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## What's New in Shoulder and Elbow Surgery

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*J Bone Joint Surg Am.* 88:230-243, 2006. doi:10.2106/JBJS.E.01165

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### Publisher Information

The Journal of Bone and Joint Surgery  
20 Pickering Street, Needham, MA 02492-3157  
[www.jbjs.org](http://www.jbjs.org)

## SPECIALTY UPDATE

WHAT'S NEW IN SHOULDER  
AND ELBOW SURGERY

BY GARY M. GARTSMAN, MD, AND SAMER S. HASAN, MD, PHD

**Sources**

The sources for this annual update on shoulder and elbow surgery were presentations and symposia at meetings of The American Orthopaedic Society for Sports Medicine (Specialty Day, February 26, 2005, Washington, DC), the Arthroscopy Association of North America (Specialty Day, February 26, 2005, Washington, DC; Twenty-fourth Annual Meeting, May 12-15, 2005, Vancouver, British Columbia, Canada; and Twenty-third Fall Course, December 2-4, 2004, Palm Desert, California), the American Academy of Orthopaedic Surgeons (Seventy-second Annual Meeting, February 23-27, 2005, Washington, DC), the Orthopaedic Research Society (Fifty-first Annual Meeting, February 20-23, 2005, Washington, DC), the American Shoulder and Elbow Surgeons (Twenty-first Open Meeting, Specialty Day, February 26, 2005, Washington, DC; and Twenty-first Annual Meeting, September 29-October 2, 2004, New York, NY) and the American Orthopaedic Association (118th Annual Meeting, June 22-25, 2005, Huntington Beach, California).

**Shoulder***Rotator Cuff*

## Basic Science

Yokota reported on changes in supraspinatus tendon composition following tendon detachment and retraction in a rat model. At various time-points following tendon detachment, the rats were killed and the supraspinatus tendons were studied histologically. Disorganized scar tissue was present between the insertion and the tendon stump, but tendon composition changed with time after detachment, suggesting that the quality of an acute tear differs from that of a chronic tear. Dines provided an interim report on tissue-engineering and gene-therapy interventions to enhance rotator cuff healing in a rat model. Rat tendon fibroblasts were transduced with genes for platelet-derived growth factor-beta with use of retroviral vectors and were seeded onto a polymer scaffold and further cultured. Supraspinatus tendon tears were created in rats, which

were randomized into three groups (control, repair, and repair with a gene-modified tendon tissue construct). Analysis of tissue harvested at six weeks following repair revealed that normal tendon architecture was reliably restored in the experimental repair group alone. Histological analysis demonstrated a normal crimp pattern and collagen bundle alignment. The study demonstrated the efficacy of biologically active implants for rotator cuff repair in a rat model that closely replicated the clinical sequence of tear, inflammation, and repair. Cole tested the hypothesis that bipolar radiofrequency energy enhances the repair of chronic supraspinatus tendon tears in a rat model. At twelve weeks, tendons that had had bipolar radiofrequency energy treatment withstood significantly greater maximum stress than those that had not ( $p < 0.05$ ), and, at eight weeks, repaired tendons and controls had an identical histological appearance. He concluded that adjunctive bipolar radiofrequency energy appears to enhance the biomechanical and histological properties of tendon repair. Frostick examined the relationship between vascular proliferation and nonsteroidal anti-inflammatory drugs in a study of patients with a torn rotator cuff. Rotator cuff tissue was obtained from fifty-three patients undergoing repair. Vascular proliferation was absent or reduced in twenty-two of thirty-five patients who were taking analgesics. Twenty of these patients were taking nonsteroidal anti-inflammatory drugs, and four were taking only Cox-II-selective inhibitors. Eight of ten patients who were not taking nonsteroidal anti-inflammatory drugs demonstrated active ongoing vascular proliferation ( $p < 0.05$ ). Because endothelial cell proliferation is an important component of the rotator cuff repair process, one could conclude that routine use of nonsteroidal anti-inflammatory drugs may compromise rotator cuff healing and repair.

In an effort to improve tendon-to-bone healing, Mazzocca reported on a novel suture material with a biologically active collagen coating. Human osteoblasts and tenocytes were plated onto three types of suture, including suture braided

Specialty Update has been developed in collaboration with the Council of Musculoskeletal Specialty Societies (COMSS) of the American Academy of Orthopaedic Surgeons.

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with type-I collagen. At forty-eight hours, the collagen-coated suture had three times the osteoblast proliferation as compared with the polyester/polyethylene suture and it had nearly eight times the osteoblast proliferation as compared with the polyester suture. Greater protein synthesis was measured on the collagen-coated suture. The study demonstrated that collagen-coated suture may hold promise for augmenting tendon-to-bone incorporation during rotator cuff repair.

Meier presented the results of a study of the effect of double-row fixation on initial rotator cuff repair strength. Rotator cuff tears were created in twenty-one cadaveric shoulders and then were repaired with use of one of three different techniques involving the use of transosseous sutures, single-row suture anchors, or double-row suture anchors. Specimens were cyclically loaded for 5000 cycles or until a 10-mm gap formed. The double-row suture-anchor technique was significantly stronger than the single-row suture-anchor technique ( $p < 0.001$ ), and both were significantly stronger than the transosseous suture technique ( $p < 0.001$ ). Other studies of rotator cuff fixation led to different conclusions. Costic studied simulated rotator cuff repairs in cadaveric shoulders. Biomechanical properties and footprint contact area were measured following single-row and double-row repair. In contrast to other recent studies, double-row repair did not demonstrate superior initial biomechanical properties. However, the increased contact area suggested the potential for better tendon-to-bone healing. Jazrawi evaluated the effect of arthroscopic suture-passing instruments on the integrity of rotator cuff repair in a study of eight cadaveric shoulders. Overall, the study demonstrated considerable differences in the number of cycles to failure, depending on the instrument used for suture passage. Suture-passing instruments with smaller and smoother tips create more symmetric holes in tendon and may prevent suture cutout.

#### Impingement

Browdy reported on the association between glenohumeral internal rotation deficit and labral pathology. Three hundred and eight professional baseball players underwent measurement of bilateral shoulder rotation in abduction, including 264 players who remained injury-free during a five-year study period, thirty players who had a history of a labral injury at the time of measurement, and fourteen players who subsequently had development of a labral injury. With the numbers available, there were no significant differences between the three groups, suggesting that glenohumeral internal rotation deficit caused by acquired posterior capsular contracture does not predispose to labral pathology in the overhead athlete. Myers evaluated posterior capsular contracture and glenohumeral internal rotation deficit with use of gadolinium-enhanced magnetic resonance imaging in a study of eleven throwing athletes with internal impingement and eleven matched control throwers without injury. Passive glenohumeral internal rotation and external rotation were mea-

sured bilaterally. Posterior capsular contracture was defined as the bilateral difference in shoulder horizontal adduction with the scapula retracted and the shoulder elevated 90°. Throwing athletes with internal impingement demonstrated significantly greater glenohumeral internal rotation deficit ( $p < 0.05$ ) and posterior capsular contracture ( $p < 0.05$ ) than control subjects did. No accompanying increase in external rotation was noted. In contrast to the study summarized above, the authors believed that posterior capsular contracture may contribute to internal impingement of the posterior part of the rotator cuff and the posterosuperior aspect of the labrum by shifting the glenohumeral contact point posterosuperiorly during throwing. DeBritz presented the results of a randomized, placebo-controlled, double-blind study that was performed to evaluate extracorporeal shock wave therapy for the treatment of impingement syndrome. Although the effectiveness of extracorporeal shock wave treatment has been documented for certain overuse conditions such as lateral epicondylitis, no benefit was demonstrated in this study of patients with recalcitrant impingement syndrome. Van Riet reported on the increase in paratracheal pressure during arthroscopic subacromial decompression. Forty patients undergoing arthroscopic decompression were managed with 21-gauge needles that were placed into the deltoid and supraspinatus muscles and into the paratracheal region. Although in most patients the average paratracheal pressure was 1 mm Hg throughout the procedure, four patients experienced a sharp and unpredictable increase in paratracheal pressure to a maximum of 133 mm Hg. The increase in paratracheal pressure that was observed in these four patients could be potentially life-threatening, suggesting that endotracheal intubation is mandatory for patients undergoing arthroscopic subacromial surgery.

#### Partial-Thickness Tears

Weber evaluated the accuracy of magnetic resonance imaging in the diagnosis of partial-thickness rotator cuff tears. Eighty consecutive magnetic resonance imaging scans that were interpreted by the radiologist as showing either a "partial rotator cuff tear" or a "possible partial rotator cuff tear" were identified over a twelve-month period. All patients underwent physical examination, a lidocaine impingement test, and diagnostic arthroscopy. The correlation between magnetic resonance imaging findings and arthroscopic findings was poor. At the time of arthroscopy, thirty-eight patients had no tear and twenty-five patients had a complete tear. The true-positive rate was 22% and the false-positive rate was 78%, so that, overall, only seventeen of eighty patients were diagnosed correctly. In contrast, seventy patients were diagnosed correctly with use of Neer's criteria on the basis of a combination of physical examination findings and a positive lidocaine impingement test.

