3 IS A DISTAL CLAVICLE RESECTION NECESSARY IN PATIENTS WITH RADIOLOGIC ACROMIOCLAVICULAR JOINT ARTHRITIS WITH ROTATOR CUFF TEAR? – A PROSPECTIVE RANDOMIZED COMPARATIVE STUDY
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Introduction: The failure of subacromial decompression could be attributed to the persistent symptoms of acromioclavicular joint (ACJ) arthritis, and inferior clavicular spurs of ACJ arthritis may be associated with the healing failure of repaired rotator cuff. The purpose of this study was to evaluate the clinical effectiveness of arthroscopic distal clavicle resection (DCR) in patients with rotator cuff tear and radiologic ACJ arthritis. Methods: Eighty-one patients of rotator cuff tear with concomitant radiologic and asymptomatic ACJ arthritis who scheduled for arthroscopic rotator cuff repair were prospectively randomized to two groups. All patients were diagnosed ACJ arthritis using preoperative MRI and plain radiographs, and they had no pain or tenderness at the ACJ. They all underwent arthroscopic rotator cuff repair and acromioplasty. The patients in the group I (40 patients) took additional arthroscopic DCR, and the patients in the group II (41 patients) did not. The clinical outcomes between two groups were compared using pain VAS, Constant score, and ASES form. The structural integrity of repaired rotator cuff was assessed using ultrasonography, CT arthrography or MRI at least 6 months after the operation. Weighted stress radiography of the ACJ was checked at 6 and 12 months postoperatively to evaluate ACJ instability. Results: The mean follow-up was 14.3 months (range 12-26 months). Both groups showed significant improvement in pain VAS and functional scores. However, there were no significant differences between two groups (p > 0.05). The failure of cuff healing occurred in 8 patients (20.0%) in group I and 9 patients (22.0%) in group II, which had no significant difference (p = 0.83). In group I, two patients (5.0%) exhibited ACJ subluxation; in group II, which had no significant difference (p = 0.83). In group I, two patients (5.0%) exhibited ACJ subluxation; in group II, two patients (5.0%) exhibited ACJ subluxation (p = 0.40, p = 0.03) as well as radiographically-observed glenoid implant failure and PE embedding damage (p = 0.45, p = 0.01). Discussion and Conclusion: To our knowledge, this is the largest reported series of retrieved RTSA components related to radiographic, clinical data, and functional scores. Notably, there were greater rates of damage on the glenosphere, especially the bearing surface, than the other components. Correlation of retrieval analysis findings with radiographic and clinical data may help establish predictors of prostheses at risk for failure.

5 ELUCIDATING TRENDS IN REVISION REVERSE TOTAL SHOULDER ARTHROPLASTY: A RETRIEVAL STUDY EVALUATING CLINICAL, RADIOGRAPHIC, AND FUNCTIONAL OUTCOMES DATA
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Introduction: Since obtaining FDA approval in 2004, reverse total shoulder arthroplasty (RTSA) has become an accepted surgical treatment for patients with severe rotator cuff deficiency. This study seeks to explore relationships between damage modes in explanted RTSA components, potential patient and radiographic risk factors, and functional data, in order to elucidate trends in RTSA failure. Materials and Methods: Fifty RTSA systems were retrieved from 44 patients, under an IRB-approved protocol. Twenty-six devices were from left shoulders and 24 from right; 30 included the glenosphere, 50 included the polyethylene (PE) liner, 21 included the glenoid baseplate, 13 included a modular humeral metaphyseal, and 17 included a humeral stem (10 stems included a non-modular humeral metaphysis). Retrieved components were examined, using stereo and scanning electron microscopes, for damage modes, including abrasion, burnishing, dishing, embedding, scratching, and pitting. PE liners were also analyzed for delamination and edge deformation. Chart reviews were performed to collect patient and surgical data. Available plain films from immediately following the index procedure and immediately prior to revision surgery were analyzed for implant alignment as well as the presence/absence of scapular notching, loosening, and wear debris. Clinical functional data was collected in eleven cases. Statistical analysis was performed on the data set, and significance was determined by α = 0.05. Correlation coefficients of 0.20-0.40, 0.40-0.60, 0.60-0.80 and 0.80-1.00 were considered weak, moderate, strong and very strong, respectively. Results: The patient cohort included 23 males and 21 females, with an average BMI of 31 (range, 18-52) and average age at index and revision procedures of 68 (range, 45-83) and 69 (range, 46-86) years, respectively. Average time between index and revision procedures was 20 months (range, 0-81). Eleven patients had clinical functional data available for comparison (Figure 1). One glenoid baseplate and two humeral stems were unable to be analyzed. Metallic components exhibited abrasion, burnishing, dishing, pitting, and scratching, while PE inserts displayed each of the eight damage modes (Figure 1). Analysis showed that 93% of glenospheres and 100% of PE liners exhibited at least one damage mode. Forty-seven patients had pre-revision radiographs available for review, 29 of which had post-index procedure radiographs for comparison. At the time of revision surgery, 22 shoulders showed evidence of scapular notching, 12 showed evidence of humeral component loosening, and 21 shoulders demonstrated glenohumeral joint dislocation. Moderate correlations were found between radiographically-observed glenoid loosening and PE dishing damage (ρ = 0.40, p = 0.03) as well as radiographically-observed glenoid implant failure and PE embedding damage (ρ = 0.45, p = 0.01). Discussion and Conclusion: To our knowledge, this is the largest reported series of retrieved RTSA components related to radiographic, clinical data, and functional scores. Notably, there were greater rates of damage on the glenosphere, especially the bearing surface, than the other components. Correlation of retrieval analysis findings with radiographic and clinical data may help establish predictors of prostheses at risk for failure.

Figure 1 Percentage of components exhibiting damage modes (left); representative scanning electron micrographs (top right), showing abrasion (A) and scratching (B) of the glenosphere, pitting, abrasion and surface cracking (C) as well as abrasion on the rim (D) of the PE liner; Average changes in clinical functional data before and after index procedure, and between index procedure and revision procedure. Negative values indicate decrease. (bottom right)
6 REVERSE TOTAL SHOULDER ARTHROPLASTY IS ASSOCIATED WITH GOOD CLINICAL OUTCOMES THAT ARE SUSTAINED THROUGH MID-TERM FOLLOW-UP: A PROSPECTIVE COHORT STUDY

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Introduction: Reverse total shoulder arthroplasty (RTSA) provides both the surgeon and patient a viable option in treating many shoulder conditions that previously had few viable options. Though the literature shows significant short-term success, mid-term results are less well understood. We aimed to evaluate the mid-term results of reverse total shoulder arthroplasty. We hypothesize that mid-term results are comparable with reported short-term results.

Methods: We performed an IRB approved multi-center prospective study of all primary RTSA performed between 2004 and 2009. Six surgeons at five institutions participated. Inclusion criteria included minimum 4-year follow-up. Patient demographic data, clinical assessments including range of motion, and complications were reviewed. All patients were assessed preoperatively and postoperatively using Normalized Constant Score, the American Shoulder and Elbow Surgeons scoring system, the Western Ontario Osteoarthritis of the Shoulder index, and Single Assessment Numeric Evaluation scoring method. Clinical scores and ROM at preoperative visit, 2-year follow-up and most recent follow-up were compared. Results: One-hundred and seventeen patients with 123 RTSAs met inclusion criteria. Average age at time of surgery was 68 years. Averaged duration of follow-up was 61.9 months. At 2-year and at most recent follow-up (4-year minimum) clinical outcome scores improved significantly compared to preoperative assessment (p < 0.0001). Forward flexion, abduction, and external rotation also significantly increased from preoperative evaluation to both follow-up durations (p < 0.0001).

There were no significant changes in any measure from 2-year follow-up to the minimum 4-year follow-up. There were 25 total complications (20.3%) in 19 patients (15.4%). Five complications occurred after the minimum 4-year follow-up. There were three failures (2.4%) due to deep infection that resulted in 1 revision to RTSA and 2 resection arthroplasties. Etiology did not show significant effect on outcome measures or complications.

Conclusion: Reverse total shoulder arthroplasty is a viable option for a number of shoulder pathologies and can produce good, reliable results. The data from this study suggests that these results are sustained through mid-term follow-up and that the complication profile does not increase with time. Further studies are necessary to confirm these mid-term results and further evaluate the longevity of this procedure.

7 DRIVING PERFORMANCE AFTER SHOULDER ARTHROPLASTY

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Introduction: Recent evidence demonstrates that an increasing number of shoulder arthroplasties are performed each year. However, proper guidelines on patient safety and return to driving postoperatively have yet to be defined. This study seeks to quantify perioperative changes in driving performance following anatomic and reverse shoulder arthroplasty using a driving simulator.

Methods: A previously validated driving simulator was used to develop a virtual circuit in which hazardous conditions necessitated evasive maneuvers. Twenty-three patients (sixteen anatomic and seven reverse shoulder arthroplasty) with a mean age 65 ± 10 years were tested at four distinct time points perioperatively. Trial 1 was conducted prior to surgery; trial 2 was held approximately 14 days after surgery; trials 3 and 4 occurred at six and twelve weeks after surgery, respectively. The number of total collisions, off-road collisions, center-line crosses, and off-exits were recorded at each trial. Each circuit was customized to the driver’s reaction time to limit variability between course output measures. Pain Visual Analog Scale (VAS), Shoulder Pain and Disability Index (SPADI) scores were documented, in addition to annual driving mileage and hours slept the previous night.

Results: Preliminary. In twenty-three subjects, the mean number of collisions increased from 5.3 at Trial 1 (pre-op) to 6.4 at Trial 2 (2-wk post-op). The mean number of collisions subsequently decreased to 5.5 by Trial 3 (6-wk post-op), and 3.9 by Trial 4 (12-wk post-op). There was a statistically significant difference in the mean number of collisions in both Trials 2 and 3 when compared to Trial 4 (p < 0.05).

