PAPERS

PAPER NO. 61

Revision of Rotator Cuff Repair, Repair Integrity Influences the Clinical Results
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INTRODUCTION: Symptomatic recurrent cuff tear can lead to revision surgery. The purpose of this study was to analyze the clinical outcome and the status of the cuff after surgical revision with secondary repair. We hypothesize that tendon healing may influence the clinical results.

METHODS: Fifty patients (24 men, 26 women) with an average age of 60 years (28-80) underwent secondary repair for symptomatic recurrent cuff tear (arthroscopic in 30 cases and open in 20 cases). The recurrent tear was distal in 30 cases (62.5%), large in 12 cases (25%) and massive in six cases (12.5%). The average delay between initial repair and revision was 3.6 years (0.5-11). The functional outcome was assessed by using the Constant score and ultrasonography was used to assess tendon integrity.

RESULTS: At follow up (av 7.1 years, 0.8-15.8), the Constant score averaged 69.8 points (36-84). The rate of retear was 69%. In distal tears the score improved from 48.3 to 70.6 points (p<0.05) with 64% of retear. In large tears the score improved from 46.7 to 68.4 points (p<0.05) with 68.6% of retear. In massive tears the score improved from 43.6 to 67.1 (p<0.05) points with 71.3% of retear. The average Constant score was 72.4 points when the tendon was healed versus 59.7 points when tear recurred (p=0.05). There was no difference between open and arthroscopic procedure.

DISCUSSION AND CONCLUSION: Revision cuff repair allows significant functional improvement whatever the size of the recurrent tear. The results are influenced by the tendon integrity. Considering the high rate of re-rupture, biologic augmentation should be discussed in this indication.

PAPER NO. 62

Intra-operative Determinants of Rotator Cuff Repair Integrity: An Analysis in 500 Consecutive Repairs
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INTRODUCTION: Rotator cuff repair has a relatively high (20-90%) chance of re-tear. Patients with an intact rotator cuff six months post surgery have better subjective and objective outcomes at six months and two years following rotator cuff repair than those who do not have an intact repair. The aim of this study was to determine if, and so which, intra-operative factors predict an intact repair six months after rotator cuff repair.

METHODS: The study consisted of a cohort of 500 consecutive patients who had an arthroscopic rotator cuff repair performed by a single surgeon and an ultrasound evaluation of the repair six months post repair using standard protocols. Exclusion criteria included previous fractures or shoulder surgery, incomplete or partial rotator cuff repair and concomitant arthropathy. Rotator cuff tear size was measured intra-operatively and mapped. The quality of the tendon, tendon mobility and repair quality were assessed and ranked based on predetermined scales (1 to 4) and recorded on a specifically designed form. Logistic regression analysis was performed with cuff integrity at six months as the dependent variable and tear/repair factors as the independent variables.

RESULTS: The overall post-operative re-tear rate was 19% at six months post repair. The best predictor of rotator cuff integrity was pre-operative tear size (correlation coefficient, r = 0.33, p < 0.001). Patients with small (≤ 2 cm²) rotator cuff tears were least likely to re-tear (re-tear rate: 10%). As the tear-size increased, the re-tear rate increased in a linear fashion: ≤ 2 cm² (10%), 2-4 cm² (16%), 4-6 cm² (31%), 6-8 cm² (50%), > 8 cm² (57%) (Fig). Other surgeon-ranked intra-operative assessments did correlate (negatively) with re-tear, but the correlations were relatively weak: repair quality (r = -0.17, p < 0.001), tendon mobility (r = -0.15, p < 0.001), tendon quality (r = -0.14 p < 0.01). Regression analysis showed that the re-tear rate at six months was best predicted from the preoperative tear size and surgeon-ranked repair quality: chance of re-tear = 0.4 + (0.02 x tear size in cm²) - (0.08 x repair quality). Tendon quality and tendon mobility did not contribute significantly to this prediction.

DISCUSSION AND CONCLUSION: Tear size was the best intra-operative predictor of repair integrity post-rotator cuff repair, with tears less than 2 cm² twice as likely to heal than tears greater than 6 cm².

PAPER NO. 63

Supraspinatus Activity during Activities of Daily Living after Arthroscopic Rotator Cuff Repair
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INTRODUCTION: The aim of this study was to evaluate the activity of the repaired supraspinatus tendon during Activities of Daily Living (ADLs) in the early post-operative period. We hypothesized that the supraspinatus muscle would be minimally active when compared to normal controls.

METHODS: Ten patients who were nine to 12 weeks post-op after arthroscopic single tendon repair of the supraspinatus attachment...
and seven healthy controls were recruited. The supraspinatus muscle and 11 other muscles of the shoulder were tested using surface and fine wire EMG while subjects performed a series of Maximum Voluntary Contractions (MVCs) in standard testing positions. Each MVC was designed to test maximum activity level from one instrumented muscle although all 12 muscles were tested in each position. After completing the standardized MVC, testing subjects completed a series of ADL tasks in randomized sequence (Table 1). The %MVC was calculated for each muscle during the ADL task so that data could be normalized across subjects.

RESULTS: All post-operative patients demonstrated greater mean %MVC than normal controls in all ADLs (Figure 1). However, this difference was statistically significant for only the mouse, phone, and push open door tasks. Among post-operative patients the supraspinatus was most active during the drinking, writing, and phone tasks (52.8, 51.5, and 50.5% MVC respectively). Among normal controls, the supraspinatus was most active during the comb task (30.1 %MVC). Comparison of quantitative EMG data between these two groups is not valid because the EMG gain must be adjusted for each muscle tested in each subject.

DISCUSSION AND CONCLUSION: In the early post-operative period after rotator cuff repair, supraspinatus activity is greater than that of healthy controls when normalized to maximum voluntary contractions.

Table 2: Activities of Daily Living Tasks performed with the tested shoulder

| Activity of Daily Living Task | %MVC
|------------------------------|------
| Drink from a cup              | 20.0%
| Reach for pen/compass         | 50.5%
| Reach for a light switch      | 51.5%
| Open door with a lever handle | 35.3%
| Open door with a lever handle | 37.5%
| Write                         | 45.5%
| Typing on a keyboard          | 25.0%
| Hold a telephone phone or ear | 15.0%

![Figure 1: Supraspinatus Activity During ADLs](image)

PAPER NO. 64

Effect of COX-2 Receptor Inhibitors on the Biomechanical Strength of Repaired Rotator Cuff Tendon in a Rat Model

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INTRODUCTION: Rotator cuff (RC) tears are a common clinical problem that can cause pain and limit shoulder function. Nonsteroidal anti-inflammatory drugs are commonly prescribed after rotator cuff repair. These agents can impair bone formation, but only few studies have evaluated their impact on tendon-to-bone healing. We assert that meloxicam, a selective COX-2 inhibitor (COX-2-I), may show negative effect on RC healing when given immediately after surgical tendon repair.

METHODS: Thirty Wistar rats underwent acute rotator cuff repairs and were randomly allocated into three groups of 10 replicates: Group A rats were given daily intraperitoneal injections of meloxicam (3 mg/kg body weight) for the first 10 days after surgery; Group B rats were given intraperitoneal meloxicam from day 10; Group C-control group rats were given daily intraperitoneal injections of saline (3 mg/kg body weight) for three weeks. Animals were sacrificed at three weeks and evaluated by gross inspection and biomechanical testing.

RESULTS: There were significantly lower failure loads in the group B treated with meloxicam from post-injury day 10 compared with the control groups at three weeks (9N VS 15N; P = 0.004), and compared with Group A (9N VS 12.9N; P=0.04). Biomechanical strength was lower in a Group A than in a Control group, however not significantly (12.9N VS 15N; P= 0.198).

DISCUSSION AND CONCLUSION: SAfter the initial injury, there are characteristic three stages of tendon healing: inflammatory, proliferative, and remodeling. Meloxicam significantly decreased biomechanical strength of the repaired RC when administered from post-injury day 10 compared with the control group and group treated for the first 10 days after surgery. This fact might indicate that COX-2 inhibitors interfere with the proliferative stage of the tendon healing, which is crucial for tendon mechanical properties.
contraction with a 1-kg weight. Statistical analyses were performed using intraclass correlation coefficient (ICC_{(1,3)}), analysis of variance, and Pearson product-moment correlation coefficient.

RESULTS: Intra-examiner reliability of three-time measurements under each condition ranged from 0.931 to 0.998 in ICC_{(1,3)}. Strain ratios both for the supraspinatus muscle and its tendon significantly decreased with increases in the load (p<0.05) (Table 1). Figure 1 and 2 present typical changes of strain in the muscle and tendon, respectively. A low positive correlation was observed in strain ratios between the muscle and the tendon (r=0.222, p=0.080).

DISCUSSION AND CONCLUSION: This study has demonstrated that the stiffness measurement using elastography has an excellent reliability. It also has a potential to detect stiffness changes in the supraspinatus muscle as well as the supraspinatus tendon under various loading conditions.

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<thead>
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<th>Changes in strain ratio of the supraspinatus muscle and tendon</th>
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**PAPER NO. 67**

**Shoulder Muscle Activity and Compensation after Arthroscopic Rotator Cuff Tear**

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INTRODUCTION: The aim of this study was to evaluate the activity of the repaired supraspinatus tendon and compensatory contributions of other shoulder muscles in the early post-operative period. We hypothesized that the deltoid muscle would provide compensation for the repaired supraspinatus muscles.

METHODS: Ten patients who were 9-12 weeks post-op after arthroscopic single tendon repair of the supraspinatus attachment were recruited. Twelve muscles of the shoulder girdle were tested using surface and fine wire EMG. Subjects performed a series of maximum voluntary contractions (MVCs) in standard testing positions. Each MVC was designed to test maximum activity level from one instrumented muscle although all 12 muscles were tested in each position. A clinical score was developed for preliminary assessment of muscle activity: 1=0-<25% active, 2 = 25% -<50% active, 3= 50% -<75% active and 4 = ≥75% active. Mean clinical scores were calculated for each muscle in the supraspinatus testing position. The mean clinical scores were also calculated for the supraspinatus muscle in each testing position.

RESULTS: In the supraspinatus testing position, resisted elevation at 90° elevation on the scapular plane with 45° internal rotation
and elbow extension, the most active muscles were the posterior deltoid, serratus, and upper trapezius with mean clinical scores of 2.9, 2.6, and 2.6 respectively (Figure 1). The supraspinatus muscle was most active when tested in the upper infraspinatus testing position (Resisted external rotation at 0° elevation and neutral rotation) and middle deltoid testing positions (Resisted abduction at 0° elevation in the scapular plane and elbow flexion to 90°) testing positions with clinical scores 3.3, and 2.9 respectively (Figure 2). DISCUSSION AND CONCLUSION: In the early post-operative period, the deltoid, serratus, and upper trapezius muscles compensate for supraspinatus activity while the supraspinatus is most active in the infraspinatus and middle deltoid positions.

DISCUSSION AND CONCLUSION: In the early post-operative period, the deltoid, serratus, and upper trapezius muscles compensate for supraspinatus activity while the supraspinatus is most active in the infraspinatus and middle deltoid positions.

PAPER NO. 68
A Mouse Model of Massive Rotator Cuff Tears
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INTRODUCTION: Rotator cuff tears (RCT) are the most common tendon injury seen in orthopaedic patients. Muscle atrophy and fatty infiltration in rotator cuff muscles are considered among the key factors responsible for the failure of attempted massive RCT repair. However, the pathophysiology of rotator cuff muscle atrophy and fatty infiltration remains largely unknown, partially due to the lack of appropriate small animal models. The goal of this study was to develop a mouse model of muscle atrophy and fatty infiltration after RCT. We also sought to study the role of denervation on muscle atrophy after massive RCT. Our data showed that denervation of the rotator cuff muscles considerably enhanced the development of atrophy and fatty infiltration in our model. This data suggests that it may be important clinically to determine the status of the suprascapular nerve as denervation may have a more important role in muscle atrophy after massive RCT.

RESULTS: Significant and consistent muscle atrophy and fatty infiltration were observed in the rotator cuff muscles after rotator cuff tendon transection in both MRI scanning (Figure 1) and histology (Figure 2). The wet weight of supraspinatus muscle reduced 25.0±1.3%, 54.5±3.7% and 68.6±4.0% and that of infraspinatus muscle reduced 29.6±3.5%, 55.2±1.5% and 72.1±3.1% in TT, DN and TT+DN group, respectively, compared to the control side. ANOVA analysis showed significant difference between each group (P<0.05) with the maximum muscle weight loss in the TT+DN group in both muscles. In histological analysis, the relative adipose tissue areas (area of fat tissue/area of muscle cross section) in the supraspinatus were 0.131±0.15%, 0.375±0.34%, 14.2±13% and 19.4±12% in the sham, TT, DN and TT+DN groups respectively. Those in the infraspinatus are 0.573±0.28%, 0.572±0.33%, 4.52±1.2% and 13.9±4.8% in the sham, TT, DN and TT+DN groups respectively (Figure 2; *, P<0.05 vs. sham; **, P<0.05 vs. TT; ***, P<0.05 vs. DN).

DISCUSSION AND CONCLUSION: Successful development of this novel mouse RCT model will provide us a powerful tool to study the molecular mechanisms of muscle atrophy and fatty infiltration by introducing transgenic and knockout mice in the future. This model will also serve as a powerful in vivo model in developing new treatments for this common disease. Denervation of rotator cuff muscles after massive RCT due to suprascapular nerve entrapment after tendon rupture is suspected to play a role in muscle atrophy after massive RCT. Our data showed that denervation of the rotator cuff muscles considerably enhanced the development of atrophy and fatty infiltration after RCT. This data suggests that it may be important clinically to determine the status of the suprascapular nerve as denervation may have a more important role in muscle atrophy after massive RCT.
Shoulder Stiffness after Rotator Cuff Repair - Risk Factors and its Influence to Outcome

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Sae Hoon Kim, MD, Seoul, Republic of Korea
Joon Yub Kim, MD
Seung Han Shin, Seoul, Republic of Korea
Yeun Ho Kim, Seongnam-Si, Gyeonggi-Do, Republic of Korea
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INTRODUCTION: The purpose of this study is to determine the incidence of postoperative stiffness following rotator cuff repair, and to evaluate the risk factors for postoperative stiffness and its influence to outcome. METHODS: We included 288 patients (mean age 59.5 ± 8.4 years) who underwent surgical repair of full-thickness rotator cuff tear between July 2003 and September 2009, and whose postoperative range of motion were measured serially at three months, six months, and final follow up (mean 22.8 ± 13.1 months, range 12 to 70 months). Simultaneously, their cuff healing was confirmed by CT arthrography or ultrasonography after at least one year after surgery (mean 17.5 ± 5.7 months), and functional outcome was evaluated using pain VAS and American Shoulder Elbow Surgeon (ASES) score. We calculated the serial incidence of postoperative stiffness at each follow-up visit. Also, we assessed the risk factors for the postoperative stiffness with various clinical variables at each period, and evaluated the correlation of stiffness with anatomical and functional outcomes. RESULTS: The incidences of postoperative stiffness were 18.6% (54/288) at three months, 2.8% (8/288) at six months, and 6.6% (19/288) at the final follow up. The mean age was higher in the stiffness group at each follow-up period (all p < 0.05). Preoperative stiffness affected postoperative stiffness only at three months (p = 0.04), but not at six months and final follow up. Whereas, higher grade of fatty degeneration (FD) in all cuff muscles and larger tear size in both AP dimension and retraction was affected by older age and preoperative stiffness. However, stiffness after at least one year of surgical rotator cuff repair was influenced by higher FD of all cuff muscles, larger tear size, and open or mini-open surgery. Furthermore, this was closely related to the failure of cuff healing after surgical repair, and brought about significantly worse functional outcomes.

Suprascapular Nerve; Does Neuropathy Exist with Large Rotator Cuff Tears? A Prospective Electromyography Study

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Luc Favard, MD, Tours, France

INTRODUCTION: An association between massive rotator cuff tears and suprascapular nerve neuropathy has been previously suggested. The anatomical course of the suprascapular nerve is relatively fixed along its passage. Injury to the nerve by trauma, compression and iatrogenic reasons is well documented. But as a reason for pain and weakness in massive rotator cuff tears due to muscle retraction and nerve impingement remains unclear. We aimed to prospectively evaluate the suprascapular nerve for electromyography (EMG) abnormalities pre-operative in shoulders with massive rotator cuff tears. METHODS: A prospective study was performed in two centers. Fifty patients with retracted tears of both supraspinatus and infraspinatus were evaluated. This was confirmed with preoperative CT scans, and the fatty infiltration of the affected muscles was graded. Forty-nine preoperative EMGs were performed in a standardized fashion and the results analyzed twice. RESULTS: The 49 EMGs were interpreted: one positive EMG with the suprascapular nerve affected; one radicular lesion of C5; one EMG affected by a history of stroke; three partial axillary nerve palsies with a history of shoulder dislocation; and 43 normal EMGs. We saw no difference or diminution of the latency or amplitude of the EMG curve in the cases of with significant fatty infiltration. DISCUSSION AND CONCLUSION: An EMG study did not detect a suprascapular lesion in the majority of cases of massive cuff tears. With a low association of neuropathy with massive cuff tears, there is no support for the routine suprascapular nerve release when performing the repair.

Comparison of Conventional Sonography and Arthrosonography in Cuff Integrity after Rotator Cuff Repair

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INTRODUCTION: We hypothesized that arthrosonography is a better method than conventional sonography in evaluating cuff integrity after rotator cuff repair. We performed conventional sonography, MRA, and arthrosonography at postoperative six months and compared the results of conventional sonography and arthrosonography to those of MRA, respectively. METHODS: Patients who were able to receive conventional sonography, MRA, and arthrosonography six months after receiving arthroscopic rotator cuff repair for a full-thickness tear of the supraspinatus between September 2009 through April 2010 were included in this study (34 cases; 10 males, 24 females, average age: 59.4 years). All imaging studies were read by musculoskeletal radiologist, and all imaging studies were performed in order to evaluate integrity of the supraspinatus. The results of each modality were compared. RESULTS: Of all 34 cases, full-thickness defects were found in three cases (8.8%) by conventional sonography, 16 cases (47.0%) by...
METHODS: A cohort of 87 patients suspected of having SSN was retrospectively identified from a referral shoulder practice. All underwent electromyography/nerve conduction velocity study (EMG/NCV) and magnetic resonance imaging (MRI) of the suprascapular nerves. The suprascapular nerves were classified into the following categories: normal muscle, minor fatty streaks, significant fatty degeneration (Goutallier stages 2, 3, and 4); infraspinatus (Goutallier stages 0 and 1), and 22 of 87 patients had significant fatty degeneration (absence of fibrillations and sharp waves, and normal NCV), and seven had C5-C6 radiculopathy and/or SSN.

DISCUSSION AND CONCLUSION: The exact association and etiology of SSN in patients with rotator cuff tears remain unclear, but it appears it is not associated with tendon tear size and retraction, and fatty degeneration does not influence the EMG/NCV results.

PAPER NO. 73
Partial Repair of Chronic Massive Rotator Cuff Tears Improves Shoulder Function in a Rat Model
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INTRODUCTION: Rotator cuff tears involving two tendons can disrupt the normal kinematics of the shoulder and lead to functional impairment. Although partial repair of the rotator cuff has been employed clinically, there have been no in vivo studies quantitatively evaluating shoulder function after restoration of the anterior-posterior cuff forces following partial repair of a chronic, massive rotator cuff tear. Therefore, the objective of this study was to use quantitative ambulatory measures in a rat rotator cuff model to determine if repair of the posterior cuff tendons and subsequent restoration of the balance of anterior-posterior forces improves shoulder function after a chronic two-tendon rotator cuff tear. We hypothesize that restoring the balance of the anterior and posterior cuff forces by repair of the infraspinatus tendon alone would improve shoulder function to a level similar to repairing both the supraspinatus and infraspinatus tendons.

METHODS: Forty-eight adult Sprague-Dawley rats underwent detachment of the supraspinatus and infraspinatus tendons. Four weeks after detachment, the rats were randomly assigned to three treatment groups: no repair (n=16), infraspinatus repair alone (n=16), and two-tendon repair (n=16). Forelimb gait and ground reaction forces were quantified using an instrumented walkway as described. Data was collected one day prior to detachment surgery to obtain baseline ambulatory values for the animals, then collected at day -1 (day prior to repair surgery), 3, 7, 10, 14, 21, and 28 days post-repair surgery. Ground reaction force data, including medial/lateral forces, braking forces, propulsion forces, and vertical forces, were collected for each walk. Paw print analysis allowed for measurement of step width, an indication of shoulder dysfunction in the rat. Data was compared using a one-way ANOVA followed by an LSD post-hoc test to study the effect of group at each time point. Comparisons of interest were infraspinatus repair alone to no repair, and infraspinatus repair alone to a two-tendon repair. To correct for multiple comparisons, significance was set at p<0.025 (0.05/2). RESULTS: At nearly every time point post-repair surgery, the medial/lateral, braking, and propulsion forces of the infraspinatus only repair animals were significantly different than those forces of the no repair group (p<0.025). Furthermore, kinetics of the infraspinatus repair group mirrored that of the two-tendon repair group, with differences found at only the early post-surgical time points (Table 1). This pattern was also seen in step width, with the no repair group having decreased step width compared to the infraspinatus only and two-tendon repair groups, indicating “tripoding” and decreased shoulder function in those animals.
DISCUSSION AND CONCLUSION: These results support our hypothesis that restoring the balance of anterior-posterior forces by repair of the infraspinatus only is sufficient to improve shoulder function to a level similar to repairing the supraspinatus and infraspinatus together. Restoring the balance of forces likely recreates a stable fulcrum for concentric rotation of the humeral head in the glenoid. Clinically, this data suggests that a partial repair of the infraspinatus only after a chronic, massive two-tendon rotator cuff tear may restore adequate shoulder function.

<table>
<thead>
<tr>
<th>TABLE 1: KINETIC VARIABLES BETWEEN GROUPS</th>
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<tr>
<td>Kinetic variable</td>
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<tr>
<td>Medial/lateral force</td>
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<td>Braking force</td>
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<td>Propulsion force</td>
</tr>
<tr>
<td>Vertical force</td>
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*NS – no significance.

PAPER NO. 74
**Novel Anti-inflammatory Agent AMD 3100 Does Not Impede Rotator Cuff Tendon Healing in an Animal Model**

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Mindy A. Cote, MS, Providence, RI
David Paller, MS, Providence, RI
Lee Kaback, MD, Albany, NY
Francis Y. Lee, MD, PhD, New York, NY
Louis U. Bigliani, MD, New York, NY
Theodore A. Blaine, MD, Providence, RI

Introduction: Rotator cuff tendonitis and subacromial inflammation are mediated in part by SDF-1α expression in the subacromial bursa. A potential target for inhibition of SDF-1α mediated inflammation includes the SDF-1 receptor, CXCR4. In a prior study, we demonstrated that SDF-1α expression and subacromial bursa cell activity could be inhibited with two clinically available CXCR4 inhibitors, AMD 3100 and T140 analog. These new anti-inflammatory agents do not have the deleterious gastrointestinal or cardiac side effects of nonsteroidal agents and steroids, and may have significant clinical utility as novel injectable agents (US provisional patent 61/444,011) to treat rotator cuff disease. Their effects on rotator cuff healing, however, have not been determined. This study was designed to determine the effects of the CXCR4 inhibitor, AMD3100, on rotator cuff healing in an animal model. We hypothesized that AMD3100 will reduce inflammation in the subacromial bursa in rat shoulders with experimentally induced rotator cuff injury, but will not adversely affect tendon healing. Methods: 58 male Lewis rat shoulders underwent surgery per a previously established protocol in which the infraspinatus tendon was transected at its insertion. Eight uninjured rat shoulders were used as controls. Osmotic minipumps (Alzet) containing either AMD3100 or Phosphate Buffered Saline (PBS) were inserted through the same skin incision as the approach to the shoulder and placed into a subcutaneous pocket developed via blunt dissection. Animals were sacrificed at 3, 7, 14, 28 and 42 days. The shoulders were dissected to isolate the infraspinatus bone-tendon complex. Tendon healing was assessed histologically and biomechanically.

DISCUSSION AND CONCLUSION: These results support our hypothesis that restoring the balance of anterior-posterior forces by repair of the infraspinatus only is sufficient to improve shoulder function to a level similar to repairing the supraspinatus and infraspinatus together. Restoring the balance of forces likely recreates a stable fulcrum for concentric rotation of the humeral head in the glenoid. Clinically, this data suggests that a partial repair of the infraspinatus only after a chronic, massive two-tendon rotator cuff tear may restore adequate shoulder function.

**Figure 1: Maximum load to failure of infraspinatus tendons after rotator cuff injury in the presence or absence of CXCR4 inhibitor pump, AMD 3100.**

Discussion: In prior studies, we have demonstrated that CXCR4 inhibitors (AMD3100) may significantly decrease inflammation in human subacromial bursa cells, providing a novel anti-inflammatory pathway for the treatment of subacromial bursitis and rotator cuff disease. In the present study, we have further shown in a rat model of rotator cuff disease that AMD3100 does not inhibit rotator cuff healing. Therefore, CXCR4 inhibitors such as AMD3100 may present a new pharmacologic pathway, with fewer side effects, for the treatment of rotator cuff disease. Further clinical studies are planned to assess the clinical efficacy of these agents.

PAPER NO. 75
**Partial Thickness Rotator Cuff Tears: Observe or Operate?**

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INTRODUCTION: Despite being more common than full thickness rotator cuff tears, the treatment of partial thickness tears of the rotator cuff remains controversial. Furthermore, the majority of published literature is related to the diagnosis and operative treatment of such. Therefore, the purposes of this study were: 1) To determine baseline clinical factors predictive of successful outcome of non-operative treatment of partial thickness rotator cuff tears; 2) To determine the mid-term clinical success rate of non-operative treatment of partial thickness rotator cuff tears; 3) To determine the mid-term anatomic outcome of non-operative treatment of partial thickness rotator cuff tears. METHODS: All patients from the senior author’s practice between 2004 and 2006 with a primary diagnosis of a partial thickness...
rotator cuff tear (made via MRI/MRA) were eligible for inclusion. Patient with associated conditions, such as OA, SLAP lesion, AC joint pathology, or subscapularis tears, or patients with major medical illnesses were excluded. Patients were assessed clinically using a standardized protocol (physical exam as well as American Shoulder and Elbow Surgeons evaluation (ASES) and the Simple Shoulder Test (SST)) at baseline and follow up. Patients treated non-operatively underwent anatomic follow up utilizing MRI or MR-arthrogram imaging based on their initial imaging study.

RESULTS: Seventy-six patients (48 males, 28 females) with an average age of 52 +/- 10 years were included in the study. Forty-six (61%) had involvement of their dominant arm. Baseline ASES scores were 54.9/100 +/- 19.6, and baseline SST scores were 5.9/12 +/- 3.1. Thirty-seven patients (49%) underwent non-operative treatment, while 39 (51%) underwent surgical repair. Logistic regression analysis indicated that the baseline variables of side (dominant or non-dominant side involved), onset (traumatic or atraumatic) and thickness of tear (< 50% or >50%) were significant predictors of outcome. That is, patients who had dominant side involvement, traumatic onset, and a tear >50% thickness were more likely to go on to surgery, whereas patients who had involvement of their non-dominant side, atraumatic onset, and a tear <50% thickness were more likely to be treated successfully with non-operative treatment. Of the patients treated non-operatively, all underwent clinical and anatomic follow up at a mean of 46 months following their initial consultation. The mean ASES score at follow up was 85.1/100, and SST was 10.0/12. Overall subjective patient satisfaction on a 10-point scale was 7.5. A total of 78% of patients were satisfied with their treatment and stated that they would undergo the same form of treatment again. Anatomic outcome was performed at an average follow-up time of 53 months. Nine patients (24%) demonstrated tear progression, of which three patients (8%) demonstrated conversion to full-thickness tears. Twenty-four patients (65%) demonstrated no significant difference on their scans, and four patients (11%) showed improved tissue quality or some evidence of healing. Overall, 76% of tears treated non-operatively at mid-term follow up did not show tear progression on anatomic imaging. However, tears that were >50% thickness on the initial imaging study demonstrated tear progression 55% of the time.

DISCUSSION AND CONCLUSION: In conclusion, non-operative treatment was utilized in approximately 50% of the patients and overall 78% of patients were satisfied with their treatment. The baseline factors of onset, shoulder involved, and thickness of tear can be used to predict the optimal type of treatment. Overall, 76% of patients treated non-operatively demonstrated no tear progression, however in patients with tears >50% thickness, the tear progressed 55% of the time.

PAPER NO. 814

**Augmentation of Rat Rotator Cuff Repairs Using a Bioengineering Approach and Myostatin Inhibitors**

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INTRODUCTION: Rotator cuff healing results from the formation of scar tissue along the respective sites of repair, including the tendon-bone interface, the tendon-muscle interface, and the transition zones. Failed repairs consistently demonstrate the combination of muscle atrophy, fibrosis, and fatty infiltration. Myostatin (GDF-8) is a negative regulator of muscle, but has conversely been implicated to have positive effects within the acute healing phases of tendon remodeling. The purpose of this study was to determine the potential role of myostatin or myostatin inhibitors during the healing of acutely repaired rotator cuff defects in a rat model, with the eventual aim of providing a biologic augmentation for rotator cuff repairs. Our hypothesis was that inhibition of myostatin (GDF-8) would show improved healing within the supraspinatus muscle belly with respect to decreased muscle atrophy, fibrosis, and fatty infiltration based on histology and biomechanical testing.

METHODS: Seventy-two Sprague Dawley rats underwent acute supraspinatus detachment and repair of the left shoulder. In the control group (n=18), a modified Mason-Allen suture was placed in the supraspinatus tendon and then secured to the humerus through a bone tunnel. A second group (n=18) underwent similar repair with injection of 250 µg of hydrogel at the repair site and within the supraspinatus muscle. A third group (n=18) underwent similar repair with the addition of 250 µg of hydrogel loaded with 10 µl myostatin (GDF-8). The fourth group (n=18) underwent treatment with 250 µg of hydrogel loaded with 10 µl of a propeptide myostatin inhibitor. At four weeks, six animals from each group were sacrificed for histology. At eight weeks, five animals from each group were sacrificed for biomechanical testing and an additional seven animals were harvested for MRI analysis combined with histologic evaluation.

RESULTS: There was no statistical difference in the biomechanical strength of the repairs. Cross-sectional area of the myostatin inhibitor group, as measured by MRI analysis, was larger but did not reach statistical significance.

DISCUSSION AND CONCLUSION: In our initial study, neither the addition of myostatin (GDF-8) nor its propeptide inhibitor improved healing in a rat model of acute rotator cuff repair. MRI analysis may provide an alternative form of measuring muscle belly dimensions for biomechanical testing purposes. In addition, MRI analysis may help to quantify the level of fatty infiltrates and muscle atrophy in small animal rotator cuff studies, as well as provide comparative analysis with histology samples.

PAPER NO. 196

**Correlation Between Strength Deficits and Glenohumeral Internal Rotation Deficit in Elite Baseball Pitchers**

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INTRODUCTION: An increasing amount of data suggests a correlation between throwing arm pathology and rotational deficits in elite level baseball players.

METHODS: Over a four-year period, 268 major league baseball (MLB) major and minor league professional pitchers were evaluated upon entry into spring camp, prior to commencement of formal training drills by the same medical team. Physical examinations were performed on a consistent protocol. Direct measurements included shoulder and elbow range-of-motion and rotator cuff strength. Glenohumeral internal rotation deficit (GIRD) was calculated in both degrees and centimeters, based upon the index form of direct measurement of internal rotation. Total arc of motion was calculated in degrees. Strength was measured in the form of a commonly accepted manual motor scale. Independent t-tests, Fisher’s exact tests and binary logistic regressions were used to assess statistical differences.

RESULTS: Binary logistic regression analysis of a Poisson model. For full information refer to page 14. An alphabetical faculty financial disclosure list can be found starting on page 19.
distribution of GIRD (degrees - all pitchers) broken into five degree increments demonstrated a statistically significant increase in prevalence of rotator cuff strength deficit with increasing GIRD (p=.031). Of the shoulders evaluated, 199 shoulders were non-Latino players, while 69 were Latino players. Overall, the total arc of motion for Latino players, 170.7°, was significantly higher than that of the non-Latino players, 160.9° (p=.021). When measuring dominant shoulder glenohumeral internal rotation deficit (GIRD), the difference between Latino shoulders (17.9°) and non-Latino shoulders (14.0°) approached significance (p=.052). A total of 59.4% of Latinos had a GIRD > 10°, compared to only 46.7% of non-Latino players (p=.01). There were no differences between ethnicities in shoulder strength (manual muscle test) or prevalence of elbow pathology. We found that Latino players had a greater GIRD (23.0°) in the presence of a strength deficit compared to non-Latino shoulders (15.0°) with strength deficits (p=.044). Within Latino players, the GIRD (23.0°) seen in shoulders with strength deficits was statistically greater than the GIRD (15.5°) in shoulders with strength deficits (p=.044). There was no such statistically significant difference in GIRD for non-Latino players (p=.519). The same finding was demonstrated for Latino players when GIRD was calculated in centimeters (p=.024). The two methods of GIRD calculation - centimeters and degrees - were found to be significantly correlated (p=.001) as an internal check of consistency.

**DISCUSSION AND CONCLUSION:** We found a significant positive correlation between the prevalence of rotator cuff strength deficits and GIRD in the throwing arms of a large series of professional baseball pitchers. Such strength deficits could potentially predict or could be representative of the development of clinically significant shoulder pathology in this elite population of throwing athletes. Furthermore, significant differences in motion, motion deficit and correlation between motion deficit and strength were identified when comparing Latino vs. non-Latino players.

PAPER NO. 197

**Demographic Trends in Arthroscopic Superior Labral Anterior Posterior Repair**

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**INTRODUCTION:** Treatment of superior labral anterior posterior (SLAP) tears remains controversial particularly in older age groups. Repair, biceps tenodesis and observation have been recommended depending on patient characteristics but there have not been any large epidemiologic studies investigating treatment trends. The purpose of this study is to investigate current trends in SLAP repair across time, gender, age and regions in the United States. **METHODS:** Patients who underwent arthroscopic SLAP repair (CPT code 29807) were identified using a publicly available national database of insurance records (patient records database) during years 2004-2009. Factors identified for each patient included gender, age group, and region in the U.S. Logistic regression analysis and the chi-square test were used for statistical measures. **RESULTS:** From 2004 to 2009 there were 25,574 cases of arthroscopic SLAP repair identified, of which 75% were male and 25% were female. There was a 105% increase in cases of SLAP repair from 2004 to 2009 as the rate of SLAP repair increased from 0.17% of all orthopaedic operations in 2004 to 0.28% in 2009 (p<0.0001). Age analysis revealed the highest rates of operation in the 20-29 (0.29%) and 40-49 (0.28%) age groups. Males (0.37%) had a significantly higher frequency of surgery than females (0.11%). The South (0.24%) and West (0.25%) regions showed significantly higher rates of SLAP repair than the Midwest (0.21%) and Northeast (0.20%). **DISCUSSION AND CONCLUSION:** Our analysis illustrates that surgeons are performing more arthroscopic SLAP repairs. This likely represents a change in treatment preference of the surgeon rather than a true increase in the incidence of the pathology. The highest rates of repair are in the 20-29 and 40-49 age groups and a significant gender difference exists with males having a threefold higher frequency of repair. Future studies are needed to determine the clinical effects of the trends identified in this study.
PAPER NO. 198

Arthroscopic Latarjet: Anatomical Assessment of Safety and Reproducibility in Cadavers

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INTRODUCTION: Today, arthroscopy is the most used method for treating recurrent shoulder dislocation. Arthroscopic repair of Bankart lesions presents clinical results (Rowe clinical score) comparable to open repair(1). However, in cases in which there are bone lesions to the glenoid greater than 25% or Hill-Sachs lesions greater than 20%, the arthroscopic procedure for Bankart repair presents a high recurrence rate, reaching 67%(2). In addition, ligament and capsule failure and the presence of ligament injury at the anatomical neck of the humerus (HAGL lesion), with or without associated bone lesion, also presents a high recurrence rate with the Bankart procedure, whether performed as an open or arthroscopic technique(3). The treatment of choice for the above situations is the Bristow-Latarjet procedure, performed as open surgery, which consists of transferring the coracoid process to the anterior border of the glenoid(4). Success in the Bristow-Latarjet procedure results from a variety of factors that depend on adequate anatomical parameters, such as: coracoid-graft (CG) position below the equator of the glenoid, parallelism with the joint surface and longitudinal division of the subscapularis above its lower third(5). All these objectives can be attained through open surgery. Arthroscopic implementation of the Bristow-Latarjet procedure is a new method for treating recurrent glenohumeral dislocation. This arthroscopic method was first described by Lafosse et al in 2007(6) and makes it possible to combine the advantages of arthroscopy with the Latarjet bone grafting procedure. Nourissat et al(5) reported on an anatomical study using five cadavers, in which the Bristow-Latarjet procedure was performed using mini-incisions aided by arthroscopy. These authors demonstrated that the procedure was safe and enabled correct CG positioning, with excellent arthroscopic viewing, without associated injuries. There are currently no studies evaluating the safety of completely arthroscopic Latarjet procedure on cadavers.

METHODS: Twelve shoulder cadaver specimens were submitted to a latarjet arthroscopic procedure in our arthroscopic lab, by four surgeons (three surgeons each). After the surgery all specimens were dissected and submitted to x-ray exams and evaluated by an independent examiner. Nineteen anatomic and radiographic parameters were evaluated including coracoid graft fixation, screw positioning and agulation, neurological and tendons integrity.

RESULTS: The mean duration of the procedures was 137 minutes each. There were no injuries to the axillary or musculocutaneous nerves. The subscapularis split was, on average, at 52.2% of the distance between the upper and lower tendon edges. The coracoid graft was properly positioned relative to equator of the glenoid in 11 cases. The main complications found were: interposition of soft tissue, suprascapular nerve injury caused by protruding screws, joint-graft deviation, coracoid graft diastasis, conjoined tendon injury and injury to the lower portion of the subscapularis. The screws average angulation in relation to the articular glenoid line was 27.2°. Four of the procedures were considered to be satisfactory, without any difference between the surgeons.

DISCUSSION AND CONCLUSION: With the techniques available, we consider that the arthroscopic Latarjet procedure is a method with a high complication rate.

PAPER NO. 199

Stress Distribution on the Glenoid Did Shift Upward Due to the Dysfunction of the Long Head of Biceps Tendon

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INTRODUCTION: A rotator cuff tear may arise from primary degenerative changes of cuff tendons and may result from mechanical damage to tendons caused by impingement at the coracoacromial arch. When the rotator cuff tear occurs, forces compressing the humeral head toward the glenoid are disturbed, and the kinematics of the glenohumeral joint change. Therefore, stress distributions in cuff tear shoulders should differ from those in normal shoulders. The distribution of mineralization of the subchondral bone plate (DMSB) by measuring the use of CT-osteabsorptiometry (CTO) reflected the stress distribution on a joint surface, and several patterns of DMSB were investigated in any shoulder joint disorders. Our study investigated the DMSB in shoulders with rotator cuff tear by the CTO, and evaluated the change of the stress distribution on the glenoid among the tear sizes.

METHODS: Our study objected 67 patients with rotator cuff tear, who were diagnosed by MRI and also underwent the three-dimensional CT (3DCT) and CTO. Of the 67 shoulders, 16 were diagnosed as incomplete tear, 10 were as small tear, 17 were as medium tear, 15 were as large tear and nine were as massive tear. Of the 67 shoulders, 18 shoulders included the long head of the biceps tendon (LHBT) rupture, dislocation or subluxation in this current study. The glenoids were divided into 13 areas; a center of the glenoid and 12 parts of the circumference of the glenoid like a clock. And each area was graded on a scale 1-4 as the density of the subchondral bone plate. The higher score indicated the higher bone mass density. Additionally, we measured the acromio-humeral interval (AHI) by 3DCT and compared the values among the tear sizes. We measured the Pearson’s correlation coefficient between the tear sizes and the value of the DMSB at each area. Furthermore, the AHI values were statistically analyzed by using one-factor ANOVA analysis, and the post hoc test was used for the multiple comparison analysis. A P value of less than .05 was considered to be significant in these analyses.

