% vs. 54.5%, \( P = .01 \)), and insured by worker’s compensation (32.7% vs. 17.7%, \( P < .0001 \)). Patients undergoing additional surgery were less likely to have been originally treated in an upper quartile facility (24.9% vs. 28.1%, \( P = .007 \)), although surgeon volume did not appear to predict re-operation. Multivariate analysis controlling for all confounding factors suggested younger age was the only independent risk factor predicting subsequent shoulder surgery (OR: 1.02, \( P < .0001 \), 95% CI 1.01-1.03). Conclusion: Additional surgery following arthroscopic RCR occurred in 6% of our sample, and nearly 60% of those patients who required subsequent surgery underwent a revision rotator cuff repair procedure. We found that need for additional ipsilateral shoulder surgery after arthroscopic RCR was associated with younger age, male gender, and worker’s compensation insurance status.
once. While surgeon experience did not appear to be associated with subsequent surgery, we found that patients who had their initial RCR at a higher-volume facility required subsequent surgery at lower rates than those that did not.

**Paper #12  THE ROLE OF VITAMIN D DEFICIENCY IN ROTATOR CUFF INTEGRITY: DOES IT AFFECT POST-OPERATIVE HEALING?**

Ryan M. Degen, MD, MSc, FRCSC, Danyal H. Nawabi, MD, FRCS (Orth), Julia Gromis, BA, Heather M. Kawalick, BA, Edward V. Craig, MD, Frank A. Cordasco, MD, Scott A. Roden, MD, Russell F. Warren, MD, Lawrence V. Gulotta, MD, Hospital for Special Surgery, New York, New York, USA

**Background:** Rotator cuff tears are a common cause of pain and dysfunction, often requiring surgical repair. With failure rates reportedly ranging from 13-94%, significant attention has been focused on improving our understanding of rotator cuff healing and identifying associated factors that may negatively impact healing in order to improve outcomes and minimize costs associated with re-operation. The role of different surgical techniques and rehabilitation protocols have been studied in depth in past years. However, the influence of systemic and hormonal factors, such as vitamin D, have not been as widely studied. Recently, several basic science studies, including a rodent rotator cuff repair model, have demonstrated that vitamin D-deficiency may affect tendon-to-bone healing. However, no clinical studies exist to corroborate these findings to date. **Purpose:** To determine the effect of vitamin D deficiency in the healing of surgically repaired rotator cuff tears. **Methods:** From May 2012 to October 2014, 61 patients undergoing arthroscopic rotator cuff repair (average age 63, range 48-76) were enrolled in this prospective study. Baseline evaluation consisted of clinical examination with documentation of strength, completion of patient reported outcome measures (ASES) and baseline bloodwork including serum 25-hydroxyvitamin-D3 levels. Patients were then followed at 2 weeks, 6 weeks, 3 months and 6 months post-operatively with repeat clinical evaluation and bloodwork. At 6 months, patients underwent ultrasonographic evaluation to assess for healing of their rotator cuff. **Results:** At an average follow-up of 7.9 months (range 5.5-14.8), all 61 patients had clinical follow-up, while 53 had ultrasonographic evaluation. Twenty-six patients were identified as vitamin-D deficient based on pre-operative serum values below 30 ng/mL, while 35 patients had values within the normal range. The re-tear rate for the entire group was 9.4% (5/53), with no statistically significant differences between the vitamin D-deficient and normal groups (4.3% vs. 13.3%, **P** = .392). Both the deficient and normal groups had similar improvements in ASES scores, with no significant differences in baseline or final follow-up scores (52.1 ± 3.6 vs. 57.1 ± 3.1, **P** = .284; 83.5 ± 3.4 vs. 85.1 ± 3.1, **P** = .746). Strength testing revealed only slight improvements in the percentage of patients achieving full strength in resisted external rotation and abduction in the normal group compared with the deficient group, although these differences were not statistically significant (**P** > .448). A secondary, stratified analysis was also performed, including patients’ final follow-up vitamin-D level, to determine if a change from deficient to normal levels, or oppositely, had an effect on outcome measures. Looking at these subgroups, there was no statistically significant difference in re-tear rates or ASES scores when considering the effect of this change, although groups were small, as only 4 patients changed from deficient to normal and 8 patients from normal to deficient over the course of the study. **Conclusion:** Vitamin D deficiency does not affect re-tear rates, functional outcome scores or muscle strength following arthroscopic rotator cuff repair. Further follow-up is necessary to ensure the longevity of these findings.

**Paper #13  CORRELATION OF THE CT, MRI, AND INTRAOPERATIVE FINDINGS OF ELBOW OSTEOCHONDROSIS DISSECANS (OCD)**

Ezekiel E. Shotts, MD, Mark S. Collins, MD, Jeffrey R. Bond, MD, Shawn W. O’Driscoll, PhD, MD, Departments of Radiology and Orthopedics, Mayo Clinic, Rochester, Minnesota, USA

**Objective:** The purpose of this study was to correlate CT imaging findings with MRI and intraoperative findings of elbow osteochondritis dissecans (OCD). The benefits of CT imaging would also be defined. **Materials and Methods:** Patients with OCD of the elbow that had preoperative CT and MRI within six months of each other and had surgery on their elbow between January 1, 2000 and April 1, 2011 were reviewed (n = 28 elbows). Preoperative CT and MRI scans were reviewed by two radiologists, and correlated with operative reports and intraoperative imaging that were reviewed in conjunction with an orthopedic surgeon. **Results:** OCD lesions occurred in three locations: the capitellum (n = 17), trochlea (N = 7), and the lateral trochlear ridge (n = 4). Twenty-seven lesions had an area of subchondral lucency and 18 lesions had residual subchondral bone identified with CT (Fig. 1). On MRI images, this lucent area corresponded with tissue signal, and soft tissue fills this area as visualized with arthroscopy. CT was superior to MRI for determining thickness and fragmentation of the subchondral bone, extent of bone resorption in the crater beneath the subchondral fragment, and detection of loose bodies. **Conclusion:** Osteochondritis dissecans has a unique appearance at CT with subchondral lucency that has tissue signal on MRI. CT provides information about OCD lesions that is not routinely recognized with MRI and may alter patient care. CT was more useful for preoperative planning due to its superior detection of loose bodies as well as its ability to determine thickness and frag-

**Figure 1** 11 year-old male with OCD of the right capitellum. (A-C) Sagittal CT (A), T2-weighted fat suppressed (B) and T1-weighted (C) MRI images through the capitellum. The CT shows a large area of subchondral lucency (arrow). There is a subtle, thin wisp of residual subchondral bone at the tip of the arrow. Corresponding MRI images show tissue signal in the area of CT lucency (B-arrow) and do not reveal the residual subchondral bone visible on CT (C-arrow). (D) Inspection of the articular surface at surgery was normal despite the large lesion shown on preoperative imaging. (E) 7 months post-operative CT of the elbow shows incorporation of bone graft material into the space that was lucent on preoperative CT and filled with soft tissue at surgery (arrow).
mentation of the subchondral bone and the extent of bone resorption in the crater beneath the subchondral fragment.

Paper #14  ARTHROSCOPIC VS. OPEN LATERAL RELEASE FOR THE TREATMENT OF LATERAL EPICONDYLITIS: A PROSPECTIVE RANDOMIZED CONTROLLED TRIAL

Peter B. MacDonald, MD, FRCSC, Tod Clark, MD, FRCSC, Sheila McRae, MSc, PhD, Jeff Leiter, MSc, PhD, Jamie Dubberley, MD, FRCSC, Pan Am Clinic, University of Manitoba, Winnipeg, Manitoba, Canada

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 < .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-scores (%) decreased in the Open group from 62.5 (17.2) 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 statistical conclusions.