When comparing the number of collisions for Trial 1 to Trial 4, there was overall a decrease in the number of collisions (p = 0.05). In addition, “at-risk driving behavior” quantified as the number of center-line crosses decreased from 20.9 at Trial 1 (pre-op) to 17.1 by Trial 4 (12-wk post-op), (p < 0.005). The number of centerline crossings from Trial 2 and Trial 3 were statistically significant when compared to Trial 4 (p < 0.05). The mean VAS scores for pain and SPADI scores decreased across all trials (p < 0.005). No significant difference was observed in the number of collisions relative to hours slept or average miles driven per year.

Conclusions: At 12 weeks status post anatomic or reverse total shoulder arthroplasty, patients showed improved driving performance, with a significant decrease in the number of collisions in the simulated driving course compared to preoperative and 2-week post-operative trials. It is our recommendation, based on improvements in VAS scores for pain and SPADI scores, and secondary outcome measures of “at-risk driving behavior” over time, that patients refrain from driving for at least 6 weeks. The present study findings suggest that patients undergoing total shoulder replacement show improvement in driving performance with the mitigation of shoulder pain and discomfort.

Table 1: Average Measure

<table>
<thead>
<tr>
<th>Clinical Outcome Measures</th>
<th>2-year follow-up</th>
<th>Most recent follow-up (4-year min., 61.9 mo. average)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normalized Constant</td>
<td>23.5</td>
<td>73.5</td>
</tr>
<tr>
<td>ASES</td>
<td>31.0</td>
<td>72.6</td>
</tr>
<tr>
<td>WOOS</td>
<td>76.2</td>
<td>26.4</td>
</tr>
<tr>
<td>SANE</td>
<td>22.8</td>
<td>69.3</td>
</tr>
<tr>
<td>Active Forward Flexion</td>
<td>48.9</td>
<td>139.7</td>
</tr>
<tr>
<td>Active Abduction</td>
<td>47.5</td>
<td>135.4</td>
</tr>
<tr>
<td>Active External Rotation</td>
<td>1.5</td>
<td>6.6</td>
</tr>
</tbody>
</table>

*Changes in all measures from preoperative to both follow-up durations are significant (p < 0.0001).

**No changes in any measure from 2-year to most recent follow-up are significant (p >.75).

8 NEUROMONITORING THE LATARJET PROCEDURE

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Background: The purpose of this study was to use intra-operative neuromonitoring to define the stages of the Latarjet procedure.
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static 3-D models that humeral head lesions that are larger in 2-D
humeral head lesion depth, but consistently underestimate width in
Jaicharan J. Iyengar, MD, Kevin N. Jiang, MD, Dennis Kwon, BS,
LESION MORPHOLOGY AND THE GLENOID TRACK CONCEPT
GLENOHUMERAL INSTABILITY: CLINICAL IMPLICATIONS OF
9 3-D MODELING OF HUMERAL HEAD DEFECTS IN

During which the nerves are at greatest risk, allowing the surgeon to
take intra-operative measures to reduce this risk. Methods: 34 pa-
tients were included in this prospective study. Mean patient age
was 28.4 years. Upper extremity neurologic function was assessed
pre-operatively, immediately post-operatively in the recovery room
before any neurologic block was performed, and at routine follow-
up visits. The Latarjet procedure was divided into 9 defined stages:
1. Incision, 2. Coracoid exposure, 3. Coracoid harvest, 4. Subscapu-
insertion, 8. Subscapularis closure, 9. Skin closure. All surgeries
were performed under total intravenous anesthesia. Bilateral me-
dian and ulnar somatosensory evoked responses (SSEPs) and tran-
cranial motor evoked potentials (tcMEPs) from all arm myotomes
were continuously monitored. A ‘nerve alert’ was defined as aver-
age aged 50% amplitude attenuation, or 10% latency prolongation
of ipsilateral SSEPs and tcMEPs. For each nerve alert, the surgeon
altered retractor placement, and if no response to this, then changed
the position of the operative extremity. Results: 26 of 34 patients
(76.5%) had 45 separate nerve alert episodes. Forty-one of these
alerts were based on attenuation of tcMEPs. Thirteen patients
(38.2%) had 2 or more nerve alerts, with 2 patients having 4 nerve
alert episodes. The most common stages of the procedure for a nerve
alert to occur were glenoid exposure (12 alerts) and graft insertion
(17 alerts). The axillary nerve was involved in 35 alerts; the muscu-
lucotaneous nerve in 22. Fourteen alerts involved both nerves.
Seven of the 34 patients (20.6%) had a clinically detectable nerve
deficit post-operatively. In all 7 cases, the neurapraxia correlated
with an intra-operative nerve alert. All cases involved the axillary
nerve, and all 7 nerve palsies resolved completely, in a timeframe
ranging from 28 – 127 days post-surgery. Prior surgery, BMI and
number of nerve alerts during surgery were not predictive of a clin-
ically detectable neurologic deficit post-operatively, however total
operative time (p = 0.042) and duration of the stage of procedure
in which the concordant nerve alert occurred (p = 0.010) were sta-
tistically significant predictors of a post-op nerve deficit. Before we
implemented neuromonitoring, 5 in a series of 48 shoulders
(10.4%) had nerve palsies after the Latarjet procedure, 2 of which
did not improve and required return to the operating room for neu-
rolysis. In this series, no post-operative nerve palsy was severe
enough to require intervention, however there was a 20.6% rate
of clinically detectable nerve palsy, despite neuromonitoring. Con-
clusions: The nerves are at risk during the Latarjet procedure, in
particular the axillary nerve and the musculocutaneous nerve. The
most common stages of the Latarjet procedure during which the
nerves are under excessive tension are glenoid exposure and graft
insertion. The surgeon should be especially meticulous and consider
duration of retraction during these stages. Attention to graft place-
ment is important. A more superior position of the graft may be pro-
tective with regard to axillary nerve palsy. With neuromonitoring,
nerve alerts happen frequently and it can be possible for the surgeon
to reduce them with some technical measures, however they do not
seem to result in lasting neurologic deficit. Transient neurologic def-
icits are noted after this surgery, which may be missed if not for care-
ful neurologic examination.

9 3-D MODELING OF HUMERAL HEAD DEFECTS IN
GLENOHUMERAL INSTABILITY: CLINICAL IMPLICATIONS OF
LESION MORPHOLOGY AND THE GLENOID TRACK CONCEPT
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Background: Two-dimensional (2-D) CT scans accurately assess
humeral head lesion depth, but consistently underestimate width in
all imaging planes [1]. Three-dimensional (3-D) CT reconstructions
are recommended to accurately characterize these lesions with
respect to size, orientation and morphology. It has been shown in
static 3-D models that humeral head lesions that are larger in 2-D
size and horizontally-oriented are more likely to engage during dy-
namic arthroscopic evaluation [2]. The “glenoid track” concept was
introduced to identify bipolar bony lesions at risk of interfacing
dynamically, but may underestimate the significance of combined
glenohumeral defects [3] [4]. To our knowledge, no studies have
looked at the relevance of 3-D lesion morphology or validated the
glenoid track concept with respect to clinical instability or treat-
ment outcomes. Methods: The aim of our study was to use 3-D modeling of
humeral head lesions to answer the following questions: 1) Does hu-
meral head lesion volume as measured on 3-D CT provide a more
reliable and relevant clinical assessment than traditional 2-D param-
eters? 2) Does engagement of the lesion as defined by the glenoid
track concept predict failure of primary arthroscopic capsulolabral
stabilization? 3) Are there any differences in humeral head lesion
morphology or glenoid track engagement between patients who un-
dergo arthroscopic capsulolabral repair versus coracoid transfer
procedures? 3-D models were reconstructed from multi-planar CT
scans and data analysis was performed using MIMICS software
(Materialise, Leuven, Belgium). Volumetric analysis was performed
using a best-fit sphere model (Figure 1) and the glenoid track was
mapped to the humeral head by using 84% of the actual glenoid
width extending from the medial margin of the rotator cuff (Figure
2) [4]. The humeral head defect was defined as “engaging” if the
glenoid track extended medially into the humeral lesion as pre-
viously defined by Yamamoto et al. [4]. Results: Thirty-three patients
who were treated for glenohumeral instability underwent pre-opera-
tive CT scans with 3-D reconstruction. The average lesion width
was 21.3 mm (range 11.0 mm-32.0 mm) and depth (5.4 mm) in our study correlated well with pub-
lished norms (22 mm and 5 mm, respectively) [5]. The mean humeral
head lesion volume was 1452.7 mm³. There was no difference in
humeral lesion volume, 2-D dimensions, morphology, width/depth
ratio or vertical orientation between those who failed prior arthro-
sopic stabilization (n = 14) versus those who did not (n = 19).
When the glenoid track was mapped to the lesion taking into ac-
count glenoid bone loss, 12 of 33 (36.3%) were engaging lesions.
There was no difference in the incidence of glenoid track engage-
ment between patients that failed previous arthroscopic stabilization
(5/14, 35.7%) and those that did not (7/19, 36.8%). Patients who
underwent coracoid transfer procedures (n = 15) were compared to
age-matched controls (n = 15) who underwent arthroscopic stabi-
lization. There was no significant difference in the incidence of gle-
roid track engagement (40.0% vs. 26.7%, NS) between these
two groups. Humeral head volume was the only significant predictor
of undergoing a coracoid transfer versus arthroscopic stabilization
procedure (1924 mm³ vs. 863 mm³, p = 0.0385). Conclusions: In our study, we utilized a novel technique of calculating humeral
head defect volume to better assess the multi-planar nature of these
lesions with 3-D CT reconstruction. Glenoid track engagement did
not correlate with failure of prior arthroscopic stabilization nor pre-
dict ultimate treatment in our clinical cohort of instability patients.
who underwent treatment. Humeral head lesion volume was significantly associated with undergoing a coracoid transfer procedure. The current phase of our study utilizes simulated physiologic humeral motion to quantify the effect of shoulder position and combined bony defects on translational distance to glenohumeral dislocation. As D-CT becomes the gold standard, glenohumeral instability treatment recommendations that currently focus on glenoid bone loss and theoretical risk of bipolar engagement may include humeral head defect volume in the decision-making algorithms.