RESULTS: In all shoulders, a high-density area was located at the two and 11 o’clock area of the glenoid, and there is no correlation coefficient against the tear size. However, the DMSB at the inferior part of the glenoid decreased as the tear size enlarged, and the six and eight o’clock area has a negative correlation between the tear size and the value of DMSB. The mean value of the AHI is 8.28mm in incomplete tear, 7.56mm in small tear, 8.07mm in medium tear, 7.02mm in large tear and 5.37mm in massive tear. We found statistical significance in the massive tear (p<.05). In the comparison of the value of DMSB with or without LHBT, the mean value of the AHI is 5.50mm in large tear without LHBT. There is statistical significance compared with the value of 7.76mm in large tear with LHBT.

DISCUSSION AND CONCLUSION: The stress distribution on the glenoid shifted upward as the size of rotator cuff tear enlarged. Although being found in the massive tear only, the significant superior migration occurred when the LHBT was disordered. Therefore, the LHBT is important as the suppressor of the humeral head in the shoulder with relatively larger rotator cuff tear.
Stress Distribution of Glenoid in Asymptomatic Baseball Players by Computed Tomography Osteoabsorptiometry

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INTRODUCTION: Little attention has been given to perform biomechanical studies on the stress distribution across the shoulder joint, because of difficulties in direct measurement and in determining loading conditions. The purposes of the current study were to evaluate the distribution of subchondral bone density across the shoulder joint surface in normal subjects (non-throwing athletes) and baseball players, including fielders and pitchers, and to clarify the alterations in the distribution pattern of subchondral bone density with pitching activities.

METHODS: Computed tomography (CT) image data from the throwing side shoulder of 10 non-throwing volunteers, 10 college baseball fielders and 10 college baseball pitchers were collected for the current analysis (all men aged 19-24, mean 20.7 years). The distribution of subchondral bone density of the glenoid cavity was measured using a CT osteoabsorptiometry method. The quantitative analysis of the obtained data focused on location and size of the maximum density area at the articular surface.

RESULTS: The maximum density area of the glenoid, (anteroinferior, posteroinferior and posterosuperior) in the pitcher and fielder group significantly increased compared with the control group. There was no significant difference of the maximum density of the glenoid between the pitcher and the fielder group.

DISCUSSION AND CONCLUSION: The results indicate that throwing motion may produce excessive or repetitive stress of the glenoid surface, especially anteroinferior, posteroinferior and posterosuperior. This stress distribution pattern of the glenoid in throwers may support theoretical background of throwing injury, such as anterior instability and a posterior capsular contracture.
**PAPER NO. 202**

**Clinical Result of Arthroscopic Bankart Repair for Skeletal Immature Patients with Anterior Shoulder Instability**

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INTRODUCTION: Success rate and postoperative clinical results such as ASES score and Rowe score of arthroscopic Bankart repair for anterior instability of shoulder in skeletal immature patients are inferior to in skeletal mature patients. A paucity of literature exists regarding the outcome of skeletal immature patients who sustain primary traumatic anterior shoulder dislocation. The purpose of this study was to compare the clinical results of arthroscopic Bankart repair for skeletal immature patients to skeletal mature patients.

METHODS: Fifty patients with anterior instability of shoulder who underwent arthroscopic surgery were enrolled in this study. Patients were divided into skeletal immature (SI) group (open physeal line of humerus at shoulder x-ray) and skeletal mature (SM) group (closed physeal line). Patients were evaluated at minimum one year after surgery (SI group: 29.5 months, SM group: 26.4 months). There were no significant differences between two groups about gender (SI group, nine males and two females; SM group, 30 males and nine females), rate of contact athlete (SI group, 81.8%; SM group, 59.0%). We compared the operative findings and the clinical outcomes of SI group with SM group.

RESULTS: Patients in SI group had significantly higher rate of capsular tear (SI group 36.4%, SM group 10.3%, P<0.05). There were no significant differences about combined lesions of bony Bankart and/or type V SLAP between two groups. Redislocation rate of SI group was significantly higher than SM group (SI group 27.3%, SM group 2.6%, P<0.01). Postoperative Rowe score (SI group 81.4, SM group 97.9, P<0.05), ASES score (SI group 95.7, SM group 98.7, P<0.05) were significantly poor in SI group.

DISCUSSION AND CONCLUSION: These findings suggest that the incidence of anterior capsular tear in SI group is higher than that in SM group. Clinical results of arthroscopic Bankart repair for SI group is inferior to SM group. Further follow up of existing study group and prospective research is warranted to fine-tune the result-based decision making for treatment of this injury.

**PAPER NO. 203**

**The Increasing Incidence of Superior Labrum Anterior Posterior Lesion Repairs**

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INTRODUCTION: Historically, superior labral anterior posterior (SLAP) lesions of the shoulder requiring surgical repair are relatively uncommon. Despite this, recent observations would suggest a significant rise in the incidence of repair for these lesions. The purpose of this study was to investigate the observed trend and explore other changes that may be associated with this procedure.

METHODS: Using the Statewide Planning and Research Cooperative Systems (SPARCS) from New York State Department of Health, non-identified data was acquired for all outpatient orthopaedic ambulatory procedures performed from 2002 to 2010. The data included in SPARCS represents both private and public facilities where ambulatory procedures are performed in the State of New York. Data was queried for cases of arthroscopic SLAP repairs using the CPT code 29807. Data was further analyzed for trends of this surgery in comparison to other orthopaedic outpatient procedures.

RESULTS: From 2002 to 2010, the number of all ambulatory procedures increased from 1,411,633 to 2,189,991 which is a rise of 55%. The number of orthopaedic ambulatory procedures during this period increased from 118,126 to 278,136 which is an increase of 153%. Correspondingly, the number of arthroscopic SLAP repairs in 2002 and 2010 were 765 and 4,313, respectively, which is an increase of 464%, Pa<0.01. This represented a population-based incidence of 4 per 100,000 in 2002 and 22.3 per 100,000 in 2010. The mean age of patients undergoing arthroscopic SLAP repair in 2002 was 37 ± 14 years (range: 13 to 83). In 2010, the mean age was 40 ± 14 years (range: 13 to 87). Additionally, the percentages of patients who were 50 years or older at the time of surgery in 2002 and in 2010 were 20.0% and 26.3%, respectively.

DISCUSSION AND CONCLUSION: The data suggests a substantial increase in arthroscopic SLAP repair that is significantly more rapid than the rising rate of outpatient orthopaedic procedures. In addition, there is a noticeable trend in the increasing age of patients who are being treated with arthroscopic SLAP repairs. The reasons behind these changes are yet to be discerned and are likely to be multifactorial in origin.
Labral anchor insertion in the posterior glenoid typically required lower insertion angles than insertion in the anterior glenoid (Figure 2). A posterior oblique insertion angle was safer than an anterior oblique insertion angle when avoiding the acromion while inserting an anchor at 10:30 o'clock. These average optimal insertion angles provide surgical guidelines that minimize risk of perforation despite the potential for substantial subject-to-subject variation in glenoid morphology.

PAPER NO. 205

Results of Treatment of Luxatio Erecta (Inferior Shoulder Dislocation)

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INTRODUCTION: Hypothesis: Traumatic inferior shoulder dislocation (luxatio erecta) injuries are rare, comprising less than 0.5% of all shoulder dislocations. Few cases have been reported, and the outcome of treatment has been ill defined.

METHODS: Between 1968 and 2000, 18 patients (20 shoulders) with luxatio erecta were evaluated at our institution. Two patients (two shoulders) were lost to follow up, leaving 16 patients (18 shoulders) for long-term follow up (average, nine years). Associated injuries included peripheral nerve injury, humeral fracture, acromial fracture and rotator cuff tear. All patients were initially managed with closed reduction, which was successful in nine shoulders. The remaining nine shoulders required operative treatment.

RESULTS: Patients were evaluated with respect to pain, function, range of motion, strength and patient satisfaction, according to the University of CA at Los Angeles Rating Scale. Overall, 13 of the 16 patients were graded as good or excellent. Patients treated with closed reduction or operative treatment compared favorably in terms of improvements in ratings for pain, strength, motion and the ability to perform work and sports.

DISCUSSION AND CONCLUSION: Our experience suggests that treatment of luxatio erecta is largely successful, with good or excellent results obtained in 83% of the shoulders. Half of the patients evaluated, required only closed reduction as their definitive treatment. Operative treatment is typically indicated for associated displaced humeral head fractures or patients with recurrent instability. Recurrent instability appears to be more likely in patients with a previous history of dislocation. Associated neurologic or vascular injury did not affect the final outcome.

PAPER NO. 206

Does the Dynamic Sling Effect of the Latarjet Procedure Improve Shoulder Stability? A Biomechanical Evaluation

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INTRODUCTION: This in vitro simulation demonstrated the Latarjet procedure's ability to increase shoulder stability through the dynamic sling effect of the conjoint tendon but also identified its inability to restore the joint's intact condition. The Latarjet procedure, a transfer of the coracoid and the conjoint tendon, is commonly used to treat anterior glenoid bone loss due to instability. The transferred conjoint tendon is thought to provide a stabilizing sling effect; however, the significance of this mechanism is unknown. The purpose of this in-vitro study was to evaluate the effects of coracoid transfer, with and without conjoint tendon loading, on shoulder stability and range of motion (ROM).

METHODS: Cadaveric human shoulders (n=8) were tested in a custom shoulder simulator capable of applying loads to the...
conjoint tendon, rotator cuff, long head of biceps and three deltoid heads. Passive ROM and shoulder stability with an anterior applied external load were evaluated with a repeated measures design. This study design utilized the following conditions: intact, Bankart lesion, 30% glenoid defect and coracoid transfer with and without tendon loading. Unloaded and 10N loaded conjoint tendon states were randomized and testing was performed in adduction and 90° combined abduction. Outcome variables include joint dislocation, translation, stiffness and internal/external rotational ROM. Joint stiffness was tested in neutral and 60° of external humeral rotation. RESULTS: All 30% glenoid defects caused dislocation in abduction and external rotation. The loaded Latarjet prevented dislocation in all specimens, while the unloaded stabilized six of eight specimens. The loaded Latarjet, as compared to the unloaded, significantly reduced anterior joint translation in abducted external rotation (8.9±9.6mm, p=0.035) and neutral (7.0±5.9mm, p=0.012). In abducted external rotation there were no significant differences in joint stiffness between loaded and unloaded transfers (p=0.176). In adduction, there were no significant differences in joint stiffness between the intact condition and the loaded Latarjet (p≥0.228), however, in neutral rotation the unloaded Latarjet significantly reduced rotational ROM as compared to unloaded (p=0.014). DISCUSSION AND CONCLUSION: The results of this study indicate that glenohumeral joint stability is improved when the transferred conjoint tendon is loaded, thus supporting the sling effect. Stability parameters however, are not fully restored to the intact level.

PAPER NO. 207
Modified Milch Versus Stimson for Awake Reduction of Anterior Shoulder Dislocation
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INTRODUCTION: The shoulder is the most common joint to dislocate. Primary care of shoulder dislocation includes reduction of the shoulder and prevention of recurrent dislocations. While many methods are described and used for reduction of shoulder dislocation, only a few can be introduced without sedation. The advantages of a non-sedation reduction include increased safety and reducing time and cost of care. On the other hand, reduction without sedation may be more difficult to perform, might cause discomfort to patient and if performed incorrectly and have lower success rates. We conducted a randomized controlled trial to compare the success and complications of the modified Milch and the Stimson techniques for anterior shoulder dislocations. METHODS: Patients admitted to the emergency department with anterior shoulder dislocation between December 2009 and June 2011 were enrolled. Patients were randomized either to the modified Milch or the Stimson group. All reductions were performed without sedation. Analgesia was administered upon patient’s request. Success of reduction, time to reduction, pain or discomfort and complications were all assessed. Other factors affecting shoulder stability were collected including age, gender, type of dislocation, hyperlaxity, number of previous dislocations, arm dominance, mechanism of dislocation. Data were analyzed by performing logistic bivariate regression. RESULTS: Sixty patients (47 men, 78%) with a mean age of 38 years (range 18-88) were included. There were 34 cases of first dislocation. A total of 35 patients were assigned to the modified Milch group and 25 were assigned to the Stimson group. The modified Milch was significantly more successful than the Stimson technique (82% vs. 28%, p=0.015). After performing logistic regression only method of reduction and time to reduction were significant factors affecting the success of the reduction (p<0.01, odds ratio 0.47, 2.84 respectively). The mean VAS score dropped 5.76pt. within mean period of 8.84min for Stimson group and 4.9pt. within 4.61min for the Milch group (p=0.25). The VAS pain score during reduction was 4.8±3 for Stimson and 6.15±2.5 for Milch. Of the 18 patients who failed first attempt at reduction, 10 were reduced using other methods and eight were reduced under sedation. No complications were recorded. DISCUSSION AND CONCLUSION: Our results suggest that non-sedation reduction provides a safe method for reduction of anterior shoulder dislocation and quick and effective ease of pain. The success rates using either techniques are limited, and the modified Milch technique is superior to the Stimson in terms of success. Modified Milch is superior to Stimson for non-sedation reduction of anterior shoulder dislocation. Non-sedation reduction may be useful in selected clinical scenarios.

PAPER NO. 208
Revision Rates and Outcomes of Superior Labrum Anterior Posterior 2 Repairs: A Prospective Analysis of 225 Patients
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INTRODUCTION: To prospectively analyze the clinical outcomes of the arthroscopic treatment of Type 2 superior labrum anterior posterior (SLAP) tears in a young, active patient population, and to determine factors associated with failure of treatment. METHODS: A total of 225 patients with mean age of 31.6 (range, 18 to 45) over a four-year period with a SLAP tear were prospectively enrolled. Two sports/shoulder trained orthopaedic surgeons performed SLAP 2 repair with between one to two anchors (mean 1.6 anchors) and suture knot construct. Patients were excluded if they underwent any additional repairs, including rotator cuff, labrum repair outside of the SLAP region, biceps tenodesis or tenotomy, or distal clavicle procedures. At a mean of 40.4 months (range 26-62months), a total of 179 patients underwent a comprehensive preoperative and postoperative assessment with WOSI, ASES, SANE, and physical examination of range of motion. In addition, a failure analysis was conducted to determine variables associated with failure. RESULTS: Out of the 225 patients, there were a total of 190 available for follow up (85%). A total of 56 patients (31%) were determined to have failed the procedure, and of those, 48 have undergone revision surgery to a biceps tenodesis (in 40), tenotomy (in four), and debridement (in four). The mean preoperative scores (WOSI=54%, SANE=50%, ASES=65) improved to postoperative scores (WOSI=82%, SANE=85%, ASES=88). However, in those that had failed, the mean scores were not statistically different from preoperative scores. The mean postoperative range of motion was 150 degrees of flexion, 145

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abduction and 60 external rotation at the side, and was much less in those that had failed the procedure. Advanced age within the cohort (>36) was associated with a statistical increase in failure. DISCUSSION AND CONCLUSION: Repairs of SLAP 2 lesions remain a challenge. This study demonstrated that over 31% of the patients had failed, with a high revision rate. Those over the age of 36 were associated with a higher chance of failure. One should approach the patient with a SLAP tear with caution and choose surgical repair only if clearly indicated. Additional work is necessary to determine optimal diagnosis, indications and surgical management for those with SLAP tears.

PAPER NO. 209
The Latarjet Procedure for Recurrence of Anterior Instability of the Shoulder after Operative Repair
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Sabrina Catanzaro, Zurich, Switzerland
Christian Gerber, MD, Zurich, Switzerland

INTRODUCTION: Recurrence of anterior shoulder instability after operative repair is a rare but disabling condition for which treatment options are insufficiently studied. Coracoid transfer according to Latarjet is a highly successful treatment option for recurrent anterior shoulder instability. It was the purpose of this study to verify the hypothesis that this procedure is also effective after recurrence of instability after previous operative repair.

METHODS: Forty-nine consecutive patients with either one (n=32), two (n=12) or at least three (n=5) previous stabilizations other than the Latarjet procedure and recurrence of anterior instability associated with a lesion of the anterior glenoid rim were revised with a coracoid transfer according to Latarjet. Clinical outcome was assessed at a mean follow up of 38 (23-63) months with standard clinical parameters including subjective shoulder value (SSV), scoring according to Constant and Murley (CS) and testing of stability. Standardized antero-posterior and axillary lateral radiographs before and after the Latarjet revision were used to assess osteoarthritis.

RESULTS: All 49 patients could be reviewed. No shoulder redislocated, subluxations recurred in two patients and five further patients reported a slight, unspecified uncertainty. No revision surgery was carried out or planned. Forty-three shoulders (88%) were subjectively excellent or good, three fair, three poor. Disatisfaction was associated with persistent pain. Preoperative pain was the key predictor of postoperative pain: Patients with postoperative pain had a more than 20 fold chance to have preoperative pain than those without postoperative pain. The mean SSV increased from 53% to 78% (p<0.001) and the CS reMed high (from 80% to 85%; p=0.061). Optimal graft placement was obtained in 30 cases and was related with better clinical outcome and lesser progression of osteoarthritis than suboptimal graft placement.

DISCUSSION AND CONCLUSION: Coracoid transfer according to Latarjet can effectively restore anterior shoulder stability if previous operation(s) have failed to do so. If such recurrence is associated with chronic pain, this is likely to persist and to compromise subjective outcome.

PAPER NO. 210
The Effect of Biceps Loading on Glenohumeral Joint Kinematics and Rotational Range of Motion
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Thay Q. Lee, PhD, Long Beach, CA

INTRODUCTION: The effect of biceps loading on glenohumeral joint rotational range of motion and kinematics is poorly understood. The purpose of this study was to evaluate the effect of loading the long and short heads of the biceps on rotational range of motion and glenohumeral kinematics.

METHODS: Eight cadaveric shoulders, four males and four females with an average age of 56.1 ± 3.7 years (range 50-60 years) were tested. Muscle loading was applied to the rotator cuff (SS: 5N, SB: 15N, IS/TM: 15), deltoid (30N), pec and lat (15N each) based on physiological cross-sectional area ratios. The short head and long head of the biceps were directed to two pulleys for muscle loading. Each head was individually loaded with 10, 20 or 40N followed by combined loading of both heads. Maximum internal and external rotation were measured with 2.2 Nm of torque. The humeral head apex position relative to the glenoid was measured at maximum internal, neutral, 90 degrees external and maximum external rotation using a MicroScribe 3DLX. All testing was performed in 60 degrees glenohumeral abduction in the scapular and coronal plane. Data for each biceps loading condition (10, 20 and 40N) was averaged together for analysis. A paired t-test with Bonferroni correction for multiple comparisons was used for statistical analysis.

RESULTS: Loading the long head of the biceps significantly decreased internal rotation in both the scapular and coronal planes (17.9 ± 1.7% and 5.7 ± 1.8%, respectively) and external rotation in the scapular plane (2.6 ± 0.6%) (p < 0.04). Loading the short head of the biceps did not significantly affect rotational range of motion. Loading either the long head or the short head of the biceps shifted the humeral head apex posteriorly in maximum internal rotation in both the scapular and coronal planes, with the posterior shift due to the long head being significantly more posteriorly than the short head in both planes. Loading the long head of the biceps also shifted the humeral head apex significantly inferiorly in maximum internal rotation and inferiorly-posteriorly in neutral rotation in the scapular plane. In maximum external rotation loading the long head of the biceps significantly shifted the humeral head apex anteriorly in both planes, whereas loading the short head of the biceps shifted the humeral head posteriorly in the scapular plane and anteriorly in the coronal plane.

DISCUSSION AND CONCLUSION: Loading the long head of the biceps has a much greater effect on rotational range of motion and glenohumeral kinematics than loading the short head of the biceps.
Effect of Incomplete Reaming on Cement Failure in Total Shoulder Arthroplasty

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Introduction: To restore normal shoulder function and minimize loosening of the glenoid implant in total shoulder arthroplasty (TSA), the glenoid is reamed to (1) neutral version and (2) to a depth that results in complete support of the glenoid implant by the underlying bone. This cannot always be achieved without sacrificing bone stock. This study examines the effects of incomplete version correction and insufficient reaming on cement mantle stress.

Methods: 3D models of scapulae were created from CTs of five patients (retroversion: 17 ± 3°) scheduled for TSA. Glenoid reaming was simulated to create three TSA scenarios: (1) ideal with full contact and neutral version; (2) incomplete contact with incomplete contact (60%) and neutral version; (3) incomplete version correction with full contact and 15° retroversion. The cement mantle was modeled with a 1 mm thickness where full contact existed and sufficient thickness to fill the gap where it did not. On the posterior edge, a 750 N load was simulated and cement stress and shear were calculated. Percent of cement at risk of fracture was determined as the volume of cement stress exceeding the material crack initiation of five MPa (Davies; J Orthop Res, 1987).

Results: Incomplete version correction resulted in the largest percent volume of cement at risk of fracture (p=0.026) and highest shear stresses (p=0.024). There were no significant differences between ideal and incomplete contact scenarios. In the ideal scenario, max stress, max shear and percent of cement at risk were respectively: 16.64 ± 2.75 MPa, 12.08 ± 0.72 MPa, 9 ± 2%. In the incomplete contact scenario, max stress, max shear and percent at risk were respectively: 14.35 ± 3.22 MPa, 13.53 ± 2.50 MPa, 12 ± 5%. In the incomplete version correction scenario, max stress, max shear and percent at risk were respectively: 14.62 ± 1.54 MPa, 15.22 ± 1.58 MPa, 17 ± 6%.

Discussion and Conclusion: When faced with the choice of incomplete version correction or insufficient support of the glenoid implant, this study suggests that correcting version should take precedence. Although more severe for incomplete version correction, both compromised scenarios demonstrate the same behavior - increased maximum shear stress and percent of cement at risk of fracture. Previous studies have reported that incomplete version correction and incomplete contact of the glenoid implant can lead to premature implant failure. This study is the first to simultaneously investigate these factors to determine their relative risks.

Infection Rate in Total Shoulder Replacement: Best Practices - Antibiotic Cement

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Introduction: Deep infection of primary total shoulder arthroplasty (TSA) is a rare but potentially devastating complication. The reported prevalence in the literature ranges from 0% to 15.4%. At present, antibiotic-impregnated cement is approved for use in second-stage reimplantation after infection. The primary use in TSA is not considered standard of care. This is in contrast to the total hip arthroplasty literature, which has documented a lower deep infection rate following primary arthroplasty. To our knowledge, no report exists of infection rates following primary total shoulder arthroplasty with the use of antibiotic-impregnated cement. We hypothesize that the primary use of antibiotic-impregnated cement in combination with standard intravenous antibiotics would decrease the rate of infection following primary total shoulder arthroplasty.

Methods: A single shoulder surgeon’s complete primary TSA experience was retrospectively reviewed. The presence or absence of a post-operative infection was recorded. All patients having undergone primary TSA were included in the study. Previous arthroscopic surgery was not an exclusion criterion. Revision procedures were excluded. Demographic data, operative information and post-operative follow up were included.

Results: Between 1999 and 2009, 603 TSAs were performed by the senior surgeon. A total of 311 procedures were primary TSA where 153 were without antibiotic-impregnated cement (Group A) and 158 with (Group B). There was no statistically significant difference in age, operative time or gender distribution between the two groups. At latest follow up, in Group A, 10 (6.5%) shoulders developed a deep infection. In Group B, only one (0.6%) shoulder developed a post-operative infection. Neither age, operative side nor surgical time influenced the development of an infection.

Table I: List of Infections

<table>
<thead>
<tr>
<th>Case #</th>
<th>Sex</th>
<th>Age</th>
<th>Prior Surgeries</th>
<th>Cement Type</th>
<th>Time to Infection</th>
<th>Organism</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>62</td>
<td>None</td>
<td>Plain</td>
<td>13 wks</td>
<td>p. acnes</td>
<td>PROSTALAC</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>58</td>
<td>None</td>
<td>Plain</td>
<td>171 wks</td>
<td>p. acnes</td>
<td>PROSTALAC</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>83</td>
<td>None</td>
<td>Plain</td>
<td>39 wks</td>
<td>Negative</td>
<td>PROSTALAC</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>59</td>
<td>None</td>
<td>Plain</td>
<td>90 wks</td>
<td>p. acnes</td>
<td>I+D and removal of loose glenoid</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>31</td>
<td>Rotator cuff surgery x2</td>
<td>Plain</td>
<td>35 wks</td>
<td>Coag. Neg.staph</td>
<td>PROSTALAC</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>62</td>
<td>None</td>
<td>Plain</td>
<td>70 wks</td>
<td>p. acnes</td>
<td>PROSTALAC</td>
</tr>
<tr>
<td>7</td>
<td>F</td>
<td>74</td>
<td>None</td>
<td>Plain</td>
<td>49 wks</td>
<td>Coag. Neg.staph</td>
<td>PROSTALAC</td>
</tr>
<tr>
<td>8</td>
<td>M</td>
<td>58</td>
<td>None</td>
<td>Plain</td>
<td>6 wks</td>
<td>p. acnes</td>
<td>I+D x 2, eventual conversion to PROSTALAC</td>
</tr>
<tr>
<td>9</td>
<td>M</td>
<td>63</td>
<td>None</td>
<td>Plain</td>
<td>42 wks</td>
<td>p. acnes</td>
<td>I+D and removal of loose glenoid</td>
</tr>
<tr>
<td>10</td>
<td>M</td>
<td>54</td>
<td>None</td>
<td>Plain</td>
<td>153 wks</td>
<td>p. acnes</td>
<td>PROSTALAC</td>
</tr>
</tbody>
</table>
Tenotomy vs. Lesser Tuberosity Osteotomy During TSA performed. An ultrasound was performed at three months to scan, and radiographs at each post-operative time point were taken. Surgeons (ASES) index. Pre-operative radiographs, MRI and CT are used to evaluate osteotomy healing. Intra-operative data collection included tendon quality, operative time, repair time, osteotomy thickness and measurement of glenoid exposure. RESULTS: There was no significant difference at baseline or at six months post-operatively when comparing the two groups for strength, ROM, VAS, SST, ASES or SF-36 scores. Group 1 FE was 138.8 ± 41.9° versus 154.0 ± 15.2° in Group 2, while ER was 52.5 ± 12.8° versus 50.0 ± 7.07°, and IR was to L2 and L3, respectively. VAS score in Group 1 compared to Group 2 at 6 months was 1.1 ± 1.8 and 2.0 ± 2.0, SST was 7.3 ± 13.4 and 10.6 ± 1.1, and ASES was 77.7 ± 17.9 and 85.7 ± 6.6, respectively. Significant gains (p < 0.05) were noted with improved ROM and outcome scores from baseline to six months post-operatively within each group. There was no significant difference between the two groups for either the subscapularis repair time or surgeon case time. The average glenoid exposure was found to be significantly better in Group 2 than Group 1, 9.4 ± 4.3 mm versus 5.4 ± 4.7 mm distance from a glenoid center pin (p = 0.04). All shoulders in Group 2 demonstrated bony healing on radiographs at three months. Thirteen shoulders in Group 1 demonstrated an intact subscapularis on ultrasound at three months. Two of 16 tenotomy shoulders demonstrated partial attenuation on ultrasound and one had a complete tendon tear. DISCUSSION AND CONCLUSION: Both subscapularis tenotomy and lesser tuberosity osteotomy result in successful objective and subjective clinical outcomes for TSA. Intra-operative case time and technique are comparable, although glenoid exposure in shoulders with an osteotomy is significantly greater. Post-operative healing is excellent in both groups, but two subscapularis tendons were found to have partial attenuation and one had a complete tear in the tenotomy group. Therefore, both techniques lead to excellent clinical outcomes, but lesser tuberosity osteotomy allows for a greater intraoperative glenoid exposure and may provide for more reliable healing. Level of Evidence: Prospective randomized study, Level 1.

PAPER NO. 318

Prospective, Randomized Study of Subscapularis Tenotomy vs. Lesser Tuberosity Osteotomy During TSA

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INTRODUCTION: Improved outcomes of subscapularis function following lesser tuberosity osteotomy compared to subscapularis tenotomy has yet to be proven in the literature. To our knowledge, this is the first prospective, randomized controlled trial to compare the intra-operative details and clinical outcomes of the two techniques. METHODS: Thirty shoulders in 29 patients undergoing total shoulder arthroplasty (TSA) for primary osteoarthritis were prospectively evaluated. Sixteen shoulders were pre-operatively randomized to subscapularis tenotomy (Group 1) and 14 shoulders to lesser tuberosity osteotomy (Group 2). Pre-operative, six week, three month, six month and one year post-operative data collected included range of motion (ROM), strength testing by dynamometer, simple shoulder test (SST), SF-36, visual analog pain score (VAS) and the American Shoulder and Elbow Surgeons (ASES) index. Pre-operative radiographs, MRI and CT scan, and radiographs at each post-operative time point were performed. An ultrasound was performed at three months to evaluate subscapularis healing for tenotomy, while radiographs were used to evaluate osteotomy healing. Intra-operative data collection included tendon quality, operative time, repair time, osteotomy thickness and measurement of glenoid exposure. RESULTS: There was no significant difference at baseline or at six months post-operatively when comparing the two groups for strength, ROM, VAS, SST, ASES or SF-36 scores. Group 1 FE was 138.8 ± 41.9° versus 154.0 ± 15.2° in Group 2, while ER was 52.5 ± 12.8° versus 50.0 ± 7.07°, and IR was to L2 and L3, respectively. VAS score in Group 1 compared to Group 2 at 6 months was 1.1 ± 1.8 and 2.0 ± 2.0, SST was 7.3 ± 13.4 and 10.6 ± 1.1, and ASES was 77.7 ± 17.9 and 85.7 ± 6.6, respectively. Significant gains (p < 0.05) were noted with improved ROM and outcome scores from baseline to six months post-operatively within each group. There was no significant difference between the two groups for either the subscapularis repair time or surgeon case time. The average glenoid exposure was found to be significantly better in Group 2 than Group 1, 9.4 ± 4.3 mm versus 5.4 ± 4.7 mm distance from a glenoid center pin (p = 0.04). All shoulders in Group 2 demonstrated bony healing on radiographs at three months. Thirteen shoulders in Group 1 demonstrated an intact subscapularis on ultrasound at three months. Two of 16 tenotomy shoulders demonstrated partial attenuation on ultrasound and one had a complete tendon tear. DISCUSSION AND CONCLUSION: Both subscapularis tenotomy and lesser tuberosity osteotomy result in successful objective and subjective clinical outcomes for TSA. Intra-operative case time and technique are comparable, although glenoid exposure in shoulders with an osteotomy is significantly greater. Post-operative healing is excellent in both groups, but two subscapularis tendons were found to have partial attenuation and one had a complete tear in the tenotomy group. Therefore, both techniques lead to excellent clinical outcomes, but lesser tuberosity osteotomy allows for a greater intraoperative glenoid exposure and may provide for more reliable healing. Level of Evidence: Prospective randomized study, Level 1.

PAPER NO. 319

Utility of Intraoperative Nerve Monitoring During Shoulder Arthroplasty

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INTRODUCTION: The incidence of clinically recognized neurologic injury after shoulder arthroplasty has been reported to range from 1% to 8%. A previous study using nerve monitoring reported intraoperative nerve alerts in 17 of 30 (56.7%) patients undergoing anatomic arthroplasty. Five patients had positive postoperative EMG finding and four of these had clinical evidence of nerve injury, which resolved by six months. The purpose of the current study was to further define the utility, application and safety of intraoperative nerve monitoring during shoulder arthroplasty in a larger group of patients.

METHODS: Outcomes of 134 shoulders in 121 patients undergoing continuous intraoperative monitoring of the brachial plexus during shoulder arthroplasty were analyzed. Mean patient age was 66 years (range, 24 - 88 years). Seventy-four patients underwent total shoulder arthroplasty, 30 hemiarthroplasty and 28 reverse shoulder arthroplasty. A total of 39 revision surgeries were included. Intraoperative monitoring consisting of transcranial electrical motor evoked potentials (tcMEPs), somatosensory evoked potentials (SSEPs) and spontaneous electromyography (EMG) was performed. The surgeon was notified of impending nerve dysfunction if there was an amplitude attenuation of greater than 50% from baseline.

RESULTS: There was no significant difference at baseline or at six months post-operatively when comparing the two groups for strength, ROM, VAS, SST, ASES or SF-36 scores. Group 1 FE was 138.8 ± 41.9° versus 154.0 ± 15.2° in Group 2, while ER was 52.5 ± 12.8° versus 50.0 ± 7.07°, and IR was to L2 and L3, respectively. VAS score in Group 1 compared to Group 2 at 6 months was 1.1 ± 1.8 and 2.0 ± 2.0, SST was 7.3 ± 13.4 and 10.6 ± 1.1, and ASES was 77.7 ± 17.9 and 85.7 ± 6.6, respectively. Significant gains (p < 0.05) were noted with improved ROM and outcome scores from baseline to six months post-operatively within each group. There was no significant difference between the two groups for either the subscapularis repair time or surgeon case time. The average glenoid exposure was found to be significantly better in Group 2 than Group 1, 9.4 ± 4.3 mm versus 5.4 ± 4.7 mm distance from a glenoid center pin (p = 0.04). All shoulders in Group 2 demonstrated bony healing on radiographs at three months. Thirteen shoulders in Group 1 demonstrated an intact subscapularis on ultrasound at three months. Two of 16 tenotomy shoulders demonstrated partial attenuation on ultrasound and one had a complete tendon tear. DISCUSSION AND CONCLUSION: Both subscapularis tenotomy and lesser tuberosity osteotomy result in successful objective and subjective clinical outcomes for TSA. Intra-operative case time and technique are comparable, although glenoid exposure in shoulders with an osteotomy is significantly greater. Post-operative healing is excellent in both groups, but two subscapularis tendons were found to have partial attenuation and one had a complete tear in the tenotomy group. Therefore, both techniques lead to excellent clinical outcomes, but lesser tuberosity osteotomy allows for a greater intraoperative glenoid exposure and may provide for more reliable healing. Level of Evidence: Prospective randomized study, Level 1.
80% tcMEPs or 50% in SSEPs. Neurologic function was assessed in the postoperative holding area, before any neurologic block was performed, and during routine follow up.

RESULTS: Of the 134 shoulders, 59 (44%) had intraoperative nerve dysfunction (i.e., nerve alerts). Of these 59 shoulders, 47 (80%) experienced an intraoperative nerve alert with a subsequent return of nerve function to above alert level or back to baseline at the completion of the procedure. The remaining 12 (20%) had nerve function below alert level or absent at the completion of the procedure. Only two patients demonstrated evidence of postoperative motor nerve injury, and in both cases multiple tcMEP alerts in multiple muscle groups were noted intraoperatively. In instances of single muscle nerve alerts or cases in which signals returned above alert level, no clinical nerve deficits were noted postoperatively.

DISCUSSION AND CONCLUSION: The results of this study show that tcMEPs are timely and sensitive indicators of impending iatrogenic nerve injury to the brachial plexus or peripheral nerves during shoulder arthroplasty. Signal amplitude reduction greater than 80% in multiple muscle groups that persists despite extremitiy and retractor adjustment is likely a signal of true nerve injury. Knowledge of these factors can allow for the early recognition of impending nerve injury and the adjustment of surgical technique to minimize the risk for clinically relevant postoperative nerve injury.

PAPER NO. 320

Early Complications of Anatomic Total Shoulder Arthroplasty
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INTRODUCTION: The reported complication rates of total shoulder arthroplasty have ranged from 12% to 39%, most occurring in the early post-operative period. The purpose of this study was to analyze early complications of contemporary anatomic total shoulder replacement in patients with primary glenohumeral osteoarthritis.

METHODS: A total of 226 shoulders in 204 patients with glenohumeral osteoarthritis underwent anatomic total shoulder arthroplasty under general anesthesia with interscalene nerve block performed by a single surgeon. The mean age was 68 years (40 to 90 years) and 97 were male. The subscapularis tendon was completely elevated from the lesser tuberosity and repaired anatomically. All but one of the humeral components were uncemented. Complications that occurred within the first 120 days of surgery were recorded and categorized as medical or surgical, as well as major or minor. Patients were routinely evaluated at one, six, 12 and 26 weeks after surgery. All but one patient was seen at least twice during the early post-operative period.

RESULTS: There were a total of 55 complications affecting 51 (23%) shoulders identified within the early post-operative period. Thirteen major (5.8%) and 42 minor (18.6%) complications were identified. There were 22 medical (9.7%) complications and 33 surgical (16.8%) complications. There were two deaths (0.9%). There were no infections or dislocations. There was one non-displaced intra-operative greater tuberosity fracture (0.4%) and no humeral shaft fractures. One patient underwent reoperation to repair a symptomatic subscapularis rupture (0.4%). Fifteen patients (6.6%) developed a post-operative distal neuropathy, either carpal tunnel syndrome (12) or cubital tunnel syndrome (three), with three requiring release within six months. There were two (0.9%) upper trunk brachial plexopathies and both resolved within three months. There were three pulmonary emboli in two patients (1.3%) that were successfully treated with anticoagulation therapy.

DISCUSSION AND CONCLUSION: Contemporary anatomic total shoulder arthroplasty is associated with a low rate of major complications and the majority of these have little or no effect on the long term functional outcome. Medical and surgical complications have a similar incidence. Attention to the medical aspects of the surgical care are important to successful outcome of total shoulder arthroplasty. A substantial number of patients develop symptomatic distal peripheral neuropathies of which the relationship to the shoulder arthroplasty is unclear.

PAPER NO. 321

The Prognosis for Improvement in Comfort and Function After the Ream and Run Arthroplasty for Glenohumeral Arthritis
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Winston J. Warme, MD, Bellevue, WA
Sarah Jackins, PT, Seattle, WA
Frederick A. Matsen, III, MD, Seattle, WA

INTRODUCTION: Knowledge of the factors affecting the prognosis for recovery of function and comfort with time after shoulder arthroplasty is important to clinical decision-making. This study sought to identify some of these factors in 176 consecutive patients having the ream and run procedure.

METHODS: The time course for recovery of function and comfort was determined for the entire group as well as for subsets by gender, age, diagnosis, presurgical function and surgery date. Patients having repeat surgery were analyzed in detail.

RESULTS: Comfort and function increased progressively after the ream and run procedure, reaching a steady state by approximately 20 months. A total of 124 patients with at least two-year follow up were improved by a minimal clinically important difference (MCID). Sixteen patients with at least two-year follow up were not improved by the MCID. Twenty-two patients had repeat procedures, but only seven had revision to a total shoulder. Fourteen patients did not have either a known revision or two-year follow up. The best prognosis was for male patients over age 60 years, with primary osteoarthritis, no prior surgeries, having a preoperative Simple Shoulder Test of five or higher, and having surgery after 2004. Repeat surgeries were more common in patients having had a greater number of surgeries before their ream and run.

DISCUSSION AND CONCLUSION: This study is unique in that it characterizes the factors affecting the time course for recovery of comfort and function after a ream and run procedure. Improvement occurs after the ream and run for at least 1.5 years after the procedure. This procedure appears to be best suited for an older male patient with reasonable preoperative function without prior surgery when performed by a surgeon with a significant amount of experience performing the procedure.
Proximal Humeral Bone Loss Occurring with Press Fit Humeral Stem: A Prospective Study with Minimum Four Year Follow up

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David B. Doherty Jr, MS, BA, Houston, TX
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INTRODUCTION: Uncemented humeral components in total shoulder arthroplasty shorten operative time and potentially simplify future revision if needed. However, just as in hip arthroplasty, stress shielding can theoretically be an issue causing proximal humeral bone loss and possible subsequent implant failure. Additionally, polyethylene wear debris from the glenoid component may contribute to osteolysis of the glenoid and proximal humerus. The purpose of this study is to assess the degree of proximal humeral bone resorption of a press fit stem humeral implant used in total shoulder arthroplasty at a minimum follow up of 48 months and to assess the factors contributing to proximal humeral bone resorption.

