

THE JOURNAL OF BONE & JOINT SURGERY

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J Bone Joint Surg Am. 2008;90:677-687. doi:10.2106/JBJS.G.01544

This information is current as of November 20, 2009

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Publisher Information

The Journal of Bone and Joint Surgery
20 Pickering Street, Needham, MA 02492-3157
www.jbjs.org

SPECIALTY UPDATE

What's New in Shoulder and Elbow Surgery

By Matthew L. Ramsey, MD, Charles L. Getz, MD, and Bradford O. Parsons, MD

This annual update on shoulder and elbow surgery is a review of the most relevant studies from July 2006 through June 2007. It includes clinical and basic science articles from *The Journal of Bone and Joint Surgery* (American Volume), *The Journal of Bone and Joint Surgery* (British Volume), the *Journal of Shoulder and Elbow Surgery*, and *Arthroscopy: The Journal of Arthroscopic and Related Surgery*. Relevant Level-I and Level-II studies from other medical journals are included where appropriate.

The level of evidence is indicated at the end of each review when it is known. Particular attention should be paid to the Level-I and Level-II studies as they represent randomized controlled studies. However, study design and analysis influences the quality of these studies. Additional Level-III and Level-IV studies representing important topics in shoulder and elbow surgery are also included in the review.

Shoulder

Rotator Cuff

Basic Science

The effect of nicotine on bone healing is well known. However, little is known about the effect of nicotine on tendon-to-bone healing. Galatz et al.¹ performed an eloquent experiment in which acute supraspinatus tendon repairs were performed in rats. During the healing phase, some rats were exposed to nicotine and others were exposed to saline solution as a control. There was a delay in tendon-to-bone healing in rats that had been exposed to nicotine. While the mechanical properties increased over time in both groups, the properties in the nicotine group lagged behind those in the control group. This study demonstrated the detrimental effect that nicot-

tine may have on rotator cuff healing following rotator cuff repair.

Extracellular matrix scaffolds have been used during rotator cuff surgery to augment deficient tissue and to close small residual cuff tears. Interestingly, very few independent data exist regarding the properties of commercially available extracellular matrix grafts. Derwin et al.² investigated the biomechanical, biochemical, and cellular properties of four graft materials. Biomechanically, all four graft materials required substantial stretch (10% to 30%) before they could carry substantial load. DNA content, indicating residual native cellular elements, was measurable in three of the four grafts but was significantly higher in one (TissueMend; Stryker Orthopaedics, Mahwah, New Jersey). The poor biomechanical properties of these grafts suggest that the use of these grafts does not protect the rotator cuff repair through load sharing. Additionally, measurable DNA content indicates that some cellular elements remain in the graft.

Rotator cuff healing following surgical repair continues to be unpredictable. Blood flow to the tendon edge has been viewed as evidence of the healing potential of the repair. Minimal débridement of the tendon has been recommended on the basis of studies that have demonstrated adequate blood flow to the torn tendon edge. However, Matthews et al.³ believed that cellular activity (as indicated by oxygen consumption) in the torn rotator cuff is a more important measure of the healing potential. Cellular oxygen consumption was measured in thirteen patients undergoing mini-open repair of small, medium, large, and massive full-thickness tears. Control measurements were taken from three patients with grossly normal tendons. All of the torn tendons had lower cellular activity than did those in the control group. Cellular activity was lower at the edge of the tear, with the lowest activity occurring in larger tears. The authors believed

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

Disclosure: The authors did not receive any outside funding or grants in support of their research for or preparation of this work. Neither they nor a member of their immediate families received 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, division, center, clinical practice, or other charitable or nonprofit organization with which the authors, or a member of their immediate families, are affiliated or associated.

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that the high rates of rerupture in patients with larger tears may be explained by diminished cellular activity at the tendon edge.

