1 ARTHROSCOPIC CAPSULAR PLICATION IN THROWING ATHLETES

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Introduction: Arthroscopic capsular plication has recently been advocated as an alternative to thermal capsulorrhaphy and open capsular shift in patients with symptomatic capsular laxity of the shoulder. Arthroscopic methods are particularly attractive in throwing athletes because they minimize trauma to the subscapularis. We report on a consecutive series of arthroscopic capsular plication procedures in throwing athletes.

Material and methods: Sixteen throwing athletes (10 men, 6 women) were treated with arthroscopic capsular plication for symptoms of recurrent anterior instability after an extended course of nonsurgical treatment failed. Patients with superior labral lesions were excluded from the study. Minimum follow-up was 2 years (range, 24-50 months). No patient was lost to follow-up. The patients’ mean age was 20.6 years (range, 16-36 years).

Results: Fifteen of 16 patients (94%) were satisfied with the outcome of their operation. However, only 11 of 16 (69%) were able to return to their premorbid level of throwing for at least 1 year after surgery. Two patients had atraumatic subluxation and both underwent revision surgery. One patient had a traumatic subluxation and underwent arthroscopic revision 2 years (range, 24-50 months). No patient was lost to follow-up.

Conclusion: Arthroscopic capsular shift in patients with symptomatic capsular laxity of the shoulder. Arthroscopic methods are particularly attractive in throwing athletes because they minimize trauma to the subscapularis. However, only 11 of 16 (69%) were able to return to their premorbid level of throwing for at least 1 year after surgery. Two of the 3 patients who underwent concomitant procedures in throwing athletes.

2 NORMALIZATION OF GLENOHUMERAL ARTICULAR CONTACT PRESSURES AFTER EITHER LATARJET OR ILIAC CREST BONE GRAFTING PROCEDURE: IMPACT OF GRAFT TYPE, POSITION, AND CORACOID ORIENTATION

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Purpose: The articular conformity after Latarjet and iliac crest bone graft (ICBG) procedures for glenoid deficiency remains poorly defined. We sought to investigate the alterations in gleno-humeral articular contact pressures in a glenoid bone loss model to determine changes in pressure with proud, flush, and recessed Latarjet or ICBG procedures, and to determine the optimal orientation of the graft.

Methods: Twelve fresh frozen cadaveric shoulders were stripped of all tissues except the labrum. In static positions of scapular abduction (50°, 60°, and 90°) and external rotation (less than optimal) with a compressive load of 440 N, the glenohumeral contact area, contact pressure, and peak pressure were determined with a Tekscan sensor (South Boston, MA) for several conditions: (1) intact glenoid, (2) glenoid with clinically relevant 15% and 30% defect from 2:00 to 6:00 position, (3) 30% glenoid defect treated with Latarjet bone block placed 2-mm proud, flush, and 2-mm recessed to the glenoid, (4) 30% glenoid defect with ICBG placed 2-mm proud, flush, and 2-mm recessed to the glenoid, and (5) Latarjet bone block oriented with either the lateral (Latarjet-LAT) or inferior (Latarjet-INF) surface of the coracoid as the glenoid face.

Results: With a glenoid bone defect of 30%, contact area decreased 35% (P < .05) and mean contact pressure increased nearly 70% (P < .01), with mean contact pressure in the anteroinferior quadrant increasing 200% to 300% (P < .001) compared with the intact state. Bone grafts in the flush position restored mean contact pressure to 85% (ICBG, P < .04), 80% (Latarjet-INF, P = .03), and 65% (Latarjet-LAT, P = .02) of normal. Latarjet-LAT demonstrated statistically higher peak pressure than the ICBG and Latarjet-INF at nearly all positions (P < .02). With bone grafts placed in a proud position, mean contact pressure increased an additional 40% (P < .01) in the anteroinferior quadrant also, with a 100% (P < .01) increase in the postero-inferior glenoid indicating a shift posteriorly. Mean contact pressures and forces of bone grafts placed in a recessed position were not significantly different from those of 30% glenoid defect, indicating continued high edge-loading.

Conclusion: Owing to the inherent congruity of the ICBG and the bony anatomy of the coracoid, contact pressures and edge-loading were lower in glenoid defects reconstructed with ICBG and Latarjet-INF compared with the Latarjet-LAT method. Grafts placed in a proud position not only increased the peak pressure antero-inferiorly but also shifted the articular contact forces to the postero-inferior quadrant. These findings may favor the potential clinical utility of optimally placed ICBG and Latarjet-INF vs Latarjet-LAT for glenoid bone reconstruction.

3 ARTHROSCOPIC BRISTOW-LATARJET-BANKART FOR THE TREATMENT OF ANTERIOR INSTABILITY IN SHOULDERS WITH GLENOID BONE LOSS AND DEFICIENT ANTERIOR CAPSULE: THE “TRIPLE BLOCKING” OF THE SHOULDER

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Background: Glenoid bone loss and capsular deficiency are limiting factors for the success of arthroscopic Bankart. We report the results of a novel technique consisting of a combined arthroscopic Bristow-Latarjet procedure with an associated Bankart repair.

Material and methods: This all-arthroscopic procedure combines 2 parts: a standard arthroscopic Bankart repair that recreates glenoid concavity and retensions the inferior glenohumeral ligament (“the belt” or intraarticular ligamentoplasty), and a transfer of the coracoid process with the conjoint tendon to compensate for glenoid bone loss and reinforce the deficient anterior capsule by lowering of the subscapularis (“the suspenders” or extraarticular ligamentoplasty). The axillary nerve was identified in all cases. The coracoid fragment with the conjoint tendon is osteotomized, passed through the subscapularis muscle, and fixed with a cannulated screw on the scapular neck. Twenty-one patients treated with this technique were prospectively followed up both clinically and radiographically at a minimum 1-year follow-up.

Results: There were no intraoperative or postoperative complications. No recurrent instability occurred. All patients were satisfied. The mean Walch-Duplay score was 89 of 100 points. On computed tomography scan with 3-dimensional reconstruction, the bone block positioning was under the equator in all cases and flush to the...
glenoid surface in 60%. A specific instrumentation has been developed to make the bone block positioning more reproducible.

**Conclusions:** This new combined technique constitutes an alternative in the treatment of anterior shoulder instability in patients with glenoid bone loss and a deficient anterior capsule. It combines the theoretic advantages of the Bristow-Latarjet bone block procedure and the arthroscopic Bankart repair, while eliminating the potential disadvantages of each. The efficacy of this procedure is related to a “triple blocking” of the shoulder: (1) bone block effect provided by the coracoid, which increases the size of the glenoid surface; (2) sling effect provided by the crossing of the lower subscapularis and conjoint tendon; and (3) glenoid concavity recreation.

## 4 Risk Factors Affecting Recurrence Rate in Patients Affected by Traumatic Unidirectional Instability Arthroscopically Treated

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**Introduction:** Shoulder arthroscopy represents a safe and effective tool to treat dislocations of the glenohumeral joint. Although this procedure is increasing nowadays, a high failure rate leading to recurrence was found in young adults. The aim of this study was to identify risk factors affecting recurrence rate in patients affected by traumatic unidirectional instability arthroscopically treated by following the same surgical technique.

**Methods:** The study enrolled 385 patients aged between 16 and 63 years with traumatic shoulder instability. Exclusion criteria were voluntary dislocation, hyperlaxity, surgery after 12 months of the first dislocation, more than 7 dislocations, glenoid erosion, and previous surgery. Patients were once treated arthroscopically and evaluated for the following factors: age, sex, dominant shoulder, time from first dislocation to surgery, number of dislocations before surgery, and arthroscopic findings (Bankart or anterior ligamentous periosteal sleeve avulsion [ALPSA] lesion). Redislocations were divided into early, intermediate, and late.

**Results:** The mean recurrence rate was 8% (31 of 385 shoulders), with rates of 17% in patients aged younger than 22 years and of 3.7% in older patients. Male patients had a mean redislocation rate of 9% compared with 5.6% in female patients. Bankart and ALPSA lesions were associated with respective failure rates of 5.5% and 12.9%.

**Conclusions:** Redislocation is more frequent in age younger than 22 years and with instability due to ALPSA lesions. Age was a reliable prognostic factor for redislocation after arthroscopic surgery. Male sex and time from first dislocation are the most significant negative prognostic factors. Despite the improvement of the surgical technique and development of new devices, recurrence of shoulder instability in young patients remains a challenge. The clarification of the histologic features of the ligaments and labrum could provide more information.

## 5 Surgical Management of the Failed Superior Labrum Anteroposterior Repair

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**Background:** Repair of superior labrum anteroposterior (SLAP) lesions has become an increasingly common procedure, despite the relative rarity of SLAP lesions. Management of the failed SLAP repair can be challenging. This series represents the first report of arthroscopic management of the failed SLAP repair.

**Methods:** Twenty-four shoulders in 22 patients were treated during a 7-year period for persistent pain after SLAP repair. Mean age was 39.845 years, and reoperation was at an average of 23.3 months. All had preoperative radiographs and magnetic resonance imaging (MRI) scans, and all patients had a prerevision lidocaine impingement test.

**Results:** SLAP repairs had failed in 7 patients and were revised with suture anchors. Four patients were treated for loose tacks; only 1 was correctly diagnosed on postoperative MRI scans. Proud metal anchors caused severe arthritis in 2 patients, both undiagnosed on radiographs. Seven patients never had bursoscopy at the time of the index procedure; 6 had positive lidocaine impingement tests and were treated successfully with arcomioplasty. Articular cartilage damage not present on the initial arthroscopy was present in 14 of 21 patients. Intraoperative photographs from the index procedure were available in 7 patients; only 2 definitively demonstrated pathology. University of California, Los Angeles scores improved from 17.6 to 29.2 and Simple Shoulder Test scores from 5.7 to 9.6.

**Conclusions:** Failure of SLAP repairs is multifactorial and is rarely due to persistence of the labral lesion; careful workups for other causes of pain is necessary. Normal repair of labral variants should be avoided due to the risk of complications, especially articular cartilage damage. Tack repairs are particularly troublesome; the painful shoulder after tack repair of SLAP lesions should be arthroscopically due to the poor sensitivity of MRI scanning for loose tacks and the subsequent risk of serious articular damage.