Kim reported on the results of arthroscopic treatment of articular-sided partial-thickness rotator cuff tears in 109

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shoulders after a mean duration of follow-up of forty-nine months. Low-grade tears underwent débridement, whereas high-grade (Ellman grade-III) tears underwent conversion to a full-thickness tear followed by arthroscopic repair. Each patient was classified as a throwing athlete, a nonthrowing athlete, or a nonathletic patient. Throwing athletes demonstrated a higher prevalence of unsatisfactory results. The study underscored that arthroscopic débridement alone is inadequate for the treatment of the throwing athlete. Following repair, the likelihood of return to full activity is lower in this high-demand population.

**Full-Thickness Tears**

Baumgarten demonstrated that smoking increases the risk of rotator cuff tears. Multiple other demographic factors, including manual labor, exercise habits, prednisone use, and diabetes, were not correlated with an increased risk of rotator cuff tears. These findings are important considerations in the evaluation and counseling of patients with shoulder pain. Ziegler used diagnostic ultrasound to compare shoulder elevation in intact and rotator cuff-deficient shoulders. In athletes, the tuberosity smoothly cleared under the acromion during active elevation at a mean elevation of 65°, suggesting that overhead shoulder dysfunction does not result from pathologic contact between the acromion and the underlying rotator cuff. Gartsman, in a study of 190 patients (192 shoulders) with a mean age of sixty-seven years who had a full-thickness rotator cuff tear, reported on the correlation between pain and functional outcome following nonoperative treatment involving pain management and a home exercise program. After a mean duration of follow-up of 3.3 years, the mean American Shoulder and Elbow Surgeons (ASES) score was 70 for the involved shoulder, compared with 87 for the uninvolved shoulder. Evidence of muscle atrophy on magnetic resonance imaging was associated with significantly worse ASES scores for pain ( $p < 0.05$ ) and activities of daily living ( $p < 0.001$ ), but tendon retraction, multiple tendon involvement, dominant arm involvement, gender, age, and duration of follow-up were not correlated with the ASES scores. The reported scores were higher than previously reported preoperative scores but were considerably lower than scores reported following rotator cuff repair. Zingg reported on the clinical and structural results following the nonoperative treatment of massive rotator cuff tears. Nineteen patients with a massive rotator cuff tear involving at least two complete tendons (as demonstrated with magnetic resonance imaging) who had not undergone an operation (because of modest symptoms and functional demands) were evaluated clinically, radiographically, and with magnetic resonance imaging after a mean duration of follow-up of forty-eight months. During the follow-up period, acromiohumeral distance decreased significantly ( $p < 0.005$ ), indicating superior migration of the humeral head, and rotator cuff tear size increased significantly ( $p < 0.005$ ). Fatty muscle degeneration increased significantly, by an average of one

grade ( $p < 0.001$ ). Glenohumeral arthritis progressed significantly ( $p < 0.05$ ) and was most pronounced in patients with three-tendon tears ( $p < 0.05$ ). Four of eight rotator cuff tears that initially had been classified as repairable became irreparable during the study period. The authors concluded that massive tears that are treated nonoperatively can maintain relatively good clinical and functional results but that structural changes progress so that one-half of all repairable massive rotator cuff tears become irreparable within four years. Isbell tested the hypothesis that patients with asymptomatic combined supraspinatus and infraspinatus tears have greater subscapularis activity during everyday activity than those with symptomatic tears do. During tasks involving shoulder elevation, asymptomatic patients had greater upper trapezius muscle activation than asymptomatic patients did. During forward elevation with an 8-lb (3.6-kg) weight, asymptomatic patients demonstrated greater subscapularis and deltoid activity than symptomatic patients did. Increased activity of the torn rotator cuff and periscapular muscles may compromise function and influence symptoms.

Stetson summarized the results of a prospective, randomized, double-blind study of forty-seven patients that evaluated the use of a pain-control infusion pump following arthroscopic rotator cuff repair. A standard epidural catheter was placed arthroscopically into the subacromial space following surgery in order to allow for a slow infusion of either normal saline solution or 0.25% bupivacaine with epinephrine. Postoperative pain levels and narcotic requirements were measured with use of a visual analog scale. The study demonstrated that patients in the experimental group experienced less pain on the day of surgery and on the first two postoperative days. Patients in the experimental group also used 25% less narcotics than those in the control group did.

Matsen presented the two to ten-year results of open rotator cuff repair without acromioplasty. At the time of follow-up, the proportion of patients who were able to perform each of the twelve functions on the Simple Shoulder Test (SST) improved significantly ( $p < 0.001$ ). The physical role function and comfort domains of the Short Form-36 (SF-36) improved significantly as well ( $p < 0.001$ ). The study demonstrated good results following rotator cuff repair with use of a technique that did not involve acromioplasty, similar to that employed by Codman seventy years earlier.

Green found that preoperative patient expectations predicted the outcome of rotator cuff repair. Self-assessment forms (including the SST; the Disabilities of the Arm, Shoulder and Hand [DASH] questionnaire; three visual analog scales for shoulder pain, shoulder function, and quality of life; and the SF-36) were completed both preoperatively and one year postoperatively by 125 patients undergoing repair of a chronic rotator cuff tear. Preoperative expectations were quantified with use of a separate questionnaire. Greater preoperative expectations were correlated with better postoperative performance on the SST, the DASH questionnaire, the

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visual analog scales, and the SF-36 (range of p values, 0.0001 to 0.03) and with greater improvement on the DASH and SF-36 (range of p values, 0.0001 to 0.02). The author noted that variations in patient expectations may help to explain the variability in outcome among different populations.

### Subscapularis Tears

Kim reported on twenty-nine patients in whom an all-arthroscopic, intra-articular repair was performed for the treatment of an isolated, partial, articular-sided avulsion tear of the subscapularis. More than one-half of the tears measured 1 cm in width. Suture anchors were employed, and concomitant biceps tenodesis was performed in sixteen patients. After a mean duration of follow-up of twenty-seven months, twenty-eight patients had a good or excellent result according to the ASES score and internal rotation strength deficits had decreased from 32% to 4%. The author noted that the intra-articular technique preserved the intact bursal-side tendon attachment but added that the duration of follow-up was short.

### Massive and Irreparable Tears

Warner reported on suprascapular nerve dysfunction in association with massive rotator cuff tears. In that study, four of seven patients who had a chronic massive rotator cuff tear associated with substantial fatty muscle atrophy and an isolated suprascapular nerve injury on electromyography underwent either complete arthroscopic repair or partial arthroscopic repair of the posterior portion of the rotator cuff. Postoperative electromyography demonstrated recovery of suprascapular nerve function. The author proposed that suprascapular nerve injury results from traction on the nerve when the torn rotator cuff tendons retract and resolves following partial or complete rotator cuff repair. Mullett reported on the role of anterior deltoid re-education in patients with chronic massive irreparable rotator cuff tears. Seventeen patients with an age of seventy years or more who had a painful massive rotator cuff tear and resultant deficits in active shoulder elevation were instructed in the use of a home exercise program. The patients were instructed to perform deltoid muscle exercises in the supine position at least three times daily for six weeks and to gradually incline the head of the bed throughout the course of the exercise program. Ninety percent of the participants reported improved upper extremity function following six weeks of treatment.

### Complications

Just presented the long-term outcome after the failure of rotator cuff repairs. Twenty patients with a mean age of fifty-nine years at the time of repair were evaluated at a mean of 3.2 years and again at a mean of 7.6 years following a repeat tear that was confirmed with use of magnetic resonance imaging. With the numbers available, the mean size of the repeat tear did not change significantly from 3.2 to 7.6 years. At the time of the latest follow-up, seven patients had a repeat tear

that was limited to the supraspinatus and eight patients had a repeat tear that had apparently healed. Fatty degeneration of the supraspinatus and subscapularis and the degree of glenohumeral arthritis did not progress during the study period, but fatty degeneration of the infraspinatus progressed significantly ( $p < 0.05$ ) and the acromiohumeral distance decreased significantly ( $p < 0.01$ ). Nineteen patients were either very satisfied or satisfied, and the relative Constant score improved from 83% at 3.2 years to 88% at 7.6 years. The study demonstrated that most repeat tears do not progress over time and that some small repeat tears may heal. In addition, a good outcome is often possible despite a repeat tear. Brislin reported on complications following arthroscopic rotator cuff repair. Twenty-eight (11%) of 263 consecutive patients who underwent arthroscopic rotator cuff repair during a six-month period had development of a postoperative complication. Twenty-three patients were diagnosed with postoperative stiffness that persisted for three months or longer. The study demonstrated that arthroscopic rotator cuff repair does not eliminate postoperative stiffness but that the overall complication rate compares favorably with that following traditional open or mini-open repair.