The natural history of rotator cuff disease is poorly understood. Specifically, the demographic and morphological characteristics of asymptomatic and symptomatic rotator cuff tears are not clearly established in the literature. Yamaguchi et al.⁴ evaluated bilateral shoulder ultrasound studies for patients presenting with unilateral shoulder pain in an attempt to compare tear characteristics and the prevalence of asymptomatic and symptomatic rotator cuff disease. Patient age correlated with both the presence or absence of a rotator cuff tear and the extent of the tear. The average age was 48.7 years for patients with no rotator cuff tear, 58.7 years for those with a unilateral tear, and 67.8 years for those with a bilateral tear. After the age of sixty-six years, the likelihood of having a bilateral rotator cuff tear was 50%. Overall, patients who presented with a full-thickness symptomatic tear had a 35.5% prevalence of a full-thickness tear on the contralateral (asymptomatic) side. We can conclude from this study that bilateral rotator cuff disease, either symptomatic or asymptomatic, is common in patients who present with unilateral symptomatic disease. The authors recommended surveillance at yearly intervals for patients with known rotator cuff tears that are treated nonoperatively.

Subacromial Decompression (Acromioplasty)

Barfield and Kuhn⁵ performed a systematic review of one Level-II and four Level-I randomized controlled prospective studies to determine whether the outcome of arthroscopic acromioplasty differs from that of open acromioplasty. With pain relief as the primary outcome, no differences were found between arthroscopic acromioplasty and open acromioplasty. Other outcomes that showed no difference included University of California at Los Angeles (UCLA) shoulder scores, range of motion, and strength. The data for the time required to perform surgery and the time to return to work could not be used to recommend one approach over the other. The authors concluded that, on the basis of the data available from the studies reviewed, they could not find appreciable differences between arthroscopic and open acromioplasty (Level II).

Acromioplasty traditionally has been performed with rotator cuff repair. However, some surgeons currently are performing arthroscopic rotator cuff repair without acromioplasty. In the randomized prospective study by Milano et al.⁶, patients undergoing arthroscopic rotator cuff repair with acromioplasty (Group 1) were compared with those undergoing arthroscopic rotator cuff repair without acromioplasty (Group 2). Acromioplasty did not significantly influence the outcome as measured with the Constant score; the Disabilities of the Arm, Shoulder and Hand (DASH) score; and the Work-DASH score (Level I). The variables that were shown to significantly

and independently influence outcome were patient age; the shape, retraction, and reducibility of the rotator cuff tear; fatty degeneration of the rotator cuff muscles; involvement of the subscapularis; and the repair technique.

Partial-Thickness Tears

The operative treatment of articular-sided partial-thickness rotator cuff tears remains controversial. Deutsch⁷ reported on forty-one patients with articular-sided partial-thickness tears that were treated with completion of the tear and arthroscopic repair of the full-thickness defect with use of a simple suture technique. After short-term follow-up of three years, significant improvements were noted in terms of the American Shoulder and Elbow Surgeons (ASES) score, pain relief, and patient satisfaction. Forty (98%) of the forty-one patients were satisfied with the outcome.

Full-Thickness Tears

Cho et al.⁸ investigated postoperative pain management following arthroscopic rotator cuff repair. In a randomized prospective study, patients undergoing arthroscopic rotator cuff repair received patient-controlled analgesia by means of subacromial infusion with 0.5% bupivacaine (Group 1) or intravenous injection with fentanyl and ketorolac tromethamine (Group 2). The immediate postoperative visual analog scale pain score was 7.6 for Group 1 and 7.4 for Group 2. At all of the time-points measured, no significant difference in postoperative visual analog scale pain scores was noted between the groups. The authors concluded that subacromial infusion of bupivacaine and intravenous injection of fentanyl and ketorolac tromethamine were equally effective methods of postoperative pain management following arthroscopic rotator cuff repair (Level II).

There has been a rapid evolution in the arthroscopic techniques for rotator cuff repair. When evaluating the literature, the success or failure of arthroscopic techniques must be judged against the results of established open techniques. In a study by Liem et al.⁹, the clinical outcomes and structural integrity of arthroscopic and mini-open rotator cuff repairs were compared. Patients were matched according to age, gender, and the duration of symptoms. Preoperative and postoperative Constant scores and early postoperative range of motion were evaluated. Structural integrity of the rotator cuff was determined with magnetic resonance imaging at the time of the latest follow-up. The clinical outcome demonstrated no differences between the two treatment groups. There was no difference in retear rates as demonstrated on postoperative magnetic resonance imaging between the arthroscopic repair group (six retears; 31.6%) and the mini-open group (seven retears; 36.8%). Smaller retears had no influence on the clinical result, whereas more retracted retears correlated with lower abduction strength, regardless of the repair method. One can conclude that the arthroscopic repair of isolated supraspinatus tears produces excellent clinical results and equivalent

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tendon integrity as compared with mini-open repair (Level III).