## 6 Local Anesthetic Toxicity and Cultured Fibroblasts

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**Background:** Analgesia after shoulder surgery can be a challenge. In addition to oral medications, options for treating postoperative pain include long-acting brachial plexus blocks, brachial plexus catheters, or the use of pain catheters inserted at the surgical site. Local infusion pain catheters placed in the surgical site have gained popularity due to their ease of placement and effectiveness in relieving pain. As the prevalence of these catheters increases, the devastating reported occurrence of glenohumeral chondrolysis has become more frequent after catheters are placed within the glenohumeral joint. The deleterious effects of bupivacaine on hyaline cartilage have been documented in a rabbit model (Gomoll et al, Arthroscopy 2006). These factors have led to the placement of these catheters within the subacromial space postoperatively, most notably after rotator cuff repairs. Because the healing process after a rotator cuff repair is dependent on fibroblast activity and proliferation, and because the effects of bupivacaine on chondrocytes are known to be toxic, we became concerned about the effects of local anesthetics on fibroblasts.

**Material and methods:** Cultured rat synovial fibroblasts were exposed to varying dilutions of 4 different local anesthetics (0.25% bupivacaine, 0.25% bupivacaine and epinephrine, Naropin [2% ropivacaine], and 1% lidocaine), which were diluted in normal 0.9% saline. The lethal dose 50 (LD50) was evaluated in 24 hours and 24 hours after exposure of the fibroblasts to the local anesthetics for 15 and 30 minutes, using normal 0.9% saline as a control.

**Results:** The LD50 for all local anesthetics ranged from 1.2 to 1.32 dilution at 30 minutes and 1.2 to 1.8 at 15-minute exposure. Bupivacaine at 0.25% was the most toxic of the drugs tested. Normal saline also proved to be mildly toxic to the fibroblasts but was significantly less so than any of the local anesthetics.

**Conclusions:** The results of our in vitro experiments, involving exposure of fibroblasts to local anesthetics, are concerning. In this model, the local anesthetics were clearly toxic to synovial fibroblast cultures. These results are significant for procedures in which postoperative fibroblast activity is essential, such as rotator cuff repair. Although further studies need to be completed prior to making any definitive conclusions concerning the use of subacromial space pain catheters, these results suggest their application with caution.
7 CLASSIFICATION OF GLENOID MORPHOLOGY IN REVERSE SHOULDER ARTHROPLASTY AND ITS SURGICAL IMPLICATIONS

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Purpose: This study classified 3-dimensional (3D) glenoid morphology in patients undergoing reverse shoulder arthroplasty (RSA) and identified the effect of altered morphology on placement of screw fixation for the glenoid component.

Material and methods: A total of 221 scapulas were analyzed from patients who had undergone RSA to treat rotator cuff deficiency along with glenohumeral subluxation, glenohumeral arthritis, or pseudoparalysis. Patients who had undergone previous arthroplasty were excluded. The analyses of glenoid morphology included (1) quantitative anatomic measurement on 3D models—glenoid height, width, version, inclination, and distance from coracoid base to glenoid surface (C-G); and (3) surgical measurement on 3D models—virtual glenoid centerline, and articular surface area of summed virtual placement of 4.5-mm screws, with 30-mm length fulfilling the criteria of beginning on glenoid surface and staying within bone.

Results: The glenoid morphology was distinctly classified into normal (68%) and abnormal (32%) by observer ratings. The anatomic measures in the normal group (34.6 ± 3.6 mm in height, 29.2 ± 2.8 mm in width, −7.0 ± 4.0° in retroversion, and 2.4 ± 2.5 mm in C-G distance) were similar to those in the literature. Inclination in the normal group was 12.4° ± 4.4°, and the centerline distance was 26.2 ± 2.9 mm. The area of virtual screws was 700.4 ± 141.8 mm². The abnormal group was further classified into anterior, posterior, superior, and global based on the erosion site. A significant difference was found between the normal and each subnormal group in at least 1 parameter. The anterior erosion group had an inclination of 35.0° ± 9.7° (P < .0001) and a centerline of 11.5 ± 3.8 mm (P < .0001). The posterior erosion group had a retroversion of −24.4° ± 15.3° (P < .0001) and a centerline of 18.7 ± 7.1 mm (P = .0002). The glenoid erosion group had a C-G distance of −8.3 ± 3.2 mm (P < .0001). The superior erosion group had an inclination angle of 22.0° ± 4.9° (P < .0001). The abnormal glenoid group had a diminished area for virtual screw placement of 425.2 ± 62.5 mm² (P = .0053).

Discussion: The glenoid morphology in RSA indicated a clear difference from that in total shoulder arthroplasty where the primary pathologic disease is arthritis. Most of RSA patients (about two-thirds) had normal morphology, suggesting a consequence of pseudoparalysis or muscular insufficiency. The remaining (about one-third) had significant glenoid erosions at various sites, implying a persistent malfunction of the joint and soft tissue imbalance. In most cases, the morphology could be reliably defined by radiographs, 2D CT scans, or 3D models.

Conclusions: Severe anterior and posterior erosions diminished centerline distance, indicating the need in altering surgical tactics or even improving implant design to achieve satisfied fixation for the glenoid component. The surface area for virtual screw placement mapped out here offers surgeons practical alternatives.

8 OUTCOMES FOLLOWING REVERSE TOTAL SHOULDER ARTHROPLASTY: AFFECT OF PREOPERATIVE DIAGNOSIS, CLINICAL COMPLICATIONS, AND SCAPULAR NOTCHING

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Background: The popularity of reverse total shoulder arthroplasty is increasing, and new indications are continually reported. The purpose of this study was to review our results after reverse total shoulder arthroplasty with respect to preoperative diagnosis, clinical complications, and scapular notching.

Methods: Reverse total shoulder arthroplasty was performed in 101 patients with average age of 68 ± 10 years by a single surgeon. Reverse total shoulder arthroplasty was performed as the primary procedure in 78 patients (77%) and as a revision procedure in 23 patients (23%). Preoperative diagnoses included cuff tear arthropathy (36%), failed prior arthroplasty (23%), fracture sequelae (13%), massive rotator cuff tear with pseudoparalysis and no arthritis (8%), acute fracture (7%), rheumatoid arthritis (6%), locked glenohumeral dislocation (5%), and postinfectious arthropathy (3%). Data were collected prospectively, and patients were followed up for an average of 21 months (range, 12-46 months). Analysis of variance and likelihood ratio tests were used to analyze the data, using the American Shoulder and Elbow Surgeons (ASES) and Constant scoring systems.

Results: Across all diagnosis groups, ASES scores (28 to 68, P < .001), Constant scores (14 to 57, P < .001), adjusted Constant scores (19 to 79, P < .001), active forward flexion (32° to 135°, P < .001), active abduction (29° to 130°, P < .001), and active external rotation (6° to 23°, P < .001) significantly improved after reverse total shoulder arthroplasty. Patients with preoperative diagnoses of cuff tear arthropathy and massive rotator cuff tear with pseudoparalysis and no arthritis had significantly higher Constant scores (67 vs 48, P = .001), adjusted Constant scores (88 vs 66, P = .003), active forward flexion (154° vs 117°, P < .001), active abduction (150° vs 111°, P < .001), and active external rotation (31° vs 13°, P < .001) compared with the patients with preoperative diagnoses of revision and fracture sequelae. Primary reverse total shoulder arthroplasty had significantly higher Constant scores [60 vs 49, P = .027], adjusted Constant scores [83 vs 66, P = .017], active abduction [134° vs 115°, P = .032], and active external rotation [26° vs 15°, P = .010] compared with revision total shoulder arthroplasty, but there was no significant difference in forward flexion [138° vs 123°, P = .083]. Fourteen patients (14%) had 1 or more clinical complications, including 8 humeral fractures, 6 glenohumeral dislocations, and 1 patient with persistent pain at the bone graft harvest site used in glenoid reconstruction. The rate of clinical complications was unrelated to length of follow-up and occurred significantly more frequently in patients with preoperative diagnoses of revision, fracture sequelae, and locked glenohumeral dislocation than in patients with other preoperative diagnoses (P < .003). The presence of clinical complications significantly decreased ASES scores (54 vs 70, P = .016), Constant scores (61 vs 82, P = .014), active forward flexion (111° vs 139°, P = .009), and active abduction (109° vs 133°, P = .025), but did not significantly affect active external rotation (18° vs 24°, P = .189). Follow-up radiographs revealed scapular notching in 75%, heterotopic ossification in 44%, humeral component lucencies in 30%, glenoid component lucencies in 8%, and humeral component tilt or subsidence in 3%. The rate of heterotopic ossification was significantly lower in patients with preoperative diagnoses of cuff tear arthropathy and acute fracture compared with patients with other preoperative diagnoses (26% vs 57%, P = .008). Preoperative diagnosis had no effect on the presence or absence of notching, component lucency, or component subsidence. Initially, the presence and severity of scapular notching increased significantly as time to follow-up increased (P = .047), and 88% of patients with 2 or more years of follow-up had radiographic signs of scapular notching. However, the presence and severity of scapular notching stabilized after 2 years of follow-up. The presence of scapular notching, and other radiographic findings, had no significant effect on outcomes.

Conclusions: Reverse total shoulder arthroplasty significantly decreased pain and improved motion, strength, and function in patients with all preoperative diagnoses. The best results were obtained in patients with preoperative diagnoses of cuff tear arthropathy and massive rotator cuff tear with pseudoparalysis and no arthritis. There was a relatively low rate of clinical complications; however, the presence of clinical complications significantly decreased outcomes. Scapular notching was common, and the rate of scapular notching increased with length of follow-up during the
first 2 years, but the presence and severity of scapular notching stabilized after 2 years and had no significant effect on outcomes.

9  TRABECULAR METAL REVERSE SHOULDER ARTHROPLASTY AND THE LACK OF SCAPULAR NOTCHING
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Background: Scapular notching with reverse shoulder arthroplasty (RSA) is a concern. Most series report a 45% to 90% incidence and that it develops within the first 6 months of implantation and can be progressive. We report the radiographic results of a new RSA design with characteristics to minimize notching, provide long-term biologic fixation, but respects proven Grammont design principles of inferiorization and medialization of the glenoid component.

Methods: A total of 144 Trabecular Metal (Zimmer, Inc, Warsaw, IN) RSA were radiographically evaluated with true anteroposterior (AP) and axillary radiographs at 1 week, 6 weeks, 3 months, 6 months, 1 year, and 2 years. The average age was 68 years (range, 39-87 years), and 58% were women. The minimum follow-up interval was 6 months. All procedures were performed by a deltopectoral approach: 50% were cuff tear arthropathy, 20% were failed rotator cuff repairs, 16% were fracture sequelae, and 14% were for failed implants. Thirty-three percent had previous surgery on the shoulder. A 36-mm glenosphere was used in 126 (87.5%), and a 40-mm was used in 18 (12.5%).