Paper #15  FACTORS THAT DETERMINE SUPINATION STRENGTH FOLLOWING DISTAL BICEPS REPAIR

Christopher C. Schmidt, MD,*, Brandon T. Brown, MS, Lars M. Givick, MD, Rafał Stachowicz, MD, Carmen Latona, MD, Mark C. Miller, PhD,† Department of Orthopaedic Surgery, University of Pittsburgh Medical School, Pittsburgh, Pennsylvania, USA; †University of Pittsburgh School of Engineering, Pittsburgh, Pennsylvania, USA; ‡Allegheny General Hospital, Department of Radiology, Pittsburgh, Pennsylvania, USA

Introduction: Distal biceps repair results in significant improvements in clinical outcome scores, but consistently fail to return supination strength through a full arc of forearm rotation. The weakness is particularly profound between neutral-to-pronated positions. The above loss in arm strength results in difficulties with daily, occupational, and recreational activities. The goal is to identify factors that maximize supination strength following a distal biceps repair. Our hypotheses are that re-insertion position, supinator muscle fatty atrophy, WMC, postoperative DASH scores, arm dominance, heterotopic bone, and tendon heterogeneity will correlate with post-operative supination strength. Methods: 36 patients (single surgeon) were enrolled retrospectively (17 posterior ECU muscle-splitting approach and 19 anterior [Henry] approach); however, 2 patients in each group failed to complete the study requirements and thus excluded from data analysis. Thus, the muscle-splitting group contained 15 patients (mean age 49.7 ± 8.7 and follow-up 1.4 ± 0.4 years) and the anterior group involved 17 patients (mean age 48.7 ± 9.7 and follow-up 4.2 ± 1.6 years). In both groups, the repair was to the near cortex of the radial tuberosity with a single cortical button. At least one year after surgery, all patients had their isometric supination strength measured in 60° of pronation, neutral (0°) and 60° of supination and expressed as percentage of the injured/uninjured arm. All patients filled out a DASH questionnaire; further, their repair sites were imaged with an elbow MRI (Fig. 1). A control group of MRIs from 10 uninjured volunteers were used for comparison. Institutional IRB approval was given. Each patient’s distal biceps tendon re-insertion location, defined as the insertion site angle (ISA), and supinator muscle fat content (SFC) were measured on their post-repair MRI (Matlab MathWorks, Natick, MA). The ISA was defined as the angle between the cortical drill hole (center of tendon insertion for control specimens) and the apex of the radial tuberosity as seen on an axial MRI. The SFC was calculated by averaging the intensity values (pixel analysis) of the supinator muscle for a 2 cm centered at the radial tuberosity using the axial proton density MRI. The values were normalized using the ulnar marrow intensity. An experienced, blinded musculoskeletal radiologist graded the fat content on a scale from 0-3: 0] no fat in the SM; 1] < 25% of the SM has fatty infiltration; 2] > 25% and < 50% fatty infiltration and 3] > 50% of the SM has fatty infiltration. The radiologist and computerized measurements were correlated (Kendall’s tau = 0.57) and were significant (P < .001). The radiologists on two separate occasions graded the presence of HO and tendon heterogeneity as previously described. Arm dominance and WMC status were documented for analysis. Statistical comparisons were made between posterior and anterior groups for strength measurements (t-test) and between control, posterior and anterior groups for ISA and SFC (ANOVA). A multiple linear regression analysis was done to determine the effect of ISA, SFC, WMC status, DASH scores, arm dominance, heterotopic bone, and tendon heterogeneity on supination strength. Results: All repaired biceps tendons healed to cortical bone (Fig. 1). No patient lost > 10° of elbow or forearm motion. Strength measurements between the posterior and anterior groups were similar in pronation and neutral, but statistically greater (P = .027) in the posterior group in a supinated forearm position (Table 1). There was no significant difference (P = .893) in the ISA values between the control (24.0 ± 8.0°) and posterior group (25.2 ± 15.4°), however the anterior group ISA (91.0 ± 21.1°) was significantly greater (P < .001) than the controls, which indicates a re-insertion site anterior to the native footprint (Fig. 1). The posterior group had significantly greater (P < .001) SFC (323.1 ± 47.4) than the controls (287.9 ± 41.2); however, no statistical difference (P = .568) between the control and anterior groups. Multiple regression analysis 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-scores (%) decreased in the Open group from 62.5 (17.2) 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 statistical conclusions.
We hypothesized that the use of indomethacin prophylaxis postoperatively would decrease the incidence of symptomatic synostosis. **Methods:** A single center retrospective chart review was performed on 124 patients undergoing distal biceps repair by four surgeons between 2011 and 2014. Patients were identified based on documented CPT. Patients were analyzed for administration of indomethacin, contraindications to administration, age, time to surgery, method of fixation, medical comorbidities and the development of symptomatic synostosis. After analysis, 12 patients did not meet inclusion criteria leaving 112 patients as our final cohort (2 females, 110 males, 73 dominant versus 39 nondominant extremities). Indomethacin (75 mg PO Q day) was prescribed postoperatively for 10-42 days per each attending’s postoperative protocol. **Results:** Average age for those treated with indomethacin versus those treated without indomethacin was 48.1 and 50.3 years respectively. Average time to surgery for those receiving and not receiving indomethacin was 61.0 and 67.1 days respectively. Seven patients underwent a one incision distal biceps repair compared to 104 patients undergoing a two incision repair. Of those patients, 104 received indomethacin post-operatively and 8 patients did not. Data was analyzed using Fisher’s exact test and pairwise comparisons. In those patients that received indomethacin the rate of synostosis was 0.96% compared to a synostosis rate of 37.5% (P = .000949) for the untreated group. No statistically significant difference was found between fixation methods and synostosis. One patient with synostosis was a single incision repair, 3 were two incision suture bridge repairs. Three patients with synostosis had relative contraindications to administration of indomethacin including concomitant Coumadin use, Plavix use and Ulcerative Colitis. No complications relating to the use of indomethacin were found including distal biceps rupture or gastrointestinal bleeding. **Conclusion:** The use of indomethacin after distal biceps repair is associated with a statistically significant reduction in the rate of symptomatic radioulnar synostosis. In addition, the use of indomethacin did not have any deleterious effects on healing, or any significant patient reported side effects despite prolonged use of up to 6 weeks. This study represents the largest study to report on the outcomes of patients undergoing distal biceps repair with concomitant synostosis prophylaxis using indomethacin.

**Table 1**

<table>
<thead>
<tr>
<th>Strength (I/U)</th>
<th>Posterior</th>
<th>Anterior</th>
<th>p-value</th>
</tr>
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<td>Pronation</td>
<td>Avg ± Std</td>
<td>Avg ± Std</td>
<td>p-value</td>
</tr>
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<td>101.2% ± 19.5%</td>
<td>0.223</td>
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<td>Neutral</td>
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<tr>
<td>Supination</td>
<td>81.3% ± 16.4%</td>
<td>66.9% ± 18.3%</td>
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**References**


**Paper #16** THE USE OF INDOMETHACIN IN THE PREVENTION OF POSTOPERATIVE RADIOULNAR SYNOSTOSIS AFTER DISTAL BICEPS REPAIR

**Callista Costopoulos, DO,** Joseph A. Abboud, MD, Matthew L. Ramsey, MD, Charles L. Getz, MD, Daniel Sholder, BS, John P. Taras, BS, Daniel Husman, MD, Mark D. Lazarus, MD, The Rothman Institute, Philadelphia, Pennsylvania, USA

**Background:** Distal biceps tendon repair is a relatively common surgical procedure around the elbow. Various techniques for fixation have been described to minimize risk and expedite recovery. One of the known risk factors after this surgery is the development of symptomatic radioulnar synostosis/heterotopic ossification (HOT). Indomethacin has been previously demonstrated to be efficacious for the prevention of heterotopic ossification. Therefore, the purpose of this study was to evaluate incidence of symptomatic synostosis after distal biceps repair in patients receiving indomethacin prophylaxis.

Analysis (r = 0.525) of the posterior and anterior repairs showed that both ISA (P = .004) and SFC (P = .039) are significant predictors of postoperative supination strength. An anatomic repair and no supinator fat resulted in return of full supination strength. DASH score, WMC status, arm dominance, heterotropic bone, and tendon heterogeneity did not correlate with post-operative supination strength. **Discussion:** This study showed that an anatomic re-insertion of the ruptured tendon and preservation of the supinator muscle were the only significant factors that demonstrated post-operative supination strength through a full arc of forearm rotation. The muscle splitting, posterior approach, in contrast to the anterior approach, recovered a statistically greater amount of supination strength in a supinated position. This gain in strength can be attributed to an anatomic insertion site. However, the patients with a posterior approach were still 19% weaker than their uninjured arm and the study findings show that the strength loss is most likely due to supinator muscle damage during tuberosity exposure. Surprisingly, WMC status, post-operative DASH scores, arm dominance, heterotropic bone, and tendon heterogeneity did not correlate with post-operative supination strength. Future directions for distal biceps tendon repair techniques should focus on anatomic insertion site restoration, while limiting supinator muscle damage.