Two studies summarized the results of arthroscopic double-row rotator cuff repair^{10,11}. Each of those studies correlated function with the structural integrity of the repair. In the first study, Sugaya et al.¹⁰ reported on eighty-six patients who underwent double-row rotator cuff repair. The repair technique varied slightly on the basis of the tear configuration but involved a medial and lateral row of suture anchors. The tear sizes ranged from small to massive. The clinical outcome measures had all improved significantly at the time of the latest follow-up. The retear rate was 5% for small-to-medium tears and 40% for large and massive tears. Patients who had a complete retear had a significantly poorer functional outcome compared with those who had a tear that partially or completely healed. Thus, arthroscopic double-row fixation results in improved healing for small to medium-sized tears. However, the retear rate for shoulders with large and massive tears remains high. Huijsmans et al.¹¹ performed ultrasound evaluation of the shoulder to determine the integrity of the rotator cuff three weeks after arthroscopic double-row rotator cuff repair and at a minimum of one year postoperatively. Three weeks after surgery, ultrasound demonstrated an intact repair in 94% of the shoulders with a small tear, in 97% of those with a medium tear, in 90% of those with a large tear, and in only 66% of those with a massive tear. At the time of the latest follow-up, ultrasound demonstrated an intact repair in 88% of the shoulders with a small tear, in 93% of those with a medium tear, in 78% of those with a large tear, and in 47% of those with a massive tear. The Constant score improved significantly in all patients, but the improvement was significantly greater in patients with a healed repair. Strength and active elevation increased significantly more in the group with an intact repair than in the group with a failed repair; however, there was no difference between the groups in terms of the pain score. Poor tissue quality was also associated with a higher failure rate than good tissue quality was. The authors concluded that a healed rotator cuff can be expected in the majority of shoulders that are treated for a large, medium, or small tear, but massive tears continue to have a high failure rate. Furthermore, strength, range of motion, and functional recovery depend on rotator cuff healing.

While the results of rotator cuff surgery are linked to tendon healing, other factors contribute to the overall results. Suprascapular neuropathy has been associated with retracted rotator cuff tears. Mallon et al.¹² evaluated eight patients with massive, retracted rotator cuff tears with atrophy and fatty replacement of the muscle. All patients had evidence of suprascapular neuropathy with denervation of the supraspinatus and/or infraspinatus muscles, and they were severely limited preoperatively in forward elevation. Four patients elected to undergo a rotator cuff débridement with partial repair of the rotator cuff with use of a margin convergence technique. Following surgery, all four patients regained for-

ward elevation above 90°. In two patients, postoperative electromyography demonstrated reinnervation potentials in the muscles supplied by the suprascapular nerve, with complete recovery occurring in one patient. The authors believed that retraction of the rotator cuff (particularly the supraspinatus) can create traction on the suprascapular nerve. Partial repair may relieve some of this traction, allowing nerve recovery and improved function.

Complications

Infection following rotator cuff repair can be difficult to diagnose and treat and may have a profound effect on the function of the shoulder. Athwal et al.¹³ performed a retrospective review of the Mayo Clinic experience with infection following rotator cuff repair in thirty-eight patients. *Propionibacterium acnes* was the causative organism in 51% of the patients who were identified with a deep infection. At the time of the most recent follow-up, the mean active elevation was 120° and the mean external rotation was 45°. In the group of patients who were available for follow-up, the overall results, as measured with the ASES shoulder rating and the Simple Shoulder Test, were excellent in seven shoulders, satisfactory in nine, and unsatisfactory in eleven. The authors noted that *Propionibacterium acnes* can be difficult to identify and requires cultures to be monitored for at least seven days.