Results: Using the Nerot classification for scapular notching, at a minimum 6-month follow-up and average 14-month follow-up, there was a 0% incidence of notching on AP or axillary views. There was no glenoid luencies or loosening. There was no screw breakage or implant dissociation. There were 5 (3.5%) instability events early (<2 months), 2 required closed reduction, and 3 a polyethylene exchange.

Discussion: The Trabecular Metal RSA has unique design elements to minimize potential scapular notch formation while respecting proven Grammont design principles. A 3-mm Trabecular Metal "pad" on the baseplate provides for long-term bone ingrowth fixation and also provides a small lateral offset to the glenosphere. The humeral component is low profile, with a 143° metallic neck shaft angle. The polyethylene insert is angled 7° for a total neck-shaft angle of 150°.

Conclusions: The early-term radiographic analysis of the Trabecular Metal RSA revealed a 0% scapular notch incidence at a minimum of 6 months and at the longest 2-year follow-up. There was no glenoid component loosening, and a very low 3.5% instability rate.

10  PROSPECTIVE EVALUATION OF REVERSE SHOULDER ARTHROPLASTY IN PATIENTS WITH RHEUMATOID ARTHRITIS
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Background: Prior studies have shown an increased risk of complications of reverse shoulder arthroplasty (RSA) in patients with rotator cuff deficiency and rheumatoid arthritis. The purpose of this study was to report the outcome and describe the pathoanatomy of patients with rheumatoid arthritis who were treated with RSA.

Methods: Eighteen shoulders in 17 patients were evaluated prospectively as part of an Investigational Review Board-approved clinical study. Patients were followed up for a minimum of 2 years, with an average duration of clinical follow-up of 28 months. In 17 of 18 shoulders, a magnetic resonance image or computed tomography scan was available for evaluation of muscular and bony deficiency.

Results: American Shoulder and Elbow Surgeon (ASES) pain and function scores significantly improved (15 to 46, P < .0001; 12 to 37, P < .0001 respectively), as did the Simple Shoulder Test (SST) scores (0.8 to 6.1, P < .0001). Forward flexion improved significantly (54.8° to 126.7°, P < .0001), as did abduction (57.0° to 116.7°, P = .0003), and external rotation (21.9° to 30.0°, P = .0313). Ten patients rated their outcome as excellent, 5 as good, 2 as satisfactory, and 1 as unsatisfactory. Muscular deficiency of the rotator cuff was seen radiographically in all of the shoulders with available imaging. Severe glenoid erosion was seen in 10 shoulders. A structural glenoid allograft was required for 5 shoulders, but no humerus required allograft reconstruction. Two patients sustained a complication that required reoperation: 1 patient sustained a posttraumatic periprosthetic glenoid fracture requiring removal of the glenosphere, open reduction and internal fixation of the fracture, and conversion to hemiarthroplasty; and 1 patient developed a deep infection requiring irrigation and debridement with retention of the components.

Conclusions: Rheumatoid arthritis of the shoulder associated with glenoid erosion and rotator cuff muscle deficiency has historically been very difficult to treat effectively. Previous studies have suggested that RSA is contraindicated in patients with rheumatoid arthritis. The data from this study indicate a marked decreased in pain and increase in function with no radiographic evidence of deterioration at a minimum of 2 years follow-up.

11  Efficacy of Surgical Preparation Solutions in Shoulder Surgery
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Background: Recent studies have shown that Propionibacterium acnes is responsible for a large proportion of deep infections that occur after shoulder surgery. 1-3 The most efficacious way to prepare the skin for shoulder surgery is unknown. The purpose of the present study was to determine the efficacy of 3 different surgical skin-preparation solutions on the eradication of Propionibacterium and other bacteria from the shoulder.

Methods: A randomized prospective study was undertaken to evaluate 150 consecutive patients undergoing shoulder surgery at 1 institution. Each shoulder was prepared with 1 of 3 randomly selected solutions: Chloraprep (2% chlorhexidine gluconate and 70% isopropyl alcohol), DuraPrep (0.7% iodophor and 74% isopropyl alcohol), or povidone-iodine scrub and paint (0.75% iodine scrub, 1% iodine paint). For the first 20 patients, culture specimens were taken from 3 different sites: anterior shoulder, posterior shoulder, and axilla both before and after application of the agent. For the next 130 patients, culture specimens were taken from 2 sites: combined anterior/posterior and axilla after application of the agent.

Results: In the povidone-iodine group, bacteria grew on culture of specimens obtained from 22% of the anterior/posterior sites and 40% of axillary sites. In the DuraPrep group, bacteria grew on culture of specimens obtained from 26% of the anterior/posterior sites and 12% of axillary sites. In the Chloraprep group, bacteria grew on culture of specimens obtained from 10% of the anterior/posterior sites and 4% of axillary sites. Chloraprep and DuraPrep were more effective at eliminating bacteria from the axillary location than povidone-iodine (P = .0013 and P = .0042, respectively). Chloraprep was more effective than DuraPrep at eliminating bacteria from the anterior/posterior location (P < .05). Neither Chloraprep nor DuraPrep differed significantly from povidone-iodine in the ability to eliminate bacteria from the anterior/posterior location (P = .12 and P = .64, respectively).

Propionibacterium acnes. When all 150 patients were evaluated after surgical preparation, coagulase-negative Staphylococcus was the most common organism isolated from the axilla (23 isolates) followed by P. acnes (9 isolates). In contrast, P. acnes was the most common organism isolated from the anterior/posterior regions (26 isolates), followed by coagulase-negative Staphylococcus (3 isolates). In the povidone-iodine group, P. acnes was isolated from 18% (9 of 50) of the anterior/posterior sites and 12% (6 of 50) of the axillary sites. In the DuraPrep group, P. acnes was isolated from 22% (11 of 50) of the anterior/posterior sites and 2% (1 of 50) of the axillary sites. In the Chloraprep group, P. acnes was isolated from 10% (5 of 50) of the anterior/posterior sites and 4% (2 of 50) of the axillary sites. With regard to the presence of residual P. acnes after surgical preparation of the
did not affect the rate of positive cultures following surgical skin prep-
than the axillary region. The presence or absence of axillary hair
commonly cultured from the anterior/posterior shoulder regions
from the anterior/posterior shoulder regions. 

P acnes

significant difference in the ability of the 3 agents to eliminate
the patients treated in this study.

Conclusions: Both Chloraprep and DuraPrep are more effica-
cious than povidone-iodine at eliminating bacteria, and specifically
P acnes, from the axillary region. There was not a statistically signifi-
cant difference in the ability of the 3 agents to eliminate P acnes
from in the posterior shoulder region of P acnes was more
commonly cultured from the anterior/posterior shoulder regions
than the axillary region. The presence or absence of axillary hair
did not affect the rate of positive cultures following surgical skin prep-
ration.

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12 TWO-DIMENSIONAL GLENOID VERSION MEASUREMENTS VARY WITH CORONAL AND SAGITTAL SCAPULA ROTATION

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Introduction: Classically, 2-dimensional (2D) computed tomogra-
phy (CT) evaluation of the shoulder has been used prior to total
shoulder arthroplasty to evaluate glenoid alignment and feasibility
of implanting a glenoid component. The glenoid component should
be implanted in proper alignment to allow for concentric loading
and decrease stress at the bone cement interface. The purpose of
this study was to investigate the effect of scapula rotation in the
coronal and sagittal planes on the variation of glenoid version as mea-
sured on 2D images.

Methods: Computer-generated 3D scapula models from CT
scans of 36 shoulders without degenerative changes from 19 differ-
ent cadavers (mean age, 84.5 ± 8.7 years; 10 males and 9 fe-
males) were used. CT scans were acquired from whole-body
cadavers placed on the scanner bed in the supine position with
arms at the side. The anatomic version of each scapula was first iden-
tified on the 3D models using a previously reported method.1 The
scapulae were then oriented with the plane of the scapula placed
in the neutral position in the coronal and sagittal planes. Scapulae
were rotated in 1-degree increments in the coronal (−20° abduction
to +20° adduction) and sagittal planes (−10° external rotation to
+30° internal rotation). Glenoid version was measured on 2D axial
images at the midglenoid level for each of the rotation increments.
Glenoid version measurements were compared with the version
measured with the scapula in the neutral position.

Results: In the in situ average sagittal and coronal position of the
scapula with the cadavers supine on the scanner bed were 16.4°
± 5.5° (range, 1.5° to 28.1°) and 2.0° ± 8.4° (range, −16.5° to
22.6°), respectively. Average anatomic glenoid version determined
on the 3D models was −2.0° ± 3.8° (range, −8.8° to +7.6°). Ver-
version measured with coronal or sagittal rotation of the scapula was
significantly different from version at neutral rotation for all degrees
of rotation (P < .0001). The magnitude of version variation was
greatest when the scapula was abducted in the coronal plane and
resulted in increased anteversion. At 20° of scapula abduction
and adduction, the mean version variation was +9.4° ± 3.1° (range
+3.5° to +14.6°) and −2.4° ± 1.1° (range, −4.7° to −0.3°), respec-
tively. In the coronal plane, glenoid version was more anteverted
with internal rotation and more retroverted with external rotation.
At 30° of internal rotation, mean version variation was +6.4° ±
4.0° (range, −0.2° to +17.4°). At 10° of external rotation, mean ver-
sion variation was −2.0° ± 1.3° (range, −4.7° to 0.8°).

Conclusions: Any malalignment of the scapula in the coronal or
sagittal planes will create inaccuracies in measuring glenoid ver-
sion. When measuring glenoid version from 2D scans, the position
of the scapula in the coronal and sagittal planes must be accounted
for. When the scapula is abducted or internally rotated, glenoid ver-
sion measurements were more anteverted; Whereas when the scap-
ula was in adduction or external rotation, the glenoid version
measurements were more retroverted. These findings support the
use of 3D models to evaluate glenoid version that do not rely on
the position of the scapula.