References

10 THE INSTABILITY SEVERITY INDEX SCORE IN ARTHROSCOPIC INSTABILITY SURGERY (ISIS): FAILURE TO VALIDATE ITS PREDICTIVE VALUE IN THE SELECTION OF ARTHROSCOPIC INSTABILITY SURGERY
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Introduction: It is now generally accepted that all patients are not acceptable for arthroscopic instability repair. Criteria by which patients can be successfully preselected for either arthroscopic or open repair remain unclear. Balg and Boileau (2007) developed the Instability Severity Index Score (ISIS) suggested that six preoperative factors that did not require expensive preoperative imaging could be assessed to select those patients appropriate for arthroscopic repair: age <20, athletic involvement, contact or forced overhead sports, shoulder hyperlaxity, external rotation view Hill-Sachs, or loss of inferior glenoid bone contour. A score over six was felt to contraindicate arthroscopic repair. If true, this would be a useful tool to recommend treatment for the patient with recurrent instability to minimize the patients’ risk of further surgery. No other authors have validated these results. The ISIS was attempted to be validated using a case-control study in a previously studied arthroscopic shoulder stabilization population with long-term follow-up. Method: Forty patients who underwent arthroscopic instability repair for traumatic unidirectional instability were retrospectively assessed with ISIS scores. All patients underwent arthroscopic suture anchor repair with permanent sutures and interval closure sutures. Results: Mean follow-up averaged 95.8 months, with minimum 5 year follow-up. Overall SST scores improved to 10.7, UCLA scores to 30.7, and Rowe scores to 85.9. Seven of 40 (17%) failed at long-term follow-up, however only 4 of 7 requiring more surgery. Mean time to recurrence was 33 months. No patient had a Hill-Sachs lesion on AP ER films. Two of six failures were under 20 however the mean age of the failures was not significantly different (24.8 versus 29.7), although 4 of 6 were 21 or under. Three of six failures were competitive athletes. The mean ISIS was 2.16, and the mean of the failures was 2.66 [p=n.s.]. No patient with failed instability surgery had an ISIS score over 5. Discussion: Despite being widely quoted at least the arthroscopic instability literature the ISIS score failed to predict recurrent instability in a high percentage of cases. Univariate analysis did show younger age and participation in competitive sports offer a positive predictive value of failure. While bone loss may represent a contraindication to arthroscopic repair, Hill-Sachs lesions visualized on ER AP films are rare. Patients with generalized joint laxity would traditionally be managed with other techniques than isolated labral repair. The mean time to recurrence gives pause to accepting instability studies with less than 5 year follow-up. The Instability Severity Index Score (ISIS) has been suggested by Balg and Boileau as a means to allow the surgeon to select patients appropriate for arthroscopic Bankart repair. The ISIS was applied to 40 patients using a case-controlled study with long-term follow-up. Seven of 40 patients (17%) had recurrent instability. Younger age and competitive sports participation did offer a positive predictive value for failure, but the other four components of the score offered no predictive value, and the ISIS scores were not significantly different between the patients with successful and unsuccessful repair (2.16 versus 2.66).

11 LONG-TERM OUTCOME OF SEGMENTAL RECONSTRUCTION OF THE HUMERAL HEAD FOR THE TREATMENT OF LOCKED POSTERIOR DISLOCATION OF THE SHOULDER
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Background: Locked, posterior, glenohumeral dislocations with impaction fractures involving less than 30 to 35% of the humeral head are most frequently treated with lesser tuberosity transfer into the defect, those involving more than 35-40% with humeral head arthroplasty (HA). As an alternative, reconstruction of the defect with segmental femoral or humeral head allograft has been proposed, but long-term outcome of this joint preserving procedure is unknown. Patients & Methods: Between 1986 and 2008, 22 shoulders of 21 patients with a locked posterior shoulder dislocation and an impaction fracture involving less than 30% (mean 24%) of the humeral head were treated with segmental reconstruction of the humeral head defect. They were reviewed clinically and radiographically at a minimum follow-up of 5 years. Results: Nineteen of the 22 shoulders could be reviewed clinically and radiographically at an average of 128 months (ranging 60-294 months) postoperatively. One patient was not followed because his allograft had collapsed at 4 months and a total shoulder was implanted at 10 months after the index operation. The patient with bilateral operations died 33 months after the second side so that only one shoulder with a follow-up of more than 60 months was included. A third patient had reported an excellent result at three months and refused any further follow-up. One of the nineteen patients had undergone
rotational osteotomy because of incomplete reduction and head collapse at ten months postoperatively. At 181 months the remaining head had collapsed and a hemiarthroplasty was implanted. A second patient had an excellent result until 180 months postoperatively, then synovial chondromatosis which led to revision with a RTSA at 186 months after allograft reconstruction. Thus at final follow-up, two of the 19 reviewed patients had a prosthesis. Of the other seventeen, four had radiographically advanced, four had mild and nine had no or minimal OA. 18 shoulders were subjectively (including two with replacement surgery) excellent none good, one fair. The final Constant Score averaged 77 points (range 52-98 p), the subjective shoulder value averaged 88% (range 75-100%) and only two patients had mild to moderate pain. Mean active anterior elevation was 145 and mean external rotation with the arm at the side was 42 degrees. Conclusion: Segmental reconstruction of humeral head defects for large anteromedial impaction fractures caused by locked posterior dislocations durably restores stability and freedom from pain with an excellent subjective long-term outcome. Development and progression of osteoarthritis did occur but was not associated with significant pain, or work disability or need for disability payments.

12 THE EFFECT OF PITCH COUNT ON SHOULDER KINEMATICS AND STRENGTH IN ADOLESCENT BASEBALL PITCHERS

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Introduction: The repetitive stress that occurs with pitching alters both structural as well as functional mechanics of the shoulder complex. The alterations in muscular strength and kinematics that occur over time may increase pitchers’ vulnerability to shoulder injury. The objectives of this study are to assess the effect of pitch count on shoulder kinematics and strength in adolescent baseball pitchers. Methods: A total of 12 baseball pitchers between the ages of 14 and 16 years, without history of shoulder pain or injury, were recruited to participate in this study. Pitchers threw indoors from an elevated artificial pitching mound into a target set at regulation distance (60.5 ft) from the rubber. The pitchers threw 90 fastballs in 6 sets (1 set = 15 pitches) with five-minute breaks between sets. Three-dimensional kinematics (angle, angular velocity) of the upper extremity (thorax, scapula, humerus, forearm, hand) were recorded using a 12-camera optical motion system (Motion Analysis Corp, Santa Rosa, CA) at 250 Hz. The pitching-side scapula was tracked using a custom-made scapula tracking device. Kinematics were calculated at relevant events: knee-up, max external rotation, cocked position, lead foot down and ball release. Parameters were computed from the last five pitches of the first, second, and last set were averaged and compared using ANOVA (p < 0.05). Voluntary maximal isometric strength of the internal and external rotators was evaluated before and after pitching using an isokinetic dynamometer (Biodex Medical Systems, Shirley, New York) in three positions (45° IR, 0° neutral, and 45° ER) with the arm in 45° of scapular elevation. A paired t-test (2-tail) was used to compare pre- and postpitching strength. As a performance outcome we measured ball speed velocity. A total of 3184 patients were included in our retrospective study based on ICD-9 code selection criteria. We compared perioperative inpatient data

13 A COMPARISON OF PERIOPERATIVE OUTCOMES FOLLOWING TOTAL ELBOW ARTHROPLASTY IN PATIENTS WITH AND WITHOUT DIABETES

Jason L. Koh, MD, Aneet Toor, MD, Jimmyiang, MD, Lewis Shi, MD, NorthShore University Health System, University of Chicago, Pritzker School of Medicine, Chicago, Illinois, USA

Background: Studies have reported increased risks for adverse events and higher costs for patients with diabetes who undergo surgery. There are few studies specifically analyzing the effect of diabetes on outcomes after total elbow arthroplasty. We investigate the immediate perioperative outcomes and complications of patients with and without diabetes following total elbow arthroplasty. Methods: We evaluated the Nationwide Inpatient Sample (NIS) database from 2005-2010 for patients who underwent a total elbow arthroplasty. The NIS is a statistically representative sample of hospitals from across the nation that includes data on approximately 8 million inpatient admissions per year. A total of 3184 patients were included in our retrospective study based on ICD-9 code selection criteria. We compared perioperative inpatient data
between patients with diabetes (n=488) and those without diabetes (n=2696). Results: Patients with diabetes had a significantly greater mean age at the time of total elbow arthroplasty (66.8 vs 58.5, p<0.001) compared to patients without diabetes. There was no statistically significant difference when comparing cost of surgery ($56,582 versus $56,092, p=0.833). There was a trend approaching statistical significance that favored longer hospital stay (4.1 versus 3.7 days, p=0.056) in diabetic patients. A higher percentage of diabetic patients underwent arthroplasty for the indication of fracture (p<0.001), but a lower percentage underwent surgery for rheumatoid arthritis (p<0.001). Patients with diabetes had significantly increased rates of pneumonia (odds ratio (OR) = 2.7, p=0.009), urinary tract infection (OR=2.2, p<0.001), blood transfusion (OR=2.1, p<0.001), and non-routine discharge (OR=1.9, p<0.001). They also had significantly increased rates of comorbidities including anemia (OR=1.9, p<0.001), congestive heart failure (OR=2.9, p<0.001), depression (OR=1.4, p=0.05), hypertension (OR=6.0, p<0.001), obesity (OR=3.5, p<0.001), peripheral vascular disease (OR=4.4, p<0.001), and chronic renal failure (OR=3.6, p<0.001). Our multivariate analysis showed that diabetes was an independent predictor of the risk of periperaoperative pneumonia (OR=2.6, p=0.013) and UTI (OR=1.9, p=0.007). However, diabetes was not an independent predictor of hospitalization length (p=0.75), cost of surgery (p=0.63), or proportion of routine hospital discharges (p=0.12). Conclusion: Patients with diabetes have higher rates of chronic comorbidities and periperaoperative complications following total elbow arthroplasty. Diabetic patients more likely underwent surgery due to elbow fracture. There was a trend approaching statistical significance towards longer length of hospitalization for diabetic patients. Cost of surgery was similar between patients with and without diabetes.