### Biceps Tendon

Bernas compared bone tunnel, keyhole, subpectoral bone tunnel, suture anchor, and bioabsorbable interference screw techniques for tenodesis of the long head of the biceps. Forty frozen cadaveric specimens were randomized to one of the five repair techniques. Completed repairs underwent destructive testing to determine load to failure, mode of failure, elongation, and linear stiffness. The bioabsorbable interference screw technique demonstrated the highest load to failure of all of the repair techniques, but the native tendon had a significantly higher load to failure ( $p < 0.05$ ), suggesting that the repair must be protected postoperatively.

### Acromioclavicular Joint

Jensen reported on horizontal acromioclavicular joint instability following chronic displaced acromioclavicular joint separations and failed distal clavicular excisions. Surgical reconstruction involved coracoacromial ligament transfer to the trapezoid insertion, posterior acromioclavicular joint ligament reconstruction, and coracoclavicular internal fixation. Forty-one patients were evaluated after a mean duration of follow-up of thirty-eight months. None of the patients had a positive acromioclavicular pivot-shift test (characterized by pain on anterior loading of the posterior aspect of the acromion while the clavicle is stabilized), and all of the patients were satisfied with the result of surgery. Krishnan reported on acromioclavicular joint reconstruction with use of an autogenous semitendinosus graft for the treatment of type-V separations. Nine consecutive patients underwent distal clavicular excision, coracoacromial ligament transfer, coracoclavicular reconstruction with use of suture, and semitendinosus graft-

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ing around the coracoid process and through drill-holes in the clavicle coupled with superior acromioclavicular joint capsule reconstruction with use of the remaining graft. The author suggested that this technique limits posterior translation of the clavicle during active motion.

**Glenohumeral Instability****Basic Science**

Jazrawi studied the effects of rotator interval closure on glenohumeral motion and translation with use of a cadaveric model. The author recommended the use of a single lateral suture for rotator interval closure because it influenced translation similar to the use of two sutures but resulted in less loss of external rotation. Closure with a single medial suture had the least effect on reducing anterior translation and may decrease external rotation excessively.

Shafer studied the effects of capsular plication and rotator interval closure in a study of seven cadaveric shoulders that were nondestructively stretched to simulate multidirectional instability. Capsular plication sequentially reduced the range of motion to that of an uninjured shoulder. The author found that rotator interval closure reduced anteroposterior translation but also noted that it may result in loss of motion or over-tightening compared with the uninjured shoulder. Vibert studied the effects of capsulorrhaphy on the reduction of glenohumeral joint volume to determine the optimal amount of capsular tissue to release and shift. Thirteen cadaveric shoulders were dissected, viscous liquid was injected, and baseline volume was recorded. The inferior axillary pouch was not eliminated until capsular release had been carried out to the 4 o'clock position prior to capsular shift.

**Anterior Instability**

Bottoni summarized the findings of a prospective, randomized clinical trial comparing arthroscopic and open anterior shoulder stabilization. Sixty-one patients with recurrent anterior shoulder instability who had had a failure of nonoperative treatment were randomized to undergo arthroscopic or open stabilization. All procedures employed bioabsorbable suture anchors and identical rehabilitation protocols. Postoperative failure was defined as recurrent dislocation, symptomatic subluxation, or the presence of symptoms that precluded a return to full duty. Outcome was assessed with use of a variety of instruments. With the numbers available, no differences in outcome were identified following open and arthroscopic stabilization after a mean duration of follow-up of twenty-eight months.

Sachs evaluated the correlation between outcome and subscapularis function in a study of thirty patients who were evaluated four years after open Bankart repair. Seven patients (23%) demonstrated incompetent subscapularis function as indicated by a positive lift-off test and a mean strength of only 27% of that on the unaffected side. Overall, only 57% of the patients with a positive lift-off test reported a good or excel-

lent result and only 57% stated that they would undergo the procedure again. In contrast, 91% of patients with a negative lift-off test reported a good or excellent result and all stated that they would undergo the procedure again.

Schroder presented the long-term outcomes of the modified Bristow procedure in a cohort of fifty-four United States Naval Academy Midshipmen (fifty-seven shoulders). Fifty-two shoulders in forty-nine patients were available for evaluation after a mean duration of follow-up of twenty-six years. The mean Rowe score was 82, with a 73% rate of good or excellent results. Five shoulders sustained recurrent dislocations and three sustained recurrent subluxations, for an overall rate of instability of 15%. Eight subsequent procedures were performed, and eight patients received disability compensation while on discharge from active duty. The study represents the longest known follow-up of patients managed with the modified Bristow procedure and demonstrated long-term results that were comparable with those of other open procedures used for the treatment of instability. Neyton evaluated the factors influencing the rate of recurrence following arthroscopic stabilization in a study of ninety-one consecutive patients who were reviewed after a mean duration of follow-up of thirty-three months. Fourteen patients (15%) had recurrent instability, with six patients having dislocations, after a mean interval of 17.6 months. The author concluded that glenoid or humeral bone defects and deficient capsular tissue increased the risk of recurrent instability and suggested that a Bristow-Latarjet reconstruction may be appropriate for these patients. Suguya reported on a series of forty-one consecutive patients (forty-two shoulders) who were managed with arthroscopic osseous Bankart repair for the treatment of chronic recurrent traumatic anterior glenohumeral instability. All shoulders underwent preoperative evaluation with use of three-dimensional computed tomography, which confirmed an osseous glenoid rim fragment that averaged 9% of the surface area and an average glenoid bone loss of 25%. At the time of arthroscopy, the osseous fragment was firmly attached to the capsulolabral complex in all shoulders. The fragment was separated from the glenoid neck prior to reduction and fixation with use of suture anchors. After a mean duration of follow-up of thirty-three months, thirty-nine shoulders (93%) were rated as good or excellent and the mean Rowe score improved from 34 to 94 ( $p < 0.01$ ). All but two of the thirty-eight patients who had been active in sports returned to their pre-injury level of sports activity.

**Posterior Instability**

Chhabra reported on 100 athletes in whom posterior instability was treated with arthroscopic capsulolabral reconstruction with use of suture anchors and capsular plication but without rotator interval repair. After a mean duration of follow-up of two years, no strength deficits were noted. There was a mean 3° loss of external rotation and a similarly modest deficit in internal rotation. All but five patients had a stable shoulder, and

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83% of the athletes returned to their previous level of sports activity. Seventy percent of the patients had an excellent ASES score, and 20% had a satisfactory score. The study highlights the success of this operation and suggests that closure of the rotator interval does not appear to be necessary in contact athletes. In contrast, Basmania concluded that rotator interval tissue deficiency may explain posterior shoulder instability and the poor outcome following anteriorly based shifts. Fifteen patients with posterior instability and multidirectional instability who already had had failure of at least one previous procedure underwent diagnostic arthroscopy followed by reconstruction of the coracohumeral ligament with use of all or part of the coracoacromial ligament. A Krakow suture was placed in the coracoacromial ligament after release from the acromial undersurface. One arm of the suture was passed through the supraspinatus tendon, the other arm was passed through the subscapularis, and a portion of the lateral aspect of the rotator interval was imbricated over the ligament transfer. After a minimum duration of follow-up of two years, twelve patients reported an excellent result. The procedure recreates an anteriorly-based tether against posterior instability with use of a strong local tissue graft, without compromising the subscapularis. Holt reached a similar conclusion about the role of the rotator interval following a retrospective review of 102 arthroscopic posterior shoulder reconstructions in ninety-seven patients. The author suggested that arthroscopic stabilization is successful in most patients but that rotator interval and adjunctive anterior repair may enhance shoulder stability.

### Multidirectional Instability

Thigpen used an electromagnetic tracking system to analyze scapular kinematics during forward flexion in twelve patients with multidirectional instability and twelve matched controls. During arm descent, the scapula rotated internally in patients with multidirectional instability and externally in control subjects. The scapula tipped significantly more posteriorly in patients with multidirectional instability than in control subjects ( $p < 0.05$ ). These differences highlight a lack of dynamic control or a compensatory movement strategy and help to confirm patterns of scapular dyskinesis in patients with multidirectional instability.

### Complications

McCluskey reported on the use of Achilles tendon allograft augmentation in a study of twenty-six patients with anterior subscapularis and capsular deficiency and recurrent anterior instability. The patients had a mean age of twenty-four years at the time of surgery and had undergone a mean of 2.2 previous procedures for the treatment of instability. After a mean duration of follow-up of forty-one months, the average ASES score had improved from 22 to 86 and the average visual analog score for pain had decreased from 8.9 to 2.1. Eighty-eight percent of the patients were satisfied with the procedure and

considered the shoulder to be stable for activities of daily living and work.