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mensional computed tomography for the analysis of the glenoid

13 SIMULATION OF SURGICAL GLENOID RESURFACING USING THREE-DIMENSIONAL RADIOGRAPHIC ANALYSIS OF THE ARTHRITIC GLENOHUMERAL JOINT: THE AMOUNT OF RETROVERSION THAT CAN BE CORRECTED

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Introduction: Total shoulder arthroplasty (TSA) is an effective
treatment for end-stage glenohumeral arthritis. Glenoid bone defi-
ciency and posterior wear are common features of advanced shoul-
der arthritis and can compromise implantation of the glenoid
component, making the procedure more difficult. The magnitude
of glenoid erosion and retroversion that can be surgically corrected
and still enable successful implantation of a glenoid component has
not clearly been established.

Methods: Nineteen patients underwent TSA. Using three-di-

mensional (3D) models created digitally from computed tomography ex-
aminations of the study patients, we simulated glenoid resurfacing
on varying degrees of eroded, osteoarthritic glenoids using an in-
line 3-peg glenoid component. Inability to successfully implant a gle-
noid was defined by perforation of the glenoid vault by any peg or
any overhang of the glenoid implant over the reamed glenoid sur-
face. Retroversion was given a positive value by convention. A
46-mm glenoid component was placed in neutral version if possible.
If unable to resurface the glenoid to neutral, the 46-mm glenoid
was placed in the least amount of retroversion possible. If still unable
to implant a 46-mm glenoid successfully, a 40-mm glenoid was
implanted.

Results: The average glenoid retroversion of patients in which
a standard 46-mm glenoid was successfully implanted at neutral ver-
sion was 8.8° ± 6.4° (range, −1.4° to 18.0°). In comparison,
the average glenoid retroversion in patients in which a glenoid
could not be implanted at neutral was 18.15 ± 7.1° (range,
12.55–37.77°). The difference between these 2 groups was statistically significant (P = .01). Applying Chauvenet’s criterion to eliminate outliers, the means of the 2 groups were 8.85° ± 6.4° vs 16.19° ± 3.2° (P = .006), respectively. We were able to successfully implant a glenoid at neutral version for 6 patients in whom the preoperative retroversion was less than 12°, but we were unable to implant a neutral glenoid in the 4 patients with retroversion greater than 18°. Using our algorithm, none of the male patients required implantation of the smaller size (40 mm) glenoid (n = 10). On the other hand, all of the patients who required a 40-mm glenoid were female (n = 3).

Conclusions: With the use of computer-aided surgical simulation, we have established through the use of a validated 3D CT model, that an in-line pegged glenoid component can be implanted to neutral whenever the preoperative glenoid retroversion is 12° or less. We have also determined that implantation to neutral is not possible when preoperative retroversion exceeds 18°. In addition, a smaller glenoid component is often required for accurate and successful implantation in the female patient. Glenoid retroversion is a critical factor, but not the sole factor, in determining successful glenoid component implantation. Other factors still need investigation and identification. Our simulation has significant clinical impact in terms of identification and evaluation of retroversion and how it impacts the shoulder surgeon’s preoperative planning.

14 CAN COMPUTER-AIDED SURGERY IMPROVE ACCURACY OF GLENOID POSITIONING IN TOTAL SHOULDER ARTHROPLASTY? A PROSPECTIVE, RANDOMIZED CLINICAL STUDY

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Purpose: Can intraoperative navigation improve accuracy of glenoid component version to avoid malpositioning?

Material and methods: We conducted a prospective-randomized clinical study in which total shoulder arthroplasty was done in 10 patients using an intraoperative optical navigation system, and 10 patients (controls) had a conventional procedure. Six patients were excluded because of failed intraoperative navigation. Inclusion criteria were osteoarthritis (type B1 or B2 glenoid according to Walsh) and an intact rotator cuff. Exclusion criteria were glenoid type A or C according to Walsh, revision surgery, and persistent instability. Standardized computed tomography (CT) scans were performed before and 6 weeks after operation, and retroversion of the glenoid or the glenoid component was measured.

Results: Navigation was stopped for technical problems in 37.5% of the cases. Operating time was significantly prolonged by 31 minutes on average due to navigation. In group 1 (navigation), we found an average change of the retroversion angle from 15.4° ± 5.8° to 3.7° ± 6.3°. In group 2 (conventional), we found an average change of the retroversion angle from 14.4° ± 6.1° to 10.9° ± 6.8°. The correction of retroversion was statistically significant in both groups (P < .05). The improvement in accuracy in the navigated group with higher values of correction of retroversion to normal were statistically significant (P < .05). Both groups were without statistical difference regarding gender, age, type of glenoid morphology, and preoperative retroversion values. We found an average difference in postoperative retroversion values between the glenoid bone stock and implants of 0.4° ± 0.7° in group 1 and of 0.6° ± 0.9° in group 2, without statistical significance.

Conclusions: The use of an intraoperative navigation significantly improved accuracy in positioning of the glenoid component. Differences in postoperative retroversion between the implant and the bone stock suggest the use of navigation devices also for the insertion of the components. The small number of patients in both groups limits the study and advocates continuation with greater patient number and longer follow-up.

15 RADIOGRAPHIC COMPARISON OF PEGGED AND KEELED GLENOID COMPONENTS USING MODERN CEMENTING TECHNIQUES: A PROSPECTIVE RANDOMIZED STUDY

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Background: Glenoid loosening is the most common indication for revision total shoulder arthroplasty, and loosening has been correlated with the development of glenoid radiographic lucency. Severe biomechanical, animal, and retrospective studies have implicated glenoid design in the development of glenoid lucency, stating the superiority of pegged over keeled glenoid components. One prospective study with early cementing techniques also demonstrated the superiority of pegged glenoid components in the immediate postoperative period. However, modern cementing techniques have improved glenoid fixation and have reduced the rate and extent of glenoid lucency seen with keeled components. With modern cementing techniques, the difference in glenoid lucency between pegged and keeled glenoid components may be eliminated. The purpose of this study was to determine the effect of glenoid design on the immediate and midterm radiographic lucency of pegged and keeled glenoid components, using modern cementing techniques.

Methods: Fifty-three total shoulder arthroplasties were performed during a 1-year period in patients with primary glenohumeral osteoarthritis. Twenty-six patients were prospectively randomized to receive a pegged glenoid component, and 27 were prospectively randomized to receive a keeled glenoid component. The keeled glenoid group all underwent glenoid bone preparation using the bone compaction technique to create a keel slot in the same dimensions of the implant keel. Initial and follow-up radiographs were evaluated by 3 raters to determine lucency on a scale from 0 (no lucency) to 5 (gross lucency). Statistical analysis was performed with the χ² test to evaluate the effect of glenoid design on immediate and follow-up radiographs.

Results: Forty-seven patients (89%) returned for follow-up evaluation (average 26 months; range, 12-38 months), including 26 in the keel group (96%) and 21 in the pegged group (81%). In the immediate postoperative period, there was no significant difference in the rate of glenoid lucency between the pegged (0%) and keeled (15%) glenoid components (P = .128). During the follow-up period, total shoulder arthroplasty in 2 patients with keeled glenoid components failed secondary to posterior dislocation in 1 and fracture of the glenoid component after a fall in 1. There were no failures in patients with pegged glenoid components. After an average follow-up of 26 months, the rate of glenoid lucency was significantly higher in patients with a keeled glenoid component (46%) compared with patients with a pegged glenoid component (10%; P = .001). Glenoid lucency was not significantly related to patient age, gender, shoulder dominance, glenoid morphology, or glenohumeral mismatch.

Conclusions: This study evaluated the effect of glenoid design on the immediate and midterm radiographic lucency of pegged and keeled glenoid components, using modern cementing techniques. Although there were no significant differences in rates of glenoid lucency in the immediate postoperative period, pegged glenoid components had significantly less glenoid lucency than keeled glenoid components after an average follow-up of 26 months. Even with modern cementing techniques, pegged glenoid components remain radiographically superior to keeled glenoid components.

16 PEGGED VERSUS KEELED GLENOID COMPONENTS IN TOTAL SHOULDER ARTHROPLASTY

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Introduction: Loosening of the glenoid component remains one of the more common complications in total shoulder arthroplasty...
(TSA). Discussion has focused on the benefits of pegged glenoid components relative to keeled implants. We proposed to radio-
graphically and clinically investigate the outcomes of these 2 types of
glenoid components to test the hypothesis that the implants would have equivalent performance.

Material and methods: One hundred patients undergoing pri-
mary TSA for osteoarthritis of the shoulder were reviewed. Fifty pa-
tients had pegged glenoid components, and 50 had keeled
implants. The 2 groups were matched relative to age, sex, and du-
ration of follow-up. All radiographs were taken using a standard
protocol at the preoperative visit, the initial postoperative visit,
and at the final follow-up. Preoperative films were used to classify
the severity of degenerative change, whereas the postoperative
films were analyzed for radiolucent lines, progressive loosening,
or attrition signs.

Results: Average follow-up was 51.3 months for the keeled
group and 45.7 months for the pegged group. There were no differ-
ences in the degree of preoperative arthritic change between the
groups. Both groups had significant improvement in range of motion
and pain ($ P < 0.05$) postoperatively, with no differences in clinical out-
come. Initial radiographs demonstrated no radiolucent lines. It was easy to
place the pegs in 46 implants or around the keel in 49 components. At fi-
nal follow-up, 10 glenoid implants were found to be at risk for loos-
ening; 6 (12%) in the pegged group and 4 (8%) in the keeled group
($ P > 0.05$).

Conclusions: Initial postoperative radiographs after TSA with
pegged and keeled glenoid components demonstrate a low rate
of radiolucent lines. These radiolucent lines develop over time. How-
ever, there is no difference in clinical or radiographic outcomes be-
tween pegged and keeled glenoid components at intermediate-term follow-up.

17 POSTERIOR GLENOID BONE GRAFTING IN TSA FOR
POSTERIOR GLENOID WEAR: TECHNIQUE AND
RADIOGRAPHIC OUTCOME
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Background: A common glenoid deformity in advanced shoul-
der degenerative joint disease (DDJ) is posterior glenoid wear. This
results in increased retroversion and possible posterior humeral
head subluxation. We report the results of posterior glenoid bone
grafting (PGBG) using a cannulated drill guide/reamer system
and PGBG with bone from the humeral head.