Analysis of perioperative outcomes and complications in patients with diabetes and without diabetes who underwent total elbow arthroplasty.

### Table: Comparison of Outcomes between Patients with Diabetes and Those without Diabetes

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Diabetes</th>
<th>No Diabetes</th>
<th>p-value</th>
<th>Odds Ratio</th>
<th>Lower</th>
<th>Upper</th>
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<tbody>
<tr>
<td>Length of Stay (Days)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Mean</td>
<td>4.09</td>
<td>3.7</td>
<td>0.056</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>3.46</td>
<td>4.23</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Discharge Cost (Dollars)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Mean</td>
<td>56,582.00</td>
<td>56,092.00</td>
<td>0.839</td>
<td></td>
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<td></td>
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<tr>
<td>Standard Deviation</td>
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<td>50,390.00</td>
<td></td>
<td></td>
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<td>Transfusion</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Yes</td>
<td>49 (10.0%)</td>
<td>138 (5.1%)</td>
<td>&lt;0.001</td>
<td>2.07</td>
<td>1.47</td>
<td>2.91</td>
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<td>439 (90.0%)</td>
<td>2558 (94.9%)</td>
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<td>0.293</td>
<td>2.21</td>
<td>0.43</td>
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<td>Died</td>
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</tr>
<tr>
<td>Yes</td>
<td>2 (0.4%)</td>
<td>5 (0.2%)</td>
<td>0.099</td>
<td>2.69</td>
<td>1.34</td>
<td>5.4</td>
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<td>No</td>
<td>486 (99.6%)</td>
<td>2688 (99.8%)</td>
<td></td>
<td>0.705</td>
<td>1.11</td>
<td>0.24</td>
</tr>
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<td>Pneumonia</td>
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<tr>
<td>Yes</td>
<td>12 (2.5%)</td>
<td>25 (0.9%)</td>
<td>0.009</td>
<td>2.69</td>
<td>1.34</td>
<td>5.4</td>
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<tr>
<td>No</td>
<td>476 (97.5%)</td>
<td>2671 (99.1%)</td>
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<td>1.38</td>
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<tr>
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<td>2684 (99.6%)</td>
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<td>3.71</td>
<td>1.04</td>
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<td>0.98</td>
<td>0.29</td>
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<tr>
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<td>2684 (99.6%)</td>
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<td>0.54</td>
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<td>Acute mental status changes</td>
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<tr>
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<td>0.98</td>
<td>0.29</td>
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<tr>
<td>No</td>
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<td>0.54</td>
<td>3.23</td>
</tr>
<tr>
<td>No</td>
<td>482 (98.8%)</td>
<td>2671 (99.1%)</td>
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<td>0.053</td>
<td>3.71</td>
<td>1.04</td>
</tr>
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<td>17 (0.6%)</td>
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<tr>
<td>No</td>
<td>485 (99.4%)</td>
<td>2679 (99.4%)</td>
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<td>0.346</td>
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<td>32 (6.6%)</td>
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<td>No</td>
<td>456 (93.4%)</td>
<td>2614 (97.0%)</td>
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<td>0.346</td>
<td>1.44</td>
<td>0.62</td>
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<tr>
<td>Fever</td>
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<tr>
<td>Yes</td>
<td>7 (1.4%)</td>
<td>27 (1.0%)</td>
<td>0.346</td>
<td>1.44</td>
<td>0.62</td>
<td>3.32</td>
</tr>
<tr>
<td>No</td>
<td>481 (98.6%)</td>
<td>2669 (99.0%)</td>
<td></td>
<td>0.95</td>
<td>0.98</td>
<td>0.41</td>
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<tr>
<td>I&amp;D</td>
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<tr>
<td>Yes</td>
<td>6 (1.2%)</td>
<td>34 (1.3%)</td>
<td>&gt;0.95</td>
<td>0.98</td>
<td>0.41</td>
<td>2.33</td>
</tr>
<tr>
<td>No</td>
<td>482 (98.8%)</td>
<td>2662 (98.7%)</td>
<td></td>
<td>0.95</td>
<td>0.98</td>
<td>0.41</td>
</tr>
</tbody>
</table>
Background: The interval throwing progression is a hallmark of the rehabilitation program designed for baseball pitchers or position players returning from shoulder or elbow injury. It typically begins with flat-ground throws at a short distance and progressively increases to 180 feet or more. For pitchers, this phase is then followed by throwing off the mound, progressing from partial-effort to full-effort pitches. Theoretically, the progression of throwing phases allows an injured athlete to gradually recover his flexibility, arm strength, and mechanics while moving from less stressful activities to more stressful activities. While this throwing program has been part of baseball rehabilitation and conditioning for decades, little is known about the biomechanical stresses generated during flat-ground throwing or variable effort pitching off the mound. Hypothesis: A biomechanical comparison of pitching and throwing various flat-ground distances will show significant differences (torque and force) in the throwing shoulder and elbow. In addition, various pitching efforts off the mound will also show significant differences between efforts. Methods: Twenty-nine healthy, college baseball pitchers were analyzed using a quantitative, 3-dimensional motion analysis system. The participants threw from flat ground at distances of 60, 90, 120, and 180 ft, being instructed to throw “hard, on a horizontal line”. The pitchers then threw fastballs from a mound to a strike zone at 3 different efforts: 60% effort, 80% effort, and full-effort. Biomechanical parameters of position, velocity, and kinetic values were recorded. For each pitcher, mean values were calculated for humeral internal rotational torque (HIRT) and elbow valgus load (EVL) for each throw type. This data was then used to compare shoulder and elbow stresses between the various throws. The differences among mean values were analyzed with a repeated-measures analysis of variance (ANOVA). Post hoc paired t-tests were performed when the ANOVA revealed a significant difference. Results: Statistically significant differences exist across all mound intensities (60%, 80%, and 100% effort) for nHIRT (p = 0.03) and nEVL (p = 0.04), as both parameters increased with percentage throwing effort. No statistically significant differences were found across all flat ground distances in either HIRT or EVL (p > 0.05). The longer flat ground throws at 180 feet did show significantly different kinematics and biomechanical parameters when compared with pitching from the mound, while shorter flat ground throws had patterns similar to those of pitching. Conclusion: Variable effort pitching off the mound demonstrates significantly lower stresses on the shoulder and elbow during partial-effort throws, illustrating the importance of these throws during the recovery and rehabilitation process. Flat ground throwing at distances as short as 60 feet had similar biomechanical stresses on the upper extremity when compared with pitching full-effort from the mound. Despite lower velocity, this similar stress illustrates the mechanical disadvantage of throwing from the flat ground in a stationary position. No increase in shoulder or elbow stress was seen with increasing distances from the flat ground, likely because the pitchers began using a “crow-hop” for the longer distances, facilitating the throw with their lower extremity. The mechanical advantage of throwing from a mound or using the crow-hop may be protective during rehabilitation and training throws, generating lower humeral internal rotational torque, lower elbow valgus load, and more throwing efficiency.

16 OLECRANON TIP OSTEARTICULAR AUTOGRFT TRANSFR FOR IRREPARABO CORONOID PROCESS FRACTURES. A BIOMECHANICAL STUDY

Miguel A. Ramirez, MD, Anand M. Murthi, MD, Department of Orthopaedics and Sports Medicine, Shoulder and Elbow Service, MedStar Union Memorial Hospital, Baltimore, Maryland, USA.

Introduction: Coronoid process fractures are common in traumatic elbow injuries and can lead to significant elbow instability. With extensive fracture comminution, few options exist for reconstruction. The olecranon tip, being morphologically similar to the coronoid, may be a suitable option for reconstruction. In this study, we evaluate the morphology, suitability and biomechanics of an olecranon tip transfer procedure for type III coronoid fractures. Materials and Methods: Twelve fresh-frozen cadaveric elbows were tested in this study. All soft tissues were removed, leaving the collateral ligaments intact. The coronoid process was osteotomized to create a type III fracture model and subsequently reconstructed using the appropriate amount of olecranon process. The elbows were mounted on a custom jig on an MTS load frame and an axial load

Table 2 Comparison of Joint Torques Among Various Efforts From Mound

<table>
<thead>
<tr>
<th>Throw</th>
<th>60% Effort</th>
<th>80% Effort</th>
<th>100% Effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIRT, mean, Nm</td>
<td>34.5</td>
<td>37.4</td>
<td>45.2</td>
</tr>
<tr>
<td>nHIRT, mean</td>
<td>0.23</td>
<td>0.25</td>
<td>0.30</td>
</tr>
<tr>
<td>EVL, mean, Nm</td>
<td>38.4</td>
<td>46.3</td>
<td>49.6</td>
</tr>
<tr>
<td>nEVL, mean</td>
<td>0.25</td>
<td>0.30</td>
<td>0.33</td>
</tr>
</tbody>
</table>

a HIRT, humeral internal rotational torque; nHIRT, normalized humeral internal rotational torque; EVL, elbow valgus load; nEVL, normalized elbow valgus load.

b The values were normalized as follows: HIRT / BW (kg) x H (cm) and EVL / BW (kg) x H (cm).