METHODS: Seventy-five patients were prospectively followed after receiving a total shoulder arthroplasty with a press fit humeral stem and a pegged or keeled all polyethylene glenoid component. Follow up averaged 56.8 months (range, 48 to 84 months). ASES and Constant scores were collected on all patients. Two orthopedic surgeons reviewed and graded the immediate post op and four-year follow up films for glenoid loosening and proximal humeral bone resorption.

RESULTS: ASES scores increased from 62.7 to 85.9 (p<.001), Constant scores increased from 33.0 to 72.0 (p<.001) and adjusted Constant scores increased from 41.3% to 94.1% (p<.001) from preoperative to final follow up. Active forward flexion increased from 96.3 preoperatively to 149.7 degrees postoperatively (p<.001). Active external rotation increased from 17.9 preoperatively to 43.6 postoperatively (p<.001). Fifty-nine percent of patients had proximal humeral bone loss at the medial calcar. Higher degrees of humeral bone loss were correlated with higher degree of glenoid lucency and with lower Constant scores. Fifty-two of 75 patients were satisfied or extremely satisfied. Nine patients required a revision for loosening of the glenoid component.

DISCUSSION AND CONCLUSION: The incidence of proximal humeral bone loss occurring at four years postoperative in a press-fit humeral stem is concerning. This may be related to stem design with proximal humeral stress shielding being responsible or osteolysis from polyethylene wear debris associated with a loose glenoid component. Further follow up of this patient cohort is warranted to better elucidate factors associated with radiographic finding.

Use of a 3-Dimensional Vault Model to Estimate Glenoid Version and Inclination in the Osteoarthritic Shoulder

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INTRODUCTION: Ideal implant placement in total shoulder arthroplasty involves correction of the pathologic glenoid to the patient’s native version and inclination. However, predicting these variables in a patient with severe osteoarthritis is difficult due to significant glenoid bone loss and osteoarthritic changes. We propose the use of a previously validated, 3D vault model as a preoperative template to accurately predict native glenoid version and inclination in the osteoarthritic shoulder. Assuming the relationship between scapula is conserved within the same individual, we hypothesize that the use of the 3D vault model in the osteoarthritic glenoid will accurately predict native glenoid version and inclination to within five degrees of the contralateral, normal side.

METHODS: Bilateral CT scans were obtained in 27 patients with radiographic evidence of unilateral glenohumeral osteoarthritis. Images were imported into software to create reconstructed 3D files of each scapula. The software was then used to place the vault model in best-fit orientation into each glenoid vault independently by two independent observers. Bilateral measurements of glenoid version and inclination were calculated by direct measurement of the glenoid, as well as by using the vault model. Measurements were then compared between the pathologic and the contralateral, normal side. Bilateral CT scans were also obtained on eight healthy cadaveric scapula. The mean glenoid version and inclination calculations were then compared between scapula.

RESULTS: Glenoid version on the arthritic side averaged -15.5 ± 1.5, compared to -7.4 ± 0.64 on the normal side. Glenoid version of the implanted vault on the arthritic side averaged -6.8 ± 0.66, compared to -5.78 ± 0.50 on the normal side. These data suggest that vault placement on the arthritic side can accurately predict normal version that was measured on the normal side to within 0.6 degrees. Glenoid inclination on the arthritic side averaged 11.1 ± 0.99 by direct measurement, compared to 12.2 ± 0.85 on the normal side. Glenoid inclination of the implanted vault model on the arthritic side averaged 10.3 ± 0.8, compared to 12 ± 0.67 on the normal side. These data suggest that vault placement on the arthritic side can accurately predict normal glenoid inclination on the contralateral healthy side to within 1.9 degrees.

DISCUSSION AND CONCLUSION: This study demonstrates the ability of the 3D vault model to accurately predict both glenoid version and inclination in a severely arthritic glenoid to within five degrees of the contralateral, normal side. We believe this tool can be a valuable preoperative tool for total shoulder arthroplasty in determining ideal glenoid component placement by accurately predicting native version and inclination in a severely arthritic glenoid. The data also demonstrates that for the osteoarthritic shoulder the bone loss is axial (version) plane rather than that of the coronal plane (inclination). Moreover, patients with rotator cuff tear arthropathy often have bone loss superiorly with an increase in inclination angle when compared to normal. This vault model method may also be useful in these patients.
Peg Perforation of the Glenoid Vault During Total Shoulder Arthroplasty: Does Early Glenoid Loosening Occur?

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INTRODUCTION: Glenoid component loosening is one of the most common reasons for early failure in total shoulder arthroplasty (TSA). A subset of patients undergoing primary TSA have a mediolized joint line secondary to glenoid wear. Implantation of a glenoid component in cases of medialized glenoid erosion may be compromised due to decreased surface area of the glenoid face and reduced depth of the glenoid vault. In some cases, the central pegs and/or peripheral pegs of a peg design glenoid component may violate the medial cortex of the glenoid vault, but it is unknown whether this leads to early failure. The objective of this study was to determine if glenoid components with uncontained pegs would be associated with a high rate of failure. We hypothesized that the anchor peg design with co-linear central and peripheral pegs would provide adequate stability in cases where one or multiple pegs perforated the medial cortex of the glenoid, and that these cases would not be associated with a high rate of failure.

METHODS: A retrospective review of all anatomic total shoulders performed at our institution between September 2004 to June 2008 was performed. Operative reports were collected and were reviewed to identify those cases in which a peg breached the medial glenoid vault. Implant survival was calculated with revision for glenoid component loosening as the primary outcome variable, and clinical outcomes for each patient were determined using the American Shoulder and Elbow Surgeons (ASES) and Penn shoulder scores.

RESULTS: A total of 25 patients were identified as having peg perforation and were evaluated at an average of 5.5 years (range, 3.1 to 6.5) follow up. Average age was 68.2 years (range, 51.6 to 81.4). Fifteen patients had central peg perforation of the glenoid vault, and 12 patients had posterior peripheral peg perforation; two patients had both central and posterior pegs that were uncontained. The average ASES score was 85.6 +/- 10.4. The average Penn shoulder score was 83.1 +/- 12.6, with sub-scores of 26.4 +/- 4.0, 8.5 +/- 2.2, and 48.3 +/- 9.1 for pain, satisfaction, and function, respectively. Of the 25 patients, no patient required a revision for a loose glenoid component. One patient had signs of polyethylene wear and lucency around the inferior glenoid component on plain films. Two patients (8.0%) required subsequent surgery at eight months and three years post-operatively, both for rotator cuff tears. The glenoid component was found to be well-fixed in both revision cases.

DISCUSSION AND CONCLUSION: With no cases of glenoid loosening at a mean follow up of more than five years, results support our hypothesis that peg perforation of the medial cortex is not associated with early glenoid loosening in this subset of patients. Glenoid erosion should not necessarily preclude implantation of an anchor peg glenoid component if the central or peripheral pegs violate the medial cortex of the glenoid vault.

Prospective Multicenter Study of Total Shoulder Arthroplasty for 1° Glenohumeral Osteoarthritis at 5 Year Follow Up

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INTRODUCTION: In the past two decades the overall number of total shoulder arthroplasties (TSA) performed to treat painful glenohumeral arthritis has increased significantly and is predicted to continue to increase in the future with an aging population. The current study prospectively followed a large cohort of subjects, from multiple centers, who received the same TSA for treatment of primary glenohumeral osteoarthritis (GHOA).

METHODS: A total of 231 shoulders in 225 patients (mean age 67.52 years), across 14 centers (13 in the USA and one international) with 21 surgeons, received a TSA with a single modular prosthesis for the treatment of primary GHOA. There were 99 females and 132 males enrolled. Some 95 patients (mean age 67.04 years) have reached five years of follow up. Outcomes included a physical examination, the American Shoulder and Elbow Surgeon [ASES] evaluation score, the Simple Shoulder Test [SST], the Constant score, the Short-Form 36 [SF-36], the EQ-5D Score [EuroQol] and the EQ-5D Visual Analog Scale [EQ-5DVAS] health score. The effects of age, sex and body mass index (BMI) were also assessed. Missing data was imputed by using 10 multiple imputations through statistical software. A p-value less than 0.05 in the pooled results was taken to represent statistical significance.

RESULTS: Significant improvements from baseline were seen in all outcomes at five years following TSA. A total of 91 of 95 patients (95.8%) reported having reduced pain in the affected shoulder five years after surgery. All active and passive range of motion outcomes, as well as average ASES outcomes, normalized Constant Score and SST Score improved significantly at five years post-operatively (p<0.001) (Figure 1a, 1b, 1c, 1d, respectively). Additionally, the EQ-5D total index improved by 0.20 points after five years (p<0.001). The majority of improvements in the measured outcomes were seen three months post-surgery. Body mass index (BMI), age and sex were found to have no correlation with functional or quality of life outcomes following TSA. Of the 231 subjects enrolled in the study, only seven required subsequent surgery on the shoulder (3%). Figure 1. Baseline and 5-year average a) ROM Outcomes; b) ASES Outcomes; c) Constant score and d) SST score. Lighter bars represent baseline data and the darker bars represent 5-year data. Error bars represent I SEM. Asterisks represent statistical significance (p<0.05).

DISCUSSION AND CONCLUSION: The current study represents the largest prospective evaluation of TSA for a single diagnosis treated with the same prosthesis at five years follow up. Pain, range of motion, function and quality of life were all shown to significantly improve following TSA, while complications and re-operation rates were very low. This clearly shows the benefits of TSA for patients with primary GHOA and that these results are not affected by age, sex or BMI.

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e. the drug or medical device is being discussed for an off label use). For full information refer to page 14. An alphabetical faculty financial disclosure list can be found starting on page 19.
Structural Bone Grafting for Glenoid Bone Deficiency in Primary Total Shoulder Arthroplasty

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INTRODUCTION: Glenoid component failure remains a significant factor leading to prosthetic failure in total shoulder arthroplasty. Patients with compromised and deficient bone stock secondary to degenerative and inflammatory arthritis may be more prone to such failure. Alternatively, bone grafting can be used to help restore asymmetrically eroded glenoid bone stock to allow better glenoid support and positioning. There are few reports to date on this technique and its effect on mid-to-long term glenoid component survival.

METHODS: Between January 1, 1976 and December 31, 2008, 34 patients underwent structural bone grafting for glenoid deficiencies during total shoulder arthroplasties at our institution. Twenty-seven patients with complete preoperative and postoperative clinical and radiographic evaluation and a minimum of two-year follow up or until the time of revision surgery were included in the study. The mean clinical follow was 8.4 years while the mean radiographic follow up was 6.4 years. Radiographic outcome included immediate and most recent post operative evidence of glenoid loosening and graft survival.

RESULTS: Range of motion improved an average of 60° (83° pre-operatively, 144° post-operatively) for elevation and 40° (25° pre-operatively, 63° post-operatively) for external rotation. A Neer rating of excellent was calculated for 18 patients, (25° pre-operatively, 63° post-operatively) for external rotation.

DISCUSSION AND CONCLUSION: Although structural bone grafting in total shoulder arthroplasty is uncommonly necessary, our results indicate that it may remain a viable option in the setting of glenoid deficiency. However, there was a moderate rate of periprosthetic lucency and evidence of component loosening.
stable two years after implantation. Radioluent lines may appear early, may progress and recede and do not appear to indicate an unstable glenoid component at two-year follow up. A majority of the patients exhibited a decrease in the rate of migration between one and two year follow up to less than 250µm per year. However, three patients, one with keeled and two with pegged glenoid components, continued to show relatively high three-dimensional translation rates between one and two years. Continued monitoring of our patient cohort using RSA will provide information regarding mid-term stability of these glenoid component designs.

PAPER NO. 328
The Effect of Surgical Volume on Shoulder Arthroplasty Quality Metrics
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INTRODUCTION: Literature regarding the relationship between surgeon and hospital volume to the outcome of elective shoulder arthroplasty is limited to data sets over a decade old1. Since that time, there has been a rapid increase in the number of these procedures performed, as well as number of providers performing these procedures. The technology and instrumentation involved in shoulder arthroplasty has also evolved rapidly, with specialized instrumentation, anatomic systems and FDA approval of the reverse total shoulder. The purpose of this study is to examine the relationship between surgeon and hospital volume and the efficiency of performing hemiarthroplasty (HA), total shoulder arthroplasty (TSA) and reverse total shoulder arthroplasty (RSA). Blood loss, length of stay, operative time and readmission rates are quality measures assessed in this study.

METHODS: In 2007, Institutional Review Board approval was obtained to utilize multicenter institutional Shoulder Arthroplasty Registry data. The registry includes identifying information, comorbidities, ICD-9 codes, implant data, surgical metrics and hospital readmissions. Data was prospectively entered and reviewed. A total of 1,176 primary cases were analyzed. Correlation and analysis of covariance were used to examine the association between surgeon and hospital volume and outcomes for shoulder HA, TSA and RSA adjusting for age, sex and body mass index (BMI).

RESULTS: Surgeon volume is inversely correlated with length of stay for HA and TSA (not RSA) (r=-0.25, -0.13), blood loss and operative time for all three procedures (r=-0.37~0.52). Hospital volume is inversely correlated with length of stay for HA only (r=-0.18), blood loss for TSA and RSA (r=-0.20~0.22) and operative time for all three procedures (r=-0.20~0.28). Among high surgeon volume, HA had less blood loss and operative time than those for TSA and RSA (p<0.01). These results are summarized in tables 1 and 2.

DISCUSSION AND CONCLUSION: This study supports the hypothesis that higher surgeon and hospital volume both improve shoulder arthroplasty quality metrics. Level of Evidence: Level III (retrospective cohort study)

Table 1: Correlation between Surgeon/Hospital Volume and Outcomes

<table>
<thead>
<tr>
<th>Outcomes (continuous)</th>
<th>Risk Factors (continuous)</th>
<th>Correlation Coefficient</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Shoulder n=711</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOS n=669</td>
<td>Surgeon Volume</td>
<td>-0.25</td>
<td>&lt;0.0001</td>
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<td></td>
<td>Hospital Volume</td>
<td>0.02</td>
<td>0.64</td>
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<tr>
<td>Blood loss n=543</td>
<td>Surgeon Volume</td>
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<tr>
<td></td>
<td>Hospital Volume</td>
<td>-0.14</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>op time n=492</td>
<td>Surgeon Volume</td>
<td>-0.52</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td>Hospital Volume</td>
<td>-0.26</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Hemi n=277</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOS n=267</td>
<td>Surgeon Volume</td>
<td>-0.13</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>Hospital Volume</td>
<td>-0.18</td>
<td>0.004</td>
</tr>
<tr>
<td>Blood loss n=227</td>
<td>Surgeon Volume</td>
<td>-0.14</td>
<td>0.03</td>
</tr>
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<td>Hospital Volume</td>
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<tr>
<td>op time n=226</td>
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<tr>
<td></td>
<td>Hospital Volume</td>
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<td>0.002</td>
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<td>Rev. Shoulder n=188</td>
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<td></td>
<td></td>
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<tr>
<td>LOS n=164</td>
<td>Surgeon Volume</td>
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<td>0.08</td>
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<td>Hospital Volume</td>
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<td>0.09</td>
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<tr>
<td>Blood loss n=135</td>
<td>Surgeon Volume</td>
<td>-0.22</td>
<td>0.01*</td>
</tr>
<tr>
<td></td>
<td>Hospital Volume</td>
<td>-0.22</td>
<td>0.01</td>
</tr>
<tr>
<td>op time n=136</td>
<td>Surgeon Volume</td>
<td>-0.39</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td>Hospital Volume</td>
<td>-0.28</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

* Marginally significant with Spearman test (p=0.08)

Table 2: Comparison of mean Length of Stay (LOS), estimated blood loss, and operative (op) time among procedure type, stratified by surgeon volume

<table>
<thead>
<tr>
<th>Annual Surgeon Volume</th>
<th>Total Shoulder Arthroplasty</th>
<th>Hemiarthroplasty</th>
<th>Reverse Total Shoulder</th>
<th>Overall* p-value</th>
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<tbody>
<tr>
<td>LOW (n=370)</td>
<td>Volume &lt;5</td>
<td>Volume &lt;1.5</td>
<td>Volume &lt;4</td>
<td></td>
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<tr>
<td>LOS (days) 1.8</td>
<td>2.01</td>
<td>2.31</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Blood loss (cc) 264.6</td>
<td>230.7 1</td>
<td>263.6 2</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Op time (min) 163.4</td>
<td>127.7 1</td>
<td>147.9 1</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>MEDIUM (n=474)</td>
<td>Volume =6-15</td>
<td>Volume =1.6-4</td>
<td>Volume =5-8</td>
<td></td>
</tr>
<tr>
<td>LOS (days) 1.9</td>
<td>1.7</td>
<td>2.6 1.2</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Blood loss (cc) 228.2</td>
<td>185.0 1</td>
<td>283.9 2</td>
<td>0.0004</td>
<td></td>
</tr>
<tr>
<td>Op time (min) 147.8</td>
<td>121.9 1</td>
<td>129.5 2</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>HIGH (n=332)</td>
<td>Volume &gt;15</td>
<td>Volume &gt;4</td>
<td>Volume &gt;8</td>
<td></td>
</tr>
<tr>
<td>LOS (days) 1.7</td>
<td>1.7</td>
<td>1.9</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>Blood loss (cc) 201.3</td>
<td>162.7 1</td>
<td>215.7 2</td>
<td>0.01</td>
<td></td>
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<tr>
<td>Op time (min) 114.4</td>
<td>87.1 1</td>
<td>115.5 2</td>
<td>0.0002</td>
<td></td>
</tr>
</tbody>
</table>

* Volume was categorized into tertial. * Ancova adjusted for age, sex, BMI. 1 = significantly different from group1 (TSA), 2 = significantly different from group 2 (HA) 3 Jain N, Pietrobon R, Hocker S, Guller U, Shankar A and Higgins LD. The Relationship between Surgeon and Hospital Volumes and Outcomes for Shoulder Arthroplasty. JBJS 86:496-505 (2004).
A Biomechanical Comparison of Three Fixation Methods of Porous Tantalum Backed Glenoid Components
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INTRODUCTION: Glenoid component loosening remains a key limiting factor in achieving long-term survival in total shoulder arthroplasty. Monoblock design, porous tantalum (PT)-backed glenoid components have been recently introduced as a method to prevent glenoid loosening by achieving bony ingrowth at the prosthesis-glenoid interface. Under current guidelines, the use of PT-backed glenoid components requires polymethyl-methacrylate (PMMA) cement fixation. However, PMMA is not osteoconductive and could potentially prevent osteointegration of the PT backing of the glenoid component. This study aims to investigate the stability of three alternative fixation methods of PT-backed glenoid components and compare them to a standard cemented all-polyethylene component.

METHODS: Three 46mm polyethylene (PE) pegged glenoid components and nine 46mm PT-backed monoblock components were implanted into American Society for Testing and Materials (ASTM) approved polyurethane bone substitute. Group I (n=3) consisted of standard fully cemented PE glenoids. Groups II - IV (n=3 per group) included PT-backed glenoids fixed by press-fit, PMMA cement and CaP cement, respectively. All samples were tested according to ASTM F-2028. The humeral head was translated ±1.5mm along the superior-inferior axis of the glenoid for a total of 50,000 cycles. Glenoid rocking and superior-inferior glenoid motion was detected by two differential variable reluctance transducers during testing.

RESULTS: Initial distraction of the glenoid edge from the bone substitute for fully-cemented PE glenoids was (0.05 ± 0.06 mm) initially and (0.69 ± 0.20mm) after cycling. For the PT-backed groups, PMMA cemented glenoids had initial and post distraction of (0.32 ± 0.06 mm) and (0.83 ± 0.09 mm), respectively, compared to (0.77 ± 0.09 mm) and (1.32 ± 0.64 mm), respectively, for the press-fit group. PT-backed glenoids with CaP fixation had (0.64 ± 0.2 mm) and (0.95 ± 0.07 mm) for initial and post-cyclic distraction, respectively. Glenoid loosening was also characterized based on number of cycles (Figure 1). All-polyethylene glenoids loosened at the slowest rate followed by PT-backed cement fixed glenoids.

DISCUSSION AND CONCLUSION: Results indicate that standard cemented PE glenoids displayed superior initial and final stability under cyclic loading compared to glenoids with PT backing. Among the PT-backed glenoids, fixation with PMMA cement provided an increase in stability at both cycle 0 and cycle 50,000 compared to press-fit or CaP cement fixation. Fixation of PT-backed glenoids with PMMA cement is recommended based on this study.

Osteotomy vs. Subscapularis Tenotomy in Shoulder Arthroplasty: Healing Rates and Fat Infiltration
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George S. Athwal, MD, London, ON, Canada

INTRODUCTION: Controversy exists regarding the optimal technique of subscapularis mobilization during shoulder arthroplasty. The purpose of this study is to compare healing rates and fatty infiltration in patients enrolled in a multicenter randomized double-blind study comparing lesser tuberosity osteotomy (LTO) to subscapularis tenotomy (ST).

METHODS: Eighty-seven patients undergoing shoulder arthroplasty were randomized to receive either a LTO or ST. Follow-up CT scans were conducted 12 months post-operatively and radiographic outcome variables included healing rates and subscapularis Goutallier fatty infiltration grade.

RESULTS: CT imaging was available in 63% of the cohort. Baseline demographic data did not differ between groups for sex (p=0.72), affected side (p=0.59) or arthroplasty type (hemiarthroplasty or total, p=0.61); however, age differed significantly (ST, 65.3 years, LTO, 70.4 years, p=0.03). The healing rate for ST (96%) and for LTO (90%) did not differ significantly between groups (p=0.62). The Goutallier mean fatty infiltration grade post-operatively and radiographic outcome variables included healing rates and subscapularis Goutallier fatty infiltration grade.

DISCUSSION: No statistically significant differences were observed in the healing rates or fatty infiltration between the ST and LTO. This trial does not demonstrate any clear difference in radiographic outcomes of one subscapularis management technique over the other.

Acromiohumeral Distance Correlation to Fatty Infiltration, Atrophy and Massive Cuff Tear Size
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INTRODUCTION: Massive rotator cuff tears have a reportedly high incidence of not healing after rotator cuff repair surgery. Repair rates have also been reported to be poor with high-
grade fatty infiltration, cuff muscle atrophy and increasing tear size. Acromiohumeral distance (AHD) has recently been reported to predict fatty infiltration, atrophy and cuff tear size.

**Hypothesis:** Measures of AHD on MRI will be significantly smaller than AHD on upright plain film X-ray. Decreasing AHD will correlate with a higher degree of fatty infiltration, increased incidence of atrophy and increased cuff tear size.

**METHODS:** A retrospective chart review was performed searching for patients with massive rotator cuff tears who had both plain radiographs and MRI and also underwent surgical intervention. Measures of AHD on plain radiograph included both AP and scapular Y (outlet) views. Similar measures were obtained on both coronal and sagittal MRI views of the study shoulder. Fatty degeneration of the infraspinatus muscle was then classified according to Goutallier's classification as modified by Fuchs into five stages using T1-MRI sequence. Atrophy of the supraspinatus muscle belly was also evaluated and graded as present or absent based on the Tangent sign. All measures were performed by orthopaedic surgery medicine fellows using the hospital PACS system. Interobserver correlations were applied.

**RESULTS:** The average AP-AHD was 7.36mm (SD=2.24) and for the outlet view was 6.64mm (SD=2.46). The average MRI measure for the sagittal view was 5.29mm (SD=1.65), whereas the average coronal view was 5.52mm (SD=1.93). The differences in reported means between the X-ray and MRI coronal and MRI sagittal findings are significant (p<0.01 and p=0.01 respectively). When evaluating AHD and its association with Goutallier classification and supraspinatus atrophy there was no correlation to plain radiographic measures in the AP or outlet views. However, when evaluating AHD measured on MRI both coronal and sagittal measures correlated with Goutallier classification and supraspinatus atrophy. Values for MRI AHD on both coronal and sagittal views were inversely proportional to increasing Goutallier classification and the presence of cuff atrophy. At the time of surgery all tears involved at least two tendons of the rotator cuff. Similar to the above information there was no association between AHD on AP or outlet X-ray views and rotator cuff tear size, however, coronal and sagittal MRI measures of AHD showed an inversely proportional relationship to cuff tear size.

**DISCUSSION AND CONCLUSION:** Measures of AHD on MRI are significantly smaller than AHD measures on X-ray. When measuring on MRI, as AHD decreases the likelihood of more advanced fatty infiltration increases, the likelihood of muscle atrophy increases and the size of rotator cuff tears increase. All of the above measures have been associated with worse outcomes after rotator cuff repair. We recommend that surgeons pay close attention to AHD on both X-ray and MRI when contemplating massive rotator cuff repair.
INTRODUCTION: The aim of this retrospective study is to evaluate clinically and radiographically the effectiveness of implanting an eccentric glenosphere and if correct glenosphere positioning would avoid the occurrence of notching. METHODS: Since 2006, 40 patients with shoulder eccentric osteoarthritis were treated with reverse shoulder arthroplasty with a 36 mm eccentric glenosphere. We have selected 25 patients, with a minimum follow up of 24 months. The patients were clinically evaluated with the Constant score and SST and with X-ray, MRI and/or CT before and after surgery. At the follow up, we evaluated the presence or absence of notch, and we measured the PSNA (prosthesis-scapular neck angle), the DBSNG (distance between the scapular neck and glenosphere) and the PGRD distance (peg glenoid distance). Statistical analysis was performed with a paired t test. RESULTS: In every patient, the range of motion was improved. The AP X-ray did not show inferior scapular notching. The mean DBSNG was found to be 4.3 mm. The mean PSNA was 92° and the mean PGRD was 21.2. The Constant score improved from 30 to 74 points and the SST from 1.7 to 8.4 points. DISCUSSION AND CONCLUSION: The scapular notching is shown as the most frequent complication in reverse shoulder replacement. In our study the results indicate that proper positioning of the glenosphere with the inferior part of the metal back that overlaps the lower glenoid rim without overhang and the implantation of an eccentric glenosphere lowers the center of rotation 4 mm and avoids contact between the humeral component and the scapular neck during the adduction. Thus, all the patients increased total joint range of motion.

PAPER NO. 425
Reverse Shoulder Arthroplasty through a Deltpectorak Approach versus a Superior Approach: A Comparison of Outcomes
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Edward Chang, MD, Philadelphia, PA
Gordon S. Crabtree, BA, Philadelphia, PA
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INTRODUCTION: The purpose of this study was to determine if there is any difference in the radiographic position of the implants and the radiographic outcomes when using the anterosuperior (AS) versus the deltopectoral (DP) approach following reverse total shoulder arthroplasty. In addition, we sought to determine if a difference in clinical outcomes and complications existed when comparing these two approaches for reverse total shoulder arthroplasty in a single surgeon series. METHODS: Ninety-three consecutive patients were treated with a reverse total shoulder arthroplasty at an average age of 74.7 years by a single surgeon. All procedures were the index arthroplasty procedure. Thirty-one patients were done through a DP approach and 62 patients done through an AS approach. Immediate postoperative radiographs were examined for glenoid inclination, superior/inferior and anterior/posterior placement of the glenosphere and position of the humeral stem. Scapular notching was evaluated using the Sirveaux classification at an average of six months. Postoperative Penn Shoulder Scores (PSS), the Simple Shoulder Test (SST) and the Single Assessment Numeric Evaluation (SANE) scores were obtained for all patients. Forward elevation was evaluated at most recent follow up and postoperative complications were documented. RESULTS: The average change in inclination of the glenoid component using the AS approach was 6.5° of superior tilt versus 0.4° of inferior tilt using the DP approach (p<0.0006). There was no significant difference in the position of the glenoid baseplate in the anteroposterior or superoinferior direction for the two surgical approaches (p=0.3 and 0.39, respectively). The average position of the humeral stem was in 2.1° of valgus for the AS approach versus 0.7° of valgus for the DP (p<0.0062). There was no significant difference in rate or amount of scapular notching between the two groups at the most recent follow up (p =0.76). There was no difference in postoperative PENN, SST or SANE scores between the two groups. The average forward elevation at most recent follow up in the AS and DP group was 155 and 149 degrees, respectively (p=0.55). There were five major complications in this cohort: One significant improvements in all outcome measurements.
Patient in the DP group suffered an anterior dislocation and there were three patients who had a deltoid dehiscence in the AS group, all requiring further surgery. One scapular spine fracture that occurred 13 months after surgery in the AS group was treated nonoperatively.

**DISCUSSION AND CONCLUSION:** Unique perioperative and postoperative complications exist for both surgical approaches and should factor into the decision making process regarding the appropriate surgical approach for reverse total shoulder arthroplasty. Postoperative radiologic measurements that may contribute to long term survival of reverse total shoulder arthroplasty may be more reproducible using a standard deltopectoral approach. Longer term outcomes are needed to determine if these radiologic findings have clinical significance.

**PAPER NO. 426**

**Revision of Total Shoulder Arthroplasty to Reverse Shoulder Utilizing Allograft Glenoid Bone Grafting**

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**INTRODUCTION:** Aseptic glenoid loosening with large contained, cavity defects remains a difficult surgical problem. Our hypothesis is that the use of composite inductive, conductive allograft during conversion to reverse shoulder arthroplasty (RSA) provides a safe, reproducible solution.

**METHODS:** Between 2004 and 2009, 24 patients with failed total shoulder arthroplasty (TSA) and dysfunctional rotator cuffs underwent conversion to RSA. The mean age was 68.2 years (range, 59-86). There were 16 females and eight male patients. All had a prior TSA with obvious polyethylene glenoid loosening on sequential radiographs. Surgical technique included: removal of all prior components and glenoid preparation with standard RSA technique, debridement with impaction bone grafting of a demineralized bone matrix with cancellous chips to provide adequate support for baseplate fixation. No custom devices were used. Serial radiographs at routine follow ups were obtained. Preoperative and postoperative American Shoulder and Elbow Surgeons Scores (ASES), Visual Analog Pain Scores (VAS) and range of motion were obtained. Surgeon directed rehabilitation was followed.

**RESULTS:** Mean follow up was 34.2 months (range, 24-72). All patients had aseptic glenoid loosening with large contained cavity defects. All were classified as either severe central (18) or moderate central (6) defects. Mean VAS decreased from 7.1 to 1.7. Mean range of motion improved from 10° to 130° of forward elevation and 15° to 30° of external rotation. Mean ASES scores improved from 35.4 to 77.2 (p<0.001). Patient reported outcome was rated as excellent in 14, good in six, satisfactory in four. There was allograft incorporation into all glenoids. Notching was evident in two shoulders (both Nerot Grade 1). There was no evidence of glenoid baseplate loosening or vault lysis. Complications included one postoperative hematoma requiring return to the OR for evacuation.

**DISCUSSION AND CONCLUSION:** Single stage conversion of failed TSA with aseptic glenoid loosening to RSA is successful using a composite cancellous chip, demineralized bone matrix allograft and stable baseplate fixation. This is a safe, reproducible technique with good outcomes for a difficult revision shoulder reconstruction.

**PAPER NO. 427**

**Hemiarthroplasty Treatment for Cuff Tear Arthropathy: Five to Eight Year Follow Up**

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**INTRODUCTION:** The purpose of this study is to review clinical and radiographic findings on a consecutive group of shoulders with the diagnosis of cuff tear arthropathy that underwent hemiarthroplasty with cuff tear arthropathy (CTA) head at five to eight year follow up.

**METHODS:** Twenty shoulders that received a hemiarthroplasty with CTA head were retrospectively evaluated with physical exam, Simple Shoulder Test (SST), Constant score, and radiographs. Five to eight year post-operative radiographs were evaluated for signs of glenoid erosion and humeral notching.

**RESULTS:** At five to eight year follow up, 10 shoulders were satisfied and 10 not satisfied with their results. Satisfied shoulders had significantly greater SST (9.7 vs 6.2, p=0.00001) and Constant scores (56.2 vs 35.4, p=0.001), as well as significantly greater forward elevation (111° vs 76°, p=0.019) and less loss of elevation over time (6° vs 25°, p=0.049). No significant difference in patient age, hand dominance, sex or pre-operative forward elevation, was identified between the two groups. Glenoid erosion and proximal humeral notching were present in both groups, without significant difference at follow up.

**DISCUSSION AND CONCLUSION:** Hemiarthroplasty for cuff tear arthropathy has inconsistent midterm results. Patient satisfaction is 50% with those satisfied having significantly greater elevation, SST score, Constant score and less loss of elevation over time.

**PAPER NO. 428**

**Clinical Midterm Outcome of Reverse Total Shoulder Arthroplasty Combined with Latissimus Dorsi Transfer**

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**INTRODUCTION:** Reverse total shoulder arthroplasty (RTSA) allows correction of pseudoparalysis of overhead elevation caused by irreparable rotator cuff tear. Loss of active external rotation is not addressed and possibly even aggravated by RTSA. Latissimus dorsi transfer has been used to restore active external rotation in massive posterolateral rotator cuff tears with pseudoparalysis of external rotation. We report the clinical results at two- and five-year follow up of 41 consecutive cases using the combination of these two procedures to treat pseudoparalysis of anterior elevation and external rotation. We report the clinical results at two- and five-year follow up of 41 consecutive cases using the combination of these two procedures to treat pseudoparalysis of anterior elevation and external rotation. Fifteen patients had prior open or arthroscopic surgery at the same shoulder and in 26 cases RTSA was a primary procedure. Thirty-one patients were available for the two-year follow up and 11 additionally for the five-year follow up.

**RESULTS:** Eight orthopedic complications occurred in 41 procedures: two infections (one implant removal), two transient partial plexus pareses, two late traumatic dislocations, one glenoid component loosening (conversion to a hemiarthroplasty) and one shoulder stiffness in one of the two patients with transient neurological complication. Three of the seven patients orthopedic complications had prior shoulder surgery. One patient with postoperative infection had prior axillary lymphadenectomy and radiotherapy for ipsilateral breast cancer. Three medical
complications occurred (two cardiac, one pulmonary embolism). The age related Constant score improved significantly from a preoperative mean of 44(range 16-78)% to 91(51-100)% at two years. The mean subjective shoulder value increased from 32(0-70)% to 72(20-100)% For the 11 patients with five year follow up the postoperative Constant score remained stable on a high level (41(16-65))% preoperatively, 94(65-100)% at two and 95(80-100)% at five years respectively as did the subjective shoulder value (33(0-70), 75(50-100), 80(60-100)%). Active external rotation significantly improved from a mean of 6(-30-60)° to 27(0-70)° at two years. At five years collective it was 9(-30-50)°, 23(0-60)° and 27(0-70)°. Postoperatively none of the patients had a negative external rotation while this was present preoperatively in 10. For these 10 patients the preoperative positive lag sign for external rotation became negative in 60% of cases; for the others in even 81% (P<0.01).

DISCUSSION AND CONCLUSION: The high complication rate requires better patient selection. Multiple previous operations appear to be associated with a high complication rate. In well selected patients, latissimus dorsi transfer combined with RTSA yields overall excellent outcome in terms of pain relief and restoration of function and very high patient satisfaction.

PAPER NO. 429

Deltoid Muscle Activity in Patients with Reverse Shoulder Prosthesis at Two Years Follow Up

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INTRODUCTION: The reverse shoulder prosthesis (RSP) was developed to relieve pain and improve functional outcomes in patients with gleno-humeral arthritis and deficiency of the rotator cuff. The medialization of the rotator cuff center increases the moment arm of the deltoid, compensating for the missing force of the deficient rotator cuff muscles. Even if clinical and functional outcomes after RSP were reported, data concerning progressive deltoid adaptation to this non-anatomical implant are still missing. Our purpose was to correlate clinical and functional outcomes with deltoid muscle fibers activity and fatigability in patients with reverse shoulder prosthesis at two years follow up.

METHODS: Twenty patients with reverse shoulder prosthesis were selected. Exclusion criteria were: axillary nerve palsy, a nonfunctioning deltoid muscle, diabetes, previous trauma, malignancy. American Shoulder and Elbow Surgeons (ASES) score, Visual Analog Scale (VAS), range-of-motion (ROM) pre-operative (pre-op), post-operative (post-op) and at two years follow up (2-yrs-f-up) were recorded. Activity of anterior, lateral and posterior deltoid of both shoulders was recorded performing electromyography.

RESULTS: Prosthetic side vs contra-lateral: ASES-2-yrs-f-up < ASES-post-op (p<0.05); VAS-2-yrs-f-up = VAS-post-op (p=n.s.); ROM-2-yrs-f-up decreased in terms of forward flexion (p=0.045), abduction (p=0.03), external rotation (p<0.001). At two years follow up anterior and lateral deltoid electromyographic activity was significantly lower compared with contra lateral side (P<0.001) and posterior deltoid activity was not detectable.

DISCUSSION AND CONCLUSION: Quantitative difference in deltoid muscle fibers recruitment and fatigability corresponds to deltoid adaptation after two years. Even if the patients remain pain free, progressive deterioration of the deltoid activity is unavoidable and leads to poor functional outcomes: a crucial aspect of which an orthopaedic surgeon should be aware.
Correlation of the Involved Compartments of Massive Rotator Cuff Tear and Loss of Active Shoulder Range of Motion

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INTRODUCTION: The management of massive rotator cuff tear (RCT) remains controversial, with no clearly defined clinical presentation as yet. The loss of active elevation following RCT is well known as pseudoparalysis, but its risk factor is unclear. The purpose of this study was to clarify the clinical symptoms of patients with massive RCT with regards to which tendons were involved, to assess the risk factor of the loss of the active range of shoulder motion and to consider the management of massive RCT.

METHODS: We divided the rotator cuff into five compartments: supraspinatus (SSN), superior subscapularis (SSC sup.), inferior subscapularis (SSC inf.), infraspinatus (ISN) and teres minor (TM). A hundred patients (50 men and 50 women, mean age: 68 years) with RCT involving two or three compartments with muscular fatty infiltration (Stage 3 or 4 regarding Goutallier's classification) were included prospectively. We included only the severe fatty infiltration cases in order to be absolutely sure that the tendon was not useful. Patients with limited passive range of shoulder motion, those having had previous surgery in the shoulder girdle, or those with glenohumeral osteoarthritis were excluded from this study. Regarding the involved tendons, we separated the patients into five groups: type A (SSN + SSC sup., eight cases), B (SSN + SSC sup. + SSC inf., 20 cases), C (SSN + SSC sup. + ISN, 22 cases), D (SSN + ISN, 35 cases) and E (SSN + ISN + TM, 15 cases) (Fig. 1). The active range of shoulder motion was assessed in each group and Tukey's multiple comparison post-hoc tests were performed on the five groups to identify the differences.

RESULTS: The range of active anterior elevation significantly decreased in types B and C patients (Fig. 2). Eighty percent of type B, 46% of type C and 33% of type E patients could not elevate their own arm actively beyond 90° (Fig. 3). External rotation was significantly decreased in types C, D and E, and the values for type E were significantly lower than those of types C and D. Internal rotation decreased significantly in types B and C.