Methods: Twenty-six shoulders (24 men, 2 women) were evalu-
ated at minimum 2-year follow-up (range, 2–6 years). True antero-
posterior (AP) and axillary radiographs were obtained at 1 week,
3 months, 6 months, 1 year, and then annually. Preoperatively, 20
patients had computed tomography (CT) scans and 6 had magnetic
resonance imaging (MRI). The average glenoid retroversion on the
advanced imaging study was $\approx 21^\circ$ (range, $10^\circ$ to $35^\circ$). There
were 15 B2 and 11 B1 glenoids. Twenty-one had osteoarthritis,
and 5 had postcapsulorrhaphy DDJ. A cannulated drill guide was
designed to place a guide pin in the glenoid and out the apex of
the glenoid vault medially and establish the glenoid centerline.
Can-
nulated drills used to machine the glenoid. It was easy to
determine in this way the magnitude of glenoid wear and the
need for PGBG. A small amount of reaming is performed anteriorly
and the PGBG is fashioned to fit the posterior defect. The bone from
the resected humeral head was fashioned to fit the defect. Because
the cortical surfaces tended to match one another, it was easiest to
place the graft into the posterior glenoid defect cortex to cortex
after light decortication. Two 3.5-mm cortical screws affixed the PGBG to
the native glenoid. They were perpendicular to the surface and bur-
ied under the cancellous surface of the graft. A pegged polyethylene
glenoid was then cemented.

Results: Radiographic analysis revealed all PGBGs incorporated
without osteolysis. There were no progressive lucent lines, and only
2 glenoids had a 1-mm line around the inferior peg. No cement was
seen between the PGBG and the native glenoid. There were no hard-
ware problems. On axillary views there was no posterior humeral
head subluxation and the retroversion of the glenoid joint surface
was corrected to an average of $\approx -4^\circ$ ($2^\circ$ to $8^\circ$). One insulin-depend-
dent diabetic patient required open release for stiffness at 8 months.

Discussion: The options in severe DDJ with posterior glenoid
wear are to either "lower the front" or "raise the back." Placing the
compound in retroversion will lead to early failure. We developed
a cannulated guide and reamer, along with the bone graft technique
to reconstruct the posterior wear, thus "raising the back," and main-
taining the joint line without significant medialization. This allowed
bone stock for glenoid component implantation in every case.

Conclusions: Severe posterior glenoid wear is almost exclusively
seen in men, and a preoperative advanced imaging study is recom-
mended. The drill guide/cannulated reamer and PGBG technique
reestablished normal glenoid version without extensive medial
bone loss due to reaming. No posterior humeral head subluxation
was seen. All grafts incorporated and all cemented glenoid compo-
nents were radiographically stable.

18 FAILURE MECHANISMS OF SEMICONSTRAINED TOTAL
ELBOW ARTHROPLASTY FOR POSTTRAUMATIC ARTHRITIS: A
2- TO 23-YEAR FOLLOW-UP STUDY
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sota

Introduction: Posttraumatic arthritis (PTA) is associated with a rela-
tively high failure rate after total elbow arthroplasty (TEA). Under-
standing these failures is needed to develop improved implants.
The purpose of this study was to analyze the long-term outcome of
semiconstrained TEA in PTA to identify its failure mechanisms.

Material and methods: From 1987 to 2004, 85 consecutive pa-
tients underwent semiconstrained TEA for posttraumatic arthritis.
Se-
venty-five were followed up for an average of 9.3 years (range, 2–
23 years). Preoperative and postoperative clinical results were
assessed for mechanical failure, and all com-
parisons were recorded.

Results: Sixteen arthroplasties (19%) failed secondary to isolated
bushing wear in 7, infection in 4, component fracture in 3, or com-
ponent loosening in 2. Four additional arthroplasties showed radio-
graphic signs of loosening, and 3 had significant wear. TEA was
associated with significant gains in pain relief, motion, and MEPS
scores ($ P < 0.002$). Forty-six patients (61%) achieved good or excel-
ent clinical results, and 82% were satisfied with their outcomes at
final follow-up. Kaplan-Meier analysis demonstrated a 15-year sur-
vivorship of 70% for revision or resection for any reason, 73.7% for
revision for mechanical failure, and 90.2% for aseptic loosening.

Conclusion: Semiconstrained TEA is associated with a relatively
high failure rate in posttraumatic arthritics. Infection continues to rep-
resent a frequent mode of early failure. Bushing wear and compo-
nent loosening or fracture are seen more commonly in the
intermediate and late term. Aseptic loosening remains relatively
uncommon.

19 REVISION OF TOTAL ELBOW ARTHROPLASTY BY
EXCHANGE CEMENTATION
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Objective: This 3-year study reports our experience with revision total
elbow arthroplasty by exchange cementation, describes a classifi-
cation system to define qualitative diaphyseal bone loss, and corre-
lates bone quality with revision outcome.

Methods: Fifty-five elbows in 54 patients underwent revision ce-
mation into the existing cement mantle or debried bone
interface, without structural bone graft, custom prosthesis, or prosthetic augmentation. Indications were aseptic loosening in 29, infection in 16, and instability for unlinked devices in 8.

Results: Mean follow-up was 85.4 months (range, 27-266 months); 14 patients had died, all with the prosthesis in situ, at a mean 124 months (range 22-190 months). Clinical results were satisfactory according to the Mayo Elbow Performance Score in 72% of elbows. Complications occurred in 32 elbows (59%). Reoperation was performed in 20 elbows (36%), including component repeat revisions in 11 (20%), for aseptic loosening in 7 (mean, 56.9 months), and for prosthetic fracture and sepsis in 2 each. Loosening occurred around 2 humeral (37%) and 8 ulnar components (14.8%). There were no failures in 16 elbows with ulnar defects that were bridged by an implant that bypassed the bony deficiencies by 2 cortical diameters. There was a statistically significant failure rate in those with grade B or greater osseous deficiencies that were not adequately bridged.

Conclusions: Recementation is a successful technique for revision elbow arthroplasty if key requirements for adequate bone stock and stem fixation are met. The classification described identifies the critical threshold of bone stock associated with successful revision and allows preoperative diaphyseal assessment to predict the need for stem extension beyond defects.

20 DISTAL BICEPS TENDON REPAIR THROUGH A SINGLE ANTERIOR INCISION SUTURE ANCHOR TECHNIQUE: A REPORT OF 134 CASES
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Purpose: This retrospective study evaluated the outcomes of the distal biceps tendon repair in 134 patients with acute distal biceps ruptures.

Methods: Between 1992 and 2006, 134 patients with acute distal biceps ruptures were managed surgically. The mean age was 43 years (range, 29-64 years). The mean time between tendon repair and time of injury was 3 weeks. The mean follow-up was 28 months (range, 12-39 months). Repair through a single anterior approach and suture technique with 2 anchors was performed in all cases.

Results: All patients maintained their preoperative range of motion, with none reporting significant postoperative pain. Mean elbow flexion was 146°, and mean pronosupination was 175°. All patients had 5/5 strength in flexion and supination on manual testing, and all returned to their employment. Mean supination strength was 90% of the contralateral healthy extremity. Of this series, only 3 patients experienced transient paresthesia or posterior interosseous nerve palsy.

Conclusions: Anatomic repair of the ruptured tendon to the bicipital tuberosity of the radius is favored in the majority of patients. Our surgical technique through a single anterior approach was safe and has yielded excellent results with restoration of elbow flexion and supination strength. There were no failures and no complications of radialnlar synostosis or posterior interosseous nerve palsy.

21 OUTCOME FOLLOWING CONSERVATIVE MANAGEMENT OF DISTAL BICEPS RUPTURES
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Purpose: This study evaluated the clinical outcomes in patients with distal biceps rupture that opted for conservative management.

Methods: This was a prospective case series of a single surgeon’s practice. All patients with a distal biceps rupture from the start of a single surgeon’s practice from August 2002 to June 2007 were eligible for inclusion into the study. All patients presented with a distal biceps rupture on physical examination and elected for conservative management. Patients were evaluated with a physical examination, diagnostic ultrasound, the American Shoulder and Elbow Surgeons (ASES) score, and a pain scale for rating of functional activities. Physical examination included elbow and forearm range of motion and supination strength testing with a hand-held dynamometer.

Results: There were 28 distal biceps ruptures coded from August 2002 to May 2007. Six elected for conservative management, which consisted of rehabilitation for elbow and forearm range of motion and strength. Complete follow-up examinations were performed in 5 of 6 (83%). All 5 were men (mean age, 61.2). Follow-up averaged 55 months (range, 33-71 months). All patients had full range of motion. The mean strength was 5.50 lbs in the injured arm compared with 6.13 lbs in the uninjured arm (10.2% deficit). The mean ASES score was 95. Pain was reported during heavy lifting in 3 patients and during repetitive movement in 1 patient. Two patients reported no pain. Ultrasound imaging revealed an inserting structure on the radial tuberosity in all 5 cases. In 2 cases, the tendon seemed to be nearly identical to that of the uninjured arm, whereas in the other 3 cases, the signal was less echogenic and thinner in the injured arm when compared with the uninjured.

Conclusion: Conservative management in this group of patients with acute biceps ruptures was effective in restoring elbow function and range motion. All patients presented with a strength deficit at long-term follow-up. This may explain the reported difficulty with heavy lifting.

22 BIOMECHANICAL EVALUATION OF PARALLEL VERSUS ORTHOGONAL PLATE FIXATION OF DISTAL HUMERAL FRACTURES USING TWO DIFFERENT TESTING CONDITIONS
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Introduction: Intraarticular fractures of the distal humerus are complex injuries. Consensus exists on the necessity of achieving stable fixation, but not on the optimal technique. The purpose of this study was to compare the biomechanical properties of orthogonal vs parallel plating in a cadaver distal humeral fracture model using 2 different loading conditions of varus loading and axial loading.

Material and methods: Two studies were performed using 10 matched pairs (range, 60-91 years) of fresh frozen cadaver upper extremities, with 5 pairs in each study. A low-type distal humeral fracture with a 10-mm metaphyseal defect was created. One elbow in each matched pair was then randomly chosen for fixation with either orthogonal plating (medial and posterior plate) or parallel plating (medial and lateral plate), using the Acumed congruent elbow plate system (Acumed, Hillsboro, OR). A custom elbow testing jig, Instron machine, and a video digitizing system were used (Figure 1). In the first study (varus loading), testing consisted of a 30° varus moment with the elbow flexed at a 50° angle (Figure 1). In the second study (axial loading), the elbows were axially loaded with the elbow flexed at a 50° angle (Figure 2). All testing included cyclic loading and subsequent load to failure tests. The 2-failed tests was used to compare continuous variables and the Fisher exact test to compare the proportion of implant loosening between the orthogonal and parallel plating groups.