Table 1 Comparison of Joint Torques Among Throws

<table>
<thead>
<tr>
<th>Fastball Pitch</th>
<th>60-ft</th>
<th>90-ft</th>
<th>120-ft</th>
<th>180-ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIRT, mean, Nm</td>
<td>45.2</td>
<td>41.0</td>
<td>43.1</td>
<td>37.2</td>
</tr>
<tr>
<td>nHIRT, mean</td>
<td>0.30</td>
<td>0.26</td>
<td>0.28</td>
<td>0.24</td>
</tr>
<tr>
<td>EVL, mean, Nm</td>
<td>49.6</td>
<td>50.0</td>
<td>47.6</td>
<td>40.1</td>
</tr>
<tr>
<td>nEVL, mean</td>
<td>0.33</td>
<td>0.32</td>
<td>0.30</td>
<td>0.26</td>
</tr>
</tbody>
</table>

a HIRT, humeral internal rotational torque; nHIRT, normalized humeral internal rotational torque; EVL, elbow valgus load; nEVL, normalized elbow valgus load.

b The values were normalized as follows: HIRT / BW (kg) x H (cm) and EVL / BW (kg) x H (cm).
of 100N was applied to the elbows at 15mm/min in 1.5-degree intervals from 0 to 120 degrees of flexion. Posterior ulnohumeral displacement was obtained using crosshead motion data in each of 3 configurations: 1. Intact coronoid 2. Osteotomized coronoid 3. Olecranon transfer. Elbow range of motion was compared between the intact and reconstructed states. A paired test was used to compare differences in posterior displacement between the osteotomized and reconstructed states. Results: The olecranon graft provided a precise anatomic fit in all specimens, and all reconstructed specimens had full range of motion. Intact translation (mean ± SD) ranged from 0.3 ± 0.1 mm to 1.1 ± 0.6 mm, and translation in the osteotomized state ranged from 1.3 ± 1.0 mm to 2.0 ± 1.0 mm. Resection of the coronoid resulted in a significant increase in posterior ulnar translation compared with intact at all flexion angles except 75 degrees. Reconstruction decreased translation versus the osteotomized state to some extent at all flexion angles, significantly at 60 and 120 degrees of flexion. There was no significant difference in translation between reconstructed and intact states at 15, 45, 60, 90, and 120 degrees of flexion. Conclusions: Reconstruction of a simulated type II coronoid fracture with an osteotomized coronoid and tip autograft resulted in a 1.2 ± 1.7 mm posterior ulnar translation to a level not different from the intact state at five of eight elbow positions tested. A decrease in translation compared with the osteotomized state was observed at all flexion positions. The olecranon graft provided a continuous osteochondral articular surface, and all reconstructed specimens had full range of motion.

18 COMPUTER- AND IMAGE-ASSISTED GUIDANCE SYSTEM FOR RADIAL HEAD ARTHROPLASTY
Simon R. Deluce, MSc; Hannah L. Shannon, MSc; Emily A. Lalone, PhD; George S. Athwal, MD, FRSCS; Louis M. Ferreira, PhD; Graham J.W. King, MD, James A. Johnson, PhD; Western University and the Bioengineering Laboratory, The Roth/McFarlane Hand and Upper Limb Centre, St. Joseph’s Health Care, London, Ontario, Canada

Introduction: Previous studies have identified the importance and difficulty associated with accurately positioning radial head replacements due to the complex shape of the native radial head. Errors in implant positioning are further exacerbated when the radial head is fractured or has previously been excised. Anatomic landmarks, such as the biceps tuberosity and radial styloid, are highly variable between patients making them suboptimal for clinical use. We hypothesized that a computer and image-assisted guidance system in addition to a posterolateral approach would lead to high degrees of accurate positioning. Methods: Pre-operative computed tomography (CT) scans were obtained from 100 fresh frozen cadaveric upper extremities. Using medical imaging processing software (Mimics, Materialize N.V., Belgium) a pre-operative surface model of the radius was generated. Custom software was developed using the Visualization Toolkit (VTK) to align this pre-operative model to an anatomic coordinate system created using manually selected landmarks and determine the ideal position for the implant stem. An active optical tracking system (Optotrak Certus, Northern Digital Incorporated, Canada) was used to obtain surface digitizations using a tracked probe and a position sensor rigidly fixed to the radius. Digitized surfaces included the accessible surface of the radial head itself, palmar aspect, and posterior facet of the radius. A surface-based registration between the pre-operative model and intra-operatively obtained digitizations was determined using the iterative closest point (ICP) algorithm. A custom interface was used to provide real-time visual navigation of the implants position and orientation relative to the pre-operative target. The stem was aligned to the target location and held manually in place as the cement hardened before recording its final position. The difference between the target as it appeared on the screen and the final position is the operator based navigation error. A landmark-based registration using fiducial markers provided the datum by which the accuracy of the surface-based registration was evaluated to determine the registration error. Total error quantifies the geometric sum of these two errors. Results: The largest component of the total alignment error was rotation about the long axis of 5.1 ± 3.1°. Total rotational errors about the medial/lateral (ML) and anterior/posterior (AP) axes were 1.1 ± 0.9° and 1.2 ± 1.7° respectively. The height mismatch was 0.5 ± 0.3 mm. Absolute positioning errors in the ML and AP directions were 0.8 ± 0.5 mm and 0.8 ± 0.6 mm respectively. The navigation error incurred during manual alignment of the implant was less than the error resulting from the surface-based registration used to align the location of the pre-operative target intra-operatively. Discussion: The error incurred during the manual alignment of the implant was much less than that incurred by the surface-based registration particularly about the long axis of the radius. This was a foreseeable difficulty as the differences between the maximum and minimum axes of the radial head are only 1-2 mm and this difference is further obscured by the offset of the capitellum in intra-operative digitizations which is not present in imaging. This leads to a loss of rotational stability in the registration which the inclusion of mid-bone digitizations and points on the distal radius was meant to prevent. Further work is required to improve the accuracy or surface-based registration of the radius. Shortcomings of the current study include the use of complete radial head digitizations in the registered dataset and the use of ipsilateral imaging to generate the pre-operative plan. In the clinical application of navigated radial head arthroplasty the radial head would be damaged limiting the region available for digitization and planning. Thus in some respects the registration achieved in the current study represents a best case scenario; registration error and hence the accuracy of implant placement would likely be worse clinically using a model obtained from the contra-lateral side. Ultimately the current system represents an important first step in the development of a computer and image-assisted system for radial head implant navigation. The majority of the error can be attributed to registration rather than navigation suggesting that further improvements in registration techniques are needed. Further work is required to determine the acceptable level of surface mismatch at the radial head in order to define clinically acceptable navigation errors. Significance: Computer and image-assisted surgery for the radial head may improve the accuracy of positioning and hence the outcome of radial head arthroplasty.

19 ALLOGRAFT LIGAMENT RECONSTRUCTION FOR POSTTRAUMATIC ELBOW POSTEROLATERAL ROTATORY INSTABILITY: A MID-TERM FOLLOW-UP STUDY
Yaser M.K. Baghdadi, MD; Bernard F. Morrey, MD; Shawn W. O’Driscoll, MD, PhD; Scott P. Steinmann, MD; Joaquin Sanchez-Sotelo, MD, PhD, Department of Orthopedic Surgery, Mayo Clinic, Rochester, Minnesota, USA

Introduction: Insufficiency of the lateral collateral ligament complex (LCLC) results in elbow posterolateral rotatory instability (PLRI). Autograft tendon reconstruction has been reported to restore elbow stability in patients with PLRI. Allograft reconstructions are commonly performed to avoid the morbidity of autograft harvesting. The outcome of allograft reconstruction of the LCLC is largely unknown, and may vary depending on the integrity of other stabilizing elbow structures. The purposes of this study were to determine the outcome of allograft reconstruction of the LCLC for patients with...
PLRI, and (2) to compare the outcomes in patients with and without associated pathology affecting the radial head, coroidon or olecranon. **Methods:** Ninety-eight elbows with PLRI underwent reconstruction of the LCLC using a tendon allograft. The radial head, coroidon and remaining ulna were completely intact in 22 elbows, whereas in the remaining 76 elbows there were various degrees of skeletal pathology. Sixteen elbows presented with persistent static subluxation or dislocation. The mean age at the time of the index reconstruction was 36.2 ± 15.1 years. Patients were followed for a mean of 3.8 ± 4.1 years. **Results:** Seven elbows (7%) required total elbow or interposition arthroplasty secondary to progressive post-traumatic osteoarthritis. Of the remaining 91 elbows, 13 (14%) developed recurrent PLRI and 9 (9%) underwent allograft reconstruction, which was successful in 6 elbows. For the 78 patients with no recurrent instability, the mean MEPS score was 89 ± 15 points, and 83% was graded as good or excellent. Using Kaplan-Meier analysis, the survival free from reoperation for recurrent instability at 4 years was 93% (95% CI: 65 to 99%) for patients with an intact skeleton versus 86% (95% CI: 73 to 93%) for patients with skeletal pathology (p=0.5). **Conclusion:** Allograft reconstruction results in low instability rates almost eight years after the primary procedure. Higher failure rates should be expected in patients with skeletal pathology. Isolated reconstruction of the LCLC may not compensate for the lack of other stabilizing elbow structures.