DISCUSSION AND CONCLUSION: This study is the first report of a classification for anterior elevation. The validated classification will be useful for anterior elevation. The validated classification will be useful for the loss of active anterior elevation is related to dysfunction of SSC. The loss of active anterior elevation is related to dysfunction of ISN and TM and the loss of active internal rotation is related to dysfunction of SSC. Due to its anatomical position, SSC could play an important role for anterior elevation. The validated classification will be useful for more detailed analyses of patients with massive RCT.
Clinical Outcomes of Reverse Total Shoulder Arthroplasty in Patients Under the Age of 60

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INTRODUCTION: Reverse total shoulder arthroplasties (RTSAs) are typically performed in an older patient population with low functional demands on their shoulder. However, the conditions that benefit from an RTSA are not restricted to an elderly population and we are not aware of any studies in the literature that specifically discuss the clinical outcome in younger patients. The purpose of this study is to report the clinical outcomes of patients under the age of 60 who underwent a primary reverse total shoulder arthroplasty. Criteria to be considered for RTSA under 60 were: symptomatic RC deficiency; poor active forward elevation (AFE) (<60°); pain; joint injury (DDI, fracture, existing implant); and no other satisfactory option was considered available.

METHODS: Thirty-five shoulders at average age of 55 years (47-60) were evaluated at an average follow up of 28 months (13-42 mm). There were 22 females and 13 males. Twenty-seven (77%) had previous surgery, with an average of 1.7 procedures. Of the eight patients without previous surgery, etiologies were early CTA (four), locked anterior dislocations (two) and rheumatoid arthritis (two). The pre-operative clinical condition compelling RTSA was: irreparable RCT without significant arthritis (11); fracture sequelae (HHR, ORIF, malunion) (11); failed arthroplasty (four); instability sequelae (RCT with DDI, locked dislocation) (four); CTA under age 60 (three); RA (two). Follow up included range of motion and strength testing and well as the Single Assessment Numeric Evaluation (SANE), Visual Analog Scale for pain (VAS), Simple Shoulder Test (SST), American Shoulder and Elbow Society (ASES), and Constant score. Pre and post-operative AP and axillary shoulder radiographs were reviewed for component loosening and scapular notching. Failure criteria were defined as a revision, gross loosening of a component, or an ASES score under 50.

RESULTS: The mean SANE score improved from 13.3 ± 16.0 to 72.0 ± 20.9 (range, 30 to 100); the VAS pain score improved from 4.67 ± 3.6 to a mean of 1.8 ± 2.0 (range, 0 to 7). The SST score improved from 1.2 ± 1.6 to 6.2 ± 3.7, and ASES score improved from 6.0 ± 4.0 to 65.2 ± 23.2 (range, 23.3 to 100). AFE improved from 52.8 ± 36.1 (range, 0 to 120) to 121.1 ± 45.5 (range, 10 to 170). The post-operative mean Constant Score was 54.3 ± 18.9 (range, 22-87). There was one post-op dislocation, open reduced at one week. There was one intra-operative humeral shaft fracture that underwent ORIF. Three patients had revisions at two months, six months and 2.8 years post-operatively. Eight patients (23%) had an ASES score lower than 50 and were considered failures.

DISCUSSION AND CONCLUSION: The results of this short term outcome analysis on a complex patient population indicate that RTSA can improve shoulder function in a relatively young population that pre-operatively had very poor functional ability. This is a limited goals procedure however, and given the short duration of follow up and the reported rates of clinical failure over five years, RTSA should still be used judiciously.
**PAPER NO. 435**

Can Rotator Cuff Repair Change the Evolution of Muscle Atrophy and Fatty Infiltration? A Case Control Study

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**INTRODUCTION:** Rotator cuff tears are closely related with muscle atrophy and fatty infiltration and both affect healing and clinical outcomes after surgical treatment. Despite the importance of these degenerative changes, no case control study has been conducted yet to assess the effect of surgical treatment on muscle atrophy and fatty infiltration. The aim of this ongoing study was to compare surgical treatment and conservative management of complete, repairable rotator cuff tears.

**METHODS:** Thirty-six patients with clinical and radiological (MRI) diagnosis of complete rotator cuff tears were retrospectively identified. At T0, 18 patients underwent surgical arthroscopic treatment repair (Group A) and 18 conservative treatment (Group B). Group A included 10 medium tears and eight large tears (according to De Orio-Coifeld classification) and Group B included seven medium tears and 11 large tears. At follow up (T1), all patients underwent clinical (VAS, Simple Shoulder Test, Constant Score and Relative Constant, Grado Score) and a new radiological (MRI) evaluation performed by a qualified radiologist.

**RESULTS:** The average follow up was 50 months for group A and 61 months for group B. The mean age was 56 years old (Group A) and 61 (group B) at the time of diagnosis. By comparing the two groups at T1, we registered a statistically significant difference in the SST ($p<0.05$), in the VAS score ($p<0.01$) and in the Grado score ($p<0.01$), with Group A having better results. Even the Constant and the Relative Constant Score showed statistically significant better results in the surgical group compared to the conservatively managed group ($p<0.05$). The radiological evaluation did not show a statistically significant increase of fatty infiltration ($p=0.16$) in Group A (according to Goutallier classification): no progression was detected in 16 out of 18 patients (89%), while an increase was detected in the other two patients (11%). From group B, we registered a statistically significant increase of fatty infiltration ($p<0.001$). Group A did not show a statistically significant worsening of muscle atrophy (according to Zanetti classification); no cases of progression were observed: four out of 18 patients (22%) showed an increased post-operative supraspinatus muscle trophism. Group B showed a statistically significant worsening of muscle atrophy ($p<0.001$). In group B, we also detected a statistically significant increase of tendon retraction ($p<0.05$), an increased number of tendons involved ($p<0.05$) and a worsening of tear size ($p<0.001$). Moreover, Group B showed an evolution in eccentric arthropathy ($p<0.012$), while group A reMed unchanged.

**DISCUSSION AND CONCLUSION:** Surgical treatment of complete rotator cuff tears decreases the irreversible changes that involve muscle belly. Rotator cuff tears have a characteristic evolution which can lead, with time, to an eccentric arthropathy. Surgery could intercept these degenerative phenomena and allow an improvement of the supraspinatus muscle trophism.

**PAPER NO. 496**

Comorbidity and Mortality of Proximal Humerus Fracture Differ According to Treatment Followed?

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**INTRODUCTION:** Fracture of the proximal part of the humerus is one of the most common fragility fractures, and the occurrence of this fracture seems to be increasing due to elderly population.

**METHODS:** A total of 200 patients with a proximal humerus fracture were prospectively followed up at least one year. One hundred were treated conservatively and 100 underwent surgery. Twenty-three patients were excluded due to missing follow-up examinations. A total of 132 were women and 45 men. The mean age was 69.49 years (70.22 conservative and 68.77 surgery group). There were 130 displaced fractures according to Neer classification, 31 conservatively treated and 99 went for surgery. Sixteen patients died during follow up.

**RESULTS:** Nine, 4% patients of conservative group and 20, 3% of surgery group were not autonomous in daily life (p=0.26). Patients suffering from osteoporosis were more in conservative group (44, 1%) than surgery group (11, 1%) (p<0.001). Conservative group mortality rate was 2, 6%, while surgery group was 17, 3% (p<0.002). Comitant disorders (cardiologic, respiratory, neurologic and metabolic) were suffered by conservative group more than surgical group p<0.003. Osteoporosis is more common in conservative group (p<0.01) and these patients suffer more fractures post-treatment (p<0.29).

**DISCUSSION AND CONCLUSION:** Both post-fracture treatment and osteoporosis is significantly greater in the conservative group. Despite having worse physical health in the conservative group, more deaths are registered in the surgery group.
Sternoclavicular Joint Reconstruction: How Far Does Danger Lurk Below?

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INTRODUCTION: Surgical stabilization of the sternoclavicular joint (SCJ) is infrequent and cardiothoracic surgery assistance is often recommended for reconstructive surgery. Patient safety and surgeon efficiency would be improved by detailed understanding of the anatomic relationships deep to the SCJ. The purpose of this study is to determine the distances from the SCJ to critical structures in the superior mediastinum and assess if side, gender, height, weight, body mass index (BMI) and age differences are present. METHODS: Distances from the posterior SCJ to adjacent mediastinal structures were recorded using contrast enhanced CT scans obtained on 49 consecutive patients evaluated in the emergency department. Patients with any defined injury to the region were excluded. Structures included the great vessels of the neck, subclavian vessels, brachial plexus, innominate (artery and veins), trachea, esophagus, vagus nerve, dome of the pleura and other structures in the superior mediastinum. The thickness of the sternum and medial clavicle were also measured. Pearson correlation coefficients were calculated to determine the relationship between distances and bony thicknesses and age, height, weight and body mass index (BMI); t-tests were used to evaluate gender differences. RESULTS: The mean distance to the nearest anatomic structure deep to the clavicular region of the SCJ was 6.6 mm and 12.5 mm for the sternal region. Significant differences between the right and left SCJs were noted. The average thickness of the clavicle was 18 mm and the average thickness of the sternum was 17 mm. The structure most at risk on both sides was the brachiocephalic vein (right 40%, left 64%). Clavicle and sternum thickness was significantly greater in males; there was no gender difference with respect to distances to critical structures. DISCUSSION AND CONCLUSION: Surgical reconstruction of the SCJ is relatively safe. The most frequent structure at risk of injury deep to the SCJ is the brachiocephalic vein. Such knowledge may improve patient safety and surgical efficiency.

Patient Perception of Physician Reimbursement in Elective Shoulder Surgery

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INTRODUCTION: Medical economics and physician reimbursement have become increasingly important issues in the United States over the past decade. A previous study revealed patients perceived physician reimbursement to be much higher than current Medicare schedules for hip and knee replacement. The purpose of this study was to evaluate patient perception of orthopaedic surgeon reimbursement for total shoulder replacement (TSR) and rotator cuff repair (RCR). METHODS: A total of 250 shoulder patients in three different practices were surveyed. Patients were asked what they believe a surgeon should be paid for performing TSR and RCR. The survey explicitly stated that the patient response should only include the surgeon’s fee (including the 90-day global period) and not the cost of hospitalization, operating room expenses, etc. Patients were then asked to estimate what Medicare actually reimbursed for each of these procedures. Finally the survey revealed the true average Medicare reimbursement rate for TSR ($1,633) and RCR ($1,175), and patients were asked if this was “much lower,” “somewhat lower,” “about right,” “somewhat higher,” or “much higher” than what a surgeon should earn. Finally, patients were asked if surgeons with advanced shoulder training should receive additional payments. RESULTS: On average, patients thought that surgeons should receive $17,373 for TSR and $9,800 for RCR. Patients estimated actual Medicare reimbursement to be $8,976 for TSR and $5,170 for RCR. Some 60% of patients stated that Medicare reimbursement was “much lower” than what it should be, and less than 1% of patients felt that it was higher than it should be. A total of 79% of patients thought that surgeons with advanced shoulder training should be reimbursed at a higher rate.

Prospective Clinical Trial Comparing Hyaluronate and Corticosteroid Injection in Adhesive Capsulitis Patients

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INTRODUCTION: The efficacy of corticosteroid or hyaluronate injection in treating shoulder pain has been reported. Hyaluronate has metabolic effects on articular cartilage, synovial tissue and synovial fluid, and is known to be safe and effective in treating patients with adhesive capsulitis of the shoulder. Corticosteroid is the most commonly used treatment modality for nonoperative management of the adhesive capsulitis, however it has been known to have some side effects such as injection flare and increase in blood glucose level in diabetes. So if hyaluronate injection can be effective as corticosteroid, it could replace some portion of patients who are not appropriate for steroid injection. The purpose of this study was to prospectively compare the early clinical results of intra-articular injections with hyaluronate and corticosteroid in idiopathic adhesive capsulitis (IAC) patients. METHODS: We prospectively randomized and recruited 71 patients, who were diagnosed as idiopathic adhesive capsulitis. Diagnosis for IAC was based on clinical examination with global range of motion limitation with forward flexion of 90-100, external rotation at side 0-20 degrees and internal rotation were near buttlock. All patients received MRI to confirm that no other shoulder pathologies were involved. All were treated with injections into the glenohumeral joint from the anterior approach. Thirty-four patients had injections of hyaluronic acid once a week for three consecutive weeks. Thirty-seven patients had a single injection of corticosteroid. All injections were done by a single, experienced orthopedic surgeon. We excluded, any
combined shoulder pathology, and those who did not have MRI to determine such pathology. Patients were followed up at two and 12 weeks after completion of injection. We evaluated the Constant-Murley (CM) score, the American Shoulder Elbow Surgeon (ASES) score and Pain visual analogue scale (VAS).

RESULTS: No statistical differences were found between two groups in terms of preoperative demographic data and shoulder functions, including age, sex, symptom duration, and VAS, CM and ASES scores. In patients treated with corticosteroid, significant improvements were found for the CM score (p=.005), ASES (p=.026), and Pain VAS (p<.001) at the two-weeks follow up. The patients treated with corticosteroid also significantly improved in the CM score (p=.002), ASES (p<.001), and Pain VAS (p<.001) after two weeks. Identical improvements were seen in both groups at 12 weeks follow-up visit. However, hyaluronate-treated group showed slightly inferior clinical results than corticosteroid-treated group, at both two weeks (42.0 vs. 48.6 in CM, 45.2 vs. 49.7 in ASES, and 4.6 vs. 4.1 in VAS) and 12 weeks (52.3 vs. 58.7 in CM, 53.8 vs. 58.4 in ASES, and 3.9 vs. 3.6 in VAS), without statistical significance.

DISCUSSION AND CONCLUSION: Intra-articular injection of hyaluronate and corticosteroid both showed clinical improvement with regard to pain and function on idiopathic adhesive capsulitis patients. Hyaluronate injection can be an alternative treatment option when corticosteroid injection is not indicated.

PAPER NO. 500

Nociceptive Effects of Melatonin in Patients with Chronic Shoulder Pain
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INTRODUCTION: Night pain is commonly observed in patients with rotator cuff tear (RCT) and adhesive capsulitis (AC), but the underlying mechanisms are still largely unknown. We hypothesized that melatonin and ASIC3 may play a role in the night pain of RCT and AC and designed the current study to verify our hypothesis.

METHODS: A total of 21 RCT, 22 AC and 20 control subjects with recurrent shoulder dislocation were included in this study. Bursa, joint capsule tissue and joint fluid were collected. Synovium from patients with rotator cuff tear was obtained for in vitro study. Real-time and conventional RT-PCR was employed to determine mRNA levels of ASIC3, MTNR1A, MTNR1B, IL-6 and IL-1β. Cytokine levels were measured using ELISA assay. Synoviocytes were primary cultured to examine the effect of melatonin.

RESULTS: We found that expressions of ASIC3, MTNR1A, and MTNR1B, IL-6 and IL-1β were significantly increased (p < 0.05). ELISA assay revealed markedly increased productions of IL-6 in the joint fluid of patients with RCT and AC (p < 0.05). To determine the effect of melatonin, in vitro study with primary cultured fibroblast like synoviocytes (FLS) was performed. We observed that IL-1β, among other inflammatory cytokines (TNF-α, TGF-β, and LPS), significantly stimulated the expression levels of MTNR1A and MTNR1B in FLS. Physiologic concentration of melatonin treatment (10 nM) induced ASIC3 expression in FLS. IL-6 production was also increased by melatonin treatment.

DISCUSSION AND CONCLUSION: Taken together, these data suggest that melatonin may exert nociceptive effect in RCT and AC and the effect of melatonin may be receptor-mediated and involved ASIC3.

PAPER NO. 501

The Incidence of Venous Thromboembolic Disease after Shoulder Arthroscopy
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INTRODUCTION: The incidence of symptomatic venous thromboembolism (VTE) after shoulder arthroscopy is unknown. Recently there has been an increased focus on prevention of thromboembolic post-operative complications. Therefore, it is important to understand the incidence of symptomatic deep venous thrombosis (DVT) and pulmonary embolus (PE) after arthroscopic shoulder surgery.

METHODS: A retrospective analysis of all arthroscopic shoulder procedures performed at Kaiser-Permanente from 1/1/2006 to 6/1/2010 was completed. A total of 36,735 arthroscopic shoulder surgeries were identified using ICD9-CM procedure codes. Thromboembolic events occurring within 90 days of surgery were identified by reviewing all inpatient, outpatient, urgent care or emergency care encounters with a diagnosis of DVT or PE. Additionally, charts were reviewed if a venous duplex ultrasound was ordered or an anti-coagulation medication was started within 90 days of surgery. Patients who had a prior history of VTE or had received anticoagulation therapy within 14 days prior to the index surgery were excluded.

RESULTS: Within the cohort of 36,735 patients, three (0.0096%) patients suffered a symptomatic thromboembolic event. No patient died as a result of VTE disease.

DISCUSSION AND CONCLUSION: The incidence of VTE in patients undergoing shoulder arthroscopy was approximately one in 10,000. These findings provide a foundation for counseling patients and decision making regarding VTE prophylaxis.

PAPER NO. 502

Biomechanical Analysis of the Pectoralis Major and Comparison of Techniques for Tendo-osseous Repair
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INTRODUCTION: Pectoralis major repair is indicated in the young active patient to restore strength and improve cosmesis after full thickness pectoralis major rupture. There is a paucity of literature on the surgical management of this condition and no consensus on the optimal technique for pectoralis major repair. The goal of the current investigation is to critically evaluate the biomechanical profiles of the native tendon and three repair techniques: traditional trans-osseous repair (TO), suture anchor repair (SA) and the novel endosteal “pec button” repair (PB), in order to make evidence based treatment recommendations for pectoralis major repair.

METHODS: Twenty-four human cadaveric shoulders were dissected, standardized for bone density and randomized into one of four groups: intact tendon group and three repair groups (TO, SA, PB). Native footprint length and width was recorded.
and used to determine percentage of footprint restoration for each subsequent repair technique. Repair of an isolated pectoralis major tear was performed using techniques determined by the senior authors. The only variable tested was bony fixation type. Each repair group used the same suture type, with six sutures crossing the repair site in a modified Mason-Allen suture configuration. Tensile testing was performed with an adjustable-angle fixture at a 30° angle, simulating the anatomic line of pull of the pectoralis major. An initial preload of 10 N was used for two minutes, followed by cyclic loading between 10-160N for 100 cycles at 100N/sec, followed by a pull to failure at 1 mm/s. Gap formation during cyclic loading and pull to failure was measured using optical tracking. Data was statistically assessed using ANOVA with a Tukey post-hoc test for multiple comparisons.

RESULTS: Pectoralis major native footprint length and mid-portion width was 65.4 +/- 12.2 mm and 6.2 +/- 1.2 mm, respectively. There was no significant difference between repairs with regard to percentage restoration of footprint length or width. The maximum load to failure of the intact tendon group was 1454.8N +/- 795.7 and was significantly greater than the maximum load to failure for the TO repair 359.2N +/- 110.4, SA repair 307.7N +/- 44.4, and PB repair 353.5N +/- 88.3. (p<.001) There were no statistically significant differences among the three repair types with regard to maximum load to failure of the repair (p>.05). None of the repair group specimens failed at the bony interface. The mode of failure for all specimens in each repair group was suture pulling through tendon.

DISCUSSION AND CONCLUSION: This study demonstrates that current tendo-osseous repair techniques for pectoralis major rupture have similar biomechanical profiles and near equal strength. All repairs failed at the suture/tendon interface. This suggests that bony fixation type may be less important, and selection of technique should remain heavily influenced by surgeon experience. Future research should focus on suture characteristics and configuration to improve the strength of the biomechanical construct. The significant difference between the strength of the intact tendon and time-zero repair groups provides a rationale for protection and immobilization during the early post-operative healing period.

PAPER NO. 503

Factors Associated with Cost and Variation in Surgical Treatment of Proximal Humeral Fractures

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INTRODUCTION: The issue of rising costs will likely dominate the healthcare debate in the forthcoming future. Limited resources may necessitate cost-cutting measures. Proximal humeral fractures account for 10% of all fractures in the elderly. We assessed factors associated with lower hospital costs and variations in surgical treatment for proximal humeral fractures.

METHODS: We used national databases for the years 2001-2008 to extract 25,731 patients undergoing surgery for proximal humeral fractures. We calculated hospital cost by converting hospital charges based on the hospital accounting reports collected by the Centers for Medicare and Medicaid Services. Hospital costs were discounted to 2001 based on the Consumer Price Index for Medical Care.

RESULTS: In a multivariate linear regression analysis, higher surgeon volume (β = -90±11), open reduction and internal fixation (versus hemiarthroplasty), and lower burden of comorbidities were some of the factors significantly associated with lower hospital cost. Higher surgeon volume was linearly associated with lower hospital costs such that on average, adjusting for all other factors, a surgeon performing 20 shoulder arthroplasties per year saves a hospital approximately $1,800 per surgery. Factors significantly associated with higher utilization of hemiarthroplasty included high surgeon volume (OR=1.46; CI=1.43, 1.97, as compared with low surgeon volume), high hospital volume (OR=1.72; CI=1.57, 1.89 versus low hospital volume) and earlier years of our study period (OR=0.61; CI=0.56, 0.66, for hemiarthroplasty in the year 2007-2008 versus 2001-2002).

DISCUSSION AND CONCLUSION: To our knowledge, this is the first study to report on the association of higher surgeon volume with lower hospital costs in musculoskeletal care. Policies on minimum volume requirements for orthopedic procedures by hospitals may result in substantial cost savings. There is provider based practice variation in the surgical treatment of proximal humeral fractures. It is likely that reimbursement for orthopedic procedures will be driven by data on comparative effectiveness in the future. Therefore, evidence-based guidelines in this area are needed.

PAPER NO. 504

Management of Conservatively Treated Proximal Humeral Fractures: Prospective Randomized Study

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INTRODUCTION: Conservative treatment of proximal humeral fractures usually includes three to four weeks of immobilization followed by a progressive rehabilitation program. The objective of this study is to analyze if longer than one-week immobilization is needed in proximal humeral fractures treated conservatively.

METHODS: Forty-two proximal humeral fractures were prospectively followed one year. They were randomly allocated to conventional four weeks immobilization regime (22 patients) or functional one-week immobilization regime (20 patients). Both groups followed the same progressive rehabilitation program. Mean age of 70.07 (60-80); 32 females and 10 males; 32 displaced fractures (4 2-part, 26 3-part Greater Tuberosity, 4-part) and 10 non-displaced. No differences as far as age, gender and displacement between conventional and functional groups. All patients included fulfilled analogical pain scale (EVA), Constant shoulder functional score, Satisfaction Score and Euroqol-5D quality of life perception at one week and at three to six and 12 months follow up. Differences between groups were analyzed using T-test. Statistical significance was set at 0.05 (p).

RESULTS: No differences at one week, three, six or 12 months between conservative and functional group in: Pain (EVA: p 0.22, 0.025, 0.16), Euroqol-5D quality of life perception at one week and at three to six and 12 months follow up. Differences between groups were analyzed using T-test. Statistical significance was set at 0.05 (p).

DISCUSSION AND CONCLUSION: No differences have been found in pain, functional score, satisfaction and quality of life perception between patients immobilized one week and those immobilized three to four weeks. This study suggests that immobilization in conservative treatment of proximal humeral fractures can be reduced to one week followed by early progressive rehabilitation program even in severely displaced fractures.
An Accelerated Learning Method for Orthopaedic Surgeons Performing Shoulder Ultrasound

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INTRODUCTION: There is an evolving interest in, and need for, point of access shoulder ultrasound performed by orthopaedic surgeons as part of their routine clinical assessment in a ‘one-stop’ shoulder clinic. Existing training guidelines from national and international radiology boards require prolonged training for non-radiologists under the supervision of a qualified ultrasonographer in order to demonstrate proficiency. This study aimed to develop an independent, accelerated learning protocol for orthopaedic surgeons wishing to perform shoulder ultrasound to evaluate the integrity of the rotator cuff. METHODS: We took four orthopaedic surgeons without previous experience of shoulder ultrasound and monitored their ability to assess rotator cuff integrity using ultrasound compared to arthroscopic findings. The surgeons attended a short formal training course prior to starting the study during which they were taught a protocol to identify and measure the size of full thickness tears of the rotator cuff. The surgeons then began scanning patients preoperatively on the same day they were admitted for shoulder arthroscopy. This allowed the surgeons performing the scans to receive same day feedback of the surgical findings from the operating team and to compare arthroscopic images with their saved ultrasound images, providing a unique educational experience. RESULTS: Overall, 156 patients were scanned by the surgeons in the study. In the initial training period (first 50 scans performed by each surgeon), the group demonstrated a sensitivity of 89% and specificity of 91% (positive predictive value, 83%; negative predictive value, 94%) for the identification of a full thickness rotator cuff tear; they agreed with the intraoperative sizing of the defect in 78% of cases. These predictive values improved in the later training period (second 50 scans performed by each surgeon) to a sensitivity of 91% and specificity of 97% (positive predictive value, 95%; negative predictive value, 94%) for the identification of a full thickness tear; agreement with intraoperative sizing of the defects increased to 95%. DISCUSSION AND CONCLUSION: The study showed that, with intraoperative sizing of the defects increased to 95%, the surgeons rapidly developed proficiency using this method, the surgeons rapidly developed proficiency in shoulder ultrasound with predictive values for their assessment of rotator cuff integrity comparable to the best published results from leading musculoskeletal ultrasonographers. The integration of same day scanning and feedback of operative findings provided a novel learning method and offered an opportunity for independent learning without the need for constant trainer supervision. Shoulder arthroscopy provides a gold standard for the diagnosis of full thickness rotator cuff tears and gives the learning individual the opportunity to compare their findings with this gold standard rather than comparison with the diagnostic opinion of a supervising clinician as is the case with existing training methods. This study demonstrates the capacity of a novel learning protocol to train surgeons with no previous ultrasound experience to reliably evaluate the integrity of the rotator cuff using ultrasound within 50 to 100 scans.

Technique and Outcome of Arthroscopic Treatment of Snapping Scapula Syndrome

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INTRODUCTION: The scapulothoracic (ST) articulation is an underappreciated yet critical component of normal glenohumeral function. Although uncommon, abnormalities within this articulation can result in pain or mechanical symptoms. The purpose of this study was to assess the efficacy of arthroscopic ST bursectomy in patients with snapping scapula syndrome. METHODS: In this Institutional Review Board approved study, 26 shoulders in 23 consecutive patients described mechanical symptoms, failed non-surgical modalities, and reported symptomatic relief from local anesthetic injection prior to surgical intervention. Pre-op and minimum one-year post-op pain levels were assessed in addition to ASES and SANE scores and pain with sports participation. Patient satisfaction with surgical outcome was also recorded using a 10-point VAS scale. Univariate and paired t-tests were used for analysis of data. RESULTS: Mean age at time of surgery was 36 years (19-58 years). The mean duration of symptoms prior to presentation was 4.6 years (range 3 months-29 years). A ST bursectomy alone was performed in two shoulders and the remaining 24 underwent both bursectomy and scapuloplasty of the superomedial or inferomedial scapular border. At a mean follow up of 2.2 years (1-3.3 years) a significant improvement in the ASES score was noted, improving from 53 points (range 17-83) to 73 points (range 38-100) post-op (p=0.018). The mean SANE score at final follow up was 75. Pain decreased from five pre-op to three post-op (p=0.003). Pre-op 7/11 (64%) patients indicated that their pain prevented sports competition but, at 2.2 years post-op only 1/7 (14%) reported pain prevented competition. Overall, patient satisfaction with outcome was 7/10 points. The majority of patients reported improved shoulder function as compared to their pre-op status. Two shoulders (7%) were revised for persistent ST pain and two others subsequently underwent additional shoulder surgery including Bankart repair and subacromial decompression with biceps tenodesis. No iatrogenic neurovascular complications occurred. DISCUSSION AND CONCLUSION: Snapping scapula syndrome can be a debilitating disorder. Non-operative management is frequently successful in managing symptoms. When these modalities fail, endoscopic procedures are capable of providing a significant measure of pain and functional improvement. Despite these encouraging results, patient reported outcomes remain less than optimal at a mean of 2.2 years from surgery. Further analysis will be necessary to determine how outcomes can be improved and if prognostic risk factors can be identified.

Periarticular Locking Plates for Proximal Humeral Fractures: Functional Outcomes

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INTRODUCTION: Recent studies have indicated that locking plates may not provide adequate fixation of proximal humeral fractures in older patients or those with medial metaphyseal extension. The purpose of this study is to assess whether locking plates can adequately hold fracture reduction in proximal humeral fractures.

Addendum: The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e. the drug or medical device is being discussed for an off label use). For full information refer to page 14. An alphabetical faculty financial disclosure list can be found starting on page 19.
METHODS: Forty-four displaced proximal humeral fractures (43 patients) were treated with a proximal humeral locking plate, including 17 two-part, 23 three-part, three four-part, and one head splitting. The average age was 66, with 29 females and 14 males. Meticalous attention was paid to intraoperative anatomic reduction, plate placement below the top of the greater tuberosity, and screw placement along the calcar and into the central and posterior regions of the head with fluoroscopic control. Patients underwent a standard rehabilitation protocol with motion delayed for at least two weeks. All were evaluated by an independent observer not involved in the patients’ care using DASH and ASES scores, patient interviews, and measurements of range of motion. Injury, immediate post-op, and final radiographs were assessed.

RESULTS: Forty-two shoulders with a mean follow up of 36 months (range 24-88 mos.) had a post op average DASH score of 11 and ASES score of 82. Average pain VAS was 0.8. More complex fracture types trended toward worse functional outcome. Average ROM was elevation 136°, ER at side 48°, in abduction 74°, and IR to T11. Medial metaphyseal extension was present in 17 fractures. Neither medial metaphyseal extension nor age affected outcome. All fractures healed in the operatively reduced position. There was no hardware failure, screw penetration, loss of reduction, varus collapse, or avascular necrosis.

DISCUSSION AND CONCLUSION: Displaced proximal humeral fractures can be successfully treated with locking plates when reduction is paid to anatomic reduction and plate placement distal to the greater tuberosity to prevent blockage to elevation, as well as screw insertion in the central and posterior portions of the humeral head with as close to subchondral bone purchase as possible. Fluoroscopic intraoperative control is critical for proper reduction and plate and screw placement.

PAPER NO. 508

Locked Plate Fixation for Displaced Proximal Humerus Fractures in Patients 70 Years and Older

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INTRODUCTION: This study tests the hypothesis that patients over the age of 70 treated with a locked plate for acute displaced proximal humerus fractures can achieve high functional and subjective outcomes with an acceptable complication rate.

METHODS: From October 2006 to October 2009, 27 patients (average age 82.3, range 70-100) with displaced proximal humerus fractures were treated with operative fixation utilizing a pre-contoured locked proximal humerus plate. A standard surgical technique was used, augmented with rotator cuff neutralization sutures tied to peripheral holes on the plate. All patients were treated in a shoulder immobilizer for one month with daily self-assisted stretching began when the immobilizer was removed at four weeks. These were a consecutive series of patients treated for acute displaced Neer two, three and four-part proximal humerus fractures. To be included in this cohort, patient age must have been over 70 with a minimum follow up of 12 months. During this same collection period, 13 patients (average age 83, range 71-91) over the age of 70 were treated with shoulder arthroplasty (four hemiarthroplasty and nine reverse shoulder arthroplasty) for four-part fractures/dislocations that could not be reduced and stabilized using a locked plate. No additional methods of fracture fixation (ie, intramedullary rods, percutaneous pins, or tension band) were used to treat similar fractures during this time period. All fractures were sustained from slip and fall injuries. Each patient was evaluated with clinical, radiographic, and functional outcomes analysis. Range of motion, manual muscle strength, and radiographic analysis was performed by an independent observer rather than the primary surgeon. There were seven patients that did not meet inclusion criteria of 12-month follow up: five died prior to 12-month follow up, one was revised for avascular necrosis in another state, and one did not respond to certified mail inquiry. A consecutive series of 20 patients (average age 80.8, range 70-100) with a minimum follow up of 12 months met inclusion criteria. Patients were evaluated for clinical, functional, radiographic, and subjective outcomes. Based on Neer criteria, there were six two-part fractures (33%), 11 three-part fractures (52%), and three four-part fractures (14%). Average follow-up was 22.8 months (range 12-47 months). Eight patients required the use of an intramedullary peg allograft (40%). Those treated with a peg allograft had an average age of 86.4 (range 70-100).

RESULTS: All fractures healed with an average head to shaft angle of 130.4° (range, 115°-143°). Average forward flexion was 123.5° (range 80°-160°), abduction 88.5° (range 65°-120°), and external rotation 38.8° (range 0°-60°). Functional outcomes averaged: VAS pain 0.9 (range 0-9), VAS Function 8.6 (range 5-10), ASES Pain 45.6 (range 5-50), ASES Function 39.3 (range 10-50), Total ASES 84.7 (range 15-100), and SST 8.7 (range 2-12). Single Assessment Numeric Evaluation (SANE) averaged 87.8 (range 48-100), and 17 patients rated their satisfaction as excellent, one satisfactory, one good, and one unsatisfactory. There were two complications: one superficial infection requiring debridement, and one avulsion of 1cm portion of the greater tuberosity treated non-operatively. No screws were noted to have penetrated the glabelhumeral joint on final radiographs.

DISCUSSION AND CONCLUSION: Use of locked proximal humerus plates in patients over 70 years results in reliable healing, restoration of function, and a low complication rate when combined with rotator cuff neutralization sutures, judicious use of intramedullary allograft, and a delayed self-directed rehabilitation protocol.

PAPER NO. 509

Cerebral Oxygenation in the Beach Chair Position: The Effect of General Anesthesia compared to Regional Anesthesia

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INTRODUCTION: The safety of the beach chair position for shoulder surgery procedures has been well established. However, rare catastrophic neurological events such as ischemic brain and spinal cord injuries have been reported. Anesthetized patients are unable to fully activate the typical sympathetic response to changes in head elevation to maintain cerebral oxygenation. We hypothesized that awake patients would be able to avoid significant cerebral deoxygenation events (CDEs) when procedures were performed in the beach chair position when compared to anesthetized patients.

METHODS: Under Institutional Review Board approval, data was prospectively collected on 60 patients undergoing elective shoulder surgery in the beach chair position. Thirty patients underwent regional anesthesia with an interscalene block and monitored sedation while awake (AWAKE), 30 patients underwent general anesthesia (ASLEEP). Regional cerebral tissue oxygen saturation (SctO2) was quantified using near-infrared spectroscopy. Baseline heart rate, mean arterial blood pressure, arterial oxygen saturation, and SctO2 were measured before patient positioning and then every three minutes for the duration of the surgical procedure. SctO2
values below a critical threshold (< 20% decrease from baseline or absolute value 15 seconds) were defined as a cerebral desaturation event (CDE) and treated using a predetermined protocol. The number of CDEs and types of intervention used to treat low ScTo2 values were recorded. The association between intraoperative CDEs and impaired postoperative recovery was also assessed.

RESULTS: Baseline mean arterial pressure and ScTo2 values did not differ between groups. ScTo2 values were lower in the ASLEEP group throughout the intraoperative period (P < 0.0001). The incidence of CDEs was higher in the ASLEEP group (53.3% vs. 3.4% AWAKE group), as was the mean number of CDEs per subject (2.97 in ASLEEP vs. 0.03 AWAKE, P<0.0001). The total number of combined desaturation events was 89 in the ASLEEP vs. one in the AWAKE.

DISCUSSION AND CONCLUSION: Patients in the beach chair position treated with regional anesthesia and sedation (AWAKE) had almost no cerebral desaturation events, unlike patients who had general anesthesia (ASLEEP). Avoidance of general anesthesia in the beach chair position may reduce the risk of ischemic neurological injury.

PAPER NO. 510
Coracoclavicular and Acromioclavicular Ligament Reconstruction with a Continuous Intramedullary Tissue Graft
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INTRODUCTION: Many techniques have been described to reconstruct acromioclavicular (AC) joint dislocations. Most of these investigations focus on reconstruction of the coracoclavicular (CC) ligaments. Previous biomechanical investigations have shown that reconstruction of only the CC ligaments may not recreate anterior-posterior (AP) translational stability. This investigation reports on the biomechanical evaluation of an AC and CC ligament reconstruction technique utilizing a continuous free tissue graft with an intramedullary clavicular component.

METHODS: Ten matched pairs (20 specimens) of fresh frozen human shoulder were utilized. CC reconstructions were carried out using fresh-frozen human semitendinosus tendons which were passed around the coracoid and fixated in the clavicle using two tenodesis screws. AC/CC combined reconstructions were performed as for CC-only reconstruction except the trapezoid strand which entered the inferior cortex of the clavicle laterally was passed through the clavicular medullary canal, across the AC joint, and was docked in the acromion. Prior to reconstruction, intact specimens underwent translational testing with both 5 Newtons (N) and 10 N loads in the superior-inferior (SI) and AP directions at 5 N and 10 N tensioning) using a customized testing jig. Displacement at the AC joint was measured. Transection of the AC and CC ligaments was then performed and these same specimens underwent either CC-only or combined AC/CC reconstruction. Translational testing was repeated on the reconstructed specimens prior to loading to failure in the superior direction. Contralateral paired specimens with intact AC and CC ligaments were also loaded to failure with linear stiffness, yield load, ultimate load, and energy absorbed being calculated. Paired t-tests were utilized for comparisons with an alpha value of 0.05 set as significant.

RESULTS: There was no significant difference in SI translation (5 N tensioning) between intact specimens and CC-only reconstructions at 5 N (3.2 vs. 2.7 mm, p=0.43) or 10 N loads (3.9 vs. 4.2 mm, p=0.20) nor between SI translation of intact specimens and AC/CC reconstructions (2.7 vs. 2.2, p=0.43; 4.6 vs. 3.7, p=0.33). There were significant differences in AP translation between intact specimens and CC-only reconstructions (Figure 1) but no difference in AP translation between intact specimens and AC/CC reconstructions (Figure 2). Load to failure was 308 N in the AC/CC reconstruction group vs. 521 N in the intact matched pairs (p=0.08). No significant difference was found in the CC-only reconstruction group vs. the matched intact pair in load to failure (421 N vs. 491 N, p=0.19).

DISCUSSION AND CONCLUSION: Reconstruction of the AC and CC ligaments using a continuous free tendon graft though a clavicular intramedullary canal recreated both SI and AP stability at the AC joint. The CC-only reconstruction technique did not restore AP stability. Load to failure characteristics were only partially restored in the combined AC/CC reconstruction group.

PAPER NO. 721
Complications Following Distal Biceps Repair
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INTRODUCTION: The currently accepted surgical treatment for distal biceps injury is an anatomic repair of the ruptured biceps tendon to the radial tuberosity. The purpose of this study is to evaluate the incidence of complications following distal biceps repair in a large patient cohort.
METHODS: A retrospective review was performed on 199 consecutive patients who underwent distal biceps repair at our institution between 2002-2009. All procedures were performed by five upper extremity fellowship trained surgeons. The records were reviewed for patient demographics, timing of surgery, surgical technique, and postoperative complications. Statistical analysis was performed with Fisher exact test and chi-square analysis.

RESULTS: The time to surgery from date of injury was a median of 21 days (range 2-3422 days). The average patient follow up was 42 weeks (range 8-144 weeks). The mean patient age was 48.2 years (range 24-73 years). A total of 169 were men and three were women. Fourteen of these patients required a tendon graft to restore length. Surgical approach performed was one incision technique in 186 and 13 with two incision. Postoperative complications included superficial infection (n=4, 2%), the development of heterotopic ossification (n=5, 2.5%), re-rupture (n=5, 2.5%), posterior interosseous nerve (PIN) palsy (n=7, 3.5%), LABCN paresthesia (n=32, 26%), superficial radial nerve paresthesia (n=11, 5.5%). There was a statistically significant increase in the rate of complication in chronic repairs (> 4 weeks, 34/77 (44%)), when compared to those repaired in the acute period (< 4 weeks, 36/121 (30%) (p=0.039). All five reruptures had suture anchor fixation through an anterior incision (5/112).

DISCUSSION AND CONCLUSION: We report a large patient cohort with few major complications, however minor complications were higher than previously reported. Patients undergoing distal biceps repair greater than four weeks after injury were found to have higher complication rates. The rate of superficial nerve paresthesia/injury was higher than previously reported. We theorize the etiology of these complications may be due to compression on the nerve from the proximal biceps tendon edge.