### Glenohumeral Arthritis

#### Basic Science

Matsen presented a canine model of nonprosthetic arthroplasty to test the hypothesis that reaming of the glenoid to a uniform concavity allows for the regeneration of a stabilizing, remodeling, viable glenoid soft-tissue surface. Twelve mature dogs that underwent humeral hemiarthroplasty coupled with glenoid reaming were killed at either ten or twenty-four weeks. At twenty-four weeks, the shoulders demonstrated complete coverage of the glenoid bone with a uniform concave layer of actively remodeling fibrocartilage supported by trabecular bone. The mean thickness of this layer was nearly three times the thickness of normal canine glenoid cartilage. The depth of the glenoid concavity increased following reaming, from 5.6 mm at ten weeks to 6.9 mm at twenty-four weeks, so that the angular stability provided by the remodeled glenoid exceeded that of the native glenoid. The study has implications for the treatment of humans, particularly young and active patients who may be at risk for glenoid implant loosening following total shoulder arthroplasty.

Eccentric posterior glenoid erosion is common in patients with osteoarthritis. Reaming to restore neutral glenoid version is generally recommended, but guidelines are lacking on the degree of eccentric erosion that can be corrected while preserving adequate bone stock to allow glenoid implantation. Clavert, in a study of five cadaveric shoulders, simulated  $>15^\circ$  of retroversion, confirmed the retroversion with computed tomography, prepared the glenoid, and inserted an appropriately sized, pegged glenoid implant. The author suggested that simply reaming to lower the anterior edge of a glenoid with  $>15^\circ$  of retroversion narrows the glenoid vault and risks penetration of the pegs of a glenoid component. In such instances, it may be better to use bone-grafting to restore glenoid orientation.

#### Clinical

Weber evaluated the efficacy of arthroscopic débridement for the treatment of glenohumeral arthritis. Forty patients with a mean age of fifty-eight years underwent the procedure over a twelve-year period. Although 86% of the patients reported good initial response after three months of follow-up, only 33% remained satisfied after a minimum duration of follow-up of two years. Six of the thirty-six patients who were available for follow-up had undergone total shoulder arthroplasty during the study period. The author concluded that although débridement remains an option for younger patients with glenohumeral arthritis, short-term relief is the norm as the procedure does not appear to alter disease progression.

#### Techniques of Conventional

##### Prosthetic Arthroplasty

Barwood reported on a dual-radius glenoid component, in-

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tended for use in shoulders with excessive glenoid wear, that has an internal radius to match the curvature of the humeral head component and an external radius corresponding to the native glenoid. After a mean duration of follow-up of thirty-three months, fourteen patients had improvement in terms of pain, clinical findings, and ASES scores. Eleven of these patients had complete glenoid component seating, and three had >90% seating. Stable component fixation was possible despite limited glenoid bone stock. Wright reported on prosthetic hemiarthroplasty coupled with allograft glenoid resurfacing in a study of eleven patients with a mean age of seventy years in whom glenoid implantation was contraindicated because of inadequate glenoid bone stock or cuff tear arthropathy. Significant improvement in both the total Shoulder Pain and Disability Index score and the functional subset score was noted at the time of the most recent follow-up ( $p < 0.05$ ), but the pain subset score did not improve. Active elevation and external rotation did not improve and remained quite modest in this challenging group of patients. Nagda reported on continuous intraoperative peripheral nerve monitoring in a study of thirty consecutive shoulder arthroplasties. Impending compromise of nerve function was signaled by sustained electromyographic activity and attenuation of transcranial electrical motor-evoked potentials. Seventeen patients had thirty episodes of nerve dysfunction during surgery. Nerve alerts were not extinguished simply by removing retractors, but twenty-three alerts were extinguished after repositioning the arm to a neutral position. The study suggested that the prevalence of nerve injury during shoulder arthroplasty is greater than has been previously reported. Positioning the arm at the end range of motion should be avoided, especially at the time of revision surgery and in patients with decreased preoperative motion. Intraoperative nerve monitoring should be considered for patients who are at risk for nerve injury.

Ponce reported on a novel subscapularis repair technique for shoulder arthroplasty that employed a lesser tuberosity osteotomy. The lesser tuberosity osteotomy technique was then used during eighty-two consecutive total shoulder arthroplasties. A sixfold decrease in the rate of subscapularis dysfunction was observed when the results of this new technique were compared with those of soft tissue side-to-side repair. No nonunions and only one late repeat tear occurred. The author concluded that the lesser tuberosity osteotomy allows for a biomechanically sound repair with good postoperative function.

### Outcomes of Arthroplasty

Martin reported on the results of cementless total shoulder arthroplasty in patients with rheumatoid arthritis. Fifty-five shoulders in forty-seven patients were evaluated after a mean duration of follow-up of 7.6 years. The mean modified ASES score improved from 17 to 78, and 90% of shoulders had little or no pain. No significant differences were noted when this group was compared with a cohort of patients with osteoar-

thritis who underwent total shoulder arthroplasty during the same period. The clinical survival rate according to the Kaplan-Meier method was 96% at five years and 85% at ten years. The author concluded that outcome following cementless shoulder arthroplasty appears to be similar to that following surgery involving the use of cemented components but acknowledged that the rate of clinical failure is slightly higher. Setter reported the results of a meta-analysis comparing total shoulder arthroplasty and hemiarthroplasty for the treatment of primary glenohumeral osteoarthritis. Twenty-four pertinent studies that had been published between 1966 and 2004 were identified, comprising a total of 1941 patients. Compared with hemiarthroplasty, total shoulder arthroplasty provided significantly greater pain relief ( $p < 0.001$ ), forward elevation ( $p < 0.001$ ), gain in forward elevation ( $p < 0.001$ ), gain in external rotation ( $p < 0.002$ ), and patient satisfaction ( $p < 0.001$ ). Although the overall prevalence of revision surgery following total shoulder arthroplasty was 7.7%, only 1% of all-polyethylene glenoid components required revision. The author cautioned that the meta-analysis also served as a stark reminder that these studies employed nonhomogeneous outcome instruments and that most demonstrated a meager level of evidence.

### Constrained Prosthetic Arthroplasty

Boileau reported on forty-five consecutive patients who underwent reverse ball-and-socket arthroplasty and were followed for a minimum of twenty-four months. The study group included patients with cuff-tear arthropathy, patients with fracture sequelae with migration or nonunion of the tuberosities, and patients with rotator cuff deficiency undergoing revision shoulder arthroplasty. The study demonstrated substantial improvement in terms of both active forward elevation (from 55° to 121°) and the Constant score (from 17 to 59 points). No improvement in active external rotation or internal rotation was noted. Overall, 67% of the patients had little or no pain and 78% were satisfied. The patients in the cuff-tear arthropathy group had significantly higher Constant scores ( $p < 0.05$ ) and ASES scores ( $p < 0.005$ ) than the patients in the revision group did. The complication and revision rates were higher in the revision group (47% and 26%, respectively). Overall, the reverse ball-and-socket arthroplasty improved function and restored forward active elevation but did not improve active rotation. Results were less predictable following fracture or revision surgery.

### Complications and Revisions

Krishnan reported on the results of revision shoulder arthroplasty for patients with a failed glenoid implant. Seventeen patients underwent cancellous grafting of the glenoid defect followed by spherical reaming and resurfacing with use of Achilles tendon allograft that was sewn into the glenoid rim. Nine patients underwent revision implantation with use of a peg glenoid allowing for bone ingrowth. After a minimum du-

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ration of follow-up of two years, the mean ASES score had improved from 22 to 77 and the mean flexion had improved from 70° to 124°. Postoperative radiographs revealed consolidation of bone graft and sclerosis in all patients.

To determine the prevalence of deep-vein thrombosis following shoulder arthroplasty, Willis prospectively followed 100 consecutive shoulder replacements (including seventy-three total shoulder replacements) for twelve weeks but excluded those in patients receiving routine anticoagulation therapy. A four-limb surveillance color-flow Doppler ultrasound examination was performed two days and twelve weeks postoperatively for all patients. Postoperative symptomatic pulmonary emboli were also recorded. Thirteen cases of deep-vein thrombosis were identified in twelve patients, including seven cases involving the lower extremity. All six upper extremity cases involved the operative side. Ten of the thirteen cases were identified at two days, and three were identified at twelve weeks. Three cases of pulmonary embolism were identified, one of which was fatal. The prevalence of thromboembolic disease following shoulder arthroplasty may be higher than previously appreciated. Additional study is needed to determine the role of routine prophylaxis against thromboembolic disease following shoulder arthroplasty.