**20 SHORT-TERM FAILURE RATES AFTER ACROMIOCLAVICULAR JOINT RECONSTRUCTION: A COMPARISON OF ANATOMIC AND NON-ANATOMIC SURGICAL TECHNIQUES**

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**Background:** The optimal surgical technique for stabilization of chronic acromio-clavicular(AC) joint separations is not known. Anatomic coraco-clavicular(CC) reconstruction offers superior initial laboratory biomechanical stability compared to coraco-acromial ligament transfer (Weaver-Dunn procedure). However, risks associated with anatomic CC reconstructions may be higher. The purpose of this study was to compare failure rates of several different open anatomic AC reconstructions with non-anatomic CA ligament transfer. **Methods:** The authors performed a retrospective cohort study review of 206 consecutive AC joint reconstruction procedures at a region wide integrated health maintenance organization system performed between 2008 and 2012. Exclusions included primary intercondylar knee capsule reconstruction, non-clinical data were obtained and analyzed to identify surgical technique, post-operative complications, radiographic (XR) failure and reoperations. Surgical techniques identified included: (1) Modified Weaver-Dunn, (2) CC fixation with hardware only (Arthrex Tightrope), (3) CC fixation with allograft loop,[4] (4) Allograft loop combined with hardware C-C reconstruction (i.e. technique (2) + (3)), (5) Allograft fixed through coracoid and clavicle tunnels (Arthrex Graftrope). Age, gender, arm dominance, smoking status, AC separation grade, and mechanism of injury were recorded. Radiographs comparing immediate post-operative to latest post-operative coracoclavicular distances were reviewed. XR failure was defined as more than five millimeter change in vertical distance from the immediate post-operative XR. Overall failure was defined as any XR failing the follow-up XR and/or reoperation. Failure rate was 22% (38 patients) and overall revision rate was 12% (20 patients). XR follow-up length was not significantly different between techniques (p=0.50). By univariate analysis, Group #4 had a lower radiographic failure rate (8.5%), compared to Technique Group #1 (25%), #2 (29%), #3 (23%), #5 (43%) using Fisher exact test (p=0.021). Group #4 had the least reoperations (2/52) compared to the other techniques. Age, gender, arm dominance, smoking status, AC separation grade and mechanism of injury were not significantly related to radiographic failure or overall failure. When controlling for age, gender, grade of AC separation and mechanism of injury, Group #4 demonstrated significantly lower XR failure (Odd Ratio 0.262, p=0.021). Mechanism of injury trended toward lower radiographic failure (Odd Ratio 2.8, p=0.079) in this model. **Conclusions:** There was a high rate of radiographic and overall failure after surgical reconstruction of chronic AC joint separations. Combined reconstruction with looped allograft and hardware C-C fixation carried the lowest failure rate when controlling for multiple other factors.

**21 ANALYSIS OF MECHANICAL FAILURES AFTER ANATOMIC ACRYMOCLAVICULAR JOINT RECONSTRUCTION**

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**Background:** Acromioclavicular (AC) joint injuries are commonly encountered in orthopaedic practice. Recent studies have advanced a technique for anatomic reconstruction as a surgical option. However, there remains a paucity of literature investigating post-operative failures. We proposed to analyze our series of anatomic AC joint reconstructions to evaluate any risk factors that may predict failure. We hypothesized there would be no difference in failure rates relative to any of these variables. **Materials and Methods:** We performed a retrospective review on a consecutive series of anatomic AC joint reconstructions from 2007-2013. Forty-three patients were included in the study, 33 male and 10 female. The average patient age was 39.7 years (range 20-68). Failure was defined as loss of AC joint reduction with concomitant pain and/or dysfunction requiring revision surgery. Multiple variables were analyzed in an attempt to identify risk factors for failure. Injury characteristics evaluated included: acute vs chronic injury and severity of AC joint disruption (type III vs type VI). Surgical techniques evaluated included: graft choice (allograft vs autograft), use of interference screws for graft fixation, use of additional non-biologic fixation (e.g. suture tape), concomitant distal clavicle excision, and superior AC capsule reconstruction. Patient factors evaluated included: age, sex, BMI, involvement of dominant extremity, occupation, smoking status, and diabetes mellitus. Independent Heats were used for numeric variables separated using normal distribution and non-parametric analyses with Fisher’s Exact test. Differences with p<0.05 were considered statistically significant. **Results:** Two patients underwent revision surgery due to infection and were excluded from the analysis of mechanical failures. Seven patients (16%) underwent revision due to failed reconstruction with pain. None of the patient demographic factors were associated with failure. There were no significant differences in failure rate for acute vs chronic injuries, use of allograft vs autograft, or superior AC capsule reconstruction. There was a significantly lower failure rate in patients where interference screws were used for graft fixation (7% vs 44%, p=0.016). Similarly, a significantly lower failure rate was found in patients who underwent concomitant distal clavicle excision. (9% vs 60%, p=0.018). Reconstructions with non-biologic fixation in addition to the tendon graft also trended toward lower failure rates (9% vs 43%, p=0.055). The failure rate was lower in type III injuries (10%) than type V injuries (22%), but this difference did not reach statistical significance due to the small size of the re-operative group. **Conclusion:** Anatomic AC joint reconstruction resulted in a 16% mechanical failure rate in this series. Multivariate analysis of 14 factors found that the use of interference screws fixation and concomitant distal clavicle excision were statistically significant protective factors against failure. There also was a strong trend toward a lower failure rate with use of additional non-biologic fixation. Type III injuries were associated with a lower failure rate than type V dislocations. While not statistically significant, this two-fold difference in failure rate may be of clinical significance.
22 THE RISING INCIDENCE OF OPERATIVE FIXATION OF ACUTE MID-SHAFT CLAVICLE FRACTURES

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Background: The reported incidence of acute mid-shaft clavicle fractures in adults is $44$ per 100,000 with mid-shaft fractures accounting for $69\%$ to $81\%$ of all clavicle fractures. Traditionally, acute mid-shaft clavicle fractures have been treated non-operatively. Over the past decade, new level I evidence has expanded the indications for operative fixation of displaced and shortened mid-shaft clavicle fractures. These studies have suggested that nonunion rates may be higher than previously reported, and patients may experience more dysfunction with non-operative treatment than operative treatment. The purpose of this study is to evaluate whether the incidence of operative treatment of mid-shaft clavicle fractures has increased in recent years. Objectives: The primary aim of this study attempts to determine whether the rate of operative fixation of acute mid-shaft clavicle fractures has increased over the last decade. The secondary objective of this study is to determine demographic information on patients who have sustained mid-shaft clavicle fractures. Methods: A search of the Healthcare Cost and Utilization Project (HCUP) California Ambulatory Surgery Database and HCUP California Emergency Department Database was conducted from 2005 to 2010 using International Classification of Diseases 9 (ICD-9) as well as Current Procedural Terminology (CPT) codes. Patients who had been diagnosed with a mid-shaft clavicle fracture and subsequently underwent operative fixation were identified each year. A search of the HCUP National Emergency Department Database using ICD-9 codes identified patients presenting with mid-shaft clavicle fractures from 2006 – 2010. Demographic data including sex, age, insurance status, and race were collected for this cohort. Results: Operative fixation of midshaft clavicle fractures increased by 337\% ($p < 0.0001$) from 2005 to 2010 in ambulatory surgery centers in California. The number of patients with clavicle fractures presenting to emergency departments in the state of California only increased by 15\% ($p < 0.05$) during that same period. Mid-shaft clavicle fractures occurred more frequently in men than women by a ratio of 3:1 at both the statewide and national level, while operative fixation occurred more frequently in men than women by a ratio of 5:1. The patients that underwent operative fixation were more likely to carry private insurance (83.2\%) than those who presented to emergency departments with acute mid-shaft clavicle fractures (56.6\%). Conclusions: The population-based incidence of operative fixation of mid-shaft clavicle fractures has increased dramatically over the past few years in California, possibly in response to high level evidence demonstrating better patient outcomes and improved surgical techniques. The majority of patients who undergo operative fixation in ambulatory surgery centers were young, male patients with private insurance.

23 COST DRIVERS IN OPERATIVE TREATMENT OF PROXIMAL HUMERUS FRACTURES

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Background: The rise creating demand for efficient and cost-effective treatment choices. Proximal humerus fractures are common in the elderly, difficult to treat and represent a substantial burden on the healthcare system. Previous analyses comparing open reduction and internal fixation to hemiarthroplasty for management of proximal humerus fractures have failed to address the added impact of complications, comorbidities, and readmissions. Objectives: To evaluate the cost drivers in proximal humerus fractures in the elderly and sought to determine the impact of complications, readmission, and procedure choice in in-hospital and total 90-day costs. Methods: Medicare claims data from 20 counties in the Upstate New York area (2008-2009) were evaluated. The study included all patients age≥65 treated with open reduction and internal fixation (ORIF) or hemiarthroplasty for fracture or shoulder trauma identified by ICD-9 procedure codes. Bivariate analysis of patients and treatment characteristics between the two procedures was performed, with factors meeting criteria $p<0.1$ further included in multivariate analysis. The primary end points included in-hospital costs and total health care costs within 90 days after the index operation including costs of readmissions, nursing home care, and outpatient treatment. Multivariate generalized linear models with negative binomial distributions and log link function were used for cost analysis. Hospital level variation was accounted for by using hospital fixed effects. A $p$ value $<0.05$ was used to identify significant predictors of costs in the multivariable models. Results: ORIF was performed in 84 cases, and hemiarthroplasty in 42 cases, total n=126. On univariate analysis, readmission on average increased in-hospital cost by $42,690 and total 90 day costs by $54848, while complications on average increased in-hospital cost by $24,159 and total 90 day costs by $33248. Age, gender, discharge classification, Elixhauser comorbidity index, readmissions, complications, and surgery type each met criteria for inclusion in multivariate analysis. In multivariate analysis, ORIF was associated with 17\% lower in-hospital cost compared to hemiarthroplasty ($p=0.004$), complications increased in-hospital cost by 13\% ($p=0.048$) and readmission was associated with a 4.76 fold in-hospital cost increase ($<0.001$). Conclusions: Complications and readmission continue to drive cost upward undermine the need for best practice. The acute inpatient period costs can be decreased through ORIF implementation in appropriately selected patients, while overall costs at 90-days were equivalent. This study provides real world cost estimates with the cost implications of complications and readmissions.