PAPER NO. 722

Radius of Curvature Plays a Critical Role in Implant Selection During Radial Head Arthroplasty

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INTRODUCTION: Radial head (RH) arthroplasty is surgically indicated for irreparable RH fractures. Selection of an RH implant should restore native characteristics including axial length and diameter. We hypothesize that RH radius of curvature (RC) should play an equally important role in implant selection.

METHODS: Five fresh-frozen cadaver humeri were denuded leaving the articular cartilage intact. Humeri were loaded horizontally onto an MTS machine; capitellum faced up, and covered with a transducer. Five different RH implant models from three common manufacturers were compared. Three CoCr radial heads were 21mm, and one 18mm in diameter, with an additional 21mm diameter pyrolytic carbon RH. RC values for radial head implants were determined by measuring the width and depth of the contact surface. RC for capitellums were calculated using lateral images of all sides and measuring the radial diameter and width.

RESULTS: Percent difference between RH and capitellar RCs were plotted against corresponding contact areas, and a linear regression completed. Negative values corresponded with larger RH to capitellar RC values. The resulting slope of 112.55, showed a significant increase in contact area with decreased RH to capitellar RC ratios. R² value of 0.88 identified a linear trend.

DISCUSSION AND CONCLUSION: Implant RC is rarely mentioned in product descriptions or literature. Intraoperative RH implant sizing comes from an evaluation of native radial head axial length and diameter, not curvature. Implants with improper RC could potentially lead to point loading and excessive contact stresses, resulting in early arthritis, pain, and eventual failure of the implant.

PAPER NO. 723

Chronic Distal Biceps Tendon Ruptures Treated without Graft Augmentation: Results Using the EndoButton Technique

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INTRODUCTION: Chronic distal biceps tendon ruptures may present difficulty in treatment due to tendon retraction and scarring. We present the clinical outcomes of patients with chronic, complete distal biceps tendon ruptures treated with the EndoButton technique without graft augmentation.

METHODS: Twenty-three patients were identified with distal biceps tendon ruptures treated with the EndoButton technique from 2009-2019. Evaluation included completion of the American Shoulder and Elbow Surgeons (ASES) Elbow Assessment form and Elbow Surgeon Survey. Statistical analysis were performed using Fisher’s exact test for categorical outcomes and Wilcoxon rank-sum test for continuous outcomes.

RESULTS: Average age was 51.5 years (range, 39-75 years); average time to surgery was 76.7 days (range, 28-309 days); and average time to follow up was 40.0 months (range, 12-107 months). The average ASES elbow score was 97.0 (range, 83-100), while the average satisfaction score on a 10-point visual analog scale was 9.7 (range, 3-10). In comparison to the contralateral extremity, there was no loss of motion in either elbow flexion or forearm rotation. Strength and endurance testing demonstrated complete return of strength and endurance in both flexion and supination. Average flexion strength recovery was 102%; average supination strength recovery was 100%. Average restoration of flexion endurance was 105%, while restoration of supination endurance was 139%.

DISCUSSION AND CONCLUSION: This is the largest study to date looking at repair of chronic, complete distal biceps tendon ruptures--regardless of fixation method. With the EndoButton technique, patients were very satisfied with their outcomes and regained full range of motion, strength, and endurance compared to the uninjured extremity. Primary EndoButton fixation of chronic, complete distal biceps tendon ruptures without the use of surgical technique, patients were very satisfied with their outcomes and regained full range of motion, strength, and endurance compared to the uninjured extremity. Primary EndoButton fixation of chronic, complete distal biceps tendon ruptures without the use of
an interpositional graft is an effective method to restore strength and function.

**Patient demographics and results (strength, endurance, outcomes)**

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<th>Age (years)</th>
<th>Time to repair (days)</th>
<th>Time to follow-up (months)</th>
<th>Flexion strength ratio (injured/uninjured)</th>
<th>Flexion endurance ratio (injured/uninjured)</th>
<th>Supination strength ratio (injured/uninjured)</th>
<th>Supination endurance ratio (injured/uninjured)</th>
<th>ASES elbow score</th>
<th>Satisfaction</th>
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**Effect of Prosthetic Design on Radiocapitellar Stability in a Terrible Triad Model**

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INTRODUCTION: Prosthetic radial heads contribute to elbow stability through a combination of mechanisms including concavity compressive forces. Terrible triad injuries involve disruption of articular (bony) and soft tissue constraints. In the setting of an elbow fracture-dislocation, an inadequately stabilized joint could result in recurrent subluxation and instability, potentially necessitating a complex revision surgery. Our aim was to compare the relative efficacies of monopolar versus bipolar, and anatomic versus non-anatomic, prostheses in restoring radiocapitellar stability in the setting of a terrible triad-type injury.

METHODS: A terrible-triad type elbow injury was created in eight fresh frozen cadaveric specimens. The soft tissues were dissected, except for the lateral collateral ligament (LCL) and medial collateral ligament. A tip subtype 2 fracture of the coronoid, created by a transverse osteotomy, was fixed using 2.7-mm screws. The LCL was then dissected and repaired to its origin using suture anchors. Two types of implants were tested. One was a bipolar implant with a circular head that could be prevented from tilting by placing a custom-made metal collar around the radial neck. The second was an anatomically shaped prosthesis. The anatomic implant’s articulating dish had a depth of 2.3 mm and a variable radius of curvature, versus a depth of 1 mm and constant radius of curvature in the circular implant. A previously described customized testing apparatus equipped with a load cell translated the radial head underneath the capitellum for 6 mm in the anterior and posterior directions, both from the starting position. The greatest force aligned with the direction of travel between the radial head and capitellum before subluxation was defined as the peak subluxation force. The native radial head was tested first, followed by either the bipolar, non-anatomic circular monopolar, or anatomic monopolar implant.

RESULTS: The peak forces required to subluxate the anatomic prosthesis (16 ± 1 N) were not significantly different from those required to subluxate the native radial head (18 ± 2 N) (p > 0.05). However, the force required to subluxate the non-anatomic circular prosthesis was significantly less than either of the other two (12 ± 1 N) (p ≤ 0.03). The bipolar design required significantly less force (1 ± 1 N) to subluxate the joint than the native, anatomic, and circular radial heads (p ≤ 0.01) (Figure 1). The force displacement curves of the native and two monopolar designs were similar, with the anatomic implant’s curve demonstrating more resemblance to the native radial head’s curve than the circular implant (Figure 2).

DISCUSSION AND CONCLUSION: This study demonstrates that in a terrible triad model of elbow fracture-dislocation, radiocapitellar joint stability is more effectively restored by monopolar than bipolar radial head implants. Additionally, articulating dish depth (2.3 mm in the anatomic implant versus 1 mm in the non-anatomic implant) significantly influences radiocapitellar stability.
cumulative intra- and inter-observer reliability was 0.8 and 0.5 for the capitellar and trochlear centers was >0.98, while the 2.6±3.7°, p=0.96). The intra- and inter-observer reliability of 2.8±3.5° (p<0.001) relative to the FEA (males 2.7±3.4°, females 16.4±5.2°, p=0.002). The mean PCL was externally rotated by 14.0±4.2° and FEA were calculated and compared using two-tailed t-tests. METHODS: From 2003-2008, 25 patients underwent RTEA with APCs on the humerus (six), ulna (18) or both (one). Reasons included loosening with fracture or cortical breach (11), loosening without fracture (four), infection (six), failed hardware (one), failed hemiarthroplasty (one), nonunion (one) and resection (one). Three reconstructive strategies were developed: intussusception of the graft and implant into the host (type 1), extension of the stem through the allograft and into the host canal with strut-like extension the graft coapted externally to the host cortex (type 2), and side to side contact between the cortices of the APC and the host bone (type 3) (Figure1). With a minimum of two year follow up, clinical outcomes using the Mayo Elbow Performance Score (MEPS), radiographic union and overall revision/complication rates were retrospectively examined. RESULTS: The mean MEPS improved from 28 to 84 points. A total of 96% of APCs incorporated. There were 10 complications in seven patients including infection (three), fracture (three), nonunion (one), malunion (one), skin necrosis (one), and triceps insufficiency (one). Five patients underwent eight re-operations. Four of 25 patients had resections (three for residual infection) and one underwent successful revision APC leaving 20/25 (80%) with functional elbows. DISCUSSION AND CONCLUSION: Larger graft-host contact areas in the three types of APCs described provided improved function and a high rate of union. APCs can provide the possibility for a safe, reliable salvage operation with an acceptable complication rate for RTEA.
Debridement of the Common Extensor Origin Versus Debridement Plus Anconeus Flap Coverage for Lateral Epicondylitis

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INTRODUCTION: Lateral epicondylitis is a common condition encountered by orthopedic surgeons. Whereas the majority of patients improve with conservative management, a small percentage of patients will fail nonoperative treatment and require surgery. The purpose of this study is to compare the clinical results of surgical debridement of the common extensor origin alone to debridement combined with rotation of an anconeus muscle flap in patients who failed conservative management of chronic lateral epicondylitis.

METHODS: Twenty patients who failed a minimum of six months of conservative treatment for lateral epicondylitis were retrospectively reviewed. Patients in Group 1 (n = 10) were treated with open debridement of the common extensor origin. Patients in Group 2 (n = 10) were treated with open debridement in addition to rotation of an anconeus muscle flap to cover the defect. Outcome measures included elbow range of motion (ROM), grip strength, visual analogue pain scale (VAS), and Disabilities of the Arm, Shoulder, and Hand (DASH) scores at an average of 11.2 months postoperatively. Statistical analyses were performed using Student’s t-test with 95% confidence intervals (p < 0.05).

RESULTS: There were no significant differences between the groups in regard to age, duration of symptoms, or number of corticosteroid injections. At final follow up, average grip strength with the elbow extended was significantly greater in patients in Group 2 (46.3 lbs in Group 1 vs. 66.8 lbs in Group 2; p = 0.04). Average DASH scores were significantly lower in patients in Group 2 (40.2 in Group 1 vs. 14.7 in Group 2; p = 0.004). There were no significant differences between the groups in regard to average elbow ROM (0-140 degrees in Group 1 vs. 5-136 degrees in Group 2), average grip strength with the elbow flexed (50 lbs in Group 1 vs. 65.5 lbs in Group 2), or VAS pain scores (3.7 in Group 1 vs. 2.1 in Group 2). There were no apparent complications in either group.

DISCUSSION AND CONCLUSION: In addition to debridement of the common extensor origin, the rotation of an anconeus muscle flap may improve outcomes in cases of lateral epicondylitis that require operative intervention. There is no apparent increased risk of complications, and microvascular experience is not required to perform this procedure.

Biomechanical Assessment of Two Lateral Ulnar Collateral Ligament (LUCL) Reconstruction Techniques

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INTRODUCTION: Posterolateral rotatory instability (PLRI) of the elbow is a clinical entity that in recent years has gained more recognition in its diagnosis and treatment. Surgical reconstruction is often needed to treat this injury. Like on the medial side of the elbow a docking technique with a tendon graft is traditionally used. However, the techniques for lateral ulnar collateral ligament (LUCL) reconstruction have evolved with attempts to decrease soft tissue dissection, allow for more reliable graft placement and provide a high load to failure construct.

METHODS: Six matched pairs of cadaveric elbows underwent biomechanical testing under two different reconstruction techniques.
techniques. In the first group, 4.5 x 15 mm soft tissue interference screws were used to secure the graft both distally and proximally. The second group used a docking technique. Palmaris tendons were harvested from each elbow. The reconstructed elbows were cyclically loaded using 0.5 Nm supination torque with 70N of axial compression for 50 cycles at 0.1Hz and then loaded to failure. RESULTS: The average stiffness when loaded to failure for the interference screw fixation group (28.2 +/- 6.5 Nm) was not significantly different from reconstructed elbows using a docking technique (29.3 +/- 7.8 Nm). In cyclical loading testing the conditional elongation also did not show any meaningful differences between the two reconstruction groups (1.09 +/- 0.27 Nm(deg vs 0.89 +/- 0.39 Nm(deg). DISCUSSION AND CONCLUSION: The optimal method of reconstruction of the LUCL has not been studied. In this study, the interference screw reconstruction technique was biomechanically comparable to the docking technique while also providing clear advantages. It minimizes soft tissue stripping allowing for faster rehabilitation and decreasing pain and technically is less demanding reducing the amount of drill holes needed and allowing for a more anatomic placement of the tendon graft. And most importantly, this technique provides the surgeon the flexibility to use a larger graft with a larger implant increasing construct stiffness not often possible with the use of a docking technique.

PAPER NO. 731
Determining the Optimal Fixation Method for a Coronoid Prosthesis
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INTRODUCTION: The coronoid process is an integral component for maintaining elbow joint stability. Large coronoid fractures are typically treated surgically with open reduction and internal fixation. However, when this is not possible due to comminution or osteopenia, prosthetic replacement may be a feasible solution for restoring stability to the coronoid-deficient elbow. The purpose of this in-vitro biomechanical study was to compare four different methods for fixation of a coronoid implant. Our hypothesis was that a cemented stem would provide the most secure fixation, reducing micro-motion of the coronoid prosthesis in comparison to screw and press-fit fixation. METHODS: A coronoid prosthesis was subjected to cyclic posteriorly-directed tip loading, after being implanted using four different fixation methods: press-fit, two anterior-to-posterior (AP) screws, two posterior-to-anterior (PA) screws, and cement fixation. Testing was performed on seven fresh-frozen denuded ulnae using a materials testing machine, with all four fixation methods tested in each specimen in a repeated-measures model. The 3-dimensional (3D) displacement of the prosthesis was monitored by an optical tracking system. One hundred cycles per load level at 1 Hz were applied, increasing in 50 N increments up to a maximum of 400 N, or until failure (defined as displacement of the prosthesis exceeding 2 mm). RESULTS: The press-fit fixation method frequently failed prior to completion of the loading protocol, consistently reaching only 150 N prior to failure, while cement and screw fixations consistently reached 400 N. The overall 3D displacement was found to be significantly greater when the implant was fixed with the press-fit method in comparison to PA screws, AP screws, and cement fixation methods(p<0.01). Cement fixation was noted to significantly reduce the displacement of the implant compared to both AP and PA screw fixation methods (p=0.02 and p=0.03, respectively). When the two screw fixation methods were compared, less displacement was observed with the use of PA screws, however this difference was not significant (p=0.07). The implant did not experience displacements exceeding 0.8 mm in screw and cement fixations during the loading protocol. DISCUSSION AND CONCLUSION: Cement fixation provides the best initial fixation for a coronoid implant. However, the stability provided by both methods of screw fixation may be sufficient to allow osseous integration to be achieved for long-term fixation. Large displacements were observed using the press-fit fixation technique, suggesting that modifications would need to be developed and tested before this technique could be recommended for clinical application.

PAPER NO. 732
Arthroscopic Fragment Fixation with HA-PLLA Pins for Osteochondritis Dissecans of Throwing Elbow
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INTRODUCTION: Various procedures had been described for the treatment of osteochondritis dissecans (OCD) of the humeral capitellum. There is a paucity of literature concerning usefulness of hydroxyapatite-poly-L-lactate acid (HA-PLLA) in the treatment for osteochondral fixation. The purpose of this study was to elucidate the clinical outcomes of arthroscopic fragment fixation with HA-PLLA pins for the treatment of OCD of the humeral capitellum. METHODS: Between 2006 and 2009, 18 adolescent baseball players with humeral capitellum OCD who underwent arthroscopic fragment fixation with hydroxyapatite-poly-L-lactate acid were enrolled in this study. The mean age of the patients at the time of surgery was 14.2 years (range, 12-16). During this arthroscopic procedure, the elbow was maintained in the maximum flexed position, and posterolateral portals were used to visualize the lesion, perform drilling with K-wire and insert the pins. The dominant side was operated on in all patients. Elbow function was assessed before and after surgery using the modified Andrew Timmermans score. Evaluation was performed an average of 26 (minimum two years: range 24-36) months after surgery. Return to sports was defined as the player resuming baseball for training or participation in the sport of baseball. Statistical analysis (Student’s t test) was carried out using statistical software. P<0.005 was considered significant. RESULTS: According to the International Cartilage Repair Society (ICRS) classification, our arthroscopic findings were classified as ICRS OCD grade II in four lesions, ICRS OCD grade III in 11 lesions and ICRS OCD grade IV in two patients. At a mean follow-up interval of 26 months (range, 24 months to 36 months), the mean Timmerman and Andrews score improved significantly from 128±3.6 to 198±4.8 postoperatively and the average of Mayo score improved from 69.4±8.4 to 98.6±3.3. The overall evaluation was excellent in 17 patients, and fair in one patient. Seventeen of the 18 patients were free from elbow pain and one had mild pain occasionally. The mean range of elbow motion increased significantly from 113 (extension, -10° ± 10°; flexion, 123° ± 13°) to 137° ± 11° (extension, -1° ± 10°; flexion, 138° ± 6°) postoperatively (p<0.005). Three patients had a loss of extension >5°. Sixteen

For full information refer to page 14. An alphabetical faculty financial disclosure list can be found starting on page 19.
INTRODUCTION: The universal goniometer (UG) is an easy-to-use instrument but its reliability and accuracy have been questioned in many studies. The potential misalignment of the instrument is an important source of error. The gold standard computed radiography should allow precise measures of the range of motion (ROM) by using the upperlimb bones as reference axis. Therefore in the present study, the universal goniometer will be confronted to radiographic measurement of ROM and carrying angle of the elbow.

METHODS: Range of motion and carrying angle of 102 healthy elbows were measured using two methods: with a universal goniometer by a single observer three times and on radiographs by two independent examiners. ICC, Paired t-test and Pearson’s correlation were used to compare and detect relationship between mean range of motion and carrying angle. Finally, the maximal errors - the highest disparity between the measurements - were calculated according to the Bland and Altman method.

RESULTS: Goniometric (0.945-0.973) and radiographic (0.980-0.991) intraclass correlation coefficients were excellent. T-tests showed significant differences for maximum flexion, maximal extension, and carrying angle between the methods. A good correlation was obtained r= 0.728; p < 0.001 for the total range of motion in flexion-extension. Finally, the maximal errors of the goniometric measurement are: for extension 10.3°, for flexion 7.0° and for carrying angle 6.5°, 95% of the time. No pattern was observed for the difference of values between the two measurements methods. The goniometer either overestimates or underestimates the range of motion in a non-predictable way.

DISCUSSION AND CONCLUSION: Both measurement methods are significantly different but they are correlated. The maximal error is +/- 10° for extension. The goniometer in still a cheap, simple and fast to use clinical tool. We however strongly recommend the use of the radiographic method for research protocols, when higher level of precision are required.

PAPER NO. 734

Effect of Stem Length on Prosthetic Radial Head Stability

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INTRODUCTION: Initial stability is important for the longevity of press-fit radial head implants. Micromotion values below 100 µm are conducive to osseous interdigitation. Little data exists regarding the importance of stem length on stability. It is possible that the initial press-fit stability of a radial head prosthetic stem might be affected not only by the length of the stem inside the canal, but also the level of the cut on the neck of the radius. We hypothesized that increasing the level of bone resection can affect initial press-fit stability, as indicated by increased micromotion at the bone-implant interface.

METHODS: Nine cadaveric radii were implanted with cementless, titanium, grit-blasted radial head stems. Ten, 12, 15, 20, and 25 mm of radial head and neck were resected in each specimen (Figure 1). After the initial 10 mm cut, the implant collar was seated flush against the neck. Then an additional 2, 5, 10, and 15 mm were resected from the radial neck until a total of 25 mm of bone had been resected. Stem-bone micromotion was measured after each cut. Values were expressed in terms of the ratio of exposed head and stem length relative to the unexposed stem length in the canal (Resection Ratio), and the quotient of exposed head and stem length relative to the total head and stem length of the prosthesis (Cantilever Quotient) (Figure 2).

RESULTS: Circumferential removal of proximal bone affected micromotion. A threshold effect was observed at 15 mm (R.R. = 70%, C.Q. = 0.4) of neck resection, with a significant increase in micromotion observed between 12 mm (40 ± 10 µm) (R.R. = 50%, C.Q. = 0.35) and 15 mm (80 ± 25 µm) (p < 0.05). Micromotion values measured with 10 mm (35 ± 5 µm) (R.R. = 40%, C.Q. = 0.3) and 12 mm of bone removal were within the suggested acceptable range of osseointegration promotion. The micromotion values after total bone resection of 20 mm (170 ± 75 µm) (R.R. = 130%, C.Q. = 0.6) and 25 mm (230 ± 45 µm) (R.R. = 250%, C.Q. = 0.7) were above the acceptable range of osseointegration.

DISCUSSION AND CONCLUSION: This study showed that initial press-fit stability of a prosthetic radial head stem is dependent on the amount of bone resected and the length of stem inserted into the bone. Stability may be compromised by excessive stem exposure outside of the canal with insufficient contact within the canal. We found a critical relationship of 70% resection ratio and 0.4 cantilever quotient. Though this concept may seem intuitive, the degrees of stability and lengths to which they correspond to have not been reported in the literature. These data carry important implications for implant design. Additionally, the findings of this study may influence the surgical technique for currently available radial head implants.

Figure 1. A. Collar flush against the radial neck. B. 12 mm, C. 15 mm, D. 20 mm and E. 25 mm of circumferential bone resection.
INTRODUCTION: The interpretation and management of unexpected positive intra-operative cultures obtained during revision arthroplasty poses a major dilemma for the surgeon. While the implications of these cultures during revision hip, knee and shoulder arthroplasty have been investigated, no similar reports are available regarding revision elbow arthroplasty. The purpose of our study is to determine the prevalence of unexpected positive cultures during revision elbow arthroplasty when infection is not suspected preoperatively, and the implications these cultures had on the final outcome.

METHODS: We retrospectively reviewed 213 revision elbow arthroplasties performed at our institution between 2000 and 2007. Of these, 16 patients (7.5%) were found to have unexpected positive intra-operative cultures during revision elbow arthroplasty. All 16 patients had no previous history of infection in the involved elbow, and none was suspected to have an infected elbow arthroplasty at the time of revision surgery.

RESULTS: The majority of cultures grew *Staphylococcus epidermidis* or *Propionibacterium acnes*. Upon discovery of these unexpected positive cultures, a decision was made in combination with an infectious disease specialist to determine if these positive cultures represented contaminants or true subclinical infections. Twelve of the 16 patients had more than two years of follow up (average of 65 months), 10 of which were considered to be contaminants, and did not receive antibiotic treatment. Nine of the 10 remaining patients developed an infection, but with a different organism. One of the 12 elbows with adequate follow up was thought to have a sub-clinical infection, based on suggestive culture results and unexplained early loosening after the index revision arthroplasty. This patient was treated with prolonged antibiotic therapy, but developed an overt infection despite treatment. Intra-operative cultures during resection arthroplasty grew the same organism as the index revision culture.

DISCUSSION AND CONCLUSION: From our experience, there is a 7.5% chance of encountering an unexpected positive intra-operative culture at the time of revision elbow arthroplasty with no preoperative suspicion of infection. The majority of these were spurious, and there was a low rate of failure even though antibiotic therapy was not administered. However, a minority of cultures did manifest to be true subclinical infections. Key factors that helped identify these patients include a sinister presentation of unexplained early loosening, and the isolation of a known pathogen on a solid culture medium.

POSTERS

POSTER NO. P286

**Shoulder Glenoid Revision to Reverse Implant: Clinical and Radiological Results Using a Modular System**

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**INTRODUCTION:** The aim of the study is to evaluate the clinical results of the shoulder prosthesis revision procedure to reverse implant without removing the humeral stem using a modular system and determine if this procedure is beneficial for the patients.

**METHODS:** Inclusion criteria: revision to reverse (RSA) of hemiarthroplasty (Hemi) originally implanted for fracture (Group I) and revision to reverse (RSA) of anatomical total prosthesis (TSA). From 2004 to 2009 26 cases responding to these parameters were identified: 18 cases in Group I (failed hemiarthroplasty for tuberosities resorptions or rotator cuff failure) and eight in Group II (failed TSA for rotator cuff complication). Mean follow up 28 months (min 24 - max 72) and the mean age was 72 (min 65 - max 80). Clinical assessment was performed with preoperative and postoperative Constant score rating scale (CS) and range of motion evaluation (ROM). Radiological assessment was performed by AP and axial X-ray views. Operative time was calculated.

**RESULTS:** Overall pre-op CS was 24 (min 18 - max 30), post-op CS was 47,8 (min 35 - max 60). In Group I the mean improvement of CS was 25,3; in Group II was 17. All patients had a clinical improvement of the range of motion. X-rays study did not show radiolucent lines related to implant mobilization. No major complications were observed in all the cases. **DISCUSSION AND CONCLUSION:** Revision surgery for failed Hemi or TSA is commonly related to a relative increase of complication and/or poorer outcome if compared to a primary RSA implant. Our study results demonstrate that using a full modular system from the first implant allowing skip the humeral stem removal / reimplant step in case of conversion of a shoulder prosthesis to a reverse with good clinical result; no radiological signs of mobilization and non major complication probably related to a shorter and less aggressive operative time and procedure.
SLAP Repair Incidence: A Longitudinal Investigation of Community and Academic Databases

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INTRODUCTION: Superior labrum anterior to posterior (SLAP) lesion repair has become controversial with regard to its indications and potential complications due to increases in rate of repair. This study aims to determine the frequency of SLAP repairs and how that frequency has changed over time.

METHODS: Three databases were used to determine the frequency of SLAP repair over a 10-year period. In Part A, the New York Statewide Planning and Research Cooperative System (SPARCS) ambulatory surgery database was used to identify all SLAP repairs and all orthopaedic surgery ambulatory procedures from 2002 to 2009. In Part B, the CA Office of Statewide Health Planning and Development (OSHPD) ambulatory surgery database was used to identify all SLAP repairs and all orthopaedic surgery ambulatory procedures from 2005 to 2009. In Part C, the American Board of Orthopaedic Surgery (ABOS) database was used to identify all SLAP repairs and all orthopaedic procedures from 2003 to 2010.

RESULTS: In Part A, there were 678 SLAP repairs in New York in 2002, representing a population incidence of 3.54 per 100,000. In 2009, there were 2,128 SLAP repairs, representing a population incidence of 10.89 per 100,000. Over these eight years, the volume of SLAP repair increased by 238%, compared with only a 125% increase in the volume of all orthopaedic surgery ambulatory procedures. For every additional year of study duration, a patient was 11.5% more likely (95% CI, 1.094 to 1.137) to have a SLAP repair compared to all other orthopaedic procedures.

DISCUSSION AND CONCLUSION: There has been a substantial increase in the overall volume and population-based incidence of SLAP repairs in recent years in community-based state level databases. No such increases were seen in the cases reported to the ABOS by surgeons who have recently finished academic training. The reasons for these differences are yet to be definitively determined and are likely multifactorial. Level of Evidence: Retrospective comparative study, Level 3.
at the time of surgery. These data suggest these techniques result in improved component selection and placement when compared to conventional planning and surgical technique.

**POSTER NO. P289**

**ALTERNATE PAPER: SHOULDER AND ELBOW I**

**Radiolucent Ring around Bioabsorbable Anchor after Rotator Cuff Repair**

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**INTRODUCTION:** To date, no study has ever evaluated the clinical and radiological significance of radiolucent ring around bioabsorbable anchor used for arthroscopic rotator cuff repair (ARCR). The present study aims to determine whether radiolucent rings around bioabsorbable anchors after ARCR will have any clinical significance and whether the number of the rings will have any correlation with the re-tear rate after ARCR.

**METHODS:** One-hundred-twenty-nine consecutive patients who underwent arthroscopic rotator cuff repair by suture bridge technique were retrospectively evaluated radiographically and clinically. The number and size of the rings that appeared at each follow up were recorded. Also, the locations of each ring were recorded as anterior, middle or posterior, and medial or lateral according to the construct of the anchors used for suture bridge technique. The size of the tear, the number of anchors used and age of the patients were compared. Re-tear rates according to ultrasound examinations were also analyzed.

**RESULTS:** After rotator cuff repair, the mean American Shoulder and Elbow Surgeons (ASES) score increased from 46.7 to 88.0 and the overall re-tear rate was 8.5% (11 cases). Seventy-three patients (56.6%) showed radiolucent ring (total number of 99 rings) at least once during the course of their follow up and the rings appeared at mean period of 18.2 months after surgery. Mean size of the rings initially was 5.6 mm and the rings increased or decreased in mean size of 0.4 mm during mean follow up of 37 months. No correlation was seen with the number of radiolucent rings and the rate of re-tears, number of anchors, size of tears, age and clinical outcome as determined by ASES score. Radiolucent ring measurement reproducibility was confirmed by independent repeated measurements. The rings appeared mostly at anteromedial anchors (75 rings, 75.8%) and the authors suggest that mechanical factors may play a role for the cause of radiolucent rings. Radiolucent ring measurement reproducibility was confirmed by independent repeated measurements. The rings appeared mostly at anteromedial anchors (75 rings, 75.8%) and the authors suggest that mechanical factors may play a role for the cause of radiolucent rings. The mean size of the rings initially was 5.6 mm and the rings increased or decreased in mean size of 0.4 mm during mean follow up of 37 months. No correlation was seen with the number of radiolucent rings and the rate of re-tears, number of anchors, size of tears, age and clinical outcome as determined by ASES score. Radiolucent ring measurement reproducibility was confirmed by independent repeated measurements. The rings appeared mostly at anteromedial anchors (75 rings, 75.8%) and the authors suggest that mechanical factors may play a role for the cause of radiolucent rings.

**DISCUSSION AND CONCLUSION:** The significance of the radiolucent ring is unknown and number and size of radiolucent rings around bioabsorbable anchors after rotator cuff repair does not appear to adversely affect the healing and clinical outcome of ARCR. Most radiolucent rings appeared at anteromedial anchors, indicating that mechanical factors may play a role for the radiolucencies.

**POSTER NO. P290**

**ALTERNATE PAPER: SHOULDER AND ELBOW V**

**Arthroscopic Management of Proximal Humerus Malunion with Tuberoplasty and Rotator Cuff Retensioning**

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**INTRODUCTION:** Sequelae of fractures of the proximal humerus include varus or valgus malunion, tuberosity displacement with secondary impingement, and stiffness. This report describes the mid- to long-term results of arthroscopic tuberoplasty and rotator cuff re-tensioning for proximal humerus malunion.

**METHODS:** Between August 2001 and October 2009, nine patients with a mean age of 49 years underwent arthroscopy tuberoplasty and rotator cuff advancement for malunion of the proximal humerus and were included in this study. The initial lesions consisted of five two-part, three three-part, and one four-part fractures. The mean delay between the initial fracture and our surgery was 19 months. We developed a systematic technique to take down the rotator cuff over the malunited proximal humerus, to then perform a tuberoplasty, and then to re-tension and repair the rotator cuff by advancing it on the greater tuberosity. The mean follow up was 50 months (range, 12 to 108).

**RESULTS:** Patients demonstrated a mean gain of 43° of active forward elevation, recovery of active external rotation (mean 45°, gain 16°), and a substantial pain reduction (3.8 points). The overall functional results according to the University of CA Los Angeles score were excellent in three cases, good in three cases, and fair in three cases. No patient required additional surgery. Eight of the nine patients (89%) were able to return to their previous sports or activities. All patients declared themselves as being satisfied with the result.

**DISCUSSION AND CONCLUSION:** Arthroscopic tuberoplasty and rotator cuff re-tensioning for proximal humerus malunion is a viable alternative to traditional open methods, particularly in young patients. Although the technique is technically demanding, it allows preservation of the native humeral head, is associated with a very low complication rate, and avoids concerns about long-term prosthetic survival in young patients.
POSTER NO. P291
ALTERNATE PAPER: SHOULDER AND ELBOW III
Can Resurfacing Shoulder Implant Replace Anatomic Shoulder Arthroplasty?
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INTRODUCTION: Resurfacing implant allows surgeons to preserve the bone of the proximal part of the humerus and to reproduce the individual anatomy. Hypothesis: Resurfacing shoulder implants are adapted to treat degenerative shoulder diseases.

METHODS: Sixty-one patients (64 shoulders) underwent a shoulder resurfacing implant and were reviewed with a minimum of two-year follow up: 28 women and 33 men of 57 years (30-80) on average. Etiologies were: primary osteoarthritis (26), post-instability arthritis (14), post-traumatic arthritis (7), rheumatoid arthritis (4), avascular necrosis (4), glenohumeral dysplasia (4), and others (5). Glenoid wear was centered in 42 out of 64 cases and was not replaced. The global fatty degenerative index (FDI) was 0.64 (0-3.25).

RESULTS: At 32 months average follow up (24-50), Constant score reached 68 points (29-100) and the DASH score 28 points (0-88). Best results were obtained for primary osteoarthritis (72 and 21 points), and for post-instability arthritis (73 and 27 points). For post-traumatic arthritis results were less favorable (66 and 33 points), worst results being obten for rheumatoid arthritis (49 and 65 points) and dysplasia (60 and 28 points). Ten patients were still painful at follow up. Radiographic analysis showed correction of the medialisation effect secondarily to glenohumeral wear and a tendency for the implant to be in varus. One case of lucent line was observed around the central peg without any evolution or migration of the implant. There were 10 cases of glenoid wear and one patient has to be revised to totalize the implant two years after the initial procedure.

DISCUSSION AND CONCLUSION: Resurfacing shoulder implant is a valuable therapeutic option to treat degenerative shoulder diseases. Reliable results can be expected especially when the humeral head is centered and the trophicity of the rotator cuff muscle is good (FDIs1). However, when there is wear of the glenoid surface, tissue interposition or glenoid component may be indicated to decrease the risk of painful shoulder.

POSTER NO. P292
Investigation of Cerebral Desaturation Events During Shoulder Arthroscopy in the Beach Chair Position
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INTRODUCTION: Patients undergoing shoulder surgery in the beach chair position may be at increased risk for serious neurocognitive complications due to cerebral ischemia. The upright position is associated with significant hemodynamic changes, often provoking hypotension and thus challenging cerebral circulation. We sought to determine the incidence, patient risk factors and clinical sequelae of intraoperative cerebral desaturation events during arthroscopic shoulder surgery.

METHODS: Data was collected on 50 consecutive patients undergoing arthroscopic shoulder surgery in the beach chair position. The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) was administered to each patient pre- and postoperatively. Regional cerebral tissue oxygen saturation (rSO2) was monitored intra-operatively using near-infrared spectroscopy (NIRS). Baseline mean arterial blood pressure and rSO2 were measured prior to intubation and patient positioning. Intraoperative decreases in rSO2 of 20% or greater from baseline were defined as a cerebral desaturation events (CDE), and treated using a predetermined protocol. The association between intraoperative CDE and postoperative cognitive decline was assessed.

RESULTS: The incidence of intraoperative CDE in our series was 18% (9/50). There was no statistical difference between the subjects that experienced CDE (9) and those that did not (41) in age, gender, smoking, diabetes, hypertension, coronary artery disease, obstructive sleep apnea, peripheral vascular disease or pulmonary disease. However, hypertension (67% vs. 36%, p=1.30), diabetes mellitus (33% vs. 12%, p=.144), and obstructive sleep apnea (33% vs. 12%, p=.144) all demonstrated a trend toward statistical significance. Increased Body Mass Index (BMI) (p=.0001) was found to have a statistically significant association with intraoperative CDE. Seventy-eight percent of subjects that had CDEs had a BMI over 34 (mean BMI of 37.32) compared to only 21% of patients without CDE (mean BMI of 28.59). There was no statistical significance in the outcome of pre- vs. postoperative RBANS, neither in the composite scores or any of the sub-indices, in either group.

DISCUSSION AND CONCLUSION: The degree and duration of cerebral ischemia required to produce neurocognitive dysfunction in this patient population remains undefined, however cerebral oximetry with NIRS allows prompt identification and treatment of cerebral hypoperfusion. Increased BMI was found to be a statistically significant patient risk factor for intra-operative CDE, with 12.4 times greater odds of desaturation for patients with a BMI of 34 or greater. Transient intra-operative CDEs however, were not associated with post-operative cognitive dysfunction in our patient population. We believe protocols aimed at detecting and reversing CDE minimize the risk of neurocognitive dysfunction and improve patient safety.
INTRODUCTION: Shoulder hemiarthroplasties may be compromised by rotator cuff tear and cranial migration of the prosthesis causing failure. This situation typically requires conversion into an inverse arthroplasty. Several implants have been designed in order to meet the need of a conversion of a hemi into an inverse shaft. This study was conducted in order to analyse differences between the height and offset of six manufacturers following a conversion of the system.

METHODS: True anteroposterior radiographs of 40 shoulders (10 female and 30 male) were acquired. Images were scaled using a 30mm steel ball. A digital image analyzing software (MediCAD®) was used in order to simulate implantation of the hemi-protheses. Two reference points were analyzed: The greater tubercle and the center of rotation. The offset was defined as the distance between the greater tubercle and the tangent of the lateral margin of the glenoid. After achieving a maximum of congruence for the hemi-prothesis using the anatomical contour of the humerus, the implant was disassembled and the stem was left within the humeral shaft. Then, implantation of an inverse system was simulated using the stem in the same position. This was performed for the smallest possible implant and the highest adaptor and implant matching the glenoid size. Values are reported as Δ-height and Δ-offset ± standard deviation. Statistical analysis was performed by means of a general linear model for repeated measures followed by a pairwise implant types comparison with Bonferroni adjustments. Significance was assumed for P<0.05.

RESULTS: The lowest decrease in height was determined for Implantcast with 11.6±3.3 mm, followed by DePuy (16±5.7 mm) and the highest for Tornier with 33±5.3 mm. Between three manufacturers (Exactech: 23±3 mm, Mathys: 24±2.6 mm and Zimmer: 25±3.4 mm) there were no significant differences in vertical height. Each of the other implants was significantly different from all others (p-values < 0.001). The biggest offset-deviation was calculated for DePuy (-21.7±3.7 mm), followed by Mathys (-14±4.1 mm) and Exactech (-8.3±4.6 mm). The smallest offset-deviation was documented for Implantcast (-3.3±2.8 mm) and Tornier (1.5±5.7 mm). All offset-deviations were significantly different from each other (p-values < 0.001).

DISCUSSION AND CONCLUSION: The data from this study were significantly different from each other (p-values < 0.001). The different manufacturers are based on the extent of bone loss, but little data exists looking at accurate quantification of bone loss across modalities and observers. The current study was designed to determine inter-observer reliability and agreement across modalities (x-ray, CT, MRI) in the assessment of glenohumeral bone loss. METHODS: Following Institutional Review Board approval, we identified 41 patients (43 shoulders) with diagnosis of recurrent shoulder instability and varying size glenohumeral bone defects. All available images were reviewed per clinical routine on a single PACS system. All images (40 MRI; 7 CT; 15 complete radiographs) were independently reviewed by four observers (two orthopaedic surgeons; two musculoskeletal radiologists) blinded to clinical outcome. Hill-Sachs lesions were measured in length, width, and depth. Glenoid width was measured 6mm below coracoid tip on axial cuts with CT and MRI. Sagittal oblique views of the glenoid were evaluated on CT or MRI. The only reproducible measurement looking at accurate quantification of bone loss across modalities (Implantcast and Tornier) in the assessment of glenohumeral bone loss. RESULTS: Forty-three shoulders in 41 patients (16-51yoa; 12F) were evaluated. Radiographs (N=15) showed poor inter-observer reliability overall when compared to CT or MRI. The only reproducible measurement on radiographs was glenoid length on the axillary view (ICC 0.88). All humeral head measures fell well below significance. CT linear measurements of the glenoid showed good agreement (length on axial view; ICC:0.73). Hill-Sachs lesions showed fair agreement with CT scan (ICC: depth:0.62; length:0.56; width:0.44). Remaining glenoid measures including Gerber-Nyfeller method and “best-fit circle” technique showed poor agreement. MRI measures proved greatest reliability of all modalities. Glenoid height (0.68) and
width (0.62) on sagittal oblique views were significant and glenoid length on axial view approached significance (0.5428). Hill-Sachs length and width demonstrated significant agreement (0.7132, 0.602) and depth approached significance (0.5376). Similar to CT, the “best fit circle” and Gerber-Nyfeller methods showed poor agreement. When evaluated by specialty (orthopaedic vs. radiology), greater correlation was seen in the orthopaedic group. Subset analyses based on sex and percent of glenoid bone loss (<15, 15-30, and >30) did demonstrate a trend towards improved agreement in the male moderate (15-30%) and severe (>30%) bone loss groups, but this did not achieve significance.