### *Adhesive Capsulitis*

Shaffer reported on the accuracy of intra-articular steroid injection in a study of thirty consecutive patients with adhesive capsulitis. The injections included radiopaque dye and were performed with use of a spinal needle through one of three commonly used shoulder portals: posterior, supraclavicular (Nevaser), and anterior. Of the ten posterior injections, only one was intra-articular and one was partially intra-articular, for an accuracy rate of 15%. In contrast, of the ten anterior injections, nine were intra-articular and one was partially intra-articular, for an accuracy of 95%. Interestingly, all patients noted improved comfort and pain (as assessed with a visual analog scale) had decreased by a mean of 39% following the injection, but with the numbers available no significant differences were noted among the three different methods. The study demonstrated that the accuracy of intra-articular injection for the treatment of adhesive capsulitis is technique-dependent. However, because the corticosteroid injections were effective irrespective of injection accuracy, efficacy could not be attributed solely to intra-articular placement.

### *Fractures*

#### *Proximal Humeral Fractures*

Keenan reported on the outcomes following closed reduction and percutaneous pinning of proximal humeral fractures. Thirty-six patients with a mean age of sixty years were managed over a five-year period. The fracture patterns that were treated included eleven two-part surgical neck fractures; nine three-part greater tuberosity and surgical neck fractures; and sixteen valgus, impacted four-part proximal humeral frac-

tures. All fractures healed and thirty patients were satisfied with the result of surgery, but the mean ASES score was 56 and the mean internal rotation was to the third lumbar level. Two patients had development of osteonecrosis and underwent prosthetic hemiarthroplasty, and one patient had development of a joint contracture and underwent arthroscopic capsular release. The authors noted that the procedure was associated with a high rate of fracture union, good clinical results, and a low rate of complications but also observed that mild residual shoulder pain and stiffness were common.

Weinstein studied the torsional stiffness provided by two types of plates used to treat proximal humeral fractures. A three-part fracture was created in each of six pairs of cadaveric humeri. One specimen of each pair was repaired with a proximal humeral locking plate, and the other was repaired with an angled blade-plate. The mean initial torsional stiffness was nearly twice as high for the locking plate as for the blade-plate, and the number of cycles to failure was higher for the locking plate ( $p < 0.05$ ). These findings suggest that the locking plate may allow for earlier postoperative motion.

Gonzalez-Hernandez reported on the results of rigid fixation of proximal humeral fractures in older adults. Twenty-seven consecutive patients who were more than sixty-five years old and who had three and four-part fractures underwent open reduction and internal fixation with use of a modular fixed-angle plate and transosseous wires. After a minimum duration of follow-up of twelve months, all fractures had healed. Pain control was good or excellent in all but two patients, and range of motion was excellent in twenty-one patients. Most patients were able to return to their pre-injury level of function. The study did not explicitly select valgus impacted four-part fractures, and osteonecrosis was not observed in this group of patients after short-term follow-up. Nevertheless, open reduction and internal fixation of three and four-part fractures may be an alternative to prosthetic hemiarthroplasty in older adults with osteopenic bone. Boileau reported on the treatment of proximal humeral fractures with use of a shoulder prosthesis specifically designed for fracture. The prosthesis is characterized by a medialized neck to facilitate tuberosity placement and by a metaphyseal window that holds bone graft excavated from the humeral head to aid with tuberosity healing. A positioning guide helps to adjust prosthetic retroversion and height and facilitates component trial-ing. The results in seventy-two patients were reviewed after a minimum duration of follow-up of twelve months. The mean active forward elevation was 107°, and the mean adjusted Constant score was 73. The tuberosities were positioned appropriately in 67% of the cases, but in the remaining cases they had migrated or were malpositioned. Humeral height was restored to within 10 mm of the native height in 70% of the cases in which the positioning guide was employed and in 30% of the cases in which it was not. Outcome was positively correlated with surgeon experience, the use of bone-grafting, and anatomic tuberosity position. Smith reviewed the results

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of operative treatment of 116 proximal humeral fractures. The overall complication rate for ninety-three fractures that were treated with internal fixation was 58%, with twenty-two shoulders requiring additional surgery. Fourteen shoulders demonstrated initial fragment malpositioning and, of the eighty-two shoulders that were followed for more than three months, seventeen demonstrated fracture displacement, eighteen demonstrated malunion, and seventeen demonstrated delayed union. Fractures that were treated with fixed-angle plates had lower rates of initial malpositioning and malunion. The study reaffirmed that complications following the operative treatment of proximal humeral fractures are common. The author suggested that the primary goal of operative treatment should be a stable shoulder with healed tuberosities.

### Clavicular Fractures

Verborgt presented the results of plate fixation for acute displaced midshaft clavicular fractures in thirty-nine semiprofessional athletes with a mean age of twenty-six years. At six weeks postoperatively, the mean Constant score was 88 and the visual analog score for pain was 3 of 10. The mean time to return to sports activity was forty-five days. Two patients sustained a refracture following new trauma, but thirty-seven fractures had united radiographically by eighteen weeks. Seventy-five percent of the patients were very satisfied, and 95% stated that they would choose the same operation again. The study suggested that early internal fixation of displaced midshaft clavicular fractures in athletes facilitates an early return to sports activity.

McKee reported on the effect of time to surgery on the outcome of open reduction and internal fixation for the treatment of clavicular fracture nonunion. Thirty-eight patients, with a mean age of forty-three years, underwent surgery for the treatment of a nonunion that had persisted for a mean of 2.1 years. All fractures were treated with plate fixation, and 64% were treated with iliac crest bone-grafting. Two patients required revision surgery, but the fractures in the remaining patients healed uneventfully. Surgery for the treatment of clavicular fracture nonunion was associated with a high rate of patient satisfaction and a low rate of residual disability, irrespective of the timing of surgery.

### Miscellaneous

Hawkins evaluated the psychometric properties of the ASES score with use of a large database comprising over 1000 patients with shoulder instability, rotator cuff disease, and glenohumeral arthritis. The ASES shoulder scale demonstrated acceptable test-retest reliability, with an intraclass correlation coefficient of 0.94. The ASES scale demonstrated acceptable internal consistency for patients with instability (Cronbach's  $\alpha = 0.61$ ), rotator cuff disease (0.64), and glenohumeral arthritis (0.62). The study validated the use of the ASES shoulder scale for the evaluation of patients with shoulder instability, rotator cuff disease, and glenohumeral arthritis. Schell

reviewed closed malpractice cases involving the shoulder, arm, and elbow over a twenty-year period at a large physician-owned medical malpractice insurance company. Of the 133 closed lawsuits, 61% resulted in indemnity for the plaintiff. Overall, 96% of shoulder claims involved adults and 58% of elbow claims involved children. Eighty-three percent of pediatric claims were related to the elbow. Surgical error accounted for 62% of allegations, whereas improper nonoperative treatment accounted for 20% and diagnosis failure accounted for 18%. The most common surgical errors were improper fracture treatment (32%), hardware failure (18%), neuropathy (12%), and insufficient surgery (12%). Trauma claims paid out twice that of elective claims, and fellowship training had no positive or negative effect on case outcomes. Five of the eight claims related to shoulder dislocation involved a missed posterior dislocation. Claims involving the humeral shaft were associated either with radial nerve injury or with plate failure. All pediatric elbow claims involved fractures.

### Elbow

#### Instability

##### Basic Science

Koh tested the hypothesis that the flexor carpi ulnaris significantly reduces loading of the ulnar collateral ligament, which is the primary static restraint to valgus elbow rotation. The study demonstrated that the flexor carpi ulnaris was an important dynamic stabilizer of the elbow to valgus forces and that moments occurred at the elbow about axes other than flexion-extension. Park employed a cadaveric model to study the dynamic contributions of the flexor-pronator muscles to valgus elbow stability. Medial collateral ligament tears were created in six cadaveric elbows, and the elbow kinematics resulting from different patterns of muscle-loading were measured. When compared with the intact ligament without muscle-loading, medial collateral ligament detachment produced a 5° valgus instability. Flexor carpi ulnaris stimulation corrected the instability nearly to the intact state. Both studies highlighted the importance of the flexor carpi ulnaris in injury prevention, intraoperatively, and during rehabilitation in patients with valgus instability.

##### Clinical

Willis reported on a new test for the diagnosis of posterolateral rotatory elbow instability, in which a posteriorly directed force is applied to the radial head anteriorly and translation of the radiocapitellar joint is evaluated. The test was applied preoperatively to six patients with surgically documented lateral ulnar collateral ligament insufficiency. All patients had a positive posterolateral rotatory drawer test and tolerated this new test without pain or apprehension. In contrast, the pivot-shift test was negative for two patients and could not be performed for three patients because of apprehension. The cadaveric study demonstrated that the radiocapitellar translation averaged 5 mm and was most pronounced between 60° and 120° of elbow

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flexion. Large reported on the results of a biomechanical comparison between Jobe and metal interference screw reconstructions of the ulnar collateral ligament. The stiffness of the intact ulnar collateral ligament in ten matched pairs of cadaveric elbows was tested under nondestructive valgus loading at different angles of elbow flexion. Each matched pair then had reconstruction of the anterior bundle with use of matched hamstring tendons with use of the Jobe or interference screw technique. Testing was repeated to compute stiffness, and the specimens were then tested to failure. The initial stiffness of the Jobe reconstruction was not significantly different from that of the intact ligament, but the interference screw construct was not as stiff. At each angle of elbow flexion, the Jobe reconstruction had superior biomechanical properties than did the interference screw construct, which typically failed as a result of tunnel slippage.