24 REVERSE SHOULDER ARTHROPLASTY FOR TREATMENT OF PROXIMAL HUMERUS FRACTURES IN OLDER ADULTS: A SYSTEMATIC REVIEW

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Background: Displaced proximal humeral fractures have traditionally been treated with hemiarthroplasty in older adults, but some may be better treated with reverse shoulder arthroplasty (RSA) due to rotator cuff deficiency. Reverse shoulder arthroplasty (RSA) can offer potentially improved outcomes in these situations. We assessed the functional outcomes of older adults treated with RSA for proximal humeral fractures compared with hemiarthroplasty. Methods: We searched MEDLINE, the Cochrane Central Register of Controlled Trials, EMBASE, and 3 clinical trials registries. We included all studies treating proximal humeral fractures with RSA in adults with a mean age older than 60 years and 1 year of follow-up. We calculated weighted mean differences (WMD) for range of motion and standardized mean differences (SMD) for shoulder scores. Postoperative complications were evaluated qualitatively. Results: Fifteen studies met inclusion criteria, including 577 patients treated with RSA and 504 patients treated with hemiarthroplasty. Compared to the RSA group had improved forward flexion (WMD 21°, $p=0.02$) and functional outcome scores (SMD 0.44, $p=0.005$) compared with the hemiarthroplasty group but decreased external rotation (WMD 5°, $p<0.0001$). Postoperative complications were similar between the 2 groups. Conclusion: RSA results in improved forward flexion and functional outcome scores compared with hemiarthroplasty for elderly adults with proximal humeral fractures. Complications do not appear to be appreciably higher in the RSA group in the existing follow-up. The results of this review suggest that RSA is a reasonable alternative for treating older adults with proximal humeral fractures, but more research and longer follow-up are needed. Level of evidence: Level IV, Systematic Review.
25 REVERSE TOTAL SHOULDER ARTHROPLASTY FOR ACUTE PROXIMAL HUMERUS FRACTURE: IS THERE A BENEFIT IN USING A FRACTURE-SPECIFIC STEM?
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Background: Optimal management of proximal humerus fractures remains controversial. Reverse total shoulder arthroplasty (RTSA) has shown promise as an effective option for the treatment of proximal humerus fractures in selected patients. Recently, fracture-specific humeral stem designs have been developed for use during RTSA for fracture, but outcomes of these specialized implants remain unknown. We present here the clinical and radiographic results of RTSA for acute proximal humerus fractures using both a standard stem and a fracture-specific stem. Materials and Methods: Between September 2006 and March 2011, 96 patients underwent RTSA for the treatment of acute proximal humerus fracture by two senior surgeons at two institutions. Fourteen patients with less than twelve month postoperative follow-up were excluded, leaving 82 patients at final review. Twenty-five patients were treated with a standard RTSA humeral component (Group 1); the remaining 57 patients were treated with a fracture-specific RTSA humeral component designed to promote tuberosity healing (Group 2). Average patient age was 77.3 years (range 50-97 years). There were 12 males and 70 females. All 82 patients were evaluated clinically and radiographically at an average of 19.1 months (range 12-70 months) postoperatively. Radiographs were reviewed by four fellowship-trained shoulder surgeons to assess greater tuberosity healing. Results: Overall, 73.2% (60/82) of greater tuberosities healed. In Group 1 the tuberosity healing rate was 68.0% (17/25), active anterior elevation was 148.6° ± 15.8°, external rotation was 37.8° ± 19.5°, and internal rotation was 34.8° ± 14.0°. In Group 2 the tuberosity healing rate was 75.4% (43/57); p = 0.484, active anterior elevation was 137.7° ± 22.8° (p = 0.033), external rotation was 29.1° ± 14.9° (p = 0.029), and internal rotation was to 40.7° ± 20.7° (p = 0.203). Overall, for patients with healed greater tuberosities, active anterior elevation averaged 146.9° ± 18.2°, external rotation averaged 36.6° ± 12.8°, and internal rotation averaged 41.8° ± 18.8°. Patients with radiographic greater tuberosity nonunion had mean anterior elevation of 124.9° ± 21.6° (p = 0.0001), mean external rotation of 18.5° ± 19.4° (p = 0.0001), and mean internal rotation of 30.9° ± 18.5° (p = 0.022). Conclusions: RTSA is an effective treatment option for selected patients with acute proximal humerus fractures. In this large series, there was no statistical difference in greater tuberosity healing between a standard humeral stem and a fracture-specific humeral stem. As has been reported previously, greater tuberosity healing was independently associated with increased range of motion in all measured parameters. Interestingly, the use of a standard humeral stem was also independently associated with increased active anterior elevation and active external rotation. This finding may be related to differences in both proximal geometry and size between the standard stem used and the fracture-specific stem used in this case series, as well as the large number of female patients who are smaller in physical stature. Based on these findings, we now recommend use of a standard humeral RTSA stem in most female patients and reserve the fracture-specific stem for males and physically larger females. Level of Evidence: Prospectively comparative case series—Level III.

26 INCIDENCE AND RISK FACTORS FOR ACUTE INFECTION AFTER PROXIMAL HUMERAL FRACTURES: A MULTICENTER STUDY
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Background: The rate of acute infection after surgery for proximal humeral fractures is not known with certainty. The aims of this study were to report the incidence and analyze the risk factors for infection after treatment for proximal humeral fracture. Methods: We report a retrospective multicenter study including 452 proximal humeral fractures. Data were modeled using univariate and linear regression analyses where appropriate to determine the ODDS ratio. A logistic regression analysis was employed to control for demographic and other characteristics with the potential to confound a true association between risk factors and infection. Results: The average age was 62.1 years, 314 were female. Eighteen patients (4%) had an acute infection. Of the 18 cases of infection, 5 needed a second surgery of which 4 had had a plate fixation and 1 a percutaneous fixation (p = 0.047). The factors that correlated with infection were length of surgery (ODDS 1.009, p = 0.05), preoperative lavage with chlorhexidine gluconate (ODDS 0.13, p = 0.008) and prophylactic antibiotic (ODDS 10.73, p = 0.03). The lowest incidence of infection was observed when the patients underwent surgery within 48 hours of trauma (rate 1.56%). The patients were clustered in two groups according to the breakpoint of the regression model function that was observed at 5 to 6 days after trauma (Figure 1). Two hundred eighty two patients underwent surgery within 6 days of the trauma. In this subgroup of patients we observed most of the acute infections (12 out of 18). A post hoc analysis in this subgroup of patients confirmed the previous data. The length of surgery was found to significantly increase the rate of infection (ODDS ratio 1.01, p = 0.02). Within 6 days of the trauma, the delay to surgery was found to be potentially related to the rate of infection (ODDS ratio 1.7, p = 0.06). Conclusion: This study suggests that washing the shoulder with chlorhexidine gluconate and avoiding the use of first generation cephalosporin in favor of more effective prophylactic therapy are effective at reducing the risk for infection after treatment for proximal humeral fractures. With the data available we cannot suggest operating within 48 hours of trauma. Although some evidence exists in this direction, more studies are needed.