DISCUSSION AND CONCLUSION: MRI and CT showed improved agreement in assessment of glenohumeral bone loss compared to plain radiographs. Radiographs were only reliable for axial length of the glenoid, a clinically relatively unimportant measure. In turn, MRI demonstrated superior agreement compared to CT scan particularly in evaluation of glenoid bone loss. Conventional CT scan may be unnecessary in formulation of treatment plans for recurrent anterior shoulder instability associated with glenohumeral bone loss. More significant correlation was seen as the degree of glenoid bone loss increases.

POSTER NO. P295
Shoulder Arthroplasty as Treatment for Locked Posterior Dislocation of the Shoulder
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INTRODUCTION: Currently, there is little information available on the outcome of shoulder arthroplasty for the treatment of locked posterior dislocations of the shoulder. Therefore, the purpose of this study was to determine the results, risk factors for an unsatisfactory outcome, and rate of revision.

METHODS: Between 1978 and 2008, 32 patients with locked posterior shoulder dislocations were treated with a shoulder arthroplasty at our institution. Twenty-nine shoulders with complete preoperative evaluation, operative records, and a minimum two year follow-up period or until the time of the revision surgery was included in the study. Average clinical follow up for range of motion was 9.9 years while average radiographic follow up was 6.6 years.

RESULTS: There was significant pain relief from 4.5 to 2.0 (1-5 scale) (P < 0.01)) as well as improvement in external rotation from -20° to 30° (P = 0.0001) and active abduction from 80° to 90° (p >0.10) with shoulder arthroplasty. On the basis of a modified Neer result rating system, there were six excellent, 13 satisfactory, and 10 unsatisfactory results. Four patients required revision surgery; two for recurrent instability, one for pain due to glenoid arthritis and one for infection.

DISCUSSION AND CONCLUSION: The data from this study was not significant with patients on average obtaining only half of normal motion. When recurrent instability did occur, it was in the early post-operative period and did not occur late.
POSTER NO. P297
Less than 100% Bone Support May Not be Associated with Radiolucencies with a Partially Cemented Glenoid Component
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INTRODUCTION: Glenoid component seating/bone support is important to component survival. It is unclear if 100% support is necessary for such and if less than 100% is associated with radiolucencies. Therefore, the purpose of this study was to assess for component radiolucencies and seating for a partially cemented glenoid component.

METHODS: Thirty-six total shoulder arthroplasties (TSAs) for osteoarthritis were in shoulders a minimum two years post surgery. All were evaluated with standardized plain films and CT (0.625 mm cuts) scans with coronal and sagittal reconstructions. Three fellowship-trained musculoskeletal radiologists independently calculated Lazarus radioluency and seating scores with plain radiographs and CT scans as well as Yian scores and bone incorporation between the central peg's radial fins by CT. We tested whether radiolucencies on plain films or CT were associated with seating scores and whether bone incorporation between the central peg's radial fins was associated with seating scores.

RESULTS: At a mean of 43 months post-surgery, neither Lazarus plain film radiolucency scores (p=0.78) nor Yian CT radiolucency scores (p=0.68) were associated with Lazarus plain film seating scores. Neither Lazarus plain film radiolucency scores (p=0.25) nor Yian CT radiolucency scores (p=0.91) were associated with modified Lazarus CT scan seating scores.

Bone incorporation between the radial fins of the central peg was not associated with plain film seating scores (p=0.19) or with modified Lazarus CT seating scores (p=0.80).

DISCUSSION AND CONCLUSION: A partially cemented glenoid component's radiolucencies were not associated with its seating scores. One hundred percent bone support of this component is not necessary for medium term (mean 43 months) survival.

POSTER NO. P298
Reverse Shoulder-Allograft Composite Prosthesis for Reconstruction following Severe Proximal Humeral Bone Loss
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INTRODUCTION: Whether due to fracture, tumor resection, or prosthetic failure, extensive proximal humeral bone loss is often a difficult scenario to manage. The introduction of reverse shoulder prosthesis successfully addresses the limitations of shoulder arthroplasty when rotator cuff insertions are lost. However, proximal humeral bone loss may remain problematic when implanting a reverse prosthesis due to the potential for instability or prosthetic loosening. The purpose of this study is to report our experience using allografts in conjunction with the reverse shoulder prosthesis in treatment of patients with severe proximal humeral bone loss.

METHODS: A prospective database of 284 patients receiving reverse shoulder arthroplasty was queried, and 13 patients were identified who received an allograft and had a minimum of one-year follow up (avg: 25 months). Clinical charts, radiographs, and patient surveys were included in our analysis. Pre and post-operative results, including ASES scores, Constant scores, and active mobility were compared using paired t-tests.

RESULTS: Statistically significant improvements (p<0.05) were seen in all Constant scores, forward flexion, and abduction. ASES score improved from 56.3 preoperatively to 62.0 at follow up. This population had an average of 69.9 mm of proximal humeral bone loss. Four patients reported a subjective grade of very satisfied post operatively, four reported satisfied, two reported dissatisfied, and three reported very dissatisfied. Despite improvements in most functional outcomes, the complication rate was high, as four patients experienced radial nerve palsy, two patients experienced multiple recurrent dislocations, two patients experienced acromion fractures, and two patients developed infections, one of which required removal of the prosthesis.

DISCUSSION AND CONCLUSION: The use of an allograft in the setting of reverse shoulder arthroplasty seems to carry a high rate of postoperative complications. Management of extensive proximal humeral bone loss remains a difficult clinical scenario for which the optimal management has yet to be adequately elucidated. Further research into the use of allografts to minimize complications seems to be warranted.

POSTER NO. P299
The Effect of Glenosphere Edge Offset on Glenoid-Glenosphere Surface Contact Area
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INTRODUCTION: Reverse shoulder arthroplasty (RSA) requires the use of a transfixing plate (e.g. baseplate, metaglene) to secure a glenosphere to the glenoid. Among current designs, there is a variable amount of contact between the glenosphere and underlying bone due to differences in glenosphere-edge offset (distance between baseplate and edge of glenosphere). The purpose of this study was to quantitatively assess contact area between the glenosphere and glenoid in currently available devices.

METHODS: Multiple available RSAs were imported into Solidworks and virtually positioned on a simulated Sawbones block. Different geometry glenospheres (including asymmetric and/or hooded) were fully seated on to each manufacturer’s baseplate. The amount of glenosphere contact area was then determined for each device in three conditions: (1) baseplate flush with glenoid, (2) baseplate inset into glenoid such that the glenosphere backside was flush with the glenoid and (3) baseplate superiorly flush with surface with 10° of inferior tilt.

RESULTS: In all devices, the glenosphere overhangs relative to the baseplate (mean: 2.55 mm, range: 0.11 mm to 7.53 mm). Additionally, an asymmetric surface and/or hooded glenosphere increased the sphere edge offset and contributed to greater contact area in all conditions. In condition (1), mean contact area was 103 mm² (range: 0 mm² to 578 mm²). In condition (2), mean contact area was 276 mm² (range: 12 mm² to 598 mm²). In condition (3), mean contact area was 179 mm² (range: 3 mm² to 524 mm²).

DISCUSSION AND CONCLUSION: Glenosphere contact with the glenoid surface can be affected by prosthetic design, with increasing contact achieved by a larger or asymmetric glenosphere.
POSTER NO. P300

Is the Coraco-humeral Distance Decreased in Patients with Subscapular Tendon Rupture?
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INTRODUCTION: The purpose of this study is to determine whether the coraco-humeral distance is decreased in patients with subscapular tendon rupture.

METHODS: Sixty-seven patients that required arthroscopic surgery for rotator cuff rupture were measured the coraco-humeral distances by two blinded observers, using digital images of pre-operative MRI. The coefficients of interclass correlation (ICC) of the intra and inter-observer reliability were 0.86 (95% CI 0.76-0.92) and 0.92 (95% CI 0.86-0.95), respectively. During the surgery, it was established if the patient presented subscapularis tendon rupture. The series was divided into two cohort groups, a control group (N = 39 patients) with rotator cuff rupture but healthy subscapular tendons and a group with subscapularis tendon rupture (N = 28 patients). Coraco-humeral distances were compared between the two groups.

RESULTS: The coraco-humeral distance measured in the group with subscapular rupture was a mean of 8.9 mm ±3.2 mm while the control group had a mean of 9 ±3.1 mm. There was no significant difference between the two groups.

DISCUSSION AND CONCLUSION: In our study, we did not find a narrowed coraco-humeral distance associated with subscapular tendon rupture.

POSTER NO. P301

Proinflammatory Cytokines and Proteases in Shoulder Arthroplasty Periprosthetic Tissue
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INTRODUCTION: Total shoulder arthroplasty (TSA), reverse total shoulder arthroplasty (RTSA) and hemiarthroplasty (HA) are options for treatment of degenerative conditions of the glenohumeral joint. Current literature describes the histopathologic cause for osteolysis in vitro in total hip arthroplasty, which has shown macrophages in the presence of particulate wear debris release a variety of proinflammatory cytokines that have been correlated with osteolysis observed clinically and subsequent total joint implant failure. The purpose of this study was to characterize proinflammatory cytokines (PICs) and matrix metalloproteinases (MMPs) expressed in the tissue surrounding shoulder arthroplasty prostheses at the time of revision and compare TSA, HA and RTSA to elucidate the effects of articulation conformity and component material composition on cytokine and MMP expression.

METHODS: At the time of revision of 11 TSA, 14 HA and three RTSA systems, waste periprosthetic tissue from the glenoid and humeral sides was collected and immediately immersed in RNA-preserving solution at -80°C until analysis. After thawing and mechanically homogenizing, the tissue samples were subjected to multiplex ELISA to quantify concentration of tumor necrosis factor-alpha (TNF-α), interleukin-1beta (IL-1β), interleukin-8 (IL-8), matrix metalloproteinase-2 (MMP-2), matrix metalloproteinase-3 (MMP-3) and matrix metalloproteinase-9 (MMP-9). The expression of these markers was normalized to the total protein concentration of the tissue sample to account for variation in mass and volume of each sample. Resulting data that was out of the ELISAs testing range was removed prior to statistical analysis. The final data sets were statistically analyzed using a Mann-Whitney rank sum test to compare PIC and MMP concentrations in TSA, HA and RTSA periprosthetic tissues. Additionally, the PIC and MMP concentrations were compared between humeral and glenoid samples for each arthroplasty system.

RESULTS: Average expression concentration and standard deviation of for the glenoid and humeral samples for each of the arthroplasty systems were calculated (Figure 1). Comparing humeral and glenoid samples in TSA, humeral samples were significantly higher in IL-1β (p=0.042) and TNF-α (p=0.023) than glenoid samples and glenoid samples were significantly higher in MMP-2 (p=0.049) than humeral samples. For HA, humeral samples had significantly higher concentrations of MMP-2 (p=0.028) than glenoid samples. When the glenoid tissue samples from HA, TSA and RTSA were compared, TSA had significantly greater IL-1β expression than HA (p=0.021), while HA showed significantly increased IL-8 than RTSA (p=0.011). Humeral samples from TSA showed significantly greater IL-1β than RTSA (p=0.043). Differences in the MMP expression between HA, TSA and RTSA tissue samples, both glenoid and humeral, showed no statistical significance.

DISCUSSION AND CONCLUSION: Results show significant differences in PIC concentration between systems with unconstrained (TSA) and semiconstrained (RTSA) articulation, which may be an effect of polyethylene (PE) wear debris size and morphology. A significant difference was also shown between systems with and without a PE component, demonstrating a possible, distinct role of metallic and PE components on the proinflammatory cascade.
Biomechanical Factors Predisposing to Propagation of Full-thickness Rotator Cuff Tears

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INTRODUCTION: Previous studies have shown that rotator cuff tear size progresses over time; however, the factors that promote tear progression are unknown. The objective of this study was to assess the biomechanical factors promoting tear propagation after full-thickness rotator cuff tear.

METHODS: Seven cadaveric shoulders were tested. From the results of clinical studies, a point 15 mm posterior to the bicipital groove was chosen as a center point for rotator cuff tear creation. Small, medium and large tears were created by extending the tear 5 mm, 10 mm and 15 mm anteriorly and posteriorly, respectively. Rotator cuff tendon strain was measured with a Microscribe 3DLX by digitizing the position of bone markers, consisting of screws placed in the bone just lateral to the rotator cuff footprint, and soft tissue markers, consisting of glass beads, each sutured to the tendon with 4-0 silk at each testing position. Strain was calculated for markers at the tear edge, 5 mm from the tear edge, and 10 mm from the tear edge, in both the anterior and posterior directions, under four rotator cuff conditions: intact, small tear (10 mm), medium tear (20 mm), and large tear (30 mm). Data were collected at three glenohumeral elevations (0º, 60º, and 60º) and five glenohumeral rotations (maximum internal rotation (IR), max IR; 30º of internal rotation, 30 IR; neutral rotation, NR; 30º of external rotation, 30 ER; and maximum external rotation, max ER) with two subsequent loading conditions: (1) passive loading of supraspinatus (20N), subscapularis (50N), infraspinatus (20N), teres minor (10N), deltoid (60N), pectoralis major (30N), and latissimus dorsi (30N) to simulate residual muscle tension, and (2) increased loading of subscapularis (60N), infraspinatus (40N), teres minor (20N) to simulate strengthening rotator cuff. Statistical comparisons were made by using Tukey’s post hoc test and a t-test.

RESULTS: Tensile strain adjacent to the torn tendon decreased with increasing distance from the torn edge. Tendon strain and distance from the torn edge were significantly correlated (P < 0.05, r = -0.46). At the tear edge on both the anterior and posterior sides, tendon strain increased with increasing tear size in all positions (P < 0.05). Tendon strain at the tear edge, 5 mm and 10 mm from the tear edge on the anterior side in the internally rotated position (30 IR and max IR) was significantly greater than that in the externally rotated position (30 ER and max ER), whereas on the posterior side the tendon strain at the tear edge and 5 mm from the tear edge in the externally rotated position was significantly greater than that in the internally rotated position. In the case of the medium and large tears on both the anterior and the posterior side of the torn tendon, tendon strain at the tear edge and 5 mm from the tear edge in 0º of elevation was significantly greater than that in 60º of elevation (P < 0.05). In the medium and large tears, tendon strain at the tear edge, 5 mm, and 10 mm from the tear edge decreased significantly with increasing rotator cuff muscle loading (P < 0.05).

DISCUSSION AND CONCLUSION: Tendon strain increased with increasing tear size, suggesting that tear propagation accelerates...
with extension of the rotator cuff tear. Rotator cuff tear may tend to propagate posteriorly in the externally rotated position, and anteriorly in the internally rotated position. Tendon strain at a low abduction angle was significantly greater than that at a high abduction angle, indicating that rotator cuff tears may propagate whether or not patients are engaged in work or sports that require extreme abduction of the shoulder. Residual cuff muscle strengthening may be effective in preventing tear propagation, specifically in the case of medium and large tears.

**POSTER NO. P304**

**Shoulder Arthroplasty as Treatment for Locked Anterior Dislocation of the Shoulder**

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**INTRODUCTION:** Currently, there is minimal information available regarding the outcome following shoulder arthroplasty for the treatment of locked anterior dislocations. Therefore, the purpose of this study was to review patients who underwent shoulder arthroplasty for locked anterior dislocation to determine the results, risk factors for an unsatisfactory outcome, and the rates of failure.  

**METHODS:** Between January 1, 1978 and December 31, 2008, 14 patients with locked anterior shoulder dislocations were treated with a shoulder arthroplasty at our institution (four reverse shoulders, four hemiarthroplasties and nine total shoulder arthroplasties). Twelve shoulders with complete preoperative evaluation, operative records, and a minimum two-year follow-up period or until the time of the revision surgery were included in the study. Average clinical follow up for range of motion was 4.3 years while average radiographic follow up was 25.6 months.  

**RESULTS:** There was significant pain relief from 4.0 to 2.0 (1-5 scale) (p < 0.01) as well as improvement in external rotation from 14° to 20° (P = 0.05) and elevation from 45° to 85° (P = 0.05) with shoulder arthroplasty. On the basis of a modified Neer result rating system, there was one excellent, seven satisfactory, and four with unsatisfactory results. On the basis of patient satisfaction, five reported much better, three reported better, three reported about the same and one reported worse overall satisfaction. One patient required revision surgery for recurrent instability.  

**DISCUSSION AND CONCLUSION:** Chronic locked anterior dislocation is an uncommon presentation that is difficult to treat effectively. The data from this study indicates that shoulder arthroplasty for locked anterior dislocation has inferior results compared to shoulder arthroplasty for osteoarthritis with a low rate of recurrent instability.

**POSTER NO. P305**

**Triceps Muscle Activation Amplitudes during Functional Activities**

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**INTRODUCTION:** The role of triceps musculature is critical in functional reaching tasks. Loss of active extension following surgical intervention of the elbow can significantly limit functional activities in the patient. To date studies of triceps activation levels have not explored all three portions and have evaluated more rigid planar motions. The purpose of this study was to examine muscular activation levels of the three (medial, central, and lateral) portions of the triceps brachii during functional elbow extension activities associated with daily living. We hypothesize that the medial and lateral portions of the triceps will produce more motor unit activation in the terminal 30° arc of extension relative to more flexed arcs of motion.  

**METHODS:** Twenty healthy subjects (30±7 years, 173±11cm, 68±4kg) had three portions of their dominant arm triceps instrumented with fine-wire electromyography (EMG) to measure muscle activation amplitudes during three functional extension activities (overhead reach, supine extension and pushing). EMG activity was collected and normalized to a maximal voluntary isometric contraction (MVIC) using a root mean square amplitude for each activity. Three independent variables were considered: muscle (medial, central, lateral), arc of motion (120-90, 90-60, 60-30, 30-0) during the activity, under different loading (2kg, 1kg, 0) across all functional activities. The orders of the functional activities were randomized to prevent fatigue bias. The dependent measure was the RMS amplitude represented as %MVIC. Each participant completed 10 repetitions of each task under the three loads. Repeated measures ANOVAs were used to compare the three muscles through the 30° arcs under the three loads with significance set a priori at p ≤.05. Bonferroni post-hoc analysis was used for further delineation to interpret significant findings.  

**RESULTS:** Overall the triceps central portion produced the lowest EMG levels for all tasks ranging from 1-26%MVIC while the medial portion generated the highest level ranging from 7-54%MVIC. During pushing and supine extension activities the medial portion increased by 11±9% in the terminal 30° compared to 120-90° arc (p < .006). Overhead reach task did not have an interaction but revealed greater muscular activation in the the medial (36±18%MVIC) and lateral (36±22%MVIC) portions compared to the central (8±8%MVIC) (p < .001).  

**DISCUSSION AND CONCLUSION:** The medial triceps data supported the proposed hypothesis in two of the functional activities indicating the importance of this portion of the triceps in common activities in daily life. The lateral portion revealed relatively constant in its activation levels throughout the entire motion supporting its role as a stabilizer. The central portion displayed minimal activation across all activities but was recruited to a greater level in more demanding activities. Surgical interventions disrupting the medial or lateral portions of the triceps musculature or tendons may have deleterious effects on regaining full functional active extension. Post-surgical patients need to be evaluated in future studies.

**POSTER NO. P306**

**Factors Expressed in the Glenoid Labrum in an Animal Model of Glenohumeral Instability**

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**INTRODUCTION:** Despite the common nature of acute anterior glenohumeral dislocation, there is little information on the molecular factors which are important in healing of the glenoid labrum. The goal of this study was to utilize a novel animal model of acute anterior shoulder dislocation to determine which molecular factors are expressed in the glenoid labrum in response to this injury. We hypothesized that IL-1β, MMP 3 and MMP13, TGF-β1, and collagen type III will be induced in the healing glenoid labrum.  

**METHODS:** We devised a novel animal model of anterior inferior...
The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e. the drug or medical device is being discussed for an off label use).

For full information refer to page 14. An alphabetical faculty financial disclosure list can be found starting on page 19.

Glenohumeral instability. Injury to the anterior-inferior labrum was surgically induced in male Lewis rats. Rats were sacrificed and injured labral tissue was harvested and compared to uninjured tissue from the contralateral shoulder. Immunolocalization experiments were performed to localize the expression of IL-1β, MMP 3 and 13, TGF-β1, and ColIII. Slides were examined by three blinded reviewers to assess the location and intensity of expression. Statistical differences were determined using the kruskal-wallis and wilcoxon rank sum test.

RESULTS: Expression of IL-1β was increased at all time periods in injured labrum compared to uninjured tissue. Expression of TGF-β1 was also increased in injured compared to uninjured tissue at three, 14, and 42 days. MMP3 and MMP13 were both expressed at increased levels in injured tissue compared to uninjured tissue at three, seven, and 14 days. Collagen III expression was also increased at three days and gradually decreased by 42 days post injury.

Figure 1: Immunohistochemical staining grades comparing injured (red) vs. non-injured (blue) rat labral tissue. top) IL-1β; middle) TGF-β1; bottom) MMP13.

DISCUSSION AND CONCLUSION: In this novel animal model of acute anterior shoulder dislocation, there is increased expression of IL-1β, TGF-β, and MMP3 and 13 in the injured labral tissue when compared to uninjured control shoulders. These data provide important information on the temporal and spatial gene expression that occurs in response to shoulder dislocation and associated labral injury.

Figure 2: Photomicrograph of injured labrum 7 days post injury stained for MMP13.

POSTER NO. P307

The Use of Patient Specific Instrumentation Improves the Accuracy of Glenoid Component Placement

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INTRODUCTION: Pre-operative assessment of glenoid pathology and pre-operative planning of bone preparation and implant placement using current imaging and templating techniques are imprecise. Moreover, difficulty arises in executing the pre-operative plan because current implant placement relies on the use of generic instruments that do not take into consideration a patient’s unique anatomy or degree of pathology. This results in a significant number of glenoid components being malpositioned, frequently resulting in premature failure requiring revision.

METHODS: Our study compared the ability of five different surgeons to place a glenoid component in a specified position when using two types of pre-operative planning and surgical instrumentation. We used a pathologic scapula in a limited exposure clinical bench top model to simulate the surgical condition. Each surgeon performed the defined operative procedure twice using standard pre-operative imaging and standard instrumentation (STD) and twice using a novel 3D CT scan based pre-operative planning software linked to patient and implant specific instrumentation (PSI). The post-operative three-dimensional implant location (version, inclination, total offset, anterior-posterior offset, medial-lateral offset and superior-inferior offset) was compared to the pre-operative planned location between the two groups.

RESULTS: PSI technology resulted in a significant improvement (p < 0.05) in the average deviation of implant position (actual vs. desired) for version, inclination and total offset when compared to the STD group (Figure 1). The wide variation in placement between and within surgeons was markedly reduced with the PSI technology. The greatest effect was seen with use of the PSI technology by the less experienced surgeons. PSI technology also resulted in a significant decrease in the number of clinically relevant screw perforations.

DISCUSSION AND CONCLUSION: This pre-clinical trial demonstrates that use of 3D pre-operative planning linked to...
instrumentation that is both patient and implant specific has the potential of improving the surgeons ability to pre-operatively define the desired location of an implant and then place this accurately at the time of surgery. These techniques are better than the standard methods of pre-operative planning and surgical technique particularly when used by a less experienced surgeon.

POSTER NO. P308

Effect of Traumatic Indication and Implant Type on Symptomatic VTE Rates in Shoulder Arthroplasty

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INTRODUCTION: The incidence of venous thromboembolism (VTE) following shoulder arthroplasty and the need for anticoagulation following surgery is not well described in the literature. The purpose of this study was to analyze risk factors associated with symptomatic VTE in patients undergoing hemiarthroplasty (HA), non-constrained total shoulder arthroplasty (TSA), and reverse total shoulder arthroplasty (RSA).

METHODS: A retrospective review of shoulder replacements performed between 2005 and 2009 in a health maintenance organization was performed. Total shoulder arthroplasty and hemiarthroplasty procedures were identified using ICD-9-CM procedure codes. Patients with previous history of VTE events and pre-operative anticoagulant use were excluded from the analysis. Ninety days post-operative symptomatic VTE events were screened for using an established ICD-9-CM algorithm, radiographic imaging, post-operative anticoagulant review, and manual chart review to confirm VTE cases. Descriptive analysis of the patient population, incidence of deep vein thrombosis (DVT) and pulmonary embolism (PE) are provided.

RESULTS: A total of 2,574 shoulder arthroplasties were identified during the study period, with a VTE incidence of 1.01% (DVT 0.51% and PE 0.54%). There were no significant differences in the incidence of VTE by year, gender, or operative side (all P>0.05). The incidence of VTE in 586 trauma versus 1,988 elective arthroplasties was higher and approached statistical significance (0.80% vs. 1.71%, P=0.055). Among elective procedures, the 212 patients with reverse shoulder arthroplasty (RSA) (1.89%) had a higher incidence of VTE than the 1130 TSA (0.97%) and HA (0.15%), P=0.03. Elective RSA (1.42%) had a higher incidence of PE than HA (0%), and TSA (0.44%), P=0.018. There was no difference in the incidence of symptomatic DVT (0.15-0.53%) between the three elective procedure types (P>0.05).

Among HA patients, 540 trauma cases had a higher incidence of VTE than the 646 elective cases (1.67% vs. 0.15%, P=0.007) and higher incidence of PE (1.1% vs.0.0%, P=0.009). Traumatic HA was found to have statistically significant higher odds of having a VTE event than elective HA (OR=10.9, P=0.023).

DISCUSSION AND CONCLUSION: Overall VTE incidence was low in this study population. Aggressive postoperative VTE prophylaxis can be supported in RSA and traumatic HA patients, as this data suggests higher VTE incidence in both procedures.

POSTER NO. P309

Rotator Cuff Interval Slide: Arthroscopic Anatomy and Specific Relationships to Suprascapular Nerve

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INTRODUCTION: Various soft tissue releases, including the interval slide technique, have been described for mobilization of massive retracted rotator cuff tears. The purpose of this study was to describe the relevant arthroscopic anatomy for surgeons performing these difficult interval slides.

METHODS: Nineteen fresh frozen cadaver shoulders were dissected. Arthroscopic anatomic measurements or observations were made for each shoulder including: 1) the number of suprascapular motor branches to the supraspinatus and infraspinatus; 2) the distance from the confluence of the supraspinatus and infraspinatus tendons to the scapular spine and the suprascapular nerve; 3) the distance from the anterior insertion of the supraspinatus to the suprascapular nerve; 4) the distance of the coracohumeral ligament to the suprascapular nerve; 5) anatomic description of the coracohumeral ligament; 6) the location of the coronoid and spine of the scapula to the face of the glenoid.

RESULTS: On average, there were 1.8 suprascapular branches (range (1-3). There was an average of 3.8 infraspinatus branches (2-8). The average distance from the anterior lateral edge of the supraspinatus insertion to the suprascapular nerve was 47.8 mm. The average distance from the CHL to the suprascapular nerve was 33.2 mm. The average distance from the suprascapular nerve to the confluence of the supra and infraspinatus tendons was 13.9 mm. The average distance from the confluence of the supra and infraspinatus to the scapular spine was 24.2 mm. The coracoid was located about 1:30 (42 degrees) from the top of the glenoid and the spine of the scapula (about 65 degrees) was at 10 o‘clock.

DISCUSSION AND CONCLUSION: This paper described the relevant arthroscopic anatomic landmarks for performing interval slide releases. It is essential to understand this anatomy when performing rotator cuff advancements because of the close proximity of the critical shoulder structures.

POSTER NO. P310

Coracoid Thickness Prediction from Glenoid Width: Reconstructive Implications in Chronic Shoulder Instability

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INTRODUCTION: Chronic anterior shoulder instability with glenoid bone loss can be a very challenging problem to treat. Restoration of stability to a glenoid with significant anteroinferior bone loss (the “inverted-pear” glenoid) requires a bone grafting
procedure. While some debate persists as to what precisely defines a “significant” degree of bone loss, >25% the width of the glenoid is generally agreed upon. Such bone loss is often managed with the Latarjet procedure, which transfers the coracoid and attached conjoined tendon to the scapular neck to restore the bony surface area and articular arc of the anterior inferior glenoid. However, a coracoid graft offers only a finite amount of bone, and in some cases with severe glenoid bone loss, iliac crest bone grating (ICBG) is required to obtain a graft of adequate size to restore glenoid stability. ICBG is associated with a high rate of donor site complications and is generally utilized only when felt absolutely necessary. While glenoid dimensions can be accurately determined using 3-D computed tomography (3-D CT) reconstructions, the thickness of the coracoid cannot be easily measured. This study aims to define a ratio between glenoid width and coracoid thickness that can be used in pre-operative planning to determine if coracoid transfer will yield adequate bone graft to restore glenoid contour, or if iliac crest bone graft must be taken. METHODS: One hundred pairs of cadaveric scapula from the Hamann-Todd Human Osteological Collection at the Cleveland Museum of Natural History were examined. The sample included 50 male and 50 female specimens. Glenoid width and height, and coracoid length (knee to tip) and superior-inferior thickness were measured using digital calipers accurate to 0.01mm for each scapula. Each scapula was measured independently by two of the authors and the results averaged. Measurements for each parameter were averaged with those from a skeleton’s contralateral scapula to obtain a single set of values for each individual. RESULTS: The average male glenoid was 27.46 +/-1.93mm in width by 37.64/+/-2.01mm in height and the average coracoid thickness was 9.69 +/-0.99mm with a length of 23.07+/-2.30mm. The thickness of average male coracoid was 35.4+/-1.1% of glenoid width. The average female glenoid was 23.11+/-1.53mm in width by 32.63 +/-1.05mm in height. The average coracoid thickness was 7.94 +/-0.87mm and length was 18.45+/-1.61mm. Average female coracoid thickness was 34.4+/-3.2% of the glenoid width. Calculation of coracoid thickness from glenoid width is as follows: coracoid thickness = glenoid width (as measured from 3-D CT reconstruction imaging) x 0.354 (for men) or x 0.344 (for women). DISCUSSION AND CONCLUSION: A novel model is presented predicting coracoid thickness and the ability of the Latarjet procedure to restore stability to a given bone deficient glenoid. Using the calculated ratio, a model male patient with a glenoid width of 30 mm as determined by 3-D CT would have a predicted coracoid thickness of 10.6mm (35.4% of the glenoid width). If the measured glenoid bone loss was less than 10.6mm, a Latarjet could be expected to be successful. If the bone loss was more than 10.6mm, ICBG would be necessary. Alternatively stated, a glenoid bone defect of less than 35.4% of the total glenoid width could be managed with a Latarjet, whereas one greater than 35.4% would require ICBG. This model may aid the shoulder surgeon in preoperative planning and help promote successful outcomes in glenoid reconstruction surgery by determining if a Latarjet or ICBG is the most appropriate procedure given the predicted amount of coracoid bone graft available.

POSTER NO. P311
Factors Affecting Rotator Cuff Healing after Arthroscopic Repair - Osteoporosis as a New Risk Factor
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INTRODUCTION: The hypothesis of this study is that bone mineral density (BMD) is an independent prognostic factor affecting rotator cuff healing following arthroscopic rotator cuff repair. METHODS: Among 408 patients who underwent arthroscopic repair for full-thickness rotator cuff tear between January 2004 and July 2008, 272 patients were included whose postoperative cuff integrity was verified by CT arthrography (CTA) or ultrasonography (USG), and simultaneously who were evaluated by various functional outcome instruments. The mean age at the time of operation was 59.5 ± 7.9 years. Postoperative CTA or USG was performed at mean 13.0 ± 5.1 months after surgery, and the mean follow-up period was 37.2 ± 10.0 months (range, 24-65 months). The clinical, structural, and surgery-related factors affecting cuff integrity including BMD were analyzed using both univariate and multivariate analysis. Evaluation of postoperative cuff integrity was performed by musculoskeletal radiologists who were unaware of the present study. RESULTS: The failure rate of rotator cuff healing was 22.8% (62 of 272). The failure rate was significantly higher in patients with lower BMD (p < 0.001); older age (p < 0.001); female gender (0.03); larger tear size (p < 0.001); higher grade of fatty degeneration (FD) of the supraspinatus, infraspinatus, and subscapularis (all p < 0.001); diabetes mellitus (p = 0.02); and associated biceps procedure (p < 0.001). However, in the multivariate analysis, only BMD (p = 0.001), FD of the infraspinatus (p = 0.01), and the retraction size (p = 0.03) showed the significant relationship with the failure of healing following arthroscopic rotator cuff repair. DISCUSSION AND CONCLUSION: BMD, as well as FD of the infraspinatus and retraction size, was an independent determining factor affecting postoperative rotator cuff healing. Further studies with prospective, randomized and controlled design are needed to confirm the relationship between BMD and postoperative rotator cuff healing.

POSTER NO. P312
ALTERNATE PAPER: SHOULDER AND ELBOW VI
Distal Humeral Replacements: Short Term Outcomes
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INTRODUCTION: This study reviews the early results of distal humeral hemiarthroplasty (DHH) for distal humeral fractures. METHODS: DHH was performed on eight patients (mean 64 years; 33-75) for unreconstructable fractures of the distal humerus or salvage of failed internal fixation. An olecranon osteotomy was used in all eight. Latitude (Tornier) prosthesis was used in
all eight. Seven patients were available to participate in follow-up examination, one was lost to follow up. Clinical review at a mean of 34 months (26 - 60) included the American Shoulder and Elbow Surgeons elbow outcomes instrument (ASES), Mayo Elbow Performance Index (MEPI), and Disabilities of the Arm, Shoulder and Hand (DASH). Radiological assessment included radiographs, densitometry (DEXA) and computed tomography (CT) evaluation.

RESULTS: At follow-up evaluation mean flexion was 122.5 (90-135) degrees, pronation 88 (82-101), and supination 74 degrees (60-93). Mean ASES 62 (37-64), MEPI 75 (50-95), DASH 33 (2-68) and satisfaction 5/10. Acute cases scored better than salvage cases. Re-operation was required in two patients; two supplementary fixation removals, zero revisions for periprosthetic fracture or aseptic loosening. Posterolateral rotatory instability was not present in any elbow, but three had laxity. Five patients reported pain with activities of daily living. Uncomplicated union occurred in all olecranon osteotomies. No elbow had an incomplete cement mantle immediately postoperatively but four had luencies >1 mm at follow up; one was loose with a poor outcome. Two elbows had significant olecranon wear on X-ray. Two patients were found to be osteoporotic. CT evaluation demonstrated asymmetric wear of the olecranon fossa in four patients with DHH.

DISCUSSION AND CONCLUSION: Clinical outcome did not correlate with wear or with bone mineral density. DHH has fair to good early results after complex distal humeral fractures with some limitations in motion, pain relief and function. Osteoporotic patients may demonstrate accelerated bony wear. Better results are obtained for treatment in the acute setting. DHH should be reserved for patients who are not candidates for other procedures.

POSTER NO. P313
The Relationship of the Coracoid to the Glenoid and Humerus: An MRI Study
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INTRODUCTION: The relationship of the coracoid to the glenoid and humerus is highly variable. Coracoplasty is performed for subscapularis tears and impingement without values to guide the normal coracohumeral interval (CHI). This purpose of this study was to evaluate the normative values between these structures and to characterize the coracoid shape.

METHODS: We examined 260 MRIs from Memorial Medical Center in Springfield, IL from January to December 2008. All MRIs were performed with a 3 Tesla magnet, with the shoulder positioned in a coil for standardization. Standardized measurements, reported in millimeters and degrees, were performed on axial, coronal, and sagittal views, including CHI, coracoid overlap (CO), coracoid recess (CR), coracoglenoid angle (CGA), and acromiohumeral interval (AHI). All coracoids were characterized by their shape as either flat, curved, or hooked. Fatty muscle atrophy, the shape of the acromion, the thickness of the coracoacromial ligament (CAL) and concurrent pathology were also recorded. Sixty patients had either a subscapularis or an anterosuperior cuff tear. SAS software was used to find correlations between measurements and the presence of a subscapularis or anterosuperior cuff tear. SAS software was used to find correlations between measurements and the presence of a subscapularis or anterosuperior cuff tear.

RESULTS: There were 116 females with an average age of 50.1 and 144 males with an average age of 49.6. The average CR, CO, CHI, AHI, and CGA were 6.5mm, 12.9mm, 11.0mm, 6.1mm, and 146 degrees for females and 6.7mm, 13.4mm, 11.0mm, 6.0mm, and 147 degrees for males. Curved coracoids had a high CO (15.2mm), a low CHI (9.4mm) and a low CGA (141 degrees). Flat coracoids had a low CO (9.3mm), a high CHI (14.4mm) and a high CGA (156 degrees). Hooked coracoids had a low CO (10.2mm), a medium CHI (12mm) and a medium CGA (152 degrees). When correlating with anterosuperior cuff tears, the axial CHI (p-value 0.12) approached significance, while the CAL thickness (p-value 0.049) was significant.

DISCUSSION AND CONCLUSION: This is the first study to characterize the shape of the coracoid on MRI. The shape of the coracoid and its relationship to the humerus and glenoid is highly variable among individuals. There was a trend towards significance of the presence of an anterosuperior rotator cuff tear and the shaped of the coracoid and the CAL. The findings in the study can help guide surgery for anterosuperior rotator cuff tears and impingement.

POSTER NO. P314
The Histological and Biomechanical Effect of Guided Tissue Regeneration Membrane in Rotator Cuff Healing in Rats
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INTRODUCTION: Rotator cuff tissue is known to have incompetent biologic healing potential. A number of efforts have been made to enhance regeneration after rotator cuff repair. We attempted to apply a novel artificial polymer to rotator cuff and investigated if it would provide the evidence to promote healing process in terms of histologic findings as well as biomechanical strength of cuff repairs over time. Our hypothesis was that guided tissue regeneration (GTR) membrane based on polycaprolactone (PCL) show evidence of promoting the healing process of rotator cuff repair improve rotator cuff tendon-healing from histological and biomechanical stand point.

METHODS: Asymmetrical porous guided tissue regeneration (GTR) membrane with hydrophilicity was prepared by an immersion precipitation method using PCL and Pluronic F127. To enhance the rotator cuff repair, PDGF-β was immobilized onto the pore surfaces of the GTR membrane via ionic interaction between heparin and PDGF-β. The growth factor immobilized on the GTR membrane was released in a sustained manner over 14 days. Thirty Sprague-Dawley rats underwent rotator cuff repairs of the infraspinatus tendon bilaterally and tendons were detached and a defect was created. One side was repaired and augmented with a PCL patch in each animal. On the other side, the same size defect was made without repair to serve as control. They were divided into three groups according to the treatments at the tendon defect site. (1) Control group received no repair, (2) Membrane group repaired and augmented with GTR membrane and (3) Growth factor group was underwent repair with PDGF-β-immobilized GTR membrane. The animals were sacrificed at two, four and six weeks after surgery. The repaired rotator cuff was evaluated with histologic analysis and biomechanical testing.