Anterior Glenohumeral Instability/SLAP

The diagnosis of traumatic anterior instability is based on the clinical history, physical examination, and supporting radiographic studies. However, the usefulness of various physical examination tests in the diagnosis of anterior instability has not been thoroughly investigated. Farber et al.¹⁴ evaluated patients with traumatic anterior shoulder instability that had been confirmed arthroscopically or documented radiographically after the trauma. The clinical usefulness of anterior apprehension, relocation, and anterior drawer tests was evaluated. All three tests for traumatic anterior shoulder instability were demonstrated to be specific but not sensitive. Apprehension is better than pain for use as a criterion for a positive apprehension or relocation test. When pain does not prevent it from being performed, the anterior drawer test is helpful for diagnosing traumatic anterior instability (Level I).

Anterior instability is frequently associated with labral detachment from the anteroinferior aspect of the glenoid. When the scapular periosteum does not rupture, an anterior labroligamentous periosteal sleeve avulsion occurs. At times, the anterior labroligamentous periosteal sleeve avulsion will heal medially to the neck of the glenoid, effectively shortening the anterior band of the inferior glenohumeral ligament. Theoretically, this will decrease passive external rotation in abduction and external rotation. Deutsch et al.¹⁵ performed a prospective study to test this hypothesis. External rotation at

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90° of abduction was assessed in the affected and unaffected shoulders on examination with the patient under anesthesia. Arthroscopy was used to identify patients who had a detached Bankart lesion (Group 1) and patients who had a medially healed Bankart lesion (Group 2). Differences in external rotation at 90° of abduction between symptomatic and asymptomatic shoulders were compared in both groups. Detachment of the labrum resulted in increased external rotation at 90° of abduction, whereas a medially healed Bankart lesion resulted in decreased external rotation at 90° of abduction compared with the asymptomatic side. The authors concluded that loss of $\geq 5^\circ$ of external rotation at 90° of abduction in the affected shoulder on examination with the patient under anesthesia should create a high degree of suspicion for the presence of a medially healed Bankart lesion (Level II).

The long-term results of operative and nonoperative treatment of first-time traumatic anterior dislocation were studied by Jakobsen et al.¹⁶ The pathologic lesion was defined arthroscopically as a capsular tear with no labral injury, capsular tear and partial labral tear, or capsular tear with labral detachment. The patients were randomized to an open repair group or a nonoperative treatment group. After a minimum duration of follow-up of two years, the rate of recurrence was 56% after nonoperative treatment and 3% after open repair. The patients were evaluated after ten years with use of the Oxford self-assessment score. Good or excellent results were obtained for 72% of the patients in the operative treatment group, whereas 75% of the patients in the nonoperative treatment group had an unsatisfactory result because of recurrence, instability, and pain or stiffness. The authors recommended considering primary repair for active patients to reduce the risk of recurrent dislocation (Level I).

Open and arthroscopic techniques for anterior glenohumeral instability have been described. To date, most studies have indicated a higher redislocation rate in association with arthroscopic repair as compared with open repair. Lenters et al.¹⁷ performed a systematic review and meta-analysis of the literature to determine the effectiveness of arthroscopic repairs as compared with open repair for the treatment of recurrent anterior instability of the shoulder. Four randomized controlled trials, ten controlled clinical trials, and four other comparative studies were identified. The results were influenced both by the quality of the study and by the arthroscopic technique. The meta-analysis revealed that, compared with open repairs, arthroscopic repairs were associated with significantly higher risks of recurrent instability, recurrent dislocation, and reoperation. Arthroscopic approaches were also less effective than open methods with regard to enabling patients to return to work and/or sports. On the other hand, analysis of the randomized clinical trials indicated that arthroscopic repairs were associated with higher Rowe scores than open repairs were. Similarly, analysis of the arthroscopic suture-anchor techniques alone showed the Rowe scores to be

higher than those associated with open methods (Level II). A randomized controlled study of arthroscopic and open stabilization for the treatment of recurrent anterior instability¹⁸ yielded a different result. Failure was defined as recurrent subluxation, recurrent dislocation, or symptoms precluding return to previous work or unrestricted active military duty. There were three clinical failures (two after open stabilization and one after arthroscopic stabilization) according to the established criteria. There was significant improvement in the Single Assessment Numeric Evaluation. The mean loss of motion (compared with the contralateral shoulder) was greater in the shoulders treated with an open method. Subjective evaluations were equal in both groups. This prospective randomized trial indicates that open and arthroscopic surgery are comparable for the treatment of recurrent anterior instability (Level I). These two studies alone do not clarify the questions that have been raised with regard to arthroscopic and open repairs. More work is required in order to define the technical nuances that account for these differences.