Results: Parallel plating for fixation of an intraarticular distal humeral fracture with a metaphyseal defect demonstrates higher stiffness compared with orthogonal plating in varus cyclic loading and similar stiffness in axial cyclic loading (Table 1). There were no significant differences in the load to failure properties between the
2 constructs for both the varus loading and axial loading. For varus loading, macroscopic evaluation of the plate and screw constructs demonstrated screw loosening in all posterior plates of the orthogonal construct but in none of the lateral plates of the parallel plating construct ($P = 0.007$). However for axial loading, screw loosening was not observed in any of the plates of the orthogonal or parallel construct.

**Conclusion:** Parallel plating may be preferable for fixation of such fractures.

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23 **THE INFLUENCE OF DISTINCT ANATOMIC SUBREGIONS OF THE SUPRASPINATUS ON HUMERAL ROTATION**


**Introduction:** Prior research has demonstrated that the supraspinatus not only abducts the humerus and stabilizes the glenohumeral joint but also induces humeral rotation. Additionally, anatomic studies have proven that the supraspinatus is composed of distinct anterior and posterior subregions. To date, the quantitative contribution of these anatomic subregions on humeral rotation has not been investigated. Therefore, the objective of this study was to quantify the magnitude and direction of humeral rotation that results from loading the distinct anterior and posterior subregions of the supraspinatus both separately and compared with the whole in a cadaveric model.

**Methods:** Fourteen cadaveric shoulder specimens were carefully dissected to divide the supraspinatus into its anterior and posterior subregions. Each specimen was tested under 4 different loading
conditions with a total weight of 140 N. Each condition was based on the supraspinatus physiologic cross section area (PCSA), where 70% of the total force is produced by the anterior subregion and 30% is produced by the posterior subregion: (1) “anterior-only,” (2) “posterior-only,” (3) “physiologic,” where each subregion was loaded simultaneously, and (4) “nonphysiologic,” where the subregion anatomy was disregarded and the tendon was loaded as a whole. Each specimen was tested at 0°, 15°, 30°, 45°, and 60° of glenohumeral abduction in the scapular plane and in 15-degree increments from 60° of internal rotation to 60° of external rotation.

The study was performed using a custom testing system (Figure 1) that maintained flexion/extension or abduction/adduction of the humerus during supraspinatus loading. The magnitude and direction of humeral rotation that occurred was then measured using a rotary variable differential transformer (RVDT).

Results: The anterior subregion induced internal rotation, while the posterior subregion either did not induce rotation or induced external rotation at every abduction angle and at every initial position of internal rotation (P < .05; Figure 2). At neutral rotation and every initial position of external rotation, both the anterior and posterior subregions either did not induce rotation or induced external rotation (P > .05). There was only one condition (30° abduction/neutral rotation, P < .05) in which the physiologic condition and the nonphysiologic condition induced a significantly different amount of rotation (Figure 3).

Conclusions: In the scapular plane, the anterior subregion of the supraspinatus acts as both an internal and external rotator depending on the initial position of the humerus. The posterior subregion never acts as an internal rotator, and instead induces no rotation or external rotation of the humerus at all initial positions. This study demonstrates a distinct functional difference between the anatomic subregions of the supraspinatus. It also confirms that the anatomy and function of the supraspinatus are more complex and that the supraspinatus can no longer be considered a single tendon with a simple function.

24 PROXIMAL HUMERAL MIGRATION IN SHOULDERS WITH SYMPTOMATIC AND ASYMPTOMATIC ROTATOR CUFF TEARS

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Introduction: Proximal humeral migration is commonly described in the setting of rotator cuff disease. The individual effects of rotator cuff tear size and pain on glenohumeral kinematics are poorly defined. The purpose of this study was to examine the influence of rotator cuff tear size and the presence of pain on proximal humeral migration in a series of patients with symptomatic and asymptomatic cuff tears.

Methods: Ninety-eight asymptomatic and 62 symptomatic shoulders were identified from a cohort of patients with unilateral shoulder pain related to rotator cuff disease. All shoulders underwent ultrasound examination for evaluation of the rotator cuff and standardized radiographic evaluation. Proximal humeral migration was measured by 3 independent observers using a software-enhanced radiographic analysis based on the glenoid and humeral head geometric centers.
25 EFFECT OF DOUBLE ROW FIXATION ON ROTATOR CUFF TENDON BLOOD FLOW: A PILOT STUDY

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Introduction: Rotator cuff tears are frequent causes of pain and disability in the shoulder. Our understanding of the biology of rotator cuff tears and the associated healing response is minimal despite the high prevalence and societal cost associated with these injuries. Current biologic theories and strategies for treatment have focused on the blood supply to the tendinous portion of the cuff although we currently have little information regarding the effect of our repair techniques on this critical variable. We hypothesize that the rotator cuff tissue will demonstrate reduced blood flow after double row in comparison with single row repair techniques.

Methods: A pilot study of 5 patients with rotator cuff tears amenable to double row fixation was completed. Each patient underwent a standard double row fixation procedure using the Arthrex SutureBridge (Naples, FL) technique. After completion of the medial row procedure, a first set of recordings was taken using a custom laser Doppler flowmetry probe (Perimed Inc, Ohio) via a standard 8.25-mm cannula. A second set of recordings was then obtained with an insertion of the lateral PushLock anchors. The 2 data sets were then compared to determine the overall effect on blood flow associated with the double row technique. The data was analyzed using the paired t test for 2 group comparisons of row and position, as well as summed group comparisons of rows, and a 2-way analysis of variance (ANOVA) was performed to compare the resulting findings.

Results: The power requirements for the overall study were not intended to be met by this small pilot group, but rather, this provides guidance for future planning to ensure a larger sample population. The trend toward significance (P = .03) of the ANOVA results that demonstrate a statistically significant difference between the single and double rows (P = .04). Our findings did identify lower blood flow in the anterior, middle, and posterior rows individually but did not demonstrate a statistically significant difference (P = .18, .17, and .36, respectively).

Conclusions: The blood supply to healing rotator cuff tissue is a critical variable that must be considered when evaluating fixation methods along with the standard factors such as fixation strength and footprint compression. We currently do not fully understand the implications of decreased blood flow in this setting or have a sense of the critical threshold values, but it is evident from this initial analysis that double row fixation provides increased fixation strength at the cost of blood flow. A larger sample population will be necessary to fully demonstrate these findings, and once this is accomplished, the challenge will then become how to best interpret this data and utilize it with regard to fixation technique and design.

26 PROSPECTIVE RANDOMIZED COMPARISON OF SINGLE ROW VERSUS DOUBLE ROW ARTHROSCOPIC ROTATOR CUFF REPAIR: A MAGNETIC RESONANCE IMAGING–CONTROLLED STUDY


Purpose: The purpose of this study was to measure the functional and structural results in terms of retear rate and muscular atrophy occurring according to Thomazeau, comparing arthroscopic single vs double row rotator cuff fixation.

Material and methods: From a prospective randomized cohort of 46 patients, 41 patients (mean age, 60.3 years) were available for follow-up and evaluated functionally and by magnetic resonance imaging (MRI) preoperatively and 24 months after arthroscopic rotator cuff repair. Nineteen shoulders underwent arthroscopic single row repair, whereas 22 shoulders were repaired with the double row technique. Preoperative and postoperative Constant score, tendon integrity, as well as the morphology in terms of muscular atrophy were evaluated. Localization and size of the tear were measured intraoperatively. The retear rate was quantified postoperatively in the MRI by 2 observers blinded to the method of treatment.

Results: Tear size according to Bateman was grade I in 9.8%, grade II in 24.4%, and grade III in 65.9% of the patients. The mean Constant score improved postoperatively in all categories: from 39.9 to 78.8 points in the single row group overall and from 62.2 to 78.7 points in the double row group. There were no significant differences between the groups. The Constant score improved postoperatively in all categories: from 39.9 to 78.8 points in the single row group overall and from 62.2 to 78.7 points in the double row group. There were no significant differences between the groups. The retear rate averaged 26.3% in the single row group and 21.7% in the double row group. This was not significant. Concerning the muscular atrophy, there were no significant differences between the groups as well as preoperatively and postoperatively.

Conclusions: The functional as well as the structural results showed no significant differences comparing arthroscopic single vs double row fixation. There was a statistical trend towards a lower retear rate in the double row group.

27 BILATERAL COMPARISON OF ARTHROSCOPIC VERSUS OPEN ROTATOR CUFF REPAIRS

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Purpose: To compare the functional outcomes after arthroscopic repair of full-thickness rotator cuff tears with those after open repairs.

Material and methods: A retrospective review compared 27 consecutive patients who underwent bilateral rotator cuff tears, one done by open technique and 1 done arthroscopically. Exclusion criteria were an irreparable tear on either side or patients requiring revision surgery. No patients were excluded based on those criteria.
Results: The initial surgery was done in a classic open technique on all patients, with complex suture technique and bone tunnels. The second contralateral rotator cuff repair was performed arthroscopically, using simple suture technique and suture anchors. There were 15 men and 12 women. Mean age was 60.3 years (range, 46-74 years). Follow-up averaged 93 months on the open side (range, 61-149 months) and 16 months on the arthroscopic side (range, 12-23 months). Tear size (maximal dimension) averaged 1.8 cm on the open side and 2.0 cm on the arthroscopic side. Mean active elevation improved from 137° to 155° on the open side and from 135° to 154° on the arthroscopic side. Mean active external rotation improved from 29° to 43° on the open side and from 27° to 42° on the arthroscopic side. Mean abduction strength improved from 3.3 to 4.5 on the open side and from 3.1 to 4.4 on the arthroscopic side. Mean external rotation strength improved from 2.9 to 4.3 on the open side and from 3.1 to 4.3 on the arthroscopic side. A t-test comparison of the improvement in active elevation, active external rotation, and abduction strength showed no statistically significant difference between the open rotator cuff repairs and the arthroscopic rotator cuff repairs. Improvement in external rotation strength approached statistical significance, with slightly better results with the open technique \( (P = .0577) \). In terms of preference, 20 patients stated that the results were similar and they had no overall preference between the 2 techniques. Four patients preferred the results of the arthroscopic technique, and 3 patients preferred the results of the open technique. In terms of ease of recovery, 23 patients stated that postoperative recovery and rehabilitation was easier on the arthroscopic side, whereas 4 patients stated that there was no difference. Study weaknesses include its retrospective nature and lack of postoperative imaging to study integrity of the rotator cuff repairs.