RESULTS: At each time point, both GTR membrane and growth factor groups had significantly higher modified tendon maturing scores than control group (p<0.05). At six weeks, GTR membrane was histologically incorporated into a structure resembling control specimen. The specimens from the GTR membrane group demonstrated a greater mean ultimate force to failure than those from the control group (p<0.05). No significant difference in load to failure was found between GTR membrane and growth factor groups at six weeks. Histologically, we noted that some evidence of fibrous tissue to incorporate into GTR membrane and expression of fibrous tissue were noted.
of collagen type I by immunohistochemical staining at six weeks. DISCUSSION AND CONCLUSION: This study suggested that GTR membrane plays a role in regeneration of tendon tissue with use of a growth stimulating agent after rotator cuff repair and may be useful as a biomaterial in the healing promotion of rotator cuff defects in rats. Further studies with use of more clinically relevant models of tendon-bone repair may support the use of growth factors to improve clinical outcomes.

POSTER NO. P315
Ultrasound-guided Versus Blind Subacromial Corticosteroid Injection for Subacromial Impingement
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INTRODUCTION: Subacromial corticosteroid injections are frequently performed for impingement syndrome of the shoulder. To improve accuracy of injection, ultrasound can be used. The aim of this study was to assess the clinical outcome of ultrasound guided subacromial injection compared to blind subacromial injection for subacromial impingement syndrome. METHODS: A prospective, randomized, double blinded trial was conducted. Fifty-six patients with subacromial impingement syndrome were randomized into two groups: 28 patients received a subacromial corticosteroid injection with ultrasound guidance (ultrasound group) and 28 patients received a subacromial corticosteroid injection without ultrasound guidance (blind group). The Visual Analog Scale (VAS) for pain with overhead activities and the American Shoulder and Elbow Surgeons (ASES) score were obtained before injection and at six weeks post injection. RESULTS: The VAS for pain with overhead activities decreased from 59 ± 5 mm (mean ± SEM) pre-injection to 33 ± 6 mm six weeks post-injection in the ultrasound group (p<0.001) and from 63 ± 4 mm to 39 ± 6 mm in the blind group (p<0.001). The mean VAS decrease was not significantly different between the groups (p=1). The mean ASES score increased from 57 ± 2 pre-injection to 68 ± 3 six weeks post-injection in the ultrasound group (p<0.01) and from 54 ± 3 pre-injection to 65 ± 4 post-injection in the blind group (p<0.01), with no significant difference in mean increase between the groups (p=0.7). Four patients (14%) in the ultrasound group and six patients (21%) in the blind group eventually needed surgery (p=0.7). DISCUSSION AND CONCLUSION: No significant differences were found in clinical outcome when comparing ultrasound guided subacromial injection to blind subacromial injection for subacromial impingement syndrome.

POSTER NO. P316
What Factors are Predictors of Emotional Health in Patients With Full Thickness Rotator Cuff Tears (FTRCT)?
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INTRODUCTION: Several reports document a link between poor emotional health and sub-optimal outcomes after surgery, including rotator cuff tear (RTC) surgery. Our goal was to establish what factors are most predictive of poor emotional health in patients with full thickness rotator cuff tears (FTRCTs). METHODS: In 2007, the Multicenter Orthopaedic Outcomes Network (MOON) Shoulder consortium began to prospectively collect data on patients with symptomatic FTRCTs. All patients completed a questionnaire collecting data on demographics, symptom characteristics, co-morbidities, willingness to undergo surgery, and patient related outcomes (SF-12, ASES, WORC, SANE score, Marx Activity Scale). Physicians recorded physical examination and imaging data. To evaluate the predictors of lower WORC emotion scores, a linear multiple regression model was fit using the above data. Interquartile range (IQR) odds ratios (ORs) are given for continuous variables. RESULTS: Baseline data for 400 patients were used for analysis. In patients with symptomatic FTRCTs, the factors most predictive of worse WORC emotion scores were higher levels of pain (IQROR = -18.9; 95%CI -20.2, -11.6;p<.0001), lower SANE scores (patient rating of percent normal they perceive their shoulder to be)(IQROR = 6.2;95% CI 2.5,9.95; p=.0012); while higher education (p=.006), specifically, compared to those with a HS education or less, a college degree (OR = 9.9; 95% CI 2.6, 17.3), or a graduate degree (OR = 12.2; 95% CI 5.1, 19.2); and employment status (p=.0025), specifically, compared to those working full-time, retired subjects (OR= 8.5, 95% CI 2.8, 14.2) was associated with higher WORC emotion scores. Other variables included in the model as potential confounders were activity level, age, sex, comorbidities, BMI, hand dominance, duration of symptoms, number of tendons torn, atrophy of the supraspinatus, and patient expectations.

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maximum internal (IR) and external rotations (ER) were measured in the scapular plane with 30° and 73° to 120° for forward flexion (p<0.0001); and from 19° to 18° (p=0.38) for external rotation. Seventeen of 62 patients (27%) had grade I glenoid notching, six (9%) had grade II notching and one had grade III notching. There were no radiolucentities noted behind any glenoid base plate. Fifty-eight humeral components (94%) showed no evidence of radiolucent lines, four humeral components (6%) had radiolucent lines <2mm in zone 4. No component showed evidence of subsidence. One hundred percent of both humeral and glenoid components showed complete bony in-growth of the porous tantalum surfaces. No components were revised for loosening or subsidence. Complications were noted in five patients (8%) with the most frequent being dislocation (5%).

DISCUSSION AND CONCLUSION: Our findings indicate that the use of fully uncemented components for RTSA is associated with secure implant fixation, minimal component lucency, and outcomes comparable to cemented RTSA. The rates of scapular notching found in our study are comparable to previous studies and did not affect the stability of the implants. To our knowledge, the clinical and radiographic outcome of uncemented porous ingrowth humeral stems for RTSA has not previously been reported. At short term follow up, reverse total shoulder arthroplasty using uncemented porous in-growth components is a safe and effective treatment for the cuff deficient shoulder.

POSTER NO. P318
Effect of Bankart Lesion Combined with Rotator Cuff Tear on Glenohumeral Stability: A Biomechanical Study
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INTRODUCTION: Rotator cuff tear combined with Bankart lesion is a common finding in elderly patients after anterior shoulder dislocation. However, no consensus has been made concerning whether both pathologies should be repaired and the biomechanical effect of rotator cuff tear combined with Bankart lesion has not been evaluated. The purpose of this study was to quantitate the biomechanical effect of rotator cuff tear combined with Bankart lesion and the effectiveness of sequential repair of the rotator cuff tear and the Bankart lesion.

METHODS: Eight fresh-frozen cadaveric shoulders were used. All soft tissues were removed except the insertion of the rotator cuff muscles and glenohumeral joint capsule. The specimens were tested on a custom testing system with simulated muscle loading based on the physiological cross-sectional area ratios. Five conditions were tested in each specimen: intact, supraspinatus tendon full-thickness tear, supraspinatus tendon full-thickness tear combined with Bankart lesion, supraspinatus tendon repair and finally a Bankart repair combined with supraspinatus tendon repair. Rotational range of motion (ROM) and humeral head apex (HHA) were measured in the scapular plane with 30° and 60° shoulder abduction under simulated muscle loading. The maximum internal (IR) and external rotations (ER) were measured with 1.1Nm of torque. The position of the HHA with respect to the glenoid was calculated using a MicroScribe 3DLX at each position from maximum IR to maximum ER in 30° increments. The anterior-inferior force required for dislocation was measured at 30° of glenohumeral abduction with 30° of ER and 60° of glenohumeral abduction with 90° of ER. A repeated-measures ANOVA with a Tukey post hoc test was used for statistical analysis.

RESULTS: Bankart lesion combined with supraspinatus tear significantly increased rotational range of motion at 30° and 60° of glenohumeral abduction (7.6±6.3° increase at 30° and 14.1±10.3° at 60° (p<0.05)). There were no significant effects on glenohumeral kinematics following Bankart repair combined with supraspinatus tear or Bankart lesion combined with supraspinatus tear. Force prior to dislocation per degree of rotation was significantly less with Bankart lesion combined with supraspinatus tear compared to intact at 60° abduction and 90° of ER (16.7±23.7% decrease (p<0.05)) (Figure 1). Supraspinatus repair alone did not restore range of motion or force prior to dislocation to the intact condition. However, Bankart repair combined with supraspinatus repair restored range of motion and force prior to dislocation. Bankart repair combined with supraspinatus repair shifted the humeral head posteriorly compared to all conditions at mid-range of rotation in 30° and 60° abduction (p<0.05).

DISCUSSION AND CONCLUSION: The repair of both rotator cuff tear and Bankart lesion are necessary to restore the increased total ROM and decreased force prior to dislocation. Abnormal kinematics following Bankart repair combined with supraspinatus repair may be due to over-tightening the joint in this model. Both rotator cuff and anterior labral repair are suggested for patients with combined Bankart lesions and rotator cuff tear to restore shoulder function and prevent recurrent dislocation. However, when repairing both pathologies, care should be taken not to over-tighten the joint which may lead to stiffness or osteoarthritis.
Postoperative MEPS scores averaged 79.3 (range, 50-100).

RESULTS: All 20 patients healed their surgical wounds completely. Patients were evaluated postoperatively for wound healing, pain, and postoperative Mayo Elbow Performance Scores (MEPS). Objective measures such as an impairment rating of postoperative outcome do not account for patients’ subjective pain experience and may not be reflective of the patients’ overall surgical outcome.

DISCUSSION AND CONCLUSION: There is an increased correlation between the studied parameters in the post-operative setting compared to the pre-operative assessment. Objective measures such as an impairment rating of post-operative outcome do not account for patients' subjective pain experience and may not be reflective of the patients' overall surgical outcome.

POSTER NO. P320
The “Anconeus Slide” Rotation Flap for Management of Posterior Wounds about the Elbow

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INTRODUCTION: Wound dehiscence at the tip of the olecranon is not an uncommon complication associated with surgical approaches to the elbow that involve a posterior skin incision. Various flaps have been described in the treatment of such soft tissue defects, but have associated morbidity. The “anconeus slide” rotation flap has low morbidity and is technically simple. In this study, we review the surgical technique and describe our experience with the anconeus rotation flap in 20 consecutive patients.

METHODS: The records of 20 patients who underwent an anconeus rotation flap by a single surgeon, from September 2006 to March 2010 were reviewed. The procedure was performed in the setting of total elbow arthroplasty (TEA) in 12 patients, revision total elbow arthroplasty in three patients, wound complications in four patients, and for an acute open distal humerus fracture in one patient. Patients were evaluated postoperatively for wound healing, pain, and postoperative Mayo Elbow Performance Scores (MEPS).

RESULTS: All 20 patients healed their surgical wounds completely. Postoperative MEPS scores averaged 79.3 (range, 50-100).

DISCUSSION AND CONCLUSION: The anconeus rotational flap is a technically simple, reliable, and safe option for treatment of posterior wound complications about the elbow, and in the setting of primary and revision TEA when wound healing is a clinical concern. We recommend its use in patients who have either compromised posterior soft tissue coverage, triceps insufficiency, or factors associated with the potential for compromised wound healing.

POSTER NO. P321
Subscapularis Footprint Morphology, Tear Characteristics and Implications for Repair

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INTRODUCTION: Advances in shoulder arthroscopy have led to the detection of more subscapularis (SB) tears, especially partial tears. To further our understanding of the SB tendon and tears, a four-part study examined SB tendon footprint anatomy, propensity for tear propagation, partial tear repair anchor location, and functional kinematics of tear and repair.

METHODS: SB footprint anatomy was analyzed using 39 human cadaveric shoulders by digitization of the bony insertion. Tear propagation was evaluated by the strain gradient of two partial tears [partial- vs. full-thickness] during cyclic loading with video digitizing (n=6 matched pairs). Strain gradient from the tear edge to tendon inferior margin was quantified using linear fit analysis. SB tears were then extended to create identical tears for repair analysis. Repair was performed with a single, double-loaded suture anchor in two different locations (medial or lateral to the superior SB insertion) and tested using cyclic loading followed by load to failure. Finally, six separate shoulders were tested to evaluate rotational range of motion (ROM) and kinematics in six conditions: intact, isolated full-thickness SB partial tears (upper ¼ SB tear and upper ½ SB tear), combined SB + supraspinatus (SS) tear, SS repair only, and SB repair + SS repair.

RESULTS: Observation of the natural bony ridges revealed a SB footprint divided into four distinct facets, whose tendon insertion to the humeral shaft axis increased from facet 1 to facet 4 from 58.2º to 94.3º, 148.2º, and 155.0º respectively. There was a negative correlation to the humeral shaft axis increased from facet 1 to facet 4 from 58.2º to 94.3º, 148.2º, and 155.0º respectively. There was a negative correlation between the studied parameters in the post-operative setting compared to the pre-operative assessment. Objective measures such as an impairment rating of post-operative outcome do not account for patients' subjective pain experience and may not be reflective of the patients' overall surgical outcome.
tendon in full-thickness facet 1 tears (-0.7, R²=0.78, p=0.04) and a positive strain gradient for partial-thickness facet 1 tears (0.7, R²=0.54, p=0.13). The medial anchor for SB tendon repair had a significantly higher ultimate load compared to the lateral anchor (p<0.05), but there were no significant differences in linear stiffness, gap formation, hysteresis, yield load, and energy absorbed. One-half SB tear (1st + 2nd facet) significantly increased maximum external rotation (ER) and shifted the humeral head apex superiorly in maximum ER (p<0.05). SS tear plus SB tear significantly shifted the humeral head posteriorly at max ER, which was corrected with SS repair. Repair of the SS or combined SS + SB repair did not restore ROM to intact levels (p<0.05).

**DISCUSSION AND CONCLUSION:** The presented descriptive morphology of the SB tendon footprint may lead to more accurate arthroscopic detailing of SB tear extent and location in the clinical scenario. The negative strain gradient of full-thickness SB tears reveals a higher strain adjacent to the tear edge versus the remaining intact tendon, indicating a greater propensity for tear propagation when compared to a partial-thickness SB tear. Increased ultimate load with medial anchor location in SB partial tear repair may be due to its location on the articular side of the SB tendon footprint, which has been shown to have higher bone mineral density. SB repair combined with SS repair may not be necessary to restore intact kinematics and ROM, however, full-thickness SB tear repair is still recommended to prevent tear propagation.

**INTRODUCTION:** Lateral offset center of rotation (COR) has been shown to reduce the incidence of scapular notching and to potentially increase external rotation range of motion (ROM) after reverse total shoulder arthroplasty (rTSA). The purpose of this study was to determine the biomechanical effects of COR on abduction and external rotation ROM, deltoid abduction force and joint stability. METHODS: A biomechanical shoulder simulator tested cadaver shoulders before and after rTSA. Spacers shifted the COR laterally from baseline by 5, 10 and 15 mm. Outcome measures of resting abduction and external rotation ROM, and abduction and dislocation (lateral and anterior) forces were recorded. RESULTS: Resting abduction increased 20° versus native shoulders (p ≤ 0.006), but was unaffected by COR lateralization (all p ≥ 0.377). External rotation decreased after rTSA and was unaffected by COR lateralization (all p ≤ 0.783). Deltoid force required for abduction significantly decreased 25% from native to baseline rTSA. COR lateralization progressively eliminated this mechanical advantage (all p ≤ 0.018). Lateral dislocation required significantly less force than anterior dislocation after rTSA (all p ≤ 0.035). Increasing lateral offset rTSA resulted in a step-wise trend increasing the lateral dislocation force. The changes were significant (all p ≤ 0.033) for all but two cases (baseline COR vs. +5 mm, +10 mm vs. +15 mm, both p ≥ 0.064). Similarly, the force to create anterior dislocation showed a step-wise trend with increasing lateral offset, but only the baseline COR vs. +10 mm case was significant (p = 0.015, all other p ≥ 0.343). DISCUSSION AND CONCLUSION: COR lateralization had no influence on ROM (adduction or external rotation), but significantly increased both abduction and dislocation forces. This suggests the lower incidence of scapular notching may not be related to the amount of abduction deficit after lateral offset rTSA, but rather may arise from limited impingement of the humeral component on the lateral scapula due to a change in the relative shape of the lateral scapula border with lateralization. Lateralization provides the benefit of increased joint stability, but at the cost of increasing deltoid abduction forces.

**POSTER NO. P323**

**Shoulder Function in Asymptomatic Elderly Individuals**

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**INTRODUCTION:** The relationship between shoulder pathology and function in the elderly is not well understood. In this population, it has been proposed that low demands on the shoulder and an acceptance of shoulder symptoms as a “part of getting older” may result in increased tolerance of shoulder dysfunction. We hypothesize that shoulder function (or tolerance of dysfunction) in asymptomatic elderly individuals is related to other elements of their physical and musculoskeletal health.

**METHODS:** The dominant shoulders of 75 individuals over the age of 65 without known dominant shoulder pathology were assessed with the Constant score, the American Shoulder and Elbow Surgeons (ASES) shoulder questionnaire, and range of motion and strength measurements. These volunteers were also evaluated with the Short Musculoskeletal Function Assessment (SMFA) and the Fried frailty phenotype measure. Demographic data, body mass index (BMI), and the use of an assist device for ambulation were recorded.

**RESULTS:** The average age of the subjects is 73.6 years, 67% are female and 33% are male. Ninety-two percent of the subjects are right-hand dominant and the average body mass index is 31.2. Twenty-eight percent of the subjects reported the use of assist devices for ambulation. The average Constant score is 79.4 and the average ASES score is 95.0. There is a strong correlation between the Constant and ASES scores (r = 0.7). The average overall SMFA score is 22.4 and the average SMFA bother index is 23.6. Higher overall SMFA scores (meaning lower function) are associated with higher Constant and ASES scores (r = -0.46 and -0.42 respectively). This relationship also exists between the SMFA bother index and Constant and ASES scores (r = -0.25 and -0.28.
The three Fried frailty phenotypes have statistically significant different Constant scores; that is, the frail phenotype has the lowest score, followed by the pre-frail phenotype, and the robust phenotype has the highest score (p<0.0001). The same relationship exists between the Fried frailty phenotypes and the ASES scores (p<0.0001). Likewise, large differences in overall SMFA scores are observed among robust, pre-frail and frail subjects (p<0.0001) (TABLE 1). Individuals who use an assist device for ambulation have lower Constant and ASES scores (p<0.0001 and p=0.045 respectively) (FIGURE 1), and higher overall SMFA scores (p<0.0001). There is no correlation between BMI and the Constant score, ASES score, SMFA score, or frailty phenotype.

**DISCUSSION AND CONCLUSION:** In a population of elderly individuals without known shoulder pathology, the Constant and ASES shoulder scores correlate with frailty status, with lower scores seen in the frail and pre-frail subjects. The use of an assist device for ambulation is also associated with lower Constant and ASES shoulder scores in this population. A weak correlation exists between the SMFA bother index and the Constant and ASES shoulder scores in these individuals.

**Table 1: Average Scores Based on Fried Frailty Phenotype**

<table>
<thead>
<tr>
<th></th>
<th>Robust</th>
<th>Pre-frail</th>
<th>Frail</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant Score</td>
<td>84.4</td>
<td>78.1</td>
<td>58.0</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>ASES Score</td>
<td>95.9</td>
<td>85.6</td>
<td>66.4</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>SMFA Score</td>
<td>16.6</td>
<td>25.2</td>
<td>44.7</td>
<td>&lt;0.0001</td>
</tr>
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**FIGURE 1**

**Constant Score by Use of Assist Device**

**ASES Score by Use of Assist Device**

**POSTER NO. P324**

**Shoulder Arthroplasty in Patients 59 Years of Age and Younger**

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**INTRODUCTION:** Shoulder arthroplasty is a well established treatment for a variety of conditions about the shoulder. However, the results of shoulder replacement in younger patients are not as predictable. The purpose of this study is to examine the indications for shoulder arthroplasty in patients 59 years old and younger, and to analyze revision rates between younger and older patients.

**METHODS:** This is a retrospective cohort study of shoulder arthroplasties performed within a statewide integrated healthcare system between 2005 and 2010. Patients were stratiﬁed into two groups based on age at time of index replacement procedure: younger patients (less than or equal to 59 years) and older patients (greater than 59 years). Cases involving trauma to the shoulder were excluded. Descriptive statistics and Cox proportional hazard regression models were used for the analysis. Age, procedure type, diagnosis, race, gender, body mass index (BMI), diabetes, and smoking status were investigated as possible risk factors for revision.

**RESULTS:** There were 2,981 primary arthroplasties performed during this period, 90 (3.0%) of which required revisions. Overall, 23 (1.4%) of total shoulder arthroplasties were revised, as well as 32 (3.9%) hemiarthroplasties, 13 (10.5%) humeral head resurfacings, and 22 (6.3%) reverse total shoulder arthroplasties. Median follow up was 801 days (interquartile range 357 to 1,388). In younger patients, 504 arthroplasties were performed, with the primary diagnosis most often osteoarthritis (81.0%) followed by osteonecrosis (10.9%). The younger patient group had a higher proportion of males (P<0.001), lower diabetes prevalence (P<0.001), different BMI distribution (P=0.011), and different racial distribution (P=0.002) than older patients. Younger patients also had a higher proportion of hemiarthroplasties and humeral head resurfacings (P<0.001), and younger patients were more likely to have a diagnosis of osteonecrosis and rheumatoid arthritis (P<0.001). There were 27 revisions among the younger group, 19 of which were for glenoid arthritis/wear (70.4%). Only 3.7% (N=1) of revisions in younger patients were for glenoid implant loosening and 7.4% (N=2) were for infections. After adjusting for procedure type and diagnosis, younger patients had a two times higher risk (95% CI 1.2-3.5, P=0.007) of revision than older patients. When looking at the risk of revision in younger and older patients separately, the risk of revision in hemiarthroplasty (RR=4.5 versus RR=1.7) and reverse total shoulder arthroplasty (RR=33.6 versus RR=3.0) compared to total shoulder arthroplasty were higher in younger patients compared to older patients. Race, gender, BMI, smoking status, and diabetes were not found to be associated with risk of revision in either younger or older patients (all P>0.05).

**DISCUSSION AND CONCLUSION:** This study suggests that shoulder arthroplasty needs to be approached in the young patient with caution. Patients 59 years and younger have an increased risk of revision at early to midterm follow up, with glenoid wear leading to total shoulder replacement being the most common revision reason. The higher risk of revision in younger patients receiving hemiarthroplasty may support the use of total shoulder arthroplasty in patients 59 years of age and younger.
INTRODUCTION: The tissue-suture interface remains the most common site of failure in rotator cuff repairs. It is currently unknown if arthroscopic sliding knots "saw" through tissue and weaken the suture-tendon interface. The purpose of this study is to evaluate the effect sliding knots have upon on the strength of the suture-tendon interface.

METHODS: Thirty-two sheep infraspinatus tendons grafts were randomized among four groups of stitches (n=8): simple-static, simple-sliding, mattress-static, and mattress-sliding. All stitch-knot combinations were created in an arthroscopic simulated environment, and sliding knots were tied with shortening of the suture and sliding of the knot down to the tissue interface to simulate surgical technique. Each graft was cyclically loaded on a mechanical testing system from 5 to 20 N for 20 cycles and then loaded to failure. An analysis of variance model was used to test significance of sliding stitches upon cyclic elongation, peak-to-peak displacement, and ultimate load. Estimated means and standard deviations are reported from the regression model.

RESULTS: A mattress-static stitch (116N) was significantly stronger than a mattress-sliding stitch (70N, p<0.001). The ultimate loads for the simple-static (46N) and sliding (50N) stitches were not statistically different. For cyclic elongation, the only difference was the mattress-sliding stitch (0.95mm) having a greater elongation than the simple-static (0.61mm; p=0.01) and simple-sliding (0.68mm; p=0.94) stitches. Both mattress stitches had significantly less peak-to-peak displacement (0.39 and 0.41mm) than the simple stitches (0.47 and 0.46mm; p<0.001).

DISCUSSION AND CONCLUSION: Sliding suture through tissue weakens the suture-tendon interface in mattress stitch constructs. Mattress stitches have superior holding strength compared with simple stitches.
METHODS: Among 195 complete repairs of large-to-massive rotator cuff tear, 35 patients experienced painful pseudoparalysis preoperatively. Propensity score matching (one-to-one) was performed between pseudoparalytic and non-pseudoparalytic groups. Finally, 29 patients in each group were matched using the following variables: age, gender, dominance, onset period, aggravation period, number of tendons involved, retraction, operation method (arthroscopic or mini-open), rows of repair (single or double), number of anchors, and fatty degeneration of the supraspinatus, infraspinatus, and subscapularis. After at least one year following surgery, range of motion (ROM), VAS for pain and satisfaction, Constant score, Simple Shoulder Test, American Shoulder and Elbow Surgeons (ASES) score, and University of CA, Los Angeles shoulder rating scale (UCLA score) were evaluated. Healing of repaired cuffs was evaluated by CT arthrogram (CTA).

RESULTS: Most ROMs were improved in both groups after rotator cuff repair. Active forward elevation had significantly improved postoperatively in the pseudoparalytic group (p < 0.001). All functional outcome scores improved at the final follow-up visit compared to preoperative values (all p < 0.05). Preoperative Constant, ASES, and UCLA scores were significantly inferior in the pseudoparalytic group, but all except Constant score showed no differences between the two groups at the final follow up (p = 0.04). Postoperatively, seven patients (24.1%) in the pseudoparalytic and one (3.4%) in the non-pseudoparalytic group showed pseudoparalysis (p = 0.03). Among 37 patients who underwent postoperative CTA, cuff healing was achieved in six of 18 (33.3%) in the pseudoparalytic and nine of 19 (47.4%) in the non-pseudoparalytic group (p = 0.385).

DISCUSSION AND CONCLUSION: Recovery from pseudoparalysis after rotator cuff repair was evident in a large portion of the study group, and postoperative function and cuff healing were not different according to the presence of pseudoparalysis. Considering possible complications and longevity of RTSA, rotator cuff repair should be the first-line treatment option for large-to-massive tears.

POSTER NO. P328
Muscular Activation and Coordination in Patients with Massive Rotator Cuff Tears: An Electromyographic Study

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INTRODUCTION: Massive rotator cuff tears (MRCT) have a negative impact on patients’ quality of life and are prevalent in the elderly population. Adaptive muscle activation strategies are poorly understood and changes in muscular coordination have not been previously studied. Electromyography (EMG) was used to investigate both muscle activation and coordination during an elevation task based on activities of daily living.

METHODS: Fourteen healthy controls and 11 patients with a MRCT were included. EMG was recorded from 13 muscles during an arm elevation exercise. Mean signal amplitude and Pearson correlation coefficient (PCC) analysed muscle activation and coordination respectively.

RESULTS: In the MRCT group, signal amplitude was significantly higher for the elbow flexors (p<0.001) and upper trapezius and serratus anterior (p=0.025) muscle groups. Mean amplitude was also greater for the deltoid (p=0.007), latissimus dorsi and teres major (p=0.007), and rotator cuff (p=0.021) groups in patients with MRCT. Correlation between the muscle groups inserting on the humeral head was high for both controls and MRCT patients (PCC = 0.85-0.91).

DISCUSSION AND CONCLUSION: There is a reorganization of muscle activation strategy along the upper limb kinetic chain in MRCT patients. Increased activity of the scapula and elbow flexing muscles represents adaptations within proximal and distal segments of the kinetic chain, reducing demand on the glenohumeral joint. Increased activation of the latissimus dorsi and teres major muscles compensate for the deficient rotator cuff in balancing the destabilising forces of the deltid. Understanding adaptive muscle activation strategies provides a basis for targeted rehabilitation programs.

POSTER NO. P329
Effect of Humeral Head Shape in Shoulder Hemiarthroplasty: Semi-elliptical vs. Spherical Heads

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Thay Q. Lee, PhD, Long Beach, CA

INTRODUCTION: While it is commonly believed that implants made with design that mimics normal anatomy will provide the best function and durability, most current humeral prosthetic heads have a spherical head shape. The purpose of this study was to biomechanically compare a customized semi-elliptical prosthetic head to a spherical humeral head in shoulder hemiarthroplasty.

METHODS: Six fresh-frozen cadaveric shoulders were chosen from CT reconstruction. The specimens were mounted on the custom testing system which allows humeral abduction (AB) and axial rotation in multiple planes of elevation under simulated anatomic muscle loading. A proximal humerus splitting technique was used to preserve the glenohumeral joint capsule after hemiarthroplasty. The two prosthetic heads were implanted in the same stem cement. Both the semi-elliptical and spherical heads were tested in random sequence. Testing was performed in 0°, 30° and 60° of glenohumeral AB in the scapular plane (SP), coronal plane (CP), and 30° forward flexion from the scapular plane (FF). Range of motion (ROM) and glenohumeral joint kinematics of the humeral head apex (IHHA) and the geometric center of the humeral head (GCHHH) of the native-split, semi-elliptical, and spherical heads were measured at rotational positions from maximum internal rotation (IR) to maximum external rotation (ER). A repeated-measures ANOVA with a Tukey post hoc test was used for the statistical analysis.

RESULTS: The semi-elliptical head had no statistical difference in ROM at all angles compared to the native-split head (p=0.05). While the spherical head significantly decreased IR at 0° and 30° of AB in the SP, and ER at 30° and 60° of AB in the CP (p<0.05). A statistical difference between the semi-elliptical and native-split head in the IHHA position was only found in mid-IR at 60° of AB in the SP (p=0.028). Statistical differences between the spherical and native-split head in the IHHA were found in max ER at 0° of AB, 30° of AB in FF, and 60° of AB in the SP and the CP (p<0.05). All the statistical differences in the GCHHH location between the spherical and native-split head were found in ER at 30° of AB in the SP anteriorly and superiorly, 30° of AB in the CP anteriorly and superiorly, and 60° of AB in the CP anteriorly (p<0.05), while the semi-elliptical head showed significant difference in max ER at 30° of AB in the SP anteriorly and mid IR at 30° of AB in FF inferiorly (p<0.05).
DISCUSSION AND CONCLUSION: Under the simulated anatomic muscle loading condition with the glenohumeral joint capsule intact, the semi-elliptical head provided a greater rotational range of motion while more closely replicating the native-split kinematics compared to the spherical head.

POSTER NO. P330
In Vivo Glenoid Polyethylene Wear Rates in Total Shoulder Arthroplasty: A Radiostereometric Analysis
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John Paul Wanner, BS
Meridith Greene, BA
Audrey Nebergall, PhD, Boston, MA
Charles R. Bradon, PhD, Boston, MA
Henrik Malchau, MD, Boston, MA
Reuben Gobezie, MD, Cleveland, OH

INTRODUCTION: Failure of total shoulder arthroplasty often results from glenoid component loosening. Although wear associated with known total shoulder arthroplasty failures has been described, in vivo polyethylene wear rates have not yet been reported. We have conducted a prospective study using radiostereometric analysis (RSA) to measure the in vivo wear of conventional ultrahigh molecular weight polyethylene (UHMWPE) glenoid components of pegged and keeled design at two-year follow up. We hypothesized that both types of component would show minimal wear two years following implantation, and that there would be no difference in wear between component types.

METHODS: Between 2007 and 2009, 26 patients underwent total shoulder arthroplasty with placement of tantalum markers in the glenoid polyethylene, and in the bone of the humerus, glenoid, and coracoid at the time of surgery. Osteoarthritis was the preoperative diagnosis in all patients. One particular system utilizing a keeled glenoid component was used in 17 patients, and a different system employing a pegged glenoid was used in the other nine patients. At six months, one year, and two years following surgery, radiostereometric analysis was used to measure medial humeral head penetration resulting from glenoid polyethylene wear. Patients were evaluated for clinical outcomes using ASES score, VAS pain score, and assessment of motion, and radiographs were assessed for radioluencies surrounding the glenoid component using a novel classification system to assess line width and location for both pegged and keeled components.

RESULTS: Radiostereometric analysis demonstrated median glenoid polyethylene wear of 0.23 mm ± 0.13 mm (-0.38 mm to 1.43 mm) at two years. There was no significant difference in wear rates based on the type of glenoid component used. All patients demonstrated statistically significant improvements in clinical outcomes at two-year follow up (p<0.01), as median ASES score improved from 29 to 77; median VAS pain score improved from 8 to 0; median active forward flexion improved from 120 to 150; and median active external rotation improved from 30 to 37.5. In the immediate postoperative period, six of 26 patients (23.1%) demonstrated radioluencies; at one year, 15 of 24 patients (62.5%) demonstrated radioluencies, which represented progression in size in one patient and progression in number of zones in 12 patients. At two years, nine of 21 patients (42.9%) demonstrated radioluencies, which represented progression in number of zones in one patient while previously visible lucencies disappeared, decreased in size, or changed location in six patients.

DISCUSSION AND CONCLUSION: Wear of a conventional UHMWPE glenoid component during the first two years progresses at slightly greater than 0.1 mm per year, regardless of the type of glenoid component used. Radiolucent lines were noted around both types of glenoid component at all follow-up times, including in the immediate postoperative period, but these did not show progression between one and two years, and did not cause clinical signs of loosening. Continued follow up of our patient cohort using RSA will provide information about mid-term glenoid polyethylene wear following total shoulder arthroplasty.

POSTER NO. P331
Metal on Metal Reverse Total Shoulder Prosthesis for Shoulder Reconstruction in Young Patients
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Thomas B. Edwards, MD, Houston, TX

INTRODUCTION: Reverse total shoulder arthroplasty has been a useful intervention for older patients with rotator cuff tear arthropathy. However, as a semi-constrained prosthesis, conventional reverse shoulder arthroplasty employing a polyethylene spacer may fail over time secondary to polyethylene wear and subsequent osteolysis. A custom metal on metal prosthesis has been manufactured to circumvent failure due to polyethylene wear in younger patients with severe shoulder pathology including severe rotator cuff deficiency. The purpose of this study is to assess the results of an initial cohort of young patients who have undergone glenohumeral prosthetic replacement using a metal on metal reverse shoulder arthroplasty.

METHODS: Six patients with an average age 34.2 years and minimum 12 months follow up underwent implantation of a custom metal on metal reverse shoulder arthroplasty. Indications included two patients with tumors requiring resection of the proximal humerus, two patients with posttraumatic arthritis with massive rotator cuff tears, and one patient with osteoarthrits and massive rotator cuff tear. RESULTS: ASES scores improved from 51.0 points preoperatively to 63.2 points postoperatively (p = .043). Constant and adjusted Constant scores improved from 21.8 points and 23% preoperatively to 53.0 points and 56.8% postoperatively (p = .12). Active forward flexion improved from 64 degrees preoperatively to 122 degrees postoperatively (p = .043). Active external rotation decreased from 12 degrees preoperatively to 11 degrees postoperatively (p = .368). Three sustained a postoperative dislocation. Two of these dislocations initially occurred at more than 12 months postoperative.

DISCUSSION AND CONCLUSION: Although a reverse total shoulder arthroplasty with a metal on metal articulation appears an attractive option in the treatment of young patients with limited reconstructive options secondary to massive rotator cuff insufficiency, postoperative outcomes are disappointing and the complication rate is high. Additionally, late onset instability occurred in two of the six patients, a complication that we have rarely observed in patients undergoing reverse total shoulder arthroplasty with a conventional polyethylene insert.
INTRODUCTION: The perioperative diagnosis of infection in the setting of revision shoulder arthroplasty may be difficult to establish. Intraoperative pathology for the identification of acute inflammatory changes has been reported of value in revision surgery after failed hip and knee arthroplasty. The purpose of this study was to evaluate the sensitivity, specificity, positive and negative predictive value of intraoperative pathology in the diagnosis of infection in revision shoulder arthroplasty.

METHODS: Between 1994 and 2008, 592 consecutive revision shoulder procedures were performed at our institution. Both intraoperative pathology and operative samples for cultures were obtained in 503 of these procedures, which form the basis of this study.

RESULTS: Pathology was read as consistent with acute inflammation in 60 procedures (11.9%). Intraoperative cultures were positive in 160 procedures (32%). Intraoperative cultures were positive in 103 procedures for only Propionibacterium acnes (20.5%). Intraoperative pathology was considered true positive (both pathology and cultures positive) in 34 surgeries (6.8%), true negative (both pathology and cultures negative) in 317 surgeries (63.0%), false positive (pathology positive but culture negative) in 26 surgeries (5.2%) and false negative (pathology negative but culture positive) in 126 surgeries (25.0%). The sensitivity and specificity of intraoperative pathology were 21.2 and 92.4 respectively. The positive and negative predictive values were 56.7 and 71.6 respectively.

DISCUSSION AND CONCLUSION: In our study, intraoperative pathology had a high specificity and negative predictive value, but low sensitivity and positive predictive value. Absence of acute inflammation is useful in the exclusion of deep infection, but the presence of acute inflammation is not sensitive or predictive enough to be of value.

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INTRODUCTION: Currently, there is little information on the benefits and problems associated with long stem humeral components in shoulder arthroplasty. Therefore, this study was developed to examine the frequency, complications, and results of using a long stem humeral component in revision shoulder arthroplasty.

METHODS: From 1976 to 2006, 612 revision shoulder arthroplasties were performed at our institution. Our study group included 82 shoulders with intermediate or long stem humeral components that were followed clinically for at least two years or until repeat revision surgery. The primary indications for revision surgery were loosening of the humeral component in 32, instability in 18, painful hemiarthroplasty in nine, infection in nine, polyethylene wear in five, acute periprosthetic fracture in five, and nonunion in four. The primary indications for use of an intermediate or long stem were proximal bone loss in 42, nonunion in 14, a malpositioned previous stem in 10, an acute intraoperative fracture in seven, and an acute preoperative periprosthetic fracture in five, distal bone loss in two, and an osteotomy to remove a well-fixed stem in two. 57 of the components were cemented and bone graft was used in 34 cases.

RESULTS: Intraoperative complications included a fracture removing the previous stem in five, cortical perforation inserting the intermediate or long stem in six, and cement extrusion in seven. Late complications included fracture nonunion in five, deep infection in two, and component loosening in one. Radiolucent lines were identified in 34 cases, but only one component met criteria to be considered radiographically “at risk” for clinical loosening.

DISCUSSION AND CONCLUSION: Intermediate or long stem humeral components are useful in revision shoulder arthroplasty in cases involving significant bone loss, fracture, or a previously malpositioned stem. Caution should be taken to avoid intraoperative fractures distally and cement extrusion. Neither clinical nor radiographic follow up show these components to be at high risk for loosening.

INTRODUCTION: To minimize component failure in total shoulder arthroplasty (TSA), the glenoid is reamed to achieve neutral version. Previous research has determined that 2D CT scans have a greater variability in depicting glenoid version when compared to 3D CT scans. This study examines how inaccurate version measurements from 2D CT scans affect the total amount of glenoid bone removed during reaming.

METHODS: Three dimensional computer models were created from CT scans of 18 pre-operative TSA patients. The 2D glenoid version was measured from midglenoid axial cuts. Using custom software, 3D glenoid version angle was measured as the angle between the vectors given by the glenoid center to medial scapular spine and anterior to posterior glenoid rim. Computer-simulated glenoid reaming was performed with a 46 mm reamer to correct for both 2D and 3D version measurements. Reaming was simulated to the depth that allowed for complete implant contact. Glenoid bone volume removed was calculated and plotted as a function of the difference in measured glenoid version.

RESULTS: The average observed absolute difference in version was 3.2º comparing 2D measurement to 3D measurement with a standard deviation of 2.7º. The maximum observed absolute difference in version was 9.4º. A linear relationship was found when compared to 3D version measurements. This study examines how inaccurate version measurements from 2D CT scans affect the total amount of glenoid bone removed during reaming.

DISCUSSION AND CONCLUSION: Accurate measurement of glenoid angle is necessary for proper version correction during glenoid reaming in total shoulder arthroplasty and has implications on the survivability of the glenoid implant. The effect of measurement modality for glenoid version on simulated vault volume reamed has not been previously studied. We have
found that as there may be significant differences in the 2D and 3D measured version, and as the measured retroversion increases, the volume of glenoid removed increases linearly independently of glenoid size. If a 2D CT were to overestimate glenoid retroversion, a significant amount of glenoid bone could be removed, potentially compromising the placement and stability of the glenoid component. Therefore, it is recommended that 3D CTs be used for pre-operative planning to ensure maximal glenoid volume preservation.