**Tendon Injuries****Basic Science**

Mullett presented the results of a cadaveric and clinical study of lateral epicondylitis. Arthroscopic examination of the radiocapitellar joint demonstrated a band of tissue that was confluent with the orbicular ligament in sixteen of thirty-four cadaveric elbows. Twenty-five patients underwent arthroscopic surgery for the treatment of recalcitrant lateral epicondylitis and had resection of a collar-like band of tissue that subluxated with forearm rotation. All but two patients had complete resolution of symptoms. Histological examination of the resected tissue demonstrated hyaline degeneration. The author implicated impingement of this degenerative band within the radiocapitellar joint in the pathogenesis of lateral epicondylitis.

**Clinical**

Rompe tested the hypothesis that repetitive low-energy extracorporeal shock wave treatment is superior to placebo in tennis players with chronic lateral epicondylitis. Seventy-eight tennis players with tennis elbow of at least twelve months' duration were randomized to receive either active shock wave treatment (given weekly for three weeks) or placebo. At three months, there was significantly greater improvement with regard to pain during resisted wrist extension in the treatment group as compared with the placebo group ( $p < 0.005$ ). Improvement in upper extremity function, measured with use of a specific outcome scale, was also significantly greater in the treatment group ( $p < 0.001$ ). Sixty-five percent of the patients in the treatment group achieved at least a 50% reduction in pain, compared with 28% of the patients in the placebo group. Szabo compared three methods of operative treatment in a study of patients with recalcitrant lateral epicondylitis; the procedures included twenty-four percutaneous releases, forty-four arthroscopic procedures, and forty-one open procedures. After a mean duration of follow-up of forty-eight months, failure (defined as the need for additional operative

intervention or a poor outcome) occurred in three (13%) of the patients who had had a percutaneous release, in one (2%) of the patients who had had an arthroscopic release, and in two (5%) of the patients who had had an open release. The author concluded that all three methods are highly effective for the treatment of recalcitrant lateral epicondylitis. John reported on the outcome of single-incision repair for the treatment of acute distal biceps tendon ruptures with use of two suture anchors placed in the radial tuberosity through a limited transverse incision in the antecubital fossa. Fifty-one of sixty consecutive patients who underwent this procedure at a mean age of forty-six years were evaluated after a mean duration of follow-up of thirty-five months. There were forty-five excellent and six good outcomes, with no fair or poor results. Cybex testing demonstrated a 5% decrease in elbow flexion and a 7% decrease in supination strength compared with the contralateral extremity, but these differences were not significant, with the numbers available. Two patients had development of heterotopic ossification that resulted in slightly limited forearm rotation and mild pain. This rather large study demonstrated the efficacy of the single-incision technique for distal biceps tendon repair. Jost reported on the excision of a proximal radioulnar synostosis in twelve patients in whom this complication developed following acute distal biceps repair. The excision was carried out as early as two months and as late as eighteen months after repair. All patients received indomethacin for four weeks postoperatively, and six patients also received radiation treatment. Preoperatively, the mean arc of rotation was  $19^\circ$  and six elbows were ankylosed in a neutral position. After a mean duration of follow-up of fifty-nine months, the mean arc of rotation had improved to  $138^\circ$  ( $p < 0.001$ ). No complications were encountered during or after excision, and radiographs demonstrated no recurrence of ectopic bone.

**Fractures and Dislocations**

Capo determined that plain radiographs are ineffective for assessing radial head fractures. Three independent physicians compared the radiographic features of sixteen radial head fractures with the findings on preoperative computed tomography scans and with intraoperative findings. Compared with intraoperative findings, plain radiographs underestimated the degree of head involvement in ten cases and overestimated the degree of head involvement in six cases. The mean error was 17%. The number of radial head fragments was overestimated in seven cases, underestimated in six, and correct in only three. When the guidelines for operative treatment are 30% head involvement, more than three fragments, and 2 mm of step-off, interpreting plain radiographs alone may lead to incorrect treatment choices. Smith compared the results of plate fixation with those of low-profile fixation for the treatment of proximal radial head and neck fractures after an average duration of follow-up of 3.8 years. Twenty patients underwent internal fixation of a Mason type-2 or 3 radial

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head or neck fracture with use of plates (ten patients) or with use of screws or threaded pins (ten patients). The author suggested that plate fixation leads to less forearm rotation and higher rates of heterotopic bone formation compared with fixation that avoids extensive annular ligament dissection and hardware placement along the radial neck.

The medial collateral ligament is the primary elbow restraint to valgus load, and the interosseous membrane is the primary stabilizer of the radioulnar relationship. Hartman evaluated the role of the radial head as a secondary elbow and radioulnar stabilizer and assessed the effectiveness of radial head replacement in reproducing these roles. A valgus elbow moment was produced in seven cadaveric upper extremities, and the resultant medial collateral ligament and interosseous ligament strains were measured. After radial head replacement with a modular press-fit implant, the strains returned to within 2% of the strains observed in the intact specimens. The study suggested that radial head replacement maintains the role of the native radial head as a secondary stabilizer of the forearm and elbow.

Doornberg described the use of coronoid process landmarks that were identified on three-dimensional computed tomography scans as reference points for proper sizing of a radial head implant. The author suggested that a radial head implant should be placed so that its articular surface is just slightly more prominent than the coronoid articular surface. Preoperative radiographs of the contralateral elbow aid in templating and help to prevent overstuffing the joint. Forthman reported on the results of treatment of acute traumatic elbow instability without medial collateral ligament repair in a study of thirty-four patients at a mean of twenty-one months after injury. All procedures involved repair of the ulna and coronoid, repair or replacement of the radial head, and repair of the lateral collateral ligament complex. A stable, mobile articulation (mean flexion-extension arc, 101°) was restored in all patients. The author concluded that medial collateral ligament repair is rarely necessary for the treatment of complex acute traumatic elbow instability. Kamineni reviewed the results of total elbow arthroplasty for the treatment of acute distal humeral fractures in a study of forty-three patients with a mean age of sixty-seven years. The mean flexion-extension arc was 24° to 132°, and the mean Mayo elbow performance score was 93. Heterotopic ossification was present in seven cases and additional surgery was required in ten cases, including five cases in which revision arthroplasty was required. The study suggested that total elbow arthroplasty should be considered whenever there is potential for distal humeral nonunion, especially in the physiologically older, lower-demand patient.

### *Stiffness*

Posttraumatic elbow stiffness is a common complication. Recovery of range of motion, especially extension, is often hampered by elbow flexor spasm. Rosenwasser tested the hypothesis that intraoperative injection of botulinum toxin A

(Botox) would prevent elbow stiffness and enhance elbow function by causing transient muscle paralysis. Twelve patients with a mean age of sixty years who had sustained a fracture or fracture-dislocation about the elbow were randomized to receive an intraoperative injection of Botox or normal saline solution into both the brachialis and biceps brachii muscles. These preliminary findings support the adjunctive intramuscular injection of botulinum toxin A during the operative treatment of elbow fractures and fracture-dislocations to prevent posttraumatic elbow stiffness.

### *Arthritis*

Silva presented the results of forty-two radial head excisions in thirty-seven patients with hemophilic elbow arthropathy. Thirty-three percent of the patients were positive for the human immunodeficiency virus, and seven elbows had undergone previous surgery. After a mean duration of follow-up of 5.8 years, the flexion-extension arc was essentially unchanged but the pronation-supination arc had significantly improved by 61° ( $p < 0.0001$ ). After a mean interval of five years, a second procedure was required in nine elbows; the procedures included six synovectomies for persistent elbow bleeding, one total elbow arthroplasty, and two ulnar nerve transpositions. The study demonstrated that radial head excision in patients with hemophilia improves forearm rotation and can be performed safely.