**Acknowledgements:** Allegheny Imaging of McCandless for MRI donation.

**References**

injury conditions had much lower stiffness than the intact shoulder. Stiffness after off-track HS remplissage was much larger than that of the intact shoulder, injury conditions, and Bankart repair only conditions. Bankart repair of the on-track HS injury condition improved stiffness to near intact, while addition of on-track HS remplissage increased stiffness over Bankart repair alone at 90°.

**Conclusions:** The glenoid track concept is supported by this model of two Hill-Sachs lesions with 15% glenoid bone loss. Our results support the paradigm of Bankart repair for on-track lesions and Bankart plus remplissage for off-track lesions. Remplissage of on-track lesions might be considered for increased stability in high-risk patients. **Level of Evidence:** Biomechanical study.
(P < .001) in ASES (65.7 to 87.0), SST (7.2 to 10.3), and VAS (3.1 to 1.1). Recurrent instability occurred in 2 of 28 shoulders (7%), including 1 patient with symptomatic subluxation and 1 patient with a recurrent dislocation resulting in rapid arthrosis requiring revision to hemiarthroplasty at 20 months after Latarjet. Conclusions: Both arthroscopic revision stabilization and Latarjet coracoid transfer result in satisfactory outcomes in patients who have failed previous arthroscopic capsulolabral repair. Recurrent instability rates were higher in the all-arthroscopic group (19% versus 8%). Longer-term studies are required to determine whether similar results are maintained over time, and to provide guidance on focused clinical indications for this challenging patient population.

Paper #19 CLINICAL AND RADIOGRAPHIC OUTCOMES OF DISTAL TIBIA ALLOGRAFT RECONSTRUCTION FOR GLENOID BONE DEFECTS IN RECURRENT ANTERIOR SHOULDER INSTABILITY
Rachel M. Frank, MDa, Petar Golijanin, BSc, Brian J. Cole, MD, MBA, Nikhil N. Verma, MDa, Anthony A. Romeo, MDa, Matthew T. Provencher, MD, Department of Orthopaedic Surgery, Rush University Medical Center, Chicago, Illinois, USA; bDepartment of Orthopaedics, Massachusetts General Hospital, Boston, Massachusetts, USA

Introduction: A variety of bone grafts are available for glenoid reconstruction in recurrent anterior shoulder instability, however, little is known about fresh distal tibia allograft (DTA) reconstruction. The purpose of this study was to assess the clinical and radiographic outcomes of patients with recurrent anterior shoulder instability treated with fresh DTA glenoid reconstruction. Methods: Consecutive patients with a minimum 15% glenoid bone loss with recurrent anterior instability underwent glenoid bone reconstruction using a fresh DTA were reviewed. Patients were evaluated with ASES, SANE and WOSI. Outcomes assessments at a minimum of two years and computed tomography (CT) at a minimum of six months postoperatively. All CT scans were graded for: 1) overall allograft healing to the native glenoid; 2) angle of allograft relative to the native glenoid (allograft angle); and 3) amount of allograft lysis. Statistical analysis was performed with paired T-tests, with P < .05 considered significant. Results: A total of 27 patients with an average age of 31 ± 5 years were included at an average 45 months (range, 30-66) following surgery. There were statistically significant improvements in pre-operative to post-operative ASES (63 to 91, P < .01), SANE (50 to 90.5, P < .01), and WOSI (46% to 11%, P < .01) scores. Analysis of CT data (available for 19 patients, Fig. 1) demonstrated an 85% (range, 60-100%) allograft healing rate to the native glenoid, average allograft angle of 14.9 degrees (range, 6.6-29.3), and average allograft lysis of 3% (range, 0-25%). One patient (5%) sustained an infection and underwent allograft removal followed by revision DTA reconstruction. There were no cases (0%) of recurrent instability. Conclusions: At an average follow-up of nearly 4 years, fresh DTA reconstruction for recurrent anterior shoulder instability results in a clinically stable joint with excellent clinical outcomes and minimal graft reabsorption. Optimal allograft placement resulted in superior bony incorporation with the native glenoid. Longer-term studies are needed to determine if these results are maintained over time.

Paper #20 PREDICTORS FOR SURGERY IN SHOULDER INSTABILITY: A RETROSPECTIVE COHORT STUDY USING THE FEDS SYSTEM
George F. Lobs, MD, Martin B. Raynor, MD, Samuel K. Nwosu, MS, Emily Wagstrom, MD, Sunil S. Jani, MD, MS, James L. Carey, MD, MPH, Carolyn M. Hettrich, MD, MPH, Charles L. Cox, MD, MPH, John E. (Jed) Kuhn, MD, The MOON Shoulder Group, Nashville, Tennessee, USA

Background: Shoulder instability is a common cause of pain and dysfunction in young, active patients. While studies have analyzed risk factors for recurrent instability and failure after instability surgery, few have examined which variables are associated with initial surgery in this patient population. Purpose: To identify variables that may be associated with surgical intervention in patients with shoulder instability in the context of the FEDS classification, a system that may be useful in the treatment of shoulder instability patients. Methods: A database of patients treated for shoulder instability from three separate institutions from 2005 to 2010 was generated using ICD9 data. Data was collected via retrospective review. Injury data was categorized according to the FEDS system, and included frequency, etiology, direction of instability, and severity. Data was analyzed for significance with the primary outcome of surgical intervention. Summary statistics were used to assess which variables were associated with eventual surgical intervention. To test the unadjusted bivariate associations between shoulder surgery and each risk factor, Pearson Chi-square tests were used for categorical variables and Wilcoxon tests were used for continuous variables. Results: Three hundred and seventy-seven patients were treated for shoulder instability over the study period. Patients who had surgery were more likely younger, had recurrent instability, and had their initial injury while playing a sport. Most patients had anterior instability; however, there were a greater proportion of posterior instability patients in the operative group. Severity of dislocation, measured by whether or not the patient required help to relocate the shoulder, was not significantly associated with eventual surgery. While imaging was not available for all patients, surgical patients were more likely to have MRI findings of anterior labral injury and less likely to have a supraspinatus or subacapsularis tear. Conclusions: Patients who underwent surgery for shoulder instability were younger, more likely to have experienced recurrent instability, and more likely to have sustained their original injury while playing sports. The FEDS classification, particularly the frequency and etiology of the patient’s shoulder instability, may be helpful in identifying patients with a higher likelihood of undergoing surgical treatment. Level of Evidence: Level II, Retrospective Design, Prognosis Study.

Paper #21 DETERMINING THE MINIMAL CLINICALLY IMPORTANT DIFFERENCE (MCID) FOR THE ASES, SST AND VAS PAIN AFTER TOTAL SHOULDER ARTHROPLASTY (TSA)
Robert Z. Tashjian, MD, Jay D. Keener, MD, Jared McAllister, MD, Gregory Ebersole, MD, Erin K. Granger, MPH, Wei Chen, PhD, Man Hung, PhD, Aaron M. Chamberlain, MD, Department of Orthopaedics, University of Utah School of Medicine, Salt Lake City, Utah, USA; bDepartment of Orthopaedics, Washington University, St. Louis, Missouri, USA