INTRODUCTION: Several morphological changes have been related to cuff disorders, such as acromial type, acromial slope, acromial coverage and glenoid version. The objective of the study is to analyze the influence of cuff tears of the angle formed by the acromion and the glenoid surface as measured on CT scan axial plane. METHODS: Eighty-two patients were included with a mean age of 66 years. There were 50 females and 32 males. Group 1 included 32 patients with a cuff tear confirmed by MRI and group 2 included 50 patients as the control group (including 25 instabilities and 25 patients with a cuff tear confirmed by MRI). Group 1 and Group 2 had a surgical complication rate of 5.9% and 3.2%, respectively. RESULTS: The recurrence rate of infection for patients in Group 1 and Group 2 was 5.9% and 3.2%, respectively. Group 1 and Group 2 had a surgical complication rate of 12% and 35%, respectively. The 31 patients in Group 2, five (16%) had minor complications related to antibiotic therapy, and one acquired a Clostridium difficile infection.

POSTER NO. P336
Reinfection Rates after Revision Shoulder Arthroplasty for Patients with Positive Intraoperative Cultures
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INTRODUCTION: Recent studies have detailed the significance of indolent infections in revision shoulder arthroplasty, but little information is available to guide treatment strategies regarding patients with positive cultures without overt signs of infection. The primary purpose of this study was to determine recurrence rates of infection for patients undergoing revision shoulder arthroplasty who were not treated for infection, but had positive intraoperative cultures. Our secondary objectives were to investigate functional outcomes and complications for untreated cases and treated cases.

METHODS: We retrospectively reviewed the results of 48 patients with at least one positive intraoperative culture. The patients were divided into two groups based on treatment strategy. Group 1 consisted of 17 patients who were not treated for infection because of limited signs of infection. These patients underwent a one stage revision surgery without an extended intravenous antibiotic regime. Group 2 consisted of 31 patients who were treated for infection by either a two-stage exchange with an antibiotic spacer (28 of 31) or a one-stage exchange procedure followed by at least a month course of intravenous antibiotics (3 of 31).

RESULTS: The recurrence rate of infection for patients in Group 1 and Group 2 was 5.9% and 3.2%, respectively. Group 1 and Group 2 had a surgical complication rate of 12% and 35%, respectively. Of the 31 patients in Group 2, five (16%) had minor complications related to antibiotic therapy, and one acquired a Clostridium difficile infection.

DISCUSSION AND CONCLUSION: We found that low virulence and clinically unexpected infections treated with one stage revision have a low risk for recurrent infection. This study suggests that intensive antimicrobial treatment strategies may not be necessary to reduce recurrent infections in patients with positive intraoperative cultures, without overt clinical signs of infection.
the postoperative re-tear was performed by magnetic resonance imaging (MRI) at one year after the surgery. On the bases of the postoperative MRI data, the mRNA expression levels in the tendons of patients with the re-tear (six patients) were compared with those of patients without the re-tear (18 patients).

RESULTS: The mRNA expression levels of MMP-3 in the ruptured tendon of patients with the re-tear were significantly increased than those without the re-tear ($P = 0.0375$). In addition to the increase of MMP-3 mRNA expression level, TIMP-1 mRNA expression was up-regulated in patients with the re-tear ($P = 0.0375$). On the contrary, there was no significant difference between the two groups concerning the other MMPs and TIMP-2 mRNA expression levels. DISCUSSION AND CONCLUSION: Increase of MMP-3 mRNA expression levels in the ruptured tendon at the time of rotator cuff repair appeared to be associated with the postoperative tendon re-tear.

POSTER NO. P338

Complications of Clavicle Open Reduction and Internal Fixation

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INTRODUCTION: Clavicle open reduction and internal fixation (ORIF) after fracture has increased in recent years. We studied the complications of clavicle ORIF using a national dataset to see if this complication rate was different than published studies (one) as the rate of surgery increased. METHODS: The American Board of Orthopaedic Surgery (ABOS) national database of cases submitted by Part II candidates was reviewed for CPT code 23515 (clavicle ORIF). From this group, the clavicle ORIF complications and early outcomes were determined from 1998 to 2009. RESULTS: There were 2,895 clavicles operatively fixed over the 12 year period. The average age of the entire group was 34 years (77% were male). Pain was decreased or absent in 95%. Function was normal or improved in 88%. Deformity was normal or improved in 94%. Patient satisfaction was good or excellent in 90%. Implant failure was seen in 4%, infection in 2.3%, non- or delayed union in 1.9%, nerve palsy in 1.7% and wound dehiscence in 1.4%. Fifteen cases returned to the OR for intervention. Thirteen cases had implant fracture, six had pneumonia, three had vascular injury, there were three dislocations, three patients expired, and there was one hemorrhage and one spinal cord injury. DISCUSSION AND CONCLUSION: Providers who choose to operatively fix clavicle fractures should know the rate and array of potential complications. In the setting of increased volumes of clavicle ORIF in recent years, the ABOS national dataset revealed a detailed but low rate of complications after clavicle ORIF when compared with prior published studies. Outcomes were excellent and catastrophic complications were extremely rare. 1 Jeray, KJ. Acute Midshaft Clavicular Fracture, JAAOS 15(4) 239-248, 2007.

POSTER NO. P339

Use of a Press-Fit Short Stem Humeral Implant in Total Shoulder Arthroplasty

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INTRODUCTION: Humeral implants in shoulder arthroplasty have traditionally extended into the humeral diaphysis although many of these implants are designed for a metaphyseal press-fit. Diaphyseal fixation of the humeral implant can lead to stress shielding and proximal humeral bone resorption. The purpose of this study is to report the efficacy and safety of a press-fit short stem humeral implant that allows complete humeral head resection for glenoid access but does not require extension into the diaphysis. METHODS: Forty-three patients with a minimum of 12 months followupunderwent total shoulder arthroplasty using a metaphyseal press-fit short humeral stem. Patients were evaluated at an average 15.1 months postoperative clinically and radiographically. RESULTS: The ASES scores increased from 62.9 preoperative to 91.6 postoperative (p<.001). Constant scores increased from 29.6 preoperative to 79 postoperative (p<.001) and the adjusted Constant score increased from 37.5 preoperative to 102.2% postoperative (p<.001). Active forward flexion increased from 92.6 degrees preop to 160.5 degrees postop (p<.001) and active external rotation increased from 14.5 degrees preop to 40.8 degrees postop (p<.001). Forty of the 43 patients (93%) were satisfied or very satisfied with their outcome. Two patients underwent revision surgery for complications, one for a posterior dislocation and one for a periprosthetic fracture. At the time of revision surgery, humeral stems were stable. Radiographically, no stem had evidence of loosening or proximal humeral bone loss. DISCUSSION AND CONCLUSION: The press-fit short stem humeral implant yields excellent clinical and radiographic results at early follow up. The short stem humeral implant also allows for complete head resection facilitating glenoid exposure. More importantly, no adverse events were associated with use of an implant that did not extend into the humeral diaphysis. Our encouraging early experience with this humeral stem use has led to its continued use in our practice.

POSTER NO. P340

Biomechanical Testing of Lateral Row Knotless Anchors in a Human Cadaveric Model

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INTRODUCTION: Rotator cuff repair performed using a “suture bridge” technique typically utilizes knotless anchors for the lateral row fixation. A variety of threaded (screw-in) or non-threaded (push-in), knotless anchor designs exist which hold sutures through friction between the anchor and adjacent bone. Recent anchors composed of biocomposite materials promote bone ingrowth into the anchor site. Mechanical testing of suture anchors is usually performed with an axially directed force in line with the direction of anchor insertion. However, clinically lateral row anchors experience distraction forces exerted in an orthogonal direction. The purpose of this study was to assess the
mechanical performance of biocomposite, knotless lateral row anchors based upon both anchor design and the direction of pull.

METHODS: Three different biocomposite knotless suture anchors are currently available and include threaded (4.75mm Knotless Healix, 4.75mm Bio-SwiveLock) or non-threaded (4.5mm Bio-PushLock), designs. These three anchors were tested by random assignment to insertion at either an anterior or posterior lateral row position on the greater tuberosity in matched pairs of fresh-frozen human cadaveric shoulders. All anchors were inserted with an attached loop of ultra-high molecular weight polyethylene containing suture. Specimens were then tested in a servohydraulic mechanical testing machine by pulling upon the suture loop with a fixed gauge either along the anchor axis (axial) or directed approximately 135 degrees from the long axis of the humerus (anatomic). All samples were cyclically loaded between 10N and 45N for 200 cycles, followed by destructive testing of those specimens that survived the cyclic loading phase. Data points included load to achieve 3mm and 5mm of displacement, load to failure, and total displacement at failure.

RESULTS: The biomechanical testing data are listed in the table. When comparing axial to anatomic loading for each anchor, significant differences were noted for both of the threaded anchors. The Knotless Healix anchor had significantly less total displacement with axial load than anatomic loading, p<0.001. The Bio-SwiveLock anchor had significantly greater maximum failure load with anatomic loading compared to axial loading, p=0.034. When compared to the non-threaded anchor, both threaded anchors displayed significantly greater maximum load to failure (Bio-SwiveLock p=0.046, Knotless Healix p=0.013) with axial loading. Also with axial loading, the threaded Knotless Healix anchor demonstrated significantly greater loads to 3mm (p=0.001) and 5mm (p=0.004) displacement versus the non-threaded anchor. During anatomic testing, both threaded anchors demonstrated significantly less total displacement at failure (Bio-SwiveLock p=0.03, Knotless Healix p=0.014), than the non-threaded anchor. The Bio-SwiveLock anchor also exhibited significantly greater loads to 3mm (p=0.008) and 5mm (p=0.034) displacement during anatomic testing compared to the non-threaded anchor. DISCUSSION AND CONCLUSION: The biomechanical performance of biocomposite, knotless lateral row suture anchors varies depending upon the direction of load testing. Threaded suture anchors withstand greater loads with less displacement than non-threaded anchors during biomechanical testing in both an axial and anatomic direction.

**Results of Biomechanical Testing**

<table>
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<th>Anchor Tested</th>
<th>Axially (n=9)</th>
<th>Anatomically (n=8)</th>
<th>Axially (n=9)</th>
<th>Anatomically (n=10)</th>
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<tr>
<td>Bio-PushLock</td>
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<td>56</td>
<td>66</td>
<td>88.8</td>
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<tr>
<td>Bio-SwiveLock</td>
<td>81.5</td>
<td>8.79</td>
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<td>Knotless Healix</td>
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<td>Anchor Tested</td>
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<td>11.4</td>
<td></td>
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<tr>
<td>Axially</td>
<td>110.4</td>
<td>6.01</td>
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</tr>
</tbody>
</table>

**A Biomechanical Comparison of Three Methods to Repair Pectoralis Major Ruptures**

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INTRODUCTION: The anatomy of the pectoralis major tendon is unique with an elongated thin footprint requiring multiple points of fixation to restore the native anatomy. The inferior fibers undergo disproportionate excursion with the arm in an abducted and extended position. Multiple options exist for tendon repairs, however the strongest construct has yet to be identified. The intent of this study was to compare the load to failure of bone trough, cortical button, and suture anchor repairs of the pectoralis major tendon.

METHODS: Thirty fresh frozen cadaveric shoulders were divided equally into three groups based on the repair technique to be performed for each shoulder. Bone mineral density of the surgical neck of the proximal humerus was assessed prior to repair in order to assess the influence of osseous integrity on each technique. Bone trough, suture anchor, and cortical button repairs were performed after isolation and release of the pectoralis major tendon. Each specimen was then loaded to failure and the mode of failure was evaluated.

RESULTS: Load to failure was greatest with bone trough repair (596 N), followed by cortical button repair (494 N), and least with suture anchor repair (383 N) [p = 0.007 for bone trough vs. suture anchor repair]. All failures in the cortical button and 9/10 failures for the bone trough group failed through the nonabsorbable polyblend suture. One specimen in the bone trough group failed via fracture of the proximal humerus. The suture anchor group failed through the implant in five specimens and through the suture in four specimens. Bone mineral density was not shown to effect the load to failure of each construct.

DISCUSSION AND CONCLUSION: Bone trough repair of the pectoralis major tendon was stronger than suture anchor repair. However, there is concern that the bone trough method may create more of a stress riser as one fracture occurred in this group. The cortical button method may be a good compromise between fixation strength and avoidance of stress riser formation.
of the humeral head with a prosthetic component assumes that the humeral head corresponds to a segment of sphere and that the osteotomy resects a spherical articular segment, oriented, identically, to the original humeral head. The objectives of this study were to define the normal geometry of the proximal humerus and cartilage/calcar interface with a view to optimizing the osteotomy of the humeral head in shoulder arthroplasty.

METHODS: Applying a novel data reconstruction technique, a hand held digitizer and surface laser scanner were used to digitize the humeral surface and points and lines identified on each of 24 cadaveric humeri. The collected data for each humerus were graphically modelled and the normal geometry determined. The humeral head and cartilage/calcar interface were examined and the constructed graphical model was used to simulate a standard osteotomy referencing along the anterior edge of the articular surface. Reconstruction was performed with a simulated idealized, fully adaptable, spherical prosthetic head. The cartilage/calcar interface was then divided into a clockface with the superior and inferior margins at 12 and 6 o’clock, respectively, and the anterior and posterior margins at 9 and 3 o’clock. Analysis of the cartilage/calcar interface was then used to optimize the osteotomy based on least deviation of the cartilage/calcar interface from an ideal plane created for each modelled specimen. The orientation (retroversion and inclination angles), head diameter, head height, and radius of curvature were calculated for each osteotomy technique and compared to the original humeral head geometry.

RESULTS: The traditional osteotomy technique resulted in a mean increase in retroversion of 11.0 degrees and a reduction in inclination of 3.8 degrees when compared to the original geometry (p< 0.001). The size of the implanted head was, on average, larger than the original head when the traditional osteotomy was applied; the head height (2.7 mm), axial diameter (3.0 mm) and radius of curvature (1.0 mm) all increased (p< 0.001). Analysis of the cartilage/calcar interface revealed that the points of least deviation were at 8 and 10 o’clock anteriorly and between 2 and 4 o’clock posteriorly. When these points were utilized for the novel osteotomy it resulted in a mean increase in retroversion of 0.4 degrees (p=0.528) and a reduction in inclination of 3.2 degrees (p< 0.001) when compared to the original geometry. The size of the implanted head was, on average, larger than the original head when the novel osteotomy was applied; the head height (0.02 mm), axial diameter (0.71 mm) and radius of curvature (1.0 mm) all increased (p< 0.001). Analysis of the cartilage/calcar interface revealed that the points of least deviation were at 8 and 10 o’clock anteriorly and between 2 and 4 o’clock posteriorly. When these points were utilized for the novel osteotomy it resulted in a mean increase in retroversion of 0.4 degrees (p=0.528) and a reduction in inclination of 3.2 degrees (p< 0.001) when compared to the original geometry.

DISCUSSION AND CONCLUSION: Differences in orientation and head size between the original head and prosthetic head associated with the standard osteotomy could alter the position of the center of rotation of the head. This may affect the stability of the joint producing eccentric loading at the glenoid resulting in wear of the native bone or loosening of a prosthetic component. Further, it may impact on soft tissue tension with a risk of secondary damage to the rotator cuff. The novel osteotomy, with the addition of posterior referencing, accounted for the variable topography of the cartilage/calcar interface and improved the orientation of the osteotomy. The novel technique may reduce the risk of implant failure by recovering the original humeral head geometry more accurately.

POSTER NO. P343
Radiographic Results of Fully Uncemented Trabecular Metal Reverse Shoulder System at One and Two Years Follow Up
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Ilya Voloshin, MD, Rochester, NY

INTRODUCTION: Current reverse total shoulder arthroplasty (RTSA) systems rely on fully cemented components for humeral fixation and a variety of methods for glenosphere fixation. However, trabecular metal (TM) coated porous-in-growth implants have shown good success and reliability in total hip literature studies and have the potential to provide stable long-term fixation in the shoulder. The purpose of this study was to assess the short term radiographic outcome of a fully uncemented reverse total shoulder system.

METHODS: We reviewed the radiographs of 98 consecutive patients undergoing reverse total shoulder arthroplasty with a circumferential metaphyseal TM coated humeral stem and TM backed glenosphere from 2007 to 2008. Indications for RTSA were rotator cuff arthropathy, arthritis with rotator cuff tear, massive cuff tear, failed hemiarthroplasty, failed TSA, proximal humeral malunion/nonunion, and proximal humerus fracture. All patients had a standardized series of radiographs that were reviewed at approximately two weeks, one year, and two years after implantation. Humeral stems were evaluated for radiolucent lines by zone and for component migration by comparing the distance between the most cephalad aspect of the greater tuberosity to the distal border of the TM surface on serial radiographs. Glenosphere base plates were evaluated for the presence notching and radiolucency of the glenoid vault. Ninety-eight patients were evaluated at one year follow up and 38 at two year follow up.

RESULTS: Average age of patients was 71.6 at the time of surgery. At one year, 92 of 98 (93.9%) humeral stems had no lucent lines, and six (6.1%) humeral stems had <2mm lucency. Seventy-five (76.6%) scapulae showed no evidence of notching, 21 (21.4%) had Type 1 scapular notching (notch extending inferior to inferior glenosphere screw), and two (2.0%) had Type 2 notching (extending to inferior glensphere screw) at one year. At two years, 34 of 38 (89.5%) humeral stems had no lucent lines, and four (10.5%) humeral stem components had <2mm of lucency. Twenty-two (57.9%) scapulae had no notching, 13 (34.2%) had Type 1 notching, two (5.3%) had Type 2 notching and one (2.6%) had Type 3 notching. No stems had lucency in more than one zone or greater than 2mm lucency at any time point. Nine of 98 showed subsidence of 2mm or less. No glenoid component had lucency behind the base plate or around the screws. The most common zone of lucency around the humeral stems at both one and two years was zone 4.

DISCUSSION AND CONCLUSION: To our knowledge, the radiographic outcome of a fully uncemented system for RTSA has not previously been reported. Our data suggest that the use of cementless TM porous coated implants for RTSA is associated with secure glenoid fixation and minimal radiographic evidence of humeral stem loosening or subsidence at short term follow up. The rates of scapular notching found in our study are comparable to previous studies and did not affect the stability of the implants. Cementless TM porous coated implants provide secure fixation for both the glenoid and humeral components in reverse total shoulder arthroplasty at short term follow up.
Glenoid Surface Area After Reaming in Computer Simulated Total Shoulder Arthroplasty
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INTRODUCTION: In total shoulder arthroplasty (TSA), the glenoid is ideally reamed to neutral version and to a depth that provides sufficient surface area to support the glenoid implant. This cannot always be achieved without significant glenoid bone loss or peg penetration and thus either version correction or bone-implant contact must be sacrificed. This study examines the relationship between depth of reaming, version correction and reamed surface area.

METHODS: 3D computer models of scapulae of 10 patients (67.5 ± 17.5 years, 4M/6F) scheduled for TSA (pre-op retroversion: 14.1 ± 6.1°) were created from CT images. A 46 mm reamer was positioned so that depth was measured from the point of initial contact with the glenoid face and angled to correct 0°, 5°, and 10° of version. It was advanced at each scenario to depths of 1, 2, 3, 4, 5 mm. At each depth, the reamed surface area was calculated and compared to the surface area of a 46 mm glenoid implant.

RESULTS: The relationship between reamed surface area and depth of reaming was found to be logarithmic for 0° version correction ($r^2 = 0.991$) and linear for 5° and 10° version correction ($r^2 = 0.989, r^2 = 0.999$). The average reamed surface area significantly increased ($p<0.001$) for each incremental increase in depth from 1 mm to 5 mm. Furthermore, at each reaming depth, there was a significant difference in reamed surface area at 0°, 5°, and 10° of version correction ($p<0.001$). To obtain sufficient surface area for complete glenoid implant contact for 0° and 5° of version correction, reaming depths of 4 and 5 mm were respectively required. Complete glenoid conformity could not be achieved when correcting 10° of retroversion.

DISCUSSION AND CONCLUSION: The relationship between glenoid surface area and reaming was found to behave logarithmically for 0° version correction and linearly for 5° and 10° of correction. At higher depths of reaming, the reamer will become fully engaged with the glenoid and the amount of reamed surface area will plateau in a similar manner as that at 0° of correction. Additionally, a sufficiently-reamed surface area for implantation was attained at significant depth with lower version corrections. This study provides a novel quantitative guideline that relates depth of reaming and version correction to reamed glenoid surface area. These results can help the surgeon balance the amount of version correction with adequate support of the glenoid implant.

Failure of Reconstruction of a Series of Acromioclavicular Joint Dislocations Treated With a Flip Button Device
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INTRODUCTION: Acromioclavicular joint dislocations (ACDs) may be treated arthroscopically with flip buttons. This type of fixation acts as an internal splint between the coracoid and clavicle to maintain reduction of an unstable ACD while ligamentous healing takes place. This technique and device is easy to implant and is well tolerated by patients.

METHODS: Between 2006 and 2010, 14 ACD patients (one woman and 13 men; mean age, 40 years) had surgery by the senior surgeon using one manufacturer’s arthroscopic technique. RESULTS: The main reported complication to date of this technique has been the partial loss of reduction at follow up due to clavicular osteolysis under the clavicular button. We have documented 13 of 14 cases with loss of reduction due to failure of the sutures between the buttons. The high failure rate in this series with the use of flip buttons may be attributed to the biomechanics of the implant’s design.

DISCUSSION AND CONCLUSION: This technique for reconstruction of ACDs may only obtain stability in the vertical plane without providing enough stability of the distal clavicle in the horizontal direction. Excessive anteroposterior movement of the clavicle during the healing phase may cause the suture to fail either from excessive motion or from fraying against the bone tunnels leading to an unacceptably high failure rate.
Primary Total Shoulder Arthroplasty Through the Rotator Interval: Subscapularis and Deltoid Sparing Technique

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Introduction: Total shoulder arthroplasty performed through the deltopectoral approach, with a subscapularis tenotomy or lesser tuberosity osteotomy, provides reproducibly good clinical results and is the current standard of care. However, many complications can arise with this surgical procedure, including failure of the subscapularis repair. Post-operative subscapularis insufficiency and failed repair are well documented to be associated with inferior clinical outcomes. This exhibit will describe NYU Hospital for Joint Diseases experience with the minimally invasive total shoulder arthroplasty that is performed through the rotator interval while maintaining the integrity of the subscapularis tendon.

Methods/Results: This exhibit presents the surgical approach, including video segments, of the minimally invasive primary total shoulder arthroplasty and the clinical and radiographic results of the first 25 patients who were treated as part of a prospective, randomized trial of minimally invasive versus standard total shoulder arthroplasty. Surgical techniques to maximize the joint exposure while minimizing the risk of complications will be highlighted.

Discussion: Subscapularis insufficiency can lead to weakness, limited range of motion, and pain after primary total shoulder arthroplasty. The minimally invasive rotator interval approach for total shoulder arthroplasty has the inherent advantage of maintaining the integrity of the subscapularis tendon during the procedure. In addition, if needed, the subscapularis can be released to allow conversion to the classic approach for total shoulder arthroplasty. Finally, as neither the deltoid nor the subscapularis are violated, postop immobilization is minimized and early active range of motion exercises can be performed with minimal restrictions for accelerated rehabilitation.

Conclusion: While total shoulder arthroplasty performed with subscapularis tenotomy or lesser tuberosity osteotomy remains the standard of care, minimally invasive primary total shoulder arthroplasty through the rotator interval may present a potential option to improve the outcome in selected patients with shoulder arthritis.

Delayed Onset Ulnar Neuropathy After Release of Elbow Contracture: Risk Factor, Treatment and Prevention.

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G. R. Huffman, MD, Philadelphia, PA
James S. Fitzsimmons, BSc, Rochester, MN
Shawn W. O’Driscoll, MD, Rochester, MN

Introduction: Arthroscopic osteocapsular arthroplasty has become a common procedure in recent years despite the risk of nerve injury. Acute transection of the nerves isn’t the only neurological complication of concern for the surgeon. Restoration of range of motion in an elbow with contracture can result in a delayed onset of ulnar nerve neuropathy (DOUN). There are no studies dedicated to this complication. The aim of this scientific exhibit is to describe clinical presentations, risk factors, and prevention of DOUN, over a period of 17 years of experience.

Methods: A retrospective study of 565 consecutive arthroscopic elbow contracture releases in 521 patients, from 1993 to 2010 was conducted. A DOUN was defined as normal neurological examination immediately after surgery plus occurrence of new ulnar nerve symptoms in a pre-operatively asymptomatic patient or worsening of preexisting ulnar nerve symptoms. The patients that were believed to have a DOUN were studied to report the most relevant clinical features of DOUN including onset and severity of symptoms. 235 contracture releases did not receive any prophylactic procedures and were used for the analysis of risk factors with a multivariate logistic regression analysis. Over the course of 17 years of experience the senior author developed several methods of prevention of DOUN: ulnar nerve decompression, limited ulnar nerve decompression, mini ulnar nerve decompression, delayed 48 hours Continue Passive Motion (CPM) and a single shot block versus immediate CPM and indwelling catheter. These methods and their effect on occurrence of DOUN were analyzed.

Results: 26 out of 235 patients (11%) developed DOUN among patients that did not receive prophylactic procedures. The onset of symptoms was between 2 to 4 days after surgery in 20 cases. In the remaining 6 cases, the time of onset was 5, 14 and 35 days after surgery in 3 cases and not certain in 3. The patients fell into one of two distinct groups based on the predominant patterns of clinical presentation: Progressive or Non-Progressive. 18 of 26 cases fell into the Progressive category, while 8 were Non-Progressive. Those with Progressive DOUN consistently presented (i) progressive sensorimotor ulnar neuropathy associated with (ii) increasing posteromedial elbow pain during flexion of the elbow, and (iii) rapidly deteriorating range of elbow flexion. This group of patients was treated by urgent ulnar nerve transposition, usually within a day or two after diagnosis. The patients with Non Progressive DOUN presented with mild sensory ulnar neuropathy without motor weakness and with neither significant pain at the cubital tunnel nor progressive loss of elbow motion. They were managed by observation and modification of the CPM protocol. None underwent ulnar nerve transposition. A diagnosis of heterotopic ossification (HO) (odds ratio 23.6, p = 0.001) and preoperative neurological symptoms (odds ratio 6.5, p = 0.001) were the only factors affecting the probability of DOUN. The tourniquet time had an odds ratio close to significance (odds ratio 1.0, p = 0.059). Among the prophylactic procedures, open ulnar nerve decompression and limited ulnar nerve decompression provided better protection than mini-decompression. The delayed CPM protocol did not appear to influence the rate of DOUN.

Discussion and Conclusion: DOUN can compromise the outcome of contracture release of the elbow. Patients with diagnoses of HO and preoperative neurological symptoms are at higher risk to develop DOUN. We recommend an 8 cm prophylactic open nerve decompression to prevent this problem.
Treatment of Bone Loss in Glenohumeral Instability

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Introduction: Patients with recurrent shoulder instability often present with osseous injury to the humeral head and glenoid. In addition to soft tissue repair, osseous defects involving the glenoid and/or humeral head may need to be reconstructed in order to adequately address the underlying pathology and optimize outcomes. Methods/Results: This exhibit reviews the clinical and diagnostic approach and treatment options for patients with shoulder instability with osseous defects. A literature review and our own case series report the extent of the problem as well as different treatment options. History, physical examination, anatomic considerations, imaging, and classification systems are outlined and treatment algorithms are presented. Several illustrative case examples are presented including glenoid and humeral head bone grafting, open and arthroscopic Latarjet procedures, and arthroplasty options. The exhibit will discuss pre-operative planning and defect size evaluation utilizing plain radiographs, MRI, CT scan and arthroscopy. Novel MRI imaging techniques to determine degree of bony loss without need for traditional CT and 3D CT will be presented. Surgical techniques with detailed video illustrations will be highlighted. Complications from our surgical series will be highlighted and discussed. Discussion: Failure to address glenoid and humeral head defects can lead to recurrent instability and abnormal shoulder biomechanics. This exhibit reviews our institution’s approach to recurrent shoulder instability in patients with osseous defects. Conclusion: Glenohumeral instability with concomitant osseous insufficiency can pose a challenging problem for the treating orthopaedic surgeon. We review our experience with surgical reconstructive procedures for glenoid and humeral head defects.

Infection After Shoulder Surgery With Propionibacterium Acnes

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Introduction: Shoulder postoperative wound infections can lead to devastating complications. Preoperative, intraoperative, and postoperative factors all impact the risk of post-operative infection. Staphylococcus aureus, S epidermidis, and Propionibacterium acnes (P. acnes) are the most commonly isolated organisms from the cultures of postoperative shoulder infections. P. acnes, an anaerobic, non-sporulating gram-positive bacillus, normally inhabits the deep layers of the skin. While previously thought to be a culture contaminant in shoulder postoperative infections, this organism has been recently recognized as a fastidious orthopaedic pathogen with a specific propensity for the shoulder. This scientific exhibit reviews the most current clinical data in the literature related to the science of P. acnes, including sensitivities, pathologic spectrum, culture type and growth as well as an algorithm for antibiotic management. We will also review methods to reduce the incidence of infection. Methods: This exhibit will review the most relevant studies that present their findings related to P. Acnes infection in the shoulder postoperatively. A comprehensive, comparative review of the data will be performed, including level of evidence for each study. We will review epidemiologic data over the past year from our institution as well as from the previous 5 years. We will examine location of infection, treatment and outcome. Furthermore, we will be looking at laboratory data and the clinical circumstances of each patient with positive cultures for P. acnes between day 11 and 21 of incubation to determine which positive cultures reflect likely infection vs. likely culture contamination. Ultimately, we would like to determine the optimal incubation period for P. acnes from our operative wound specimens and thus the time for appropriate prophylactic antibiotics. Results: Basic Science and Clinical data concerning P. acnes infection and the association with shoulder surgery will be reviewed and presented in table form (with level of evidence of clinical studies) along with images demonstrating the consequences of this type of infection. We will subsequently present findings from our institution regarding time needed until final culture results should be deemed negative. Discussion and Conclusion: Deep tissue infections from P. acnes represent a rare but significant subset of postoperative complications following shoulder surgery. A heightened awareness and methods to reduce and treat this complication are crucial to the operative shoulder surgeon. This comparative review of recent literature and the aforementioned studies that are ongoing at our own institution, in combination with a data driven algorithm designed to reduce and prevent this potentially devastating complication will aid in this regard.

Scapular Winging: A Great Masquerader of Shoulder Pathology

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Introduction: The exact incidence of scapular winging is unclear, but an increasing number of studies suggest this disorder may be more common than previously thought. Winging of the scapula can be difficult to diagnose; the presenting complaint and physical exam maneuvers may direct the practitioner towards more common conditions affecting the shoulder and neck. Inappropriate surgery may be preformed or failure of surgery may result from ongoing scapular dysfunction. Methods: We reviewed the literature, as well as our own experience, involving the treatment of scapular winging and identified a series of patients with this condition who were initially misdiagnosed with other shoulder or spine pathology. Results: We identified only nine clinical studies that report a series of patients with an initial misdiagnosis of scapular winging (N = 53 patients). This exhibit systematically describes the common misdiagnoses (instability, labral pathology, impingement, and cervical spine disease), the clinical scenarios and examination findings that led to the diagnostic error, the definitive treatment and technical aspects of surgical intervention, and finally the clinical outcomes and complications. The exhibit also reviews the important aspects of the patient history, the physical examination
of the scapula, and the associated studies necessary to make the correct diagnosis of scapular winging. **Discussion**: This exhibit seeks to educate the orthopaedic surgeon on the common pitfalls related to the diagnosis and management of scapular winging. Significant morbidity to the patient can be avoided by the prompt diagnosis and recognition of scapular winging as the cause of, or a contributing factor to, the patient’s shoulder pathology.

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**SCIENTIFIC EXHIBIT NO. SE62**

**The Kinetic Chain of Overhead Throwing: A Systematic Review of Biomechanics and Associated Pathoanatomy**

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**Introduction**: The overhead throw requires precise synchronization of specific muscle units throughout each phase of the throwing motion. Given the complexity of this coordinated activity, it is important to understand muscle activation patterns and their role in optimizing throwing performance, preventing injury, and understanding relevant pathoanatomy. **Materials and Methods**: Several articles have investigated the biomechanics of throwing and the role of the kinetic chain. Both EMG and motion analysis studies have demonstrated that the kinetic chain acts to minimize loads experienced at small, distal segments by increasing the efficiency of larger, proximal segments and decreasing the forces at supporting tendons and ligaments by coordinating motions that align the involved extremities. **Results**: Overuse injuries can result from the large, repetitive forces and torques developed at both the shoulder and elbow. The observed pathology can be explained by sport-specific biomechanics. The intent of this exhibit is to: 1) Review the concept of the “kinetic chain” as it pertains to the overhead athlete 2) Examine sport-specific throwing mechanics based on EMG and motion analysis data 3) Discuss characteristic pathoanatomy using supplemental video, imaging and intraoperative photographs 4) Describe adaptive changes observed within throwing athletes utilizing 3-dimensional biomodels 5) Present patient-specific risk factors for injury and sport-specific rehabilitation protocols to avoid injury. **Discussion**: Managing overhead athletes requires a comprehensive understanding of the kinetic chain in order to help optimize throwing mechanics, prevent injury, and understand pathoanatomy of shoulder and elbow injuries. This exhibit will provide data to assist surgeons managing throwing athletes through patient counseling, diagnostic considerations and evidence-based, sport-specific treatment algorithms.

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**SCIENTIFIC EXHIBIT NO. SE63**

**Biomechanical Comparison of Proximal Radius Locking Plates Under Dynamic Loading**

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**Introduction**: Locked plating systems are utilized with increasing frequency in the management of complex and highly comminuted fractures. Specifically, 20% of all elbow trauma is associated with radial head/neck fractures, which historically have been treated with excision or prosthetic replacement. However, recent literature advocates radial head preservation whenever possible. The purpose of this ongoing study is to compare the biomechanical properties of six, contemporary, head-preserving, proximal radius locking plate devices under dynamic loading mimicking the immediate post-operative and rehabilitative phases of the fracture healing process. **Methods**: Nine plates of each design were fixed to corticocancellous composite sawbones. A plate-specific gap, ranging between 4mm and 6mm, was created to simulate radial neck comminution. Each construct was loaded for 2000 cycles at 100N, 200N and 300N, respectively at 2Hz and then to failure at 2N/s (Figure 1). The motion of the osteotomy gap was video captured and measured after each cyclic loading phase. Locking screws were visually inspected for loosening and load-deformation curves determined. **Results**: The load-displacement curves and averaged stiffness were similar for each of the plate designs tested. No screw loosening was observed although locking screw disengagement was observed in one design which resulted in a dramatic decrease in construct stiffness (Figure 2). All plates failed at loads significantly above 500N which is considered physiologic for the post-operative fracture healing and rehabilitative phases. **Discussion and Conclusion**: No significant differences (p>0.05) were found in the averaged stiffness for the proximal radius locking plate designs studied. All failed at loads significantly higher than the 500N expected during the post-operative fracture healing phase. Contemporary proximal radius locking plates assist head preservation while promoting fracture healing by minimizing the prospect of initial displacements associated with mal- or non-union. From this study, fracture pattern and screw configuration are seen to be the relevant variables in guiding plate selection.
Magnetic Resonance Imaging of the Elbow: Techniques and Spectrum of Disease

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Introduction: Magnetic resonance imaging (MRI) allows for high-resolution evaluation of the elbow osseous and soft tissue structures including ligaments, tendons, nerves, and muscles. Multiple imaging techniques and pulse sequences exist for evaluation. The purpose of this scientific exhibit is to educate and update orthopaedic surgeons on current MRI techniques and illustrate the spectrum of elbow disease detectable by MRI. Methods: Medline was searched using keywords “MRI” and “elbow” for studies less than 5 years old evaluating MRI techniques. These manuscripts, the authors’ experience, and textbooks on the topic of MR imaging of the elbow provided the information to prepare this exhibit. Results: 1. This exhibit describes the essentials and applications of the following techniques: 1. Conventional, non-Gadolinium enhanced MRI 2. Gadolinium enhanced MRI 3. Magnetic resonance arthrography II. The classic MRI appearances of the following are demonstrated: 1. Occult Fractures 2. Loose Bodies 3. MCL Injury 4. LCL Complex Injury 5. Biceps Tendon Injury 6. Triceps Tendon Injury 7. Lateral Epicondylitis 8. Medial epicondylitis 9. Septic Arthritis 10. Osteomyelitis 11. Osteochondritis Dissecans 12. Osteochondral Lesion 13. Compression Neuropathies 14. Synovial Disorders 15. Soft-Tissue Masses Discussion/Conclusion: MRI is a valuable, non-invasive method of evaluating the elbow. This exhibit will make the orthopaedic surgeon aware of various MRI techniques available and allow him or her to recognize the MR appearance of the most commonly seen elbow pathologies.

Radial Head Arthroplasty Alters Radiocapitellar Loads and Ulnar Kinematics in Complete Essex-Lopresti Injuries

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Introduction: We created a biomechanical model to understand the impact of radial head arthroplasty alone in complete and partial Essex-Lopresti injuries with the assumption that disruption of function will alter biomechanics. We examine the impact of the radial head on radiocapitellar pressure, axial radioulnar displacement and distal ulnar loads after complete and partial IOLC injuries. Methods: Two studies were conducted, each utilizing eight fresh-frozen cadaveric arms. The initial study evaluated the effect of radial head arthroplasty on radiocapitellar pressure and axial radioulnar displacement in complete injuries while the subsequent study assessed the impact on distal ulnar impaction forces in complete and partially injured arms. Pressure transducers were placed within the radiocapitellar joint after radial head arthroplasty to measure radiocapitellar pressures; metallic radiolucent beads were placed into the distal radius and ulna to measure displacement. A force transducer employing strain gauges was mounted on the distal ulna of the second set of arms to measure the distal ulnar impaction force. Complete and partial IOLC injuries (central band alone, central band + DRUJ + TFCC, central band + DRUJ + TFCC + PRUJ) were created. Fluoroscopic measurements, radiocapitellar pressures, load and displacement data from the MTS machine, and ulnar forces were recorded and analyzed by multiple comparison ANOVA. Results: Radiocapitellar joint pressures in native arms with intact IOLC measured 0.24 +/- 0.19 N/mm². Completely disrupted arms treated with radial head implant were found to have elevated radiocapitellar pressures (0.51 +/- 0.04 N/mm²), significantly higher than native controls (p<0.05). Intact arms all demonstrated minimal radioulnar axial displacement (3.4 ± 0.9 mm). After destabilization, the radioulnar displacement increased significantly to 15.5 ± 3.3 mm (p < 0.001). Axial displacement was reduced from 15.5 mm to 6.1 ± 2.4 mm following radial head replacement; however, this improvement was still statistically different from the normal intact state (p = 0.032). Distal ulnar impaction forces in control arms after radial head arthroplasty measured 10.4 +/- 5N. Arms with partial or complete disruption of the IOLC produced the following distal ulnar loads: (1) central band disruption + radial head 9.8 +/- 5N (p=0.38), (2) central band/DRUJ/TFCC disruption + radial head 6.5 +/-3N (p=0.08), (3) central band/DRUJ/TFCC/PRUJ disruption + radial head 4.0 +/-2N (p<0.05), (4) central band/DRUJ/TFCC/PRUJ + radial head excision 19.3 +/-3N (p<0.05). Discussion and Conclusion: Radial head arthroplasty following COMPLETE disruption of the IOLC: 1. Improves radioulnar axial displacement but not to intact levels. 2. Doubles the radiocapitellar pressure during axial loading. 3. Reduces the distal ulnar load by half that of intact arms. Radial head arthroplasty following PARTIAL disruption of the central band alone or central band + DRUJ/TFCC: 1. Produced distal ulnar loads that were similar to intact arms.