Conclusions: Functional results of bilateral open and arthroscopic repairs, in the same patients, showed no statistically significant differences between the groups. There was no difference in patient preference at long-term results, but most patients had an easier recovery with arthroscopic rotator cuff repair.

28 COMPLETE REMOVAL OF MUSCLE LOAD IS DETRIMENTAL TO ROTATOR CUFF HEALING
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Introduction: Healing after rotator cuff repair has emerged as an important clinical problem. The role of the mechanical environment on the healing insertion site is unclear. We previously showed that cast immobilization is beneficial to healing compared with exercise. Removal of load by paralyzing the supraspinatus muscle has been suggested as a way to reduce "tendon pull-off." The purpose of this study was to evaluate the effect of the mechanical environment on the healing rotator cuff by paralyzing the supraspinatus muscle and casting the operative shoulder in a rat model of rotator cuff injury and repair.

Material and methods: The supraspinatus tendons in unilateral shoulders of 64 rats were transected from the bone and repaired with suture through a transosseous bone tunnel. The supraspinatus muscles of 32 shoulders were injected with 0.5 U/g of body weight of botulinum toxin A. The supraspinatus muscles of 32 control rats were injected with an equal volume of saline. Shoulders were immobilized in a cast postoperatively to protect the repair. Forty rats were sacrificed 21, 14, and 21 days after repair for biomechanical testing. The remainder were sacrificed 7, 14, 21, and 56 days after surgery for histologic analysis. All studies were approved by the Institutional Animal Care and Use Committee. Biomechanical testing consisted of a stress relaxation test, followed by a uniaxial test to failure, as previously described. Ultimate stress, tangent modulus, ultimate force, stiffness, and viscoelastic parameters were determined. Histologic specimens at 7, 14, 21, and 56 days were stained with toluidine blue, picrosirius red, Masson trichrome, and hematoxylin and eosin stains. Slides were examined by 3 investigators for differences in cellularity, fibrocartilage formation, and collagen organization.

Results: Gross observations of the botulinum toxin-injected specimens demonstrated obvious atrophy of the rotator cuff musculature.

Figure 1 Stiffness was significantly greater in the saline group compared to the Botox group at 56 days.

Figure 2 Ultimate load was significantly higher in the saline group at 21 days (left) and 56 days (right).
The cross-sectional area of the tendons in the Botox (Allergan Inc, Irvine, CA) group was significantly smaller than that in the saline group at both time points ($P < .001$). Biomechanical testing demonstrated that the structural properties of the healed tendons were significantly greater in the saline-injected specimens compared with the butulinum toxin-injected specimens (Figures 1 and 2). Material properties, specifically ultimate stress and tangent modulus, showed no statistically significant difference when comparing botulinum toxin-injected with saline-injected specimens. The viscoelastic material properties were significantly better in the paralyzed group compared with the saline-injected control group at 21 days. This difference was not seen at 56 days. Histologic results showed no differences in cellularity, fibrocartilage formation, or collagen organization.

**Discussion:** Completely removing mechanical load from a healing rotator cuff insertion is detrimental to tendon healing. We previously showed that cast immobilization (without paralysis of the supraspinatus muscle) was beneficial to healing. In this study we demonstrated that when all load is removed from the healing tendon by paralyzing the supraspinatus muscle and casting the shoulder, the cross-sectional area and the structural properties are decreased compared with control specimens. The viscoelastic material property results suggest that there may be some improvement in the early quality of the healing tissue with paralysis. However, in the longer-term, both saline and paralyzed groups produced similarly poor-quality scar tissue. Thus, the improvement in the structural properties in the saline-injected side was the direct result of an increased quantity of scar material.

**Clinical significance:** Optimizing the repair environment both biologically and mechanically is important to improve tendon healing. Providing the proper load environment has clinical implications in terms of immobilization and rehabilitation protocols after surgery. Paralyzing the supraspinatus to minimize the risk of tendon pull-off may be detrimental to rotator cuff repair if coupled with sling immobilization.

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### 29 SUBSCAPULARIS FUNCTION FOLLOWING TENDON-TO-TENDON REPAIR IN SHOULDAR REPLACEMENT ARTHROPLASTY

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**Background:** Recent studies have suggested that primary tendon-to-tendon or tendon-to-bone repairs of the subscapularis tenotomy required for shoulder replacement surgery contributes to weakness, instability, and inferior results and recommend osteotomy of the lesser tuberosity to achieve improved outcome. The purpose of this study was to analyze the integrity of the subscapularis repaired by a tendon-to-tendon technique in shoulder replacement arthroplasty.

**Methods:** A total of 42 arthroplasties in 40 patients were available for the study. They were assessed by an independent observer, uninolved in the surgery, by preoperative and postoperative physical examination, including the lift-off and belly-press tests, patient interview, radiograph, and American Shoulder and Elbow Surgeons (ASES) scores, with minimum of 1 year of follow-up.

**Results:** Preoperatively, 22 patients had a negative lift-off test, and 20 could not perform the test because of inability to reach behind themselves. Postoperatively, 38 patients had a negative lift-off test, and 4 patients were still unable to reach behind themselves to perform the study. All 42 of the shoulders had a negative belly-press test preoperatively and postoperatively. All motions improved postoperatively by a mean of 45° in elevation, 20° in external rotation at the side, 32° external rotation in abduction, 3 vertebral segments in internal rotation, and ASES score by 40 points (all $P < .0001$). No patient had instability clinically or by radiograph. The critical difference for our patients was in the protocol, which limited external rotation at the side in the early postoperative rehabilitation period to no more than 15° compared with as much as 45° allowed in the other studies that report a high failure rate of tendon-to-tendon repair. Our ultimate results for motion and outcome are still comparable with those of other reports.

**Conclusions:** Tendon-to-tendon repair is simpler, quicker, and avoids the possibility, albeit low, of a nonunion of the lesser tuberosity osteotomy. Therefore, tendon-to-tendon repair of the subscapularis tenotomy in shoulder arthroplasty remains a viable surgical option in the presence of a reasonable quality tendon, utilizing relaxing sutures, and, most importantly, limiting early postoperative external rotation to avoid placing undue stress on the repair during the early healing period.

### 30 GLENOHUMERAL CONTACT PATTERNS AFTER TOTAL SHOULDER REPLACEMENT FOR OSTEOARTHRITIS: CAN WE RETURN TO NORMAL?

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**Introduction:** Although total shoulder arthroplasty (TSA) has been shown to reliably improve pain and function in patients with osteoarthritis, it remains unknown whether this procedure restores glenohumeral articular contact mechanics to a normal state. Such information is critical to the understanding of loads across the glenoid and potential for durability of the reconstruction. Prior work has demonstrated normal glenohumeral contact patterns, but no such information yet exists for patients who have undergone TSA. We performed an in vivo study in patients after anatomic TSA and hypothesized that this reconstruction would restore contact patterns similar to those observed in the normal shoulder.

**Methods:** Thirteen shoulders in 12 patients (aged 37-72 years), all at least 2.5 years after surgery and with a subjective shoulder value of 90% or better compared with a normal shoulder, were recruited under Investigational Review Board guidelines and informed consent. The replaced shoulder was scanned using 2 fluoroscopes while the patient performed abduction and rotation motion. The shoulder was positioned at approximately 0°, 45°, and 90° abduction, neutral rotation, and 90° abduction with maximum internal and external rotation. The fluoroscopic images and computer-aided design models of the humeral head, stem, and glenoid components were used to create a virtual dual fluoroscopic imaging system. The humeral head and stem component positions were adjusted in 6 degrees of freedom within the virtual system until their projections matched the patient’s TSA images captured during active abduction and pronation. The glenoid construct was matched by beads implanted in the glenoid fixation pegs from the manufacture. The in vivo TSA position at each abducted and rotated position was therefore reproduced using the TSA models. From these models, the glenohumeral articular contact was determined by the overlap between the humeral and polyethylene glenoid articular surfaces. The contact point was defined as the centroid of the articular overlap area. To make data presentation consistent, contact points of right shoulders were mirrored onto left glenoid surfaces. Each patient was individually investigated, and the contact points were analyzed using contact frequency on the 4 quadrants of the glenoid surface. The repeatability and accuracy of this method was previously established at 0.1 mm and 0.3 mm, respectively, in an in vitro model.

**Results:** For all positions, contact was found 61.5% of the time in the superior posterior quadrant of the glenoid surface. Contact was primarily superior to the glenoid midline, representing 76.9% of the contact frequency. Zero degree abduction neutral rotation exhibited the greatest variation of contact locations, but at no time was contact found in the superior anterior quadrant. For all shoulder positions examined, contact was not found at the center of the glenoid articular surface.

**Conclusions:** In vivo glenohumeral contact patterns following TSA in the patients we studied demonstrated contact kinematics that are not ball-in-socket, but instead translation coupled with rotation. This pattern of contact kinematics is virtually identical to previous observations in normal shoulders; thus, our hypothesis that anatomic TSA could restore normal glenohumeral contact kinematics...
31 SUBSCAPULARIS TENDON RECONSTRUCTION IN TOTAL SHOULDER ARTHROPLASTY: BIOMECHANICAL EVALUATION

Introduction: As with other total joint replacements, total shoulder arthroplasty can be associated with a multitude of complications, the most common of which include prosthetic loosening, periprosthetic fracture, rotator cuff tears, infection, neural injury, and glenohumeral instability. The latter is one of the most common complications seen following total shoulder arthroplasty, occurring in 1.5% of shoulders. Anterior instability may commonly occur from rupture, dysfunction, and weakness of the repaired subscapularis. The purpose of this study was to evaluate and compare the initial biomechanical strength of a traditional subscapularis tenotomy repair and a novel lesser tuberosity osteotomy repair.

Material and methods: Eight pairs of fresh frozen cadaveric upper limbs without any shoulder pathology were used. The humerus was cut approximately 15 cm distal to the superior articular surface, and the humeral shaft was potted in a cylinder of bone cement. In each pair of shoulders, the tenotomy and osteotomy repairs were performed with randomization between the left and right shoulders (n = 8 shoulders per repair). The subscapularis tenotomy repair used No. 0 Ethibond (Ethicon, Somerville, NJ). A mechanical testing machine (MTS Systems, model 858 Bionix, Minneapolis, MN) was used. Each specimen was loaded cyclically to 100 N at a rate of 1 Hz for 3000 cycles. This value is approximately 10% of the maximum voluntary contraction of the subscapularis. The position of the shoulder during testing allowed the subscapularis repair to be stressed in line with its muscle-tendon axis. Once the humerus was positioned, the free subscapularis muscle was held in a cryo-jaw and frozen using liquid carbon dioxide. Cyclic displacement was measured with use of a 6 mm differential variable reluctance transducer (DVRT, Microstrain, Burlington VT). Following the 3000 cycles, the specimen was tested to failure and maximum force recorded. The cyclic displacement and maximum force to failure were analyzed with a test and significance level was set at P < .05.