### *Miscellaneous*

Kim reported on the arthroscopic treatment of posterolateral elbow impingement resulting from synovial plicae in a study of twelve patients who were either throwers or golfers. None of the patients had lateral epicondylitis, all patients had posterolateral elbow pain, and seven patients complained of clicking or catching. At the time of arthroscopy, a thickened lateral synovial plica was identified and débrided. After a mean duration of follow-up of thirty-four months, eleven patients reported an excellent outcome. Patients returned to competitive sports activity at an average of five months postoperatively. John reported on an aggressive nonoperative treatment protocol that was used for thirty-eight patients with osteochondritis dissecans of the capitellum who were followed for a minimum of twenty-four months. Patients who were without symptoms associated with loose bodies and who had an intact cartilage cap on magnetic resonance imaging were allowed to continue athletic activity with the elbow in a double-hinged brace that allowed only pain-free motion. Patients who met the criteria for operative intervention at any point during treatment underwent arthroscopic removal of loose bodies, débridement, and drilling of the lesion. Seventeen of twenty-three patients who were managed with the brace avoided surgery, and 88% returned to their previous level of sports activity. All patients who were managed nonoperatively had a good or excellent result. Eighteen of the nineteen patients who were managed operatively had a good or excellent result. The study suggested

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that many patients with osteochondritis dissecans of the capitellum can be managed successfully without immobilization or cessation of activity. Naidu used the decrease in ulnar nerve conduction velocity across the elbow to compute the probability of the diagnosis of cubital tunnel syndrome. One hundred normal nerve conduction studies in 100 normal subjects and 100 studies in patients with the clinical diagnosis of cubital tunnel syndrome were evaluated with logistic regression analysis. The analysis demonstrated that even a 20% reduction in conduction velocity across the elbow predicted cubital tunnel syndrome with 70% likelihood. A 25% reduction predicted cubital tunnel syndrome with 80% likelihood. A 40% reduction predicted cubital tunnel syndrome with 95% likelihood. The findings refuted the classic teaching that a one-third decrease in conduction velocity is always clinically important. Cubital tunnel syndrome remains a clinical diagnosis, and nerve conduction velocity studies merely verify its presence.

**Evidence-Based Orthopaedics**

The editorial staff of *The Journal* reviewed a large number of recently published research studies related to the musculoskeletal system that received a Level of Evidence grade of I. Over 100 medical journals were reviewed to identify these articles, which all have high-quality study design. In addition to articles published previously in this journal or cited already in this Update, five level-I articles were identified that were relevant to shoulder and elbow surgery. A list of those titles is appended to this review after the standard bibliography. We have provided a brief commentary about each of the articles to help to guide your further reading, in an evidence-based fashion, in this subspecialty area.

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The authors did not receive grants or outside funding in support of their research for or preparation of this manuscript. They did not receive payments or other benefits or a commitment or agreement to provide such benefits from a commercial entity. No commercial entity paid or directed, or agreed to pay or direct, any benefits to any research fund, foundation, educational institution, or other charitable or nonprofit organization with which the authors are affiliated or associated.

doi:10.2106/JBJS.E.01165

**Upcoming Meetings**

Arthroscopic Rotator Cuff Repair. May 12-13, 2006, and October 13-14, 2006. Gary M. Gartsman, MD, T. Bradley Edwards, MD, Hussein Elkousy, MD, course chairmen. Joe W. King Orthopedic Institute, Houston, Texas. Contact: Dan O'Connor. E-mail address: info@jwkoi.com

Arthroscopic Glenohumeral Reconstruction. September 22-23, 2006. Gary M. Gartsman, MD, T. Bradley Edwards, MD, Hussein Elkousy, MD, course chairmen. Joe W. King Orthopedic Institute, Houston, Texas. Contact: Dan O'Connor. E-mail address: info@jwkoi.com

Advanced Shoulder Arthroplasty. February 17-18, 2006, and December 15-16, 2006. Gary M. Gartsman, MD, T. Bradley Edwards, MD, Hussein Elkousy, MD, course chairmen. Joe W. King Orthopedic Institute, Houston, Texas. Contact: Dan O'Connor. E-mail address: info@jwkoi.com

ASES Twenty-second Annual Open Meeting. March 25, 2006. Chicago, Illinois. Contact: Emily Jones. E-mail address: jones@aaos.org

AAOS/ASES Open and Arthroscopic Techniques in Shoulder Surgery. January 20-22, 2006. Rosemont, Illinois. Contact: Nancy Cocalis. E-mail address: cocalis@aaos.org

St. Luke's Episcopal Hospital: Annual Orthopaedic Symposium. April 21-22, 2006. Current Concepts in Shoulder Surgery. Houston, Texas. Contact: Janice Lipnick. E-mail address: jlipnick@slsh.com

5th Biennial AAOS/ASES Shoulder and Elbow: Current Techniques and Controversies. April 6-9, 2006. Orlando, Florida. Contact: Nancy Cocalis. E-mail address: cocalis@aaos.org

San Diego Shoulder Arthroscopy: Twenty-third Annual Meeting. June 21-24, 2006. San Diego, California. Contact: James Esch, MD. E-mail address: jesch@shoulder.com

AAOS/ASES The Shoulder: An Arthroscopic Odyssey. July 28-29, 2006. Rosemont, Illinois. Contact: Nancy Cocalis. E-mail address: cocalis@aaos.org

Orthopedic Learning Center: AAOS Elbow. September 29-30, 2006. Rosemont, Illinois. Contact: Nancy Cocalis. E-mail address: cocalis@aaos.org

Orthopaedic Learning Center: AAOS Shoulder Arthroplasty. October 6-7, 2006. Rosemont, Illinois. Contact: Nancy Cocalis. E-mail address: cocalis@aaos.org

AAOS/ASES Recent Advances in the Treatment of Rotator Cuff Tears. October 14-16, 2006. Los Angeles, California. Contact: Nancy Cocalis. E-mail address: cocalis@aaos.org

**Recent Publications of Interest  
Related to the Shoulder****Rotator Cuff****Basic Science**

**Karduna AR, Kerner PJ, Lazarus MD.** Contact forces in the subacromial space: effects of scapular orientation. *J Shoulder Elbow Surg.* 2005;14:393-9.

**Park MC, Cadet ER, Levine WN, Bigliani LU, Ahmad CS.** Tendon-to-bone pressure distributions at a repaired rotator cuff footprint using transosseous suture and suture anchor fixation techniques. *Am J Sports Med.* 2005;33:1154-9.

**Impingement**

**Paoloni JA, Appleyard RC, Nelson J, Murrell GA.** Topical glyceryl trinitrate application in the treatment of chronic supraspinatus tendinopathy: a randomized, double-blinded, placebo-controlled clinical trial. *Am J Sports Med.* 2005;33:806-13.

**Budoff JE, Rodin D, Ochiai D, Nirschl RP.** Arthroscopic rotator cuff debridement without decompression for the treatment of tendinosis. *Arthroscopy.* 2005;21:1081-9.

**Tendon Tears**

**Kelly BT, Williams RJ, Cordasco FA, Backus SI, Otis JC, Weiland DE, Altchek DW, Craig EV, Wickiewicz TL, Warren RF.** Differential patterns of muscle activation in patients with symptomatic and asymptomatic rotator cuff tears. *J Shoulder Elbow Surg.* 2005;14:165-71.

**Walch G, Edwards TB, Boulahia A, Nove-Josserand L, Neyton L, Szabo I.** Arthroscopic tenotomy of the long head of the biceps in the treatment of rotator cuff tears: clinical and radiographic results of 307 cases. *J Shoulder Elbow Surg.* 2005;14:238-46.

**Roddey TS, Cook KF, O'Malley KJ, Gartsman GM.** The relationship among strength and mobility measures and self-report outcome scores in persons

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after rotator cuff repair surgery: impairment measures are not enough. *J Shoulder Elbow Surg.* 2005;14(1 Suppl S):95-8S.

**Malkani AL, Sundine MJ, Tillett ED, Baker DL, Rogers RA, Morton TA.** Transfer of the long head of the triceps tendon for irreparable rotator cuff tears. *Clin Orthop Relat Res.* 2004;428:228-36.

**Instability****Basic Science**

**Schneider DJ, Tibone JE, McGarry MH, Grossman MG, Veneziani S, Lee TQ.** Biomechanical evaluation after five and ten millimeter anterior glenohumeral capsulorrhaphy using a novel shoulder model of increased laxity. *J Shoulder Elbow Surg.* 2005;14:318-23.

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**Debski RE, Weiss JA, Newman WJ, Moore SM, McMahan PJ.** Stress and strain in the anterior band of the inferior glenohumeral ligament during a simulated clinical examination. *J Shoulder Elbow Surg.* 2005;14(1 Suppl S):24-31S.

**Miller BS, Sonnabend DH, Hatrick C, O'Leary S, Goldberg J, Harper W, Walsh WR.** Should acute anterior dislocations of the shoulder be immobilized in external rotation? A cadaveric study. *J Shoulder Elbow Surg.* 2004;13:589-92.

**Anterior Instability**

**Kirkley A, Werstine R, Ratjek A, Griffin S.** Prospective randomized clinical trial comparing the effectiveness of immediate arthroscopic stabilization versus immobilization and rehabilitation in first traumatic anterior dislocations of the shoulder: long-term evaluation. *Arthroscopy.* 2005;21:55-63.

**Mazzocca AD, Brown FM Jr, Carreira DS, Hayden J, Romeo AA.** Arthroscopic anterior shoulder stabilization of collision and contact athletes. *Am J Sports Med.* 2005;33:52-60.

**Sperling JW, Duncan SF, Torchia ME, O'Driscoll SW, Cofield RH.** Bankart repair in patients aged fifty years or greater: results of arthroscopic and open repairs. *J Shoulder Elbow Surg.* 2005;14:111-3.