As arthroscopic repairs for the treatment of anterior instability have been associated with a higher rate of redislocation than open repairs have, it is critical to understand the reasons for failure. Boileau et al.¹⁹ evaluated the outcomes of arthroscopic Bankart repairs to identify risk factors for recurrent instability. Labral repair combined with capsular re-tensioning was performed with use of absorbable suture anchors. Recurrent instability occurred in 15.3% of the patients. The risk of postoperative recurrence was related to the presence of a compression defect or attritional bone loss on the glenoid, a large Hill-Sachs lesion, inferior and/or anterior hyperlaxity, or the use of three or fewer suture anchors. Osseous Bankart lesions were not associated with a higher rate of recurrent instability. The combination of glenoid bone loss and inferior hyperlaxity led to a 75% recurrence rate. Unfortunately, the authors did not report the extent of the tear over which the anchors were placed, but they recommended using four or more anchors in the repair and being cautious in patients with bone loss and hyperlaxity (Level IV).

Glenohumeral Arthritis

Basic Science

Glenoid component failure remains an area of interest related to total shoulder arthroplasty as glenoid component longevity has been linked to survivorship of the glenoid component. Terrier et al.²⁰ utilized a three-dimensional finite-element model to study the effect of glenohumeral joint conformity and glenoid version on glenoid stresses. Humeral and glenoid components were implanted in the model for two different orientations of the glenoid component (0° and 15° of retroversion). Different degrees of radial mismatch (1 to 15 mm) between the humeral head and the glenoid were then tested. As mismatch increased, glenohumeral contact pressure increased significantly (threefold between 1 and 15 mm), and, as a result, stress within the polyethylene increased. Above 10 mm of

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mismatch, the stress exceeded the polyethylene yield strength. Cement stress increased with progressively greater radial mismatch but was only severe for the retroversion case above 10 mm of mismatch. Retroversion increased all values by more than twice and exceeded critical values above 10 mm of mismatch. This study confirmed all previous findings indicating that radial mismatch between the humerus and the glenoid should not exceed 10 mm. Additionally, the detrimental effect of retroversion on glenoid stresses was highlighted.

Concern about glenoid component survival has led some authors to attempt alternative treatments for glenohumeral arthritis. Lateral meniscal allografts have been used in conjunction with hemiarthroplasty for the treatment of glenohumeral arthritis for patients in whom glenoid replacement is deemed undesirable. Creighton and colleagues²¹ investigated the effect of a lateral meniscus allograft on the articular contact areas and pressures. The interposed lateral meniscus allograft group showed a significant decrease in total force at both 220 and 440 N as well as a decrease in contact area for the 220-N testing condition. No difference was noted in contact area at 440 N or in peak forces or peak contact areas for either 220 or 440-N forces. Thus, from a biomechanical point of view, decreased forces on the glenoid surface support biologic resurfacing with a lateral meniscus allograft of the glenohumeral joint.

Outcomes of Arthroplasty

Hemiarthroplasty has been advocated by some for the treatment of osteoarthritis of the shoulder. Rispoli et al.²² evaluated the results of hemiarthroplasty for the treatment of osteoarthritis. The forty-nine patients (fifty-one shoulders) in that study were followed for a minimum of five years or until revision surgery. The patients demonstrated significant long-term pain relief as well as improvement in abduction, internal rotation, and external rotation. However, moderate pain was reported in nine shoulders and severe pain was reported in seven. Ten shoulders required revision surgery, which was performed for the treatment of painful glenoid arthritis in nine cases. Radiographs demonstrated an increase in glenoid erosion at an average of 10.7 years postoperatively. A modification of the Neer rating system was used to measure outcome. There were ten excellent results, twenty satisfactory results, and twenty-one unsatisfactory results. The authors concluded that the clinical improvement demonstrated after hemiarthroplasty for the treatment of osteoarthritis of the shoulder must be viewed in the context of a high rate of unsatisfactory results and a frequent need for revision surgery (Level IV).