Figure 1

27 HUMERAL HEAD REPLACEMENT COMBINED WITH MENISCAL ALLOGRAFT INTERPOSITION VERSUS NON-PROSTHETIC GLENOID ARTHROPLASTY: PRELIMINARY DATA FROM A PROSPECTIVE RANDOMIZED CLINICAL TRIAL
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Background: Treatment of glenohumeral arthritis in young patients after failure of nonoperative measures presents a unique clinical challenge. Concerns about wear and loosening of polyethylene glenoid prostheses have led many surgeons to consider hemiarthroplasty in this patient group. Both non-prosthetic glenoid arthroplasty (NPGA; “ream and run”) and meniscal allograft interposition (MAI) have shown promise for improving function and comfort in single-surgeon case series, but no comparative study...
has yet been performed to compare the relative efficacy of each method. The purpose of this work is to present interim results of a prospective, randomized clinical trial with minimum two-year follow-up of all reported patients. **Methods:** Approval for a prospective, randomized clinical trial was obtained from the applicable IRB prior to beginning enrollment in 2005. Patients with glenohumeral arthritis who wished to avoid prosthetic glenoid implantation due to high activity levels and concerns for glenoid wear were included. After informed consent was provided, patients were randomized at the time of glenoid exposure to undergo humeral head replacement with either meniscal allograft resurfacing or non-prosthetic glenoid arthroplasty as previously described. Patient outcomes were assessed at yearly intervals using American Shoulder and Elbow Society (ASES), Simple Shoulder Test (SST) and Visual Analog Scale (VAS) self-reported scores as well as standardized true anteroposterior (AP) and axillary lateral radiographs and physical examination of range of motion (ROM). Patients with a minimum of two-year clinical follow-up were included. The change between pre- and post-operative outcome measures in each group was subjected to statistical analysis. **Results:** 26 patients underwent randomization between October 2005 and July 2010 (MAI: n=12; NPGA: n=14). Of these, minimum 2-year clinical follow-up was obtained for 24 patients (MAI: 12/12; NPGA: 12/14) by way of clinical visits, mailed questionnaires or telephone surveys. Average follow-up times were 4.1 years (MAI) and 3.6 years (NPGA). SST scores improved significantly in both groups (MAI pre-op.: 5.0±3.3, latest follow-up: 9.4±3.1; NPGA pre-op.: 3.5±3.3, latest follow-up: 9.8±2.9; p<0.01). ASES scores, ROM testing for active elevation and passive external rotation, and VAS at rest and with strenuous activity were significantly improved at latest follow-up in both groups when compared to pre-operative values (p<0.01 for all outcomes). There was no statistically significant difference in change from pre- to post-operative outcome for SST, VAS or ROM between the two groups. Radiographic follow-up was obtained for 18 patients (MAI: n=9, mean follow-up 4.0 yrs; NPGA: n=9, mean follow-up 2.6 yrs). This showed significantly decreased glenohumeral joint space in the MAI group as measured on a true AP radiograph (immediate post-op.: 3.2±1.2 mm, latest follow-up: 0.8±0.8 mm, p<0.001). Posterior glenoid erosion measured on an axillary lateral radiograph increased in the MAI group (immediate post-op.: 6.8±4.8; latest follow-up: 11.2±5.7, p=0.06), but this did not reach the defined level of statistical significance. When compared to the NPGA group, the MAI group also showed a greater decline in glenohumeral joint space (p=0.004) and a greater increase in posterior subluxation (p=0.02). **Conclusions:** This interim analysis shows improved function and comfort for patients who underwent both procedures at 2-year minimum follow-up. No significant clinical differences or trends were noted between the groups in terms of ROM or standardized scoring systems. Radiographic evaluations showed greater loss of glenohumeral joint space and increased posterior subluxation in the MAI group. Enrollment to 36 patients per group based on a priori power analysis will continue as planned.

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**28 IN VIVO MICROMOTION COMPARISON OF A KEELLED VERSUS PEGGED GLENOID IN A TOTAL SHOULDER REPLACEMENT: A TWO-YEAR RADIOSTEREOMETRIC ANALYSIS STUDY**

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**Introduction:** Total shoulder arthroplasty (TSA) is a well-established treatment for degenerative joint disease, but there are still concerns about loosening of the glenoid component due to cyclic edge loading [1]. A recently introduced pegged glenoid design was thought to withstand edge loading better than the standard keeled design [2]. The primary objectives of this study were the following: 1. To establish the validity and reliability of RSA to measure glenoid micromotion; 2. To measure the translational and rotational micromotion of the glenoid components of the pegged and keeled design as measured by RSA; and 3. Compare the two groups with respect to patient reported quality of life and function. **Methods:** An RSA phantom study was performed prior to the clinical trial to determine appropriate marker placement and the accuracy of the system. A Sawbones (Pacific Research Laboratories, Inc, Washington) humerus and scapula were mounted to an acrylic base and seven markers were inserted into the glenoid, acromion, and coracoic process and three markers into the humerus (Figure 1). High accuracy linear motion stages were used to incrementally translate the humerus with respect to the scapula in all directions to attain the system accuracy. For the clinical trial, fifteen participants (1 bilateral; 16 shoulders) were randomized to one of two study groups, to receive either the pegged or keeled glenoid design. The participants consisted of ten men (one bilateral) and five women with an average age of 64 (range 46 to 75) at the time of surgery. All patients received a humeral stem and modular head in combination with a pre-marked pegged (eight shoulders) or keeled (eight shoulders) polyethylene glenoid (Biomet Orthopaedics, Warsaw, IN). Six tantalum markers were pre-embedded in the glenoid components by Biomet Orthopaedics. Between five and ten tantalum markers were inserted during surgery (Figure 2). RSA exams, physical assessment, and three subjective outcome scores, Western Ontario Osteoarthritis of the Shoulder Index (WOOS), American Shoulder and Elbow Society Shoulder Score (ASES), and the Simple Shoulder Test (SST), were completed at 6 weeks, 6-, 12-, and 24-months post-surgery. Initially, the RSA radiographs were obtained across the body (medial-lateral), but this lead to occlusion of many of the implanted markers by the humeral head (Figure 3). Based on the advice of a fellow RSA researcher (Dr. Charles Bragdon), x-rays were obtained in a longitudinal (superior-inferior) direction. Analysis of RSA radiographs was performed using UmRSA version 6.0 (RSA Biomedical, Umea, Sweden). For all comparisons, statistical power was p<0.05. **Results:** From the TSA phantom, the translational precision and accuracy was better than 20 microns in any direction and the precision (zero-displacement between glenoid component and scapula) was better than 10 microns in any direction (Table 1). Altering the orientation of the RSA radiographs led to an increase in the number of markers visualized in each patient exam, thereby reducing the number of exams that were rejected. Improvement was seen in later patients who underwent longitudinal oriented RSA exams, in which an average (SD) of 6.2 (1.3) markers were visible, compared to 5.1 (0.8) markers in earlier patients (p=0.16). Five patients were removed from analysis due to a lack of visible markers and at the 2-year exam, an additional two patients' data were removed due to high errors. Three participants from the keeled group withdrew from the study due to unrelated health concerns. No differences were detected between the pegged (n=5) versus keeled (n=3) glenoid designs in terms of rotation in the coronal plane (Figure 4) or translation (Figure 5). Some patients showed high early micromotion of the glenoid component; however, this may be a result of a lack of visible markers causing large errors in motion. All subjective outcome scores improved significantly for both study groups from pre- to post-surgery. Pre-to 24-months post-surgery, mean (SD) ASES score improved from 37.6% (15.3) to 84.5% (15.8), WOOS from 32.3 (18.0) to 79.5% (21.4), and SST from 3.2 (1.8) to 8.9 (3.1). No differences in subjective measures between groups were detected at any post-surgery time points. **Discussion:** Although the improvement in RSA exam orientation was not statistically significant, we feel that it was a substantial improvement as all data resulting from examination of patients using the new method, was of good quality. Therefore, we will continue to use the superior orientation for future RSA studies of the Shoulder. Due to the small number of patients in this study, no statistical difference was found between the pegged versus keeled glenoid fixation...
styles, which is consistent with one previous study [3], but inconsistent with another [2]. One limitation of this study was the small number of participants which may have lead to a Type II error. Overall, we were not able to infer any trends or patterns of in vivo motion for either glenoid component. Patients who showed high early migration of their glenoid components will be monitored closely for signs of early loosening.

References:

Table 1: Precision and accuracy of phantom testing.

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<thead>
<tr>
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<th>Precision</th>
<th>Accuracy</th>
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<td>Linear Displacement - Translation</td>
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<td>0.088°</td>
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Figure 1: TSA phantom model (a) and dual x-ray RSA setup (b).

Figure 2: Sample radiograph showing bead placement.

Figure 3: Medial/lateral (a), superior-inferior (b) orientation of the RSA setup.

Figure 4: Edge-lifting rotation (coronal plane) of the glenoid components.

Figure 5: 2-Dimensional translation (Sup/Inf & Med/Lat) of the glenoid.

29 THE RELATIONSHIP BETWEEN THE SUBCHONDRAL BONE DENSITY DISTRIBUTION AND GLENOID DEPTH: AN IN-VIVO PILOT STUDY OF MALE TOTAL SHOULDER ARTHROPLASTY SUBJECTS

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Background: Glenoid component loosening in Total Shoulder Arthroplasty (TSA) may be prevented with optimal component placement on a fully congruent and structurally adequate bony surface. Subchondral bone density (SBD) variability may have a significant correlation with this concept. The purpose of this study was to analyze the three-dimensional (3D) spatial distribution of glenoid SBD in a series of patients who underwent TSA for primary glenohumeral osteoarthritis. Materials and Methods: Three-Dimensional Computed Tomography Osteoabsorptiometry (CT-OAM) was...
performed on 42 male subjects, 21 patients with eccentric and 21 with concentric wear patterns in primary glenohumeral arthritis. Glenoid SBD was measured at varied depths from the joint surface based on five clinically relevant topographic zones. A comparison was performed to assess if wear pattern correlated with SBD distribution. Results: Subarticular layers of diseased glenoids could be quantified into distinct regions - calcified cartilage (up to 1.5 mm), subchondral plate (2 to 4.5 mm) and cancellous bone (greater than 5 mm). There were significant differences in SBD among these layers within and between concentric and eccentric wear patterns. In the concentric group, SBD distribution was homogenous. Mineralization was greater in the central zone 1749.1 ± 162.3 HU (at 2.5 mm depth) compared to the posterior, anterior and superior zones (p = 0.0002, p = 0.0005, and p = 0.0032 respectively). In the eccentric group, SBD distribution was inhomogenous. Mineralization was greatest in the posterior zone 1739.0 ± 172.6 HU (at 2.5 mm depth), followed by the inferior zone 1722.1 ± 186.6 HU (at 3 mm depth). Conclusion: This study represents the first study utilizing CT-OAM to evaluate the 3D SBD distribution of the glenoid vault for different wear patterns seen in osteoarthritis. Both wear patterns had localized increased subchondral density distribution, however concentric glenoids had a homogenous SBD distribution whereas eccentric glenoids had an inhomogeneous distribution. This may lead to a differential influence on the natural progression of articular cartilage and bone loss in glenohumeral osteoarthritis. Future studies are necessary to determine if this influence occurs. SBD distribution is a function of (1) depth from the articular surface, (2) topographic zone and (3) degenerative wear pattern. CT-OAM may be an effective tool to assist in pre-operative planning for shoulder arthroplasty.