**Posterior Instability**

**Wolf BR, Strickland S, Williams RJ, Allen AA, Aitchek DW, Warren RF.** Open posterior stabilization for recurrent posterior glenohumeral instability. *J Shoulder Elbow Surg.* 2005;14:157-64.

**Glenohumeral Arthritis****Clinical**

**Chapman C, Mattern C, Levine WN.** Arthroscopically assisted core decompression of the proximal humerus for avascular necrosis. *Arthroscopy.* 2004;20:1003-6.

**Lyman S, Jones EC, Bach PB, Peterson MG, Marx RG.** The association between hospital volume and total shoulder arthroplasty outcomes. *Clin Orthop Relat Res.* 2005;432:132-7.

**Gartsman GM, Elkousy HA, Warnock KM, Edwards TB, O'Connor DP.** Radiographic comparison of pegged and keeled glenoid components. *J Shoulder Elbow Surg.* 2005;14:252-7.

**Sperling JW, Cofield RH, Rowland CM.** Minimum fifteen-year follow-up of Neer hemiarthroplasty and total shoulder arthroplasty in patients aged fifty years or younger. *J Shoulder Elbow Surg.* 2004;13:604-13.

**Carroll RM, Izquierdo R, Vazquez M, Blaine TA, Levine WN, Bigliani LU.** Conversion of painful hemiarthroplasty to total shoulder arthroplasty: long-term results. *J Shoulder Elbow Surg.* 2004;13:599-603.

**Buckingham BP, Parsons IM, Campbell B, Titelman RM, Smith KL, Matsen FA.** Patient functional self-assessment in late glenoid component failure at three to eleven years after total shoulder arthroplasty. *J Shoulder Elbow Surg.* 2005;14:368-74.

**Stiffness and Trauma**

**Farrell CM, Sperling JW, Cofield RH.** Manipulation for frozen shoulder: long-term results. *J Shoulder Elbow Surg.* 2005;14:480-4.

**Diwan DB, Murrell GA.** An evaluation of the effects of the extent of capsular re-

lease and of postoperative therapy on the temporal outcomes of adhesive capsulitis. *Arthroscopy.* 2005;21:1105-13.

**Ledger M, Leeks N, Ackland T, Wang A.** Short malunions of the clavicle: an anatomic and functional study. *J Shoulder Elbow Surg.* 2005;14:349-54.

**Miscellaneous**

**Bradley MP, Tung G, Green A.** Overutilization of shoulder magnetic resonance imaging as a diagnostic screening tool in patients with chronic shoulder pain. *J Shoulder Elbow Surg.* 2005;14:233-7.

**Recent Publications of Interest Related to the Elbow****Instability**

**Ahmad CS, Park MC, Elattrache NS.** Elbow medial ulnar collateral ligament insufficiency alters posteromedial olecranon contact. *Am J Sports Med.* 2004;32:1607-12.

**Hull JR, Owen JR, Fern SE, Wayne JS, Boardman ND 3rd.** Role of the coronoid process in varus osteoarticular stability of the elbow. *J Shoulder Elbow Surg.* 2005;14:441-6.

**Jensen SL, Olsen BS, Tyrdal S, Sojbjerg JO, Sneppen O.** Elbow joint laxity after experimental radial head excision and lateral collateral ligament rupture: efficacy of prosthetic replacement and ligament repair. *J Shoulder Elbow Surg.* 2005;14:78-84.

**Tendon Injuries**

**Ruland RT, Dunbar SR, Bowen JD.** The biceps squeeze test for diagnosis of distal biceps tendon ruptures. *Clin Orthop Relat Res.* 2005;437:128-31.

**Trauma**

**Herbertsson P, Josefsson PO, Hasselius R, Karlsson C, Besjakov J, Karlsson MK.** Displaced Mason type I fractures of the radial head and neck in adults: a fifteen- to thirty-three-year follow-up study. *J Shoulder Elbow Surg.* 2005;14:73-7.

**Arthritis**

**Wright TW, Hastings H.** Total elbow arthroplasty failure due to overuse, C-ring failure, and/or bushing wear. *J Shoulder Elbow Surg.* 2005;14:65-72.

**Nemoto K, Arino H, Yoshihara Y, Fujikawa K.** Arthroscopic synovectomy for the rheumatoid elbow: a short-term outcome. *J Shoulder Elbow Surg.* 2004;13:652-5.

**Appendix: Evidence-Based Articles Related to the Shoulder and Elbow****Shoulder**

**Fabbricani C, Milano G, Demontis A, Fadda S, Ziranu F, Mulas PD.** Arthroscopic versus open treatment of Bankart lesion of the shoulder: a prospective randomized study. *Arthroscopy.* 2004;20:456-62

Sixty patients with traumatic anterior shoulder instability were divided into two groups; thirty patients underwent an arthroscopic repair, and thirty patients had an open procedure. Both groups underwent repair with use of metallic anchors and nonabsorbable sutures. Two-year follow-up included Constant and Rowe shoulder scores. The only significant difference between the groups was in the active range of motion as measured with the Constant score, which was significantly improved in the arthroscopic repair group. No recurrence of dislocation was reported in either group. The authors concluded that arthroscopic repair with suture anchors is an effective technique and that open repair can negatively affect the recovery of full range of motion. The findings of this study contrast with the experience of Weber as described earlier.

**Teefey SA, Rubin DA, Middleton WD, Hildebolt CF, Leibold RA, Yamaguchi K.** Detection and quantification of rotator cuff tears. Comparison of ultrasonographic, magnetic resonance imaging, and arthroscopic findings in seventy-one consecutive cases. *J Bone Joint Surg Am.* 2004;86:708-16.

One hundred and forty-five consecutive patients were studied with ul-

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trasonography and magnetic resonance imaging. Seventy-one patients had subsequent arthroscopy, and those seventy-one patients formed the study group. Ultrasonography correctly predicted the degree of retraction of 73% of the full-thickness tears and the length of 85% of the partial-thickness tears, whereas magnetic resonance imaging correctly predicted 63% and 75%, respectively. Ultrasonography correctly predicted the width of 87% of the full-thickness tears and 54% of the partial-thickness tears, whereas magnetic resonance imaging correctly predicted 80% and 75%, respectively. In expert hands, such as those of the senior author, ultrasonography is an accurate method of rotator cuff assessment and allows the orthopaedic surgeon to select the appropriate test on the basis of other factors, such as clinical information regarding lesions of the glenoid labrum, joint capsule, or surrounding muscle or bone; the presence of an implanted device; patient tolerance; and cost.

**Gartsman GM, O'Connor DP.** Arthroscopic rotator cuff repair with and without arthroscopic subacromial decompression: a prospective, randomized study of one-year outcomes. *J Shoulder Elbow Surg.* 2004;13:424-6.

Gartsman and O'Connor used an arthroscopic technique to repeat the pioneering work of Matsen, who found that the results of open rotator cuff repair demonstrated no improvement when acromioplasty was added to the rotator cuff repair. Similarly, Gartsman and O'Connor reported that the results of arthroscopic rotator cuff repair were no different between patients who had been randomized to cuff repair with or without arthroscopic subacromial decompression. The study group was confined to patients with a type-2 acromion and a full-thickness supraspinatus tear. Follow-up was limited to one year, and the outcome was determined on the basis of patient self-assessment. Nonetheless, this study further complicates the surgeon's decision-making by calling into question both the role of acromioplasty in patients who are man-

aged with operative repair of a full-thickness rotator cuff tear and the theory of external, extrinsic compression as a cause of rotator cuff lesions. Additional study is necessary before a definitive conclusion can be reached.

**Elbow**

**Hayton MJ, Santini AJ, Hughes PJ, Frostick SP, Trail IA, Stanley JK.** Botulinum toxin injection in the treatment of tennis elbow. A double-blind, randomized, controlled, pilot study. *J Bone Joint Surg Am.* 2005;87:503-7.

The authors studied the effects of botulinum injection in this prospective, randomized, double-blind clinical trial. Forty patients were divided into two equal groups. One group received 50 U of botulinum toxin type A, and the other group received normal saline solution. Three months following the injections, there was no significant difference between the two groups with regard to grip strength, pain, or quality of life. There appears to be no benefit associated with the use of botulinum injection for the treatment of tennis elbow.

**Dunkow PD, Jatti M, Muddu BN.** A comparison of open and percutaneous techniques in the surgical treatment of tennis elbow. *J Bone Joint Surg Br.* 2004;86:701-4.

The authors conducted a prospective, randomized trial of forty-seven elbows in forty-five patients. The patients were preoperatively and postoperatively assessed with the Disabilities of the Arm, Shoulder and Hand (DASH) scoring system. Both groups were followed for a minimum of twelve months. The patients undergoing percutaneous tenotomy release returned to work an average of three weeks earlier and improved significantly more quickly than those undergoing an open procedure did. It appears that the quicker and simpler procedure produces significantly better results.