Background: The minimal clinically important difference is the smallest difference in an outcome score that a patient perceives as beneficial. No prior study has determined the MCIDs for the ASES score, the SST and the VAS pain score using an anchor-based method after shoulder arthroplasty. The purpose of this study was to determine the minimal clinically important difference for the ASES score,
the SST score and VAS pain for patients treated with a total shoulder arthroplasty. Methods: 319 patients had a primary anatomic total shoulder arthroplasty (TSA) or primary reverse total shoulder arthroplasty (RSA) by one of 5 shoulder and elbow surgeons at one of two institutions. Each patient completed the Simple Shoulder Test (SST), American Shoulder and Elbow Surgeons (ASES) score and a visual analog pain scale (VAS pain) preoperatively and at a minimum of 2 years postoperative (average 3.5 years). At final follow-up, each patient also answered the question “Since your total shoulder arthroplasty, please rate your response to the surgery. A: none—no good at all, ineffective treatment, b: poor—some effect but unsatisfactory, c: good—satisfactory effect with occasional episodes of pain or stiffness, d: excellent—ideal response, virtually pain-free”. Patients who answered “none” or “poor” were classified as having no change in the status of their shoulder. Patients who answered “good” were classified as having experienced a small change equivalent to the “minimal clinically important difference”. The MCIDs were calculated for the ASES score, SST and VAS pain by subtracting the mean change score of all patients classified as having no change from the mean change score of all patients who were classified as experiencing a minimal important difference. Tests were performed to compare means between unchanged and minimal important difference groups. A secondary analysis was performed to determine the effect of age, sex, duration of follow-up and type of arthroplasty (TSA or RSA) on the MCID. Results: 112 patients reported their results as “good” whereas 20 patients reported their results as “none” or “poor”. The MCID for the ASES score, SST and VAS pain was 20.9 (P < .001), 2.4 (P < .0001) and 1.4 (P < .158), respectively. Duration of follow-up and type of arthroplasty did not have a significant affect on the MCIDs (P < .1) except shorter follow-up correlated with a larger MCID for the ASES score (P < .0081). Younger age correlated with larger MCIDs for all scores (P < .024). Female sex correlated with larger MCIDs for the VAS pain (P = .123) and ASES score (P = .05). Conclusions: Patients treated with a shoulder arthroplasty require a 1.4 point improvement in VAS pain scores, a 2.4 point improvement in the SST and a 21 point improvement in the ASES score in order to achieve a minimal clinical improvement from the procedure. Females and younger patients typically require a larger change to report this improvement. Duration of follow-up and implant type (RSA vs TSA) had no effect on achieving this change.

Paper #23 A FINITE ELEMENT ANALYSIS OF AUGMENTED GLENOID COMPONENTS
Nikolas K. Knowles, MESc, G. Daniel G. Langohr, MASc, George S. Athwal, MD, FRCS, Louis M. Ferreira, PhD, University of Western Ontario and Roth|McFarlane Hand and Upper Limb Centre, London, Ontario, Canada

Background: Acquired glenoid bone loss due to osteoarthritis can be classified by two common morphological erosion patterns: symmetric and asymmetric. In symmetrically eroded glenoids requiring joint replacement, the articular surface is typically reamed to match the curvature of the implant for full backside contact. This method, when used on bi-concave asymmetrically eroded glenoids to correct the version angle, is referred to as eccentric reaming. Alternatively, posterior augmented glenoid components provide another surgical treatment option. The purported advantage of augmented implants is their inherent bone preserving design, which corrects version without removal of excessive anterior bone by eccentric reaming. For these patients dislocated, one with a proximal humerus nonunion and one with severe RA. One patient died at 9 months postop unrelated to the shoulder arthroplasty surgery. 12 out of 15 remaining shoulders had at least 2 year follow-up. Follow-up averaged 40 months with a range of (24-66). All patients improved dramatically with the preop and postop scores reported in that order: SPADI 500 N 10/45, SST 2/7, ASES 31/73, UCLA 10/25, Constant 27/65 Active elevation 75/112 and Active external rotation 0/29. 2 patients had late complications with a periprosthetic fx at 3 years postop and one scapular fracture due to an assault. The periprosthetic fracture was revised. Discussion: RTSA for the treatment of the symptomatic arthritic or irreparable rotator cuff tears in patients with impaired lower extremities can result in marked improvement in pain and function. However the surgeon must accept an increased major adverse event rate 26%. The big challenge is managing these patients immediately post op as they are very depend on their limbs. Often this means placement in a total care nursing facility for 6 to 12 weeks. However once past this postoperative period the patients greatly benefit from the increased mobility and function afforded them by the RTSA. Conclusion: RTSA for the proper indications in patients where the wheelchair is their major mode of mobility can be very rewarding but the surgeon must be prepared to manage these patients in the immediate post-operative period when they are limited to one functional extremity. Most complications occur during this post-operative period.
conditions. The compressive contact area, global neoglenoid bone displacement, and implant liftoff were measured (Fig. 1). Results: Compressive contact area was found to increase linearly with applied load and as the net joint load vector moved from anterior to posterior. The posterior-step and full-wedge implants had similar compressive contact areas for posteriorly directed loads, while the full-wedge showed greater compressive contact area for central and anterior directed loads. Greater implant liftoff in the anterior hemisphere of the glenoid and greater neoglenoid bone displacements were observed with posteriorly directed loads. The posterior-wedge implant resulted in the lowest amount of reactive posterior glenoid bony displacement. Similarly, with anterior directed loads, anterior liftoff was decreased and neoglenoid bone displacements were reduced in all implants.

Table 1 presents peak neoglenoid bone displacements as a function of net joint load vector magnitude/direction. Discussion: This study examined three designs of augmented glenoid components and compared them with respect to compressive contact, global reactive bone displacement, and implant lift off. These simulations found the posterior-step implant displayed the best compressive contact with the remaining glenoid bone under posteriorly-directed net joint load vectors. However, the posterior-step also showed the highest displacements of the neoglenoid under posterior loading than the other two implants. This is likely due to the increased bone removal required to insert the posterior-step, which creates a posterior diving board-type phenomenon. In our model, the wedged implants preserved more neoglenoid bone, which likely decreased the global bone displacements observed in this region. The results suggest that compressive contact areas, global neoglenoid bone displacements, and implant lift off are a function of the magnitude and direction of the applied joint load and the backside morphology of augmented implants. This study introduces the loading characteristics of augmented implants to simulated joint loads in B2 glenoids.
subscapularis. The purpose of this prospective study is to quantify rTSA outcomes in patients with and without subscapularis repair at a minimum follow-up of two years to determine if repair or no repair has any impact on clinical outcomes. **Methods:** An international multicenter data registry was utilized. The mean age of the 611 patients was 72 years (range 42-93 years) who received an rTSA and had a minimum of 2 years follow-up, 320 patients received an rTSA and had the subscapularis repaired with a mean age of 74 years (219 females and 101 males), and 291 patients received an rTSA and did not have the subscapularis repaired with a mean age of 71 years (167 females and 124 males). The patients were scored preoperatively and at latest follow-up using the SST, UCLA, ASES, Constant, and SPADI metrics; active abduction, forward flexion, and active and passive external rotation were also measured. The average follow-up for all patients was 37.2 months (subscap repaired: 37.0 months; subscap not repaired: 37.4 months). A Student’s two-tailed, unpaired t-test was used to identify differences in preoperative, postoperative, and pre-to-post-operative improvements in results, where \( P < .05 \) denoted a significant difference. IRB approval was obtained at each institution. **Results:** All patients had significant improvements in pain, range of motion and function following rTSA. For the subscapularis repaired cohort, ASES scores significantly improved from a preoperative mean of 38 to a postoperative mean of 86; Constant scores significantly improved from 33 to 71; active forward flexion significantly improved from 86° to 139°; and active external rotation significantly improved from 11° to 33°. For the subscapularis not-repaired cohort, ASES scores significantly improved from 28 to 84; Constant scores significantly improved from 27 to 73; active forward flexion significantly improved from 78° to 140°; and active external rotation significantly improved from 14° to 32°. Nineteen complications (5.9%) were reported for the subscapularis repaired cohort (1 dislocation, 0.3%) compared with 26 complications (8.9%) reported for the subscapularis not-repaired cohort (5 dislocations, 1.7%). The overall dislocation rate was 0.98%. The subscapularis repaired cohort had a scapular notching rate of 10% with an average of Grade 1, while the subscapularis not-repaired cohort had a scapular notching rate of 17% with an average of Grade 2. **Discussion:** This study is one of the largest to date that compares rTSA outcomes with and without subscapularis repair. Treatment with rTSA significantly improved all 5 outcome score measurements and all 4 motion measurements regardless of repair. Repair of the subscapularis did not lead to inferior clinical outcomes or decreased range of motion, especially active external rotation and elevation, as predicted by biomechanical models. While not repairing the subscapularis lead to significant clinical improvements, there was a higher complication rate, including dislocations, and higher scapular notching rate. This database analysis provides physicians with information regarding expected improvements with rTSA when the subscapularis is repaired or not repaired, and suggests that the subscapularis should be repaired if possible. Longer-term follow-up is required to confirm these findings and determine if they hold up over time.