Results: The 2 techniques of subscapularis reconstruction were found to have a significant effect on the cyclic displacement (P < .05) but no effect on the maximum load to failure. Following the tenotomy repair, the average cyclic displacement was 0.82 mm (SD, 0.20 mm), and average maximum load to failure was 481 N (SD, 78 N). For the osteotomy repair, the average displacement was 1.76 mm (SD, 0.62 mm), and maximum load was 466 N (SD, 101 N).

Conclusions: The data from this study suggest that subscapularis tenotomy repair can provide a greater initial strength than an osteotomy repair technique for prevention of anterior instability during the early postoperative period.

32 CEMENTED VERSUS UNCEMENTED FIXATION OF HUMERAL COMPONENTS IN TOTAL SHOULDER ARTHROPLASTY FOR OSTEARTHRITIS OF THE SHOULDER

Introduction: Although cement fixation of the humeral component has been recognized as the standard of care, uncemented fixation has shown the potential to provide long-term, stable fixation with a low complication rate.

Purpose: This prospective, randomized double-blinded clinical trial compared cemented fixation of the humeral component with uncemented/tissue-ingrowth fixation in total shoulder arthroplasty for primary osteoarthritis of the shoulder. This was a Tier 1 Project of the JOINTs Canada group.

Methods: All patients presenting to 7 tertiary care centers with primary osteoarthritis of the shoulder requiring replacement were screened for eligibility. After signing informed consent, patients received a baseline assessment and were scheduled for a computed tomography (CT) scan and subsequent standardized total shoulder arthroplasty. Patients were randomized in the operating room after glenoid preparation to the cemented or uncemented group by a computer-generated, stratified randomization procedure. Outcome measures included disease-specific quality of life assessment (Western Ontario Osteoarthritis of the Shoulder Index [WOOS]), global health status (Short Form-12 Health Survey), shoulder function (American Shoulder and Elbow Surgeons score), activity level (McMaster Toronto Arthritis patient preference questionnaire), radiographic evaluation of component fixation, operative time, complications, and revision surgery. Patients were assessed by a blinded evaluator in postoperative intervals of 2 and 6 weeks, and 3, 6, 12, 18, and 24 months. The primary end point was the WOOS score at 2 years.

Results: A total of 161 patients were consented and randomized for the study. There were 80 patients in the cemented and 81 patients in the uncemented group. At baseline, the groups were alike with regards to demographics and baseline evaluations. The WOOS scores at postoperative intervals of 12, 18, and 24 months showed a significant difference (P = .009, P = .001, and P = .028, respectively) in favor of the cemented group. The cemented group also had better strength at 3 (P = .038), 12 (P = .036), 18 (P = .051), and 24 months (P = .053); and forward flexion at 6 (P = .031) and 12 (P = .04) months. As expected, the operative time was significantly less for the uncemented group (1.69 ± 1.9 hours vs 2.26 ± .63 hours; P = .03).

Conclusions: These findings provide the first evidence that cemented fixation of the humeral head provides better quality of life, strength, and range of motion than uncemented fixation.

33 HEMIARTHROPLASTY VERSUS TOTAL SHOULDER REPLACEMENT: A LONGER-TERM REVIEW
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Methods: This study prospectively compared hemiarthroplasty (HA) and total shoulder replacement (TSR) in osteoarthritis, using the Global Shoulder Arthroplasty system (DePuy, Warsaw, IN), with intraoperative randomization after glenoid exposure. Postoperative mobilization for the 2 groups was identical. The patients were formally assessed initially at a minimum of 2 years and then reassessed at a minimum of 10 years. Apart from those who died, no patients failed to follow-up. Up until 2 years, patients were assessed using the University of California, Los Angeles, and Constant score, as well as analog pain scales and a functional questionnaire. At the 10-year review, patients were assessed using a similar range of subjective evaluations by telephone or reviewed in the clinic as was possible.

Results: Thirty-three shoulders (13 HA and 20 TSR) in 32 patients entered the trial; all (apart from 2 unrelated deaths) were followed up initially for a minimum of 2 years. At 6 months and 1 year, function scores and motion were similar, but the TSR group had less pain than the HA patients (P < .05), and this became more apparent at 2 years postoperatively (P < .02). At 2 years, 2 patients in the HA group had undergone revision to TSR due to severe pain.
secondary to glenoid erosion, and 3 further HA shoulders were subsequently revised (2 at 3 years, and 1 at 4 years). Two shoulders in the TSR group were revised at 5 and 7 years. The decision to revise a HA or TSR was triggered by a significant deterioration in shoulder function and increase in pain. The pain scores for those patients who underwent revision were significantly worse than all other patient scores for both HA and TSR at the respective times. In all the revised HA patients, there was significant erosion of the glenoid that made the conversion to TSR more challenging. The patient numbers in the 2 groups were uneven because the trial was terminated prematurely by the Institutional Review Board, prior to achieving anticipated patient accumulation, because sufficient data had been accumulated to identify a statistically significant advantage in terms of pain, function, and revision rate for TSR at 2 years.

At 10 years from the initial arthroplasty, 5 of the 13 HA and 6 of the 20 TSR patients had died. Nine of the 13 HA (69%) and 18 of the 20 TSR (90%) repairs remained in situ at death or at the 10-year review. Owing to the small numbers of patients in each group, it is not possible to identify a significant difference between the groups at 10 years; however, overall outcomes in each group was similar with respect to pain, function, daily activities.

Discussion: This study suggests that early (6 months) recovery of motion and function is comparable in HA and TSR for a similar surgical approach, but increasing pain and deterioration of shoulder function in patients undergoing HA may develop within the first 2 years due to glenoid erosion. TSR was clearly better than HA with respect to pain and function at 2 years postoperatively. The longer-term durability of the glenoid components is raised as an issue; however, there has not been a disproportionate late deterioration in the TSR due to glenoid component failure. Although some glenoids will inevitably fail, overall 90% of TSR remain in situ at death or at 10 years, whereas 69% of HA were intact at the same times.

Conclusions: On the basis of this longer-term review, our recommendation remains that TSR has advantages over HA with respect to pain and function at 2 years, and there has not been a reversal of the outcomes on prolonged follow-up. Revision from HA to TSR is made difficult due to glenoid erosion. The contention that HA will avoid later arthroplasty complications, and in particular, an unacceptable rate of glenoid failure, is not supported by this longer-term review.

34 TWELVE-TO EIGHTEEN-YEAR FOLLOW-UP OF HEMIARTHROPLASTY FOR GLENOHUMERAL OSTEOARTHRITIS
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Background: Ongoing controversy regarding the optimal management of glenohumeral osteoarthritis with total shoulder replacement (TSA) or humeral head replacement (HHR) still exists. Long-term concerns include glenoid loosening in TSA compared with incomplete pain relief and inferior patient satisfaction in HHR. However, the long-term data on the outcome of humeral head replacement for glenohumeral osteoarthritis is lacking.

Methods: Thirty-one patients who had HHR for glenohumeral osteoarthritis were evaluated at long-term follow-up. Twenty-two of these patients were available for evaluation; 3 died, 1 refused to participate, and 5 are either unavailable or have not yet replied. Follow-up information was obtained through phone conversations and mail surveys which included the Short Form-36 Health Survey (SF-36), American Shoulder and Elbow Surgeons (ASES) score, EuroQol, Simple Shoulder Test, a modified Neer Score, and a unique self-reporting questionnaire with visual diagrams of varying degrees of range of motion designed to allow patients to document their range of motion. Outcomes were correlated to preoperative characteristics including concentric or eccentric glenoid wear, primary or secondary causes of osteoarthritis, and age at the time of surgery.

Results: At 14.85 years of follow-up (range 12-18 years), the average overall ASES score was 76 (range, 36-98). The modified Neer satisfaction rating was 36.4%. Patients who had concentric glenoids had improved outcomes (45%) compared with eccentric glenoids (27.3%). Similarly, gains in active forward elevation and external rotation in the concentric group (average 64° and 58°, respectively) were better than the eccentric group (50° and 51°). No difference in satisfaction or range of motion ratings was found in the primary and secondary osteoarthritis groups. Of the 25 patients who were either followed up or died, there was a 28% revision rate (3 of 13 concentric and 4 of 12 eccentric glenoids). In the revised group, the average patient age at the time of surgery was 51.3 years, whereas those not requiring revision averaged 57.9 years.

Conclusions: Although hemiarthroplasty remains a viable treatment option for patients with glenohumeral osteoarthritis, only 36% of patients are satisfied with their outcome at 15 years. Patients with concentric glenoid wear have only slightly better outcomes with hemiarthroplasty than those with eccentric wear.

35 TOTAL SHOULDER ARTHROPLASTY IN PATIENTS WITH PARKINSON’S DISEASE
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Background: Currently, little information is available on the results of total shoulder arthroplasty in patients with Parkinson’s disease. Therefore, the purpose of the current study was to determine the results, risk factors for an unsatisfactory outcome, and rates of failure of total shoulder arthroplasty in patients with Parkinson’s disease.

Methods: Between 1978 and 2005, 49 total shoulder arthroplasties were performed in patients with Parkinson’s disease. Forty-three shoulders (36 patients) were followed up for a minimum of 2 years (mean, 8 years) or until the time of revision surgery.

Results: Total shoulder arthroplasty in patients with Parkinson’s disease was associated with significant improvement in pain from 4.6 to 1.8 (P < .001), external rotation from 21° to 44° (P < .001), and active abduction from 100° to 119° (P = .0489). There was no significant improvement in internal rotation (P = .09). There was no significant difference in outcome between men and women, nor was there an association with stage of Parkinson’s disease and outcome (P > .05). The Neer result rating system showed 10 excellent, 13 satisfactory, and 20 unsatisfactory results. Eight shoulders underwent revision arthroplasty, and 3 of these revisions were performed less than 1 year from the time of surgery due to instability.

Conclusion: Total shoulder arthroplasty is associated with significant long-term improvement in pain, external rotation, and abduction in patients with Parkinson’s disease. However, early postoperative instability appears to be increased in this patient population.