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**Paper #26** SLEEP DISTURBANCE FOLLOWING ROTATOR CUFF REPAIR: A PROSPECTIVE 2-YEAR INVESTIGATION

**Luke S. Austin, MD, Fotios P. Tjoumakaris, MD, Bradford S. Tucker, MD, Alvin C. Ong, MD, Nicholas J. Lombardi, BS, Matthew D. Pepe, MD, Ratham Institute, Thomas Jefferson University, Philadelphia, Pennsylvania, USA**

**Background:** Sleep disturbance is a known complaint of patients undergoing rotator cuff repair. Poor and inadequate sleep has been shown to affect up to 83% of patients in the early postoperative period. To date, no studies have examined long-term sleep disturbance in patients undergoing rotator cuff repair. **Hypothesis:** Improvements in sleep disturbance following arthroscopic rotator cuff repair are maintained at 2-year follow-up. **Methods:** Fifty-six patients undergoing arthroscopic rotator cuff repair for full-thickness tears were enrolled in a prospective study. Patients were surveyed preoperatively and at intervals of 2, 6, 12, 18 and 24 weeks, and at 2 years postoperatively: Patient outcomes were scored using the Pittsburgh Sleep Quality Index (PSQI), Circadian Rhythm Test (SST), and Visual Analog Scale (VAS). The PSQI is a valid and standardized measure of sleep quality; it is scored on a 0-21 scale with...
a higher score indicating greater sleep disturbance. A PSQI score above 5 is indicative of poor sleep quality. **Results:** Eighty-nine percent of patients reported preoperative PSQI scores indicative of sleep disturbance. Following surgery, a statistically significant improvement in PSQI was achieved at 3 months (p 0.0012, 91% follow-up) and continued through 2 years follow-up. Two years following surgery 37% of patients continued to have sleep disturbance. **Conclusions:** Sleep disturbance is common in patients undergoing rotator cuff repair. Following surgery, sleep disturbance improves to levels comparable with the general public and is maintained in long term follow-up.

![PSQI, VAS, SST versus Time Following Rotator Cuff Repair](image)

Paper #27 **CORRELATION OF CLINICAL OUTCOMES OF RETEAR AND TEAR PROGRESSION AFTER ARTHROSCOPIC ROTATOR CUFF REPAIR**

Sang-Jin Shin, MD, PhD, Juyeob Lee, MD, Young-Won Koh, MD, Department of Orthopaedic Surgery, Ewha Womans University School of Medicine, Seoul, South Korea

**Background:** Rotator cuff retear rate after arthroscopic cuff repair is still high despite advanced arthroscopic techniques and instrument evolution. Even if a retear occurs after rotator cuff repair, improvement in shoulder function is generally maintained, and it is known that rotator cuff integrity does not correlate with clinical outcomes. However, recent studies reported that clinical results of patients with a cuff retear are worse than those with a healed cuff. Therefore, functional outcomes of patients with rotator cuff retear are still on debate. This study evaluated factors related to clinical outcomes of rotator cuff retear after arthroscopic rotator cuff repair focusing on the importance of preoperative and postoperative changes of tear size. **Materials and Methods:** Four hundred and forty-two patients with full-thickness rotator cuff tear who underwent arthroscopic rotator cuff repair were included in this study. Patients who were possible to cover footprint completely, able to follow up over 2 years, and conducted postoperative MRI at 6 months for tendon integrity were included. The size of tear was measured on the oblique coronal and sagittal images of both preoperative and postoperative MRI. Intact tendon was defined as sufficient thickness of the repaired tendon showing continuity and a homogeneous low-intensity signal in the substance of cuff. Retear was defined as the repaired tendon showing complete discontinuity from footprint. Pain was measured by using VAS score, range of motion was recorded and functional outcomes were measured with ASES and Constant scores. Clinical outcomes were compared between patients with retears and intact cuff. Factors may affect clinical outcome such as preoperative tear size, changes of tear size and retear patterns were evaluated. **Results:** There were 233 males and 209 females with a mean age of 55 years (range, 46-75 years). Average follow-up period was 33 months (range 24-43 months). Fifty-eight patients (13.1%) had a retear confirmed by postoperative MRI. Patients with a healed cuff showed better shoulder functions than the patients with a return cuff (ASES; healed patients, 92.6 ± 9.5 and retear patients, 87.6 ± 12.4, P = 0.008). 1). Effect of preoperative rotator cuff tear size: In the patients with a preoperative large to massive size, patients with retear showed significant difference in functional outcomes (ASES: 86.5 ± 12.4 and Constant score: 88.7 ± 8.0) when compared with patients with a healed rotator cuff (ASES: 76.9 ± 9.7, P = .02 and 76.9 ± 11.7, P = .001). However, in patients with preoperative small and medium-sized tears, clinical outcomes were not significantly different irrespective of the status of healing of the cuff (ASES: healed cuff, 93.9 ± 7.8 and cuff retear, 93.8 ± 9.2 (P = .37), Constant score: healed cuff, 90.0 ± 11.7 and cuff retear, 91.5 ± 8.5 (P = .47)). 2). Comparative size of retear: Patients with smaller size of retear than the preoperative tear size (n = 28) showed significantly better functional outcomes and muscle strength recovery (Constant score: 90.5 ± 8.8) than those with equal or larger size of retear after surgery (n = 30) (Constant score: 83.7 ± 11.7, P = .025). 3). Retear pattern: Postoperative tear either at the footprint or at the musculotendinous junction did not influence the functional outcomes. 4). Risk factors for retear: Fatty degeneration more than grade 3 (odds ratio = 2.74, CI: 1.19-6.36, P = .018) and preoperative large to massive rotator cuff tears (odds ratio = 2.2 (CI: 1.17-4.15), P = .015) were preoperatively affecting factors which were significant related to retear after surgery. Age at surgery, sex, symptom duration, arm dominance and associated pathology had no significant effect on the outcome of surgery. **Conclusion:** Preoperative large to massive rotator cuff tears, and fatty degeneration more than grade 3 are important contributing factors for retear after arthroscopic rotator cuff repair. Patients with preoperative small to medium sized tears had satisfactory clinical outcomes regardless of postoperative tendon integrity. However, in patients with a preoperative large to massive tear who develop retear, the functional outcomes are poorer than patients with a healed cuff. The patients with an equal or larger retear tendon than preoperative size showed poorer Constant score and muscle strength regardless of preoperative sizes of tear. Therefore, surgeons should take more efforts and employ techniques to reduce the size of retear even if retear occurs.

Paper #28 **INITIATION OF ROTATOR CUFF TEARS: MRI STUDY OF 245 SHOULDERS**

Seung Gyoong Kang, MD, Seung Yeop Song, MD, Keun Min Park, MD, Jae Chul Yoo, MD, Department of Orthopaedic Surgery, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, South Korea

**Introduction:** Recent ultrasonographic studies have suggested that rotator cuff tears (RCTs) initiates near the junction of the supraspinatus and infraspinatus. However, it is quite common to see small RCTs in the anterior aspect of the supraspinatus. **Aim:** To determine whether the suggested initiation location of RCTs can be reproduced in MRI. **Methods:** A retrospective analysis was conducted which included 245 patients who were diagnosed as RCT(nearly full-thickness or partial-thickness tear) between January 2011 to December 2013. RCTs were measured on MRI by OsiriX(Geneva) software. The width and distance from biceps tendon to the anterior margin of the tear on T2 weighted sagittal image. Each tear was showed as a column of serial numbers representing the tear width and distance posterior to the biceps tendon. All tears were collected to represent graphically and frequency histograms of the collected data were generated, and the common site of tears was determined. **Results:** The mean width and the tears were 5 mm. Histograms of the tear showed the location of 8 to 12 mm posterior to the biceps tendon to be the most commonly torn location. The histograms of nearly full-thickness tears and partial-thickness tears showed similar distributions of tear locations, indicating that the region approximately 10 mm posterior to the biceps tendon maybe where rotator cuff tears most commonly initiate. **Conclusion:** Our study reveals that rotator cuff tears most commonly involve more anterior location than ultrasonography. This result demonstrates that cuff tears may initiate in a region 8 to 12 mm...
Paper #29  METAL ALLERGY IN SHOULDER ARTHROPLASTY PATIENTS
Jia-Wei Kevin Ko, MD, Thema A. Nicholson, MS, C. Edward Hoffier, MD, Gerald R. Williams, Jr., MD, Charles L. Getz, MD, The Rothman Institute, Thomas Jefferson University, Philadelphia, Pennsylvania, USA

Introduction: Metal allergy is an uncommon and poorly understood cause of persistent pain and failure of orthopaedics implants with no standardized criteria for diagnosis. The majority of reactions to implants are thought to be related to a Type-IV delayed hypersensitivity reaction from metallic ions from the implant. The most commonly reported allergy is to nickel although other metal allergies have also been described. Most descriptions of metal allergy in orthopaedics are from hip and knee arthroplasty literature. Variable patient symptoms have been reported from gross cutaneous findings to more subtle and subjective findings such as pain and poor function. To our knowledge, there have been no reports on the management of shoulder arthroplasty patients with metal allergy. Our objective is to present our experience on the diagnosis and management of metal allergy in this patient population and to identify the most common presenting findings along with possible risk factors. Methods: Patients with metal allergy undergoing shoulder arthroplasty were identified through retrospective chart review from January 1, 2012 to January 31, 2013. Case characteristics collected included patient risk factors (age, sex, BMI, allergies, prior cutaneous reactions to metal), metal allergy factors (type of metal allergy, method of diagnosis), and surgery factors (implant type, primary/revision, type of shoulder arthroplasty). Clinical outcomes measured included ASES, SANE, and Penn Shoulder Scores. Results: 10 patients were identified out of 1243 primary shoulder arthroplasties and 91 revision shoulder arthroplasties performed during this time period. All patients were female with an average age of 63.2 years. Of these patients, 5 patients were identified with a metal allergy prior to their index procedure and 5 patients were identified with a metal allergy prior to undergoing revision surgery. 8/10 patients demonstrated allergy to nickel with the other 2 patients demonstrating allergy to cobalt and chromium respectively. 4 patients were diagnosed through a Memory Lymphocyte Immunostimulation Assay (MELISA), 4 were diagnosed through skin patch testing, and 2 were diagnosed through clinical history. 5 of the patients recalled cutaneous reactions to jewelry upon questioning. Amongst the revision surgeries, none of the patients demonstrated cutaneous manifestations of metal allergy and all presented with either pain and/or stiffness. 4/5 revision patients had the onset of their symptoms start within 2 months of their index procedure. All revision surgeries were deemed to be free of infection using a combination of inflammatory markers and tissue culture at the time of revision. 4/5 of the revisions were performed within 30 months of the index procedure. All patients had their primary or revision shoulder arthroplasty performed with a full titanium implant. Results of patients with metal allergy undergoing a primary shoulder arthroplasty at an average of 16 months follow-up demonstrates an average ASES score of 85.7, SANE score of 82 and Penn score of 66.3. Results of patients with metal allergy undergoing revision surgery for a failed shoulder arthroplasty at an average of 16 months demonstrates an average ASES score of 58.3, SANE score of 59, and Penn score of 42.2. Discussion and Conclusions: Metal allergy is relatively uncommon in shoulder arthroplasty but may be a cause of an unsatisfactory arthroplasty after other more common causes of failure have been ruled out. While cutaneous symptoms have been described elsewhere in the body, it was not common in the shoulder in this small series and most patients had an onset of their symptoms within 2 months of the index surgery. A history of cutaneous reaction to jewelry and female gender may be risk factors for symptomatic metal allergy. Screening for metal allergy by clinical history is recommended given the superior results of primary shoulder arthroplasty compared to revision shoulder arthroplasty in this patient population.

Paper #30  PERIPROSTHETIC SHOULDER INFECTION: ONE-STAGE BETTER THAN TWO-STAGE?
Geoffrey P. Stone, MD, Rachel Clark, BA, CCRC, Kathleen C. O’Brien, BS, Lisa Vaccaro, BS, Richard S. Tannenbaum, BS, Benjamin J. Cottrell, BS, Adam Lorenzetti, MD, Brent Stephens, MD, Peter Simon, PhD, Derek Pupello, MBA, Mark A. Frankle, MD, Florida Orthopaedic Institute and Foundation for Orthopaedic Institute, Tampa, Florida, USA

Background: The treatment of periprosthetic joint infection is a difficult challenge in shoulder arthroplasty. Controversy exists whether a single versus two-stage approach to periprosthetic joint infection (PJI). This study’s goal was to investigate one-stage modular component exchange versus one-stage complete removal and reimplantation versus two-stage revision arthroplasty for PJI and compare the re-operation rates for infection, overall complication rates, and two-year functional outcomes. Methods: Between 1/1/2004 and 12/31/2012, 109/475 (23%) revision surgeries were identified as treated for infection. Eighty-nine out of 109 were available for one-year follow-up. Fifteen one-stage component exchange, 55 one-stage complete removal and reimplantation (CRR), and 19 two-stage group were evaluated for infection and non-infection related complications. Pre-operative and intra-operative data was evaluated to determine if there was a selection bias with regards to the procedure performed. A binary logistic regression was performed to determine factors presenting the greatest risk of reinfection. Results: Overall, 4/15 one-stage component exchange (27%), 2/55 one-stage (CRR) (4%), and 4/19 two-stage procedures (21%) required a re-operation for infection with a minimum of one-year follow-up. There was a significant difference between the one-stage CRR group and one-stage exchange group (P = .017) as well as the two-stage group (P = .035). No pre-operative and intraoperative selection bias between the groups was found. Binary logistic regression predicted that reinfection was highest in patients that cultured Staphylococcus Aureus (P = .011) and those treated with one-stage component exchange (P = .005). There was no significant difference between groups with regards to non-infection related complications (P = .284). All procedures provided improved functional outcomes and pain relief (Table). Conclusion: One-stage revision arthroplasty with complete removal and reimplantation for periprosthetic shoulder infection results in lower reoperation rates for infection and similar clinical outcomes compared to one-stage component exchange and two-stage revision in our series. Treatment with one-stage revision with complete removal and reimplantation decreases the number of overall surgeries required for successful eradication of infection. Patients with Staphylococcus Aureus may require additional surgeries to treat infection.
### Table

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### Paper #31

**THE TIMING OF ELECTIVE SHOULDER SURGERY AFTER INTRA-ARTICULAR SHOULDER INJECTION AFFECTS POSTOPERATIVE INFECTION RISK**

**Brian C. Werner, MD, Jourdan M. Cancienne, MD, Justin W. Griffin, MD, M. Tyrrell Burrus, MD, F. Winston Gwathmey, MD, Stephen F. Brockmeier, MD, University of Virginia, Charlottesville, Virginia, USA**

**Objectives:** While intra-articular shoulder injections are generally regarded as safe, there have been reports of subsequent infections following shoulder joint injections. Given these risks, many surgeons will delay elective shoulder surgery for several months following shoulder injections, although current evidence does not support this practice. The goal of the present study is to employ a national database to evaluate the association of preoperative intra-articular shoulder injection before shoulder arthroscopy and arthroplasty with the incidence of postoperative infection. **Methods:** A national insurance database was queried for patients who underwent shoulder arthroscopy or shoulder arthroplasty following ipsilateral shoulder injection between 2005 and 2012. Control cohorts were created for each study group by matching patients who underwent the same procedure without a preoperative injection to the study cohorts based on age, gender, obesity, diabetes and smoking. Three shoulder arthroscopy cohorts were created: arthroscopy within 3 months of ipsilateral shoulder injection (n = 3,625), arthroscopy between 3 and 12 months after ipsilateral shoulder injection (n = 7,069) and matched control arthroscopy without prior injection (n = 186,678). Three shoulder arthroplasty cohorts were created: arthroplasty within 3 months of ipsilateral shoulder injection (n = 636), arthroplasty between 3 and 12 months after ipsilateral shoulder injection (n = 1,573) and matched control arthroplasty without prior injection (n = 6,211). Infection rates within 3 and 6 months postoperatively were assessed using ICD-9 and CPT codes. **Results:** The arthroscopy and arthroplasty cohorts were well matched to their respective controls, as no significant differences in age, gender, obesity, diabetes or smoking rates were noted. The incidence of infection after shoulder arthroscopy at 3 months (0.7%, OR 2.2, P < .0001) and 6 months (1.1%, OR 1.6, P = .003) was significantly higher in patients who underwent injection within the 3 months prior to arthroscopy compared to matched controls (Table 1A-B). The incidence of infection after shoulder arthroplasty at 3 months (3.0%, OR 2.0, P = .007) and 6 months (4.6%, OR 2.0, P = .001) was significantly higher in patients who underwent injection within the 3 months prior to arthroplasty compared to matched controls (Table 2A-B). There was no significant difference in infection rates in patients who underwent shoulder arthroscopy or arthroplasty between 3-12 months after injection compared to controls. **Conclusions:** The present study demonstrates a significant increase in postoperative infection in patients who underwent ipsilateral intra-articular shoulder injection within three months prior to shoulder arthroscopy and arthroplasty. This association was not noted when shoulder arthroscopy or arthroplasty occurred more than three months after shoulder injection.

### Paper #32

**THE INCIDENCE OF SUBSEQUENT SHOULDER SURGERY FOLLOWING ISOLATED ARTHROSCOPIC SUPERIOR LABRUM ANTERIOR AND POSTERIOR (SLAP) REPAIRS**

**Brent Mollon, MD, FRCSC, Siddharth A. Mahure, MD, Kelsey L. Ensor, MD, Joseph D. Zuckerman, MD, Young W. Kwon, MD, PhD, Andrew S. Rokito, MD, Department of Orthopaedic Surgery, NYU Hospital for Joint Diseases, New York University Langone Medical Center, New York, New York, USA**

**Introduction:** There exists much debate regarding the causes and rates of failure following arthroscopic superior labrum anterior and posterior (SLAP) lesion repair. No study to date has evaluated rates and risk factors of subsequent surgery following SLAP repair in a state-
wide cohort of patients. The purpose of this study was to quantify the incidence of subsequent shoulder procedures on individuals with an isolated diagnosis of SLAP lesion undergoing arthroscopic repair. We hypothesized that advancing age and workers compensation insurance would predict reoperation in this cohort. Methods: The New York State Department of Health’s Statewide Planning and Research Cooperative System (SPARCS) database was searched between 2003 and 2010 to identify individuals with an isolated diagnosis of a SLAP lesion who underwent isolated arthroscopic SLAP repair. Baseline demographics and all subsequent ipsilateral shoulder procedures were collected for analysis. Differences between those requiring additional surgery and those that did not was assessed by Pearson Chi-square (for categorical variables) or Student’s T-test (for continuous variables). Results: 2803 patients with a primary diagnosis of SLAP lesion underwent arthroscopic SLAP repair over the eight-year study period. After 3 to 10 years of follow-up, 9.1% (254/2803) of patients underwent repeat surgical intervention on the same shoulder as the initial SLAP repair. Repeat shoulder surgery was performed a mean of 24 ± /− 22 months after the initial SLAP repair. The most frequently performed subsequent procedures included subacromial decompression (37%), arthroscopic debridement (27%), repeat SLAP repair (27%), and biceps tenodesis (12%). Additional surgery on the biceps anchor occurred in 3.6% of our series. Need for a subsequent procedure was significantly associated with workers compensation cases alone. Conclusion: This study identified a 9.1% incidence of repeat surgery following SLAP repair. The reasons for this are likely multifactorial and include both surgeon and patient-related factors and point to the inherent difficulty in diagnosing and treating these lesions.

Paper #33 LIPOSOMAL BUPIVACAINE VS. INTERSCALENE NERVE BLOCK FOR PAIN CONTROL AFTER SHOULDER ARTHROPLASTY: A RETROSPECTIVE COHORT ANALYSIS Umashutan Srikumaran, MD, MBA, Catherine Hannan, BS, Matthew Albrecht, MHS, Edward G. McFarland, MD, Bashir A. Zikria, MD, MSc, Steve A. Petersen, MD, Johns Hopkins University, Baltimore, Maryland, USA

Introduction: Periarticular local infiltration analgesia with liposomal bupivacaine is an emerging alternative to interscalene nerve block (ISNB) for pain control after joint arthroplasty. Recent literature has shown that liposomal bupivacaine provides better pain control, shortens hospital stays, and decreases costs for knee and hip arthroplasties compared to traditional nerve block methods. This study compares liposomal bupivacaine and ISNB in terms of postoperative pain control, medication use, and length of stay after shoulder arthroplasty. Methods: We conducted a retrospective analysis of 58 shoulder arthroplasties performed by 1 surgeon from 2012 through 2015, comparing local infiltration of liposomal bupivacaine versus single-shot ISNB in terms of length of hospital stay, opioid consumption, and pain at 4 postoperative time periods. Results: Baseline data for age, sex, body mass index, and American Society of Anesthesiologists Physical Status Classification were similar between the ISNB (n = 21) and liposomal bupivacaine (n = 37) groups. Pain was the same in both groups immediately after surgery (P = .99) and 8-14 hours after surgery (P = .208), but the liposomal bupivacaine group reported less pain than the ISNB group at 18-24 hours (P = .001) and 27-36 hours (P = .029) after surgery. The liposomal bupivacaine group had lower opioid consumption than the ISNB group on postoperative days 2 (P = .001) and 3 (P = .002). The average length of stay for the liposomal bupivacaine group was 46 ± 20 hours versus 57 ± 14 hours for the ISNB group (P = .012). Sixteen of 37 patients in the liposomal bupivacaine group were discharged on the first postoperative day versus 2 of 21 ISNB patients (P < .01). Conclusion: Liposomal bupivacaine provided better pain control 18-24 hours and 27-36 hours after surgery, decreased opioid consumption, and shortened hospital stays after shoulder arthroplasty compared with ISNB.

Paper #34 EFFECT OF HYPERCHOLESTEROLEMIA ON FATTY INFILTRATION AND ROTATOR CUFF HEALING IN A CHRONIC ROTATOR CUFF TEAR MODEL OF RABBIT Joo Han Oh, MD, PhD, Seok Won Chung, MD, Sae Hoon Kim, MD, HaeBong Park, MD, Jeun Kwon, MD, Jong Pil Yoon, MD, Department of Orthopaedic Surgery, Seoul National University College of Medicine, Konkuk University School of Medicine, CM Chungmu Hospital, Seoul National University Hospital, National Police Hospital, Seoul, South Korea

Introduction: The purpose of this study is to verify the effect of hypercholesterolemia on fatty infiltration and rotator cuff healing in chronic rotator cuff tear model using a rabbit supraspinatus. We also aimed to investigate whether the control of hypercholesterolemia can help the improvement of fatty infiltration and healing after rotator cuff repair. Methods: Forty-eight rabbits were randomly allocated into 4 groups (12 rabbits per each group, 8 for the electromyographic (EMG) and mechanical tests in right shoulder and the histological test of fat proportion in both shoulders; additional 4 (bilateral shoulder) for the histology of tendon-to-bone healing): Group A (high-chol. + repair), Group B (high-chol.+statin+repair), Group C (repair), and Group D (control). Initial hypercholesterolemia was made by feeding rabbits of Group A and B with a high-cholesterol meal for 4 weeks, then the supraspinatus tendon was detached in Group A, B, and C. Six weeks after detachment, the supraspinatus tendon was repaired in a transosseous manner. Group A got the high-cholesterol diet persistently until final evaluation (6 weeks after repair), however, Group B changed the diet to general diet with an administration of cholesterol lowering agent (simvastatin) from the time of repair. The EMG test, mechanical test, and histological test of tendon-to-bone healing was performed at final evaluation, and the histological evaluation for the fat-to-muscle proportion was performed at two times at the time of repair and at final evaluation. Results: For EMG test, Group A showed significantly smaller area in compound muscle action potential (6.69 ± 2.23 ms · mV) compared with Group C and D (10.50 ± 2.96 ms · mV and 14.40 ± 2.79 ms · mV, P = .008 and <.001). Group B (9.05 ± 3.23 ms · mV) showed larger area than group A without statistical significance (P = .112), almost to the level of group C. For mechanical test, Group A showed significantly lower load-to-failure and stiffness (42.01 ± 13.80N and 36.32 ± 14.70N/mm) compared with Group C (65.12 ± 22.81N and 65.31 ± 23.21N/mm, P = .020 and 0.006, respectively). The load-to-failure and stiffness of Group B (58.23 ± 22.39N and 47.22 ± 14.14N/mm) was higher than Group A without statistical differences (P = .103 and 0.153, respectively), but the stiffness of group B was still much less than group C (P = .065). The Group D (normal control) showed much higher load-to-failure (148.01 ± 26.12N) than any other groups (all P < .001), however, the stiffness of Group D (62.51 ± 14.29N/mm) was between that of Group B and C. For the histological test, Group A and B showed significantly higher fat-to-muscle proportion (59.26 ± 17.80% and 64.02 ± 11.87%) compared with Group C (44.26 ± 7.85%, P = .044 and 0.004, respectively) or D (8.02 ± 5.29%, all P < .001) at 6 weeks after detachment. At the final evaluation, the fat-to-muscle proportion (Fig. 1) of Group A was more increased to 78.23 ± 10.87%

Figure 1 Photos show the fatty infiltration of the supraspinatus muscle of each group at 6 weeks after detachment and at 6 weeks after repair (H&E stain, ×100).
(P = .015), but that of Group B was decreased to 54.68 ± 10.47% (P = .146). Group A showed coarse and poorly organized collagen fibers with fat interposition in tendon-to-bone insertion area, but Group B and C showed better collagen fiber continuity and orientation with higher collagen density than group A (Fig. 2).

Conclusions: The hypercholesterolemia resulted in the deleterious effect on the fatty infiltration and tendon-to-bone healing assessed by electromyographic, mechanical, and histological evaluation, and the control of hypercholesterolemia seemed to be able to reverse these harmful effects to some degree even after rotator cuff repair surgery.

Paper #35 2D/3D IMAGE REGISTRATION TO DETERMINE HOST BONE COVERAGE OF GLENOID SIDE REVERSE SHOULDER IMPLANTS

Andres F. Cabezas, BS, MS, Peter Simon, PhD, Adam Lorenzetti, MD, Kristi Krebes, BS, Brandon G. Santoni, PhD, Geoffrey P. Stone, MD, Rachel Clark, BA, CCRC, Mark A. Frankle, MD, Foundation for Orthopaedic Research and Education and Florida Orthopaedic Institute, Tampa, Florida, USA

Background: In cases with severe glenoid bone loss undergoing reverse shoulder replacement, glenoid side implantation is particularly challenging with regards to secure seating of the glenoid component. We hypothesized that increased host bone coverage would correlate to higher outcomes. The aim of this study is to 1) quantify host bone coverage area of the baseplate and implant utilizing 2D/3D image registration, and 2) correlate clinical outcomes and bone loss classification to host bone coverage. Methods: Patients who received a primary reverse shoulder for glenoid bone loss were selected (n = 20, mean age: 73). A pre-operative CT scan of the affected shoulder and post-operative x-rays (frontal, oblique, and sagittal) of the patient were acquired. Glenosphere component sizes used during the procedure were collected for the patient population, in addition to accurate virtual models of the hardware. CT scans were imported into Mimics (Mimics 17: Materialise; Leuven, Belgium) and 3D reconstructions of the scapula and glenosphere bodies were generated. Placement of the instrumented surgical implant components was determined through aligning a projection of the implant and scapula model’s outer contours via a virtual emitter (Fig. 1). These projections are aligned to contours outlined on multiple 2D x-ray images of the scapula and glenosphere bodies, with the 3D projections contours conforming to their respective outline as presented on the x-ray. The area representing the contact between the implant (including glenosphere and baseplate surfaces) and glenoid bodies was generated (Fig. 2). The area of these intersecting surfaces were generated to determine the total amount of host bone coverage, here presented as a percentage of maximum potential contact surface area. The relationship between the percentage of host bone coverage and change between pre-operative and two year follow-up ASES scores (ΔASES) was determined using Univariate ANOVA with significance at P = .05. Results: The mean value of 22 ± 14% contact area (range: 5-46%) (Table 1). There was no significant corollary between host bone coverage and follow-up ASES total scores (P = .13) (Fig. 3). Discussion: The results from this study demonstrate that decreased host bone coverage may have no deleterious effect on clinical outcome. The technology used in this study demonstrates the feasibility of utilizing pre-operative CT scans with post-operative x-rays to determine implant placement. This tool can allow the surgeon to compare their surgical plan to their actual instrumentation. Additionally, this tool is able to provide information that would otherwise only be available in a post-operative CT scan, while circumventing exposure to additional radiation.
Table 1

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<th>Patient</th>
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<th>Maximum Potential Coverage (mm²)</th>
<th>Percentage Coverage</th>
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<tr>
<td>SD</td>
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<td>102</td>
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Figure 3  Plot of Percentage of Coverage vs. AASE Total Score

Cryosections at 10 μm were stained with H&E and modified Gomori trichrome, which allowed gross biopsy composition to be quantified. Immunostaining for perilipin (adipose), CD68 (macrophages), caspase 3 (apoptosis), and laminin and (muscle fiber and blood vessel basal lamina) were used to further quantify fiber atrophy, degeneration/regeneration, inflammation, and vascularity. In samples containing muscle, fiber area, the percentage of fibers with central nuclei, and the number of samples demonstrating intra-fiber lipid accumulation was also quantified. Results: Of 29 total biopsies with average area of 20.6 mm² analyzed, 23 (79.3%) contained no muscle tissue. Instead, they contained a mix of dense, organized collagen similar to healthy tendon (53.19 ± 16.5%), and disorganized, more cellular ECM in the later stages of remodeling (fibrosis), where cellular and enriched for macrophages and vasculature suggest that the majority of biopsies contain connective tissue resembling tendon. The large areas of poorly organized ECM that are consistently found in the literature describing the response of rotator cuff muscle to tendon tear in both human and animal studies. While clinical decisions are often based on imaging studies, histological data identifying structural changes following chronic tendon tears. As such, there is no compelling description of the structure or natural history of “muscle degeneration” or “fatty degeneration”. This

Paper #36 HISTOLOGICAL QUANTIFICATION OF CHRONIC HUMAN ROTATOR CUFF MUSCLE DEGENERATION
Anshuman Singh, MD, Michael C. Gibbons, MS, Oke A. Anakwenze, MD, Timothy Cheng, MD, Hassan Azimi, MD, Simon Schenk, PhD, Samuel R. Ward, PT, PhD, Department of Orthopaedics, Southern California Kaiser Permanente, University of California at San Diego, San Diego, California, USA

Introduction: The terms “fatty atrophy” and “fatty infiltration” are consistently found in the literature describing the response of rotator cuff (RC) muscle to tendon tear in both human and animal studies. While clinical decisions are often based on imaging studies, knowledge of the correlating composition of the tissue on a cellular level is nearly absent. The objective of this study was to histologically quantify chronically torn human RC muscle composition. Methods: Twenty-one consecutive patients undergoing primary reverse total shoulder arthroplasty (RSA) were consented for biopsy under an Institutional Review Board approved protocol. Biopsies were harvested 1 cm medial to the glenoid face from the supraspinatus and/or infraspinatus fossae.
has impaired our ability to compare animal models to the human condition or generate logical hypotheses for the progression of these muscle changes. Here, we show that RC muscle biopsies from patients with massive RC tears demonstrate active degenerative and regenerative processes, high levels of fibrosis, vascularity and apoptosis, and novel “fatty replacement” of muscle tissue.

**Acknowledgements:** This work was supported by NIH grant HD073180.

**References**