Another option for hemiarthroplasty in patients who are deemed to be inappropriate candidates for total shoulder arthroplasty is hemiarthroplasty with biologic resurfacing of the glenoid. Krishnan et al.²³ reported their experience with this procedure. A variety of tissues were used to resurface the glenoid, including anterior capsule for seven shoulders, autogenous fascia lata for eleven, and Achilles tendon allograft for

eighteen. The result was excellent for eighteen shoulders, satisfactory for thirteen, and unsatisfactory for five. Glenoid erosion averaged 7.2 mm and appeared to stabilize at five years. Factors that were associated with unsatisfactory results were the use of capsular tissue as the resurfacing material and infection. The authors currently recommend Achilles tendon allograft as the preferred resurfacing material (Level IV).

The increase in the number of total shoulder replacements performed will undoubtedly result in an increase in the number of revision procedures. Dines et al.²⁴ investigated the relationship between final outcome and the indication for revision surgery. Patients were divided into those with osseous or component-related problems (Group 1), including revision of the glenoid component, conversion from hemiarthroplasty to total shoulder arthroplasty, revision of the humeral stem, and periprosthetic fracture. The remainder of the patients (Group 2) were those with soft-tissue deficiency, including rotator cuff repair, failed tuberosity reconstruction, cuff tear arthropathy, instability, and infection. The final outcome was satisfactory in 50% of the shoulders and unsatisfactory in 50%. The average scores for the shoulders in Group 1 were significantly better than those for the shoulders in Group 2. Component revisions, excluding humeral head revision for salvage, provide the best results, whereas soft-tissue reconstructions can be expected to yield poorer results overall (Level II).

Reverse Total Shoulder Arthroplasty

There has been heightened interest in reverse total shoulder arthroplasty in the United States since approval for these devices was granted by the Food and Drug Administration in 2004. Increased interest, combined with the experience of our European colleagues, has resulted in a number of reports appearing in the literature. The following studies document the early to intermediate-term experience with this device.

A multicenter study of the European experience was performed by Guery et al.²⁵ to determine the survival rate based on the diagnosis leading to reverse total shoulder arthroplasty. Eighty prostheses were implanted for the treatment of cuff tear arthropathy, rheumatoid arthritis, or trauma or for revision following previous surgery. The survival rates with prosthetic revision and glenoid loosening as the end points were 91% and 84%, respectively, at 120 months. Shoulders that had cuff tear arthropathy demonstrated a significantly better result than those that had been replaced for any other etiology. On the other hand, the survival rate with an absolute Constant score of <30 as an end point was 58% at 120 months, with no significant difference noted with respect to the reason for replacement. The survival curves declined at two time-points. The first decline occurred at three years as a result of revision of the implant. This decline reflected early loosening of the prosthesis. The second decline started at around six years and reflected progressive deterioration of the functional result. The authors concluded that this implant should be reserved for

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low-demand patients who are more than seventy years old. The best results are achieved in patients being managed for cuff tear arthropathy (Level IV).

Boileau et al.²⁶ analyzed the intermediate-term results and complications of reverse total shoulder arthroplasty in forty-five patients. The procedure was performed for cuff tear arthropathy, the sequela of fracture, and failure of a previous arthroplasty (revision). Fourteen complications (including three dislocations, three deep infections, one case of aseptic humeral loosening, two periprosthetic humeral fractures, one intraoperative glenoid fracture, one wound hematoma, two late acromial fractures, and one axillary nerve palsy) occurred in eleven patients. Complications were more frequent when the reverse total shoulder arthroplasty was performed for revision than when it was performed for the treatment of cuff tear arthropathy (prevalence, 47% compared with 5%). All three groups showed a significant increase in active elevation and the Constant score but no significant change in active external rotation or internal rotation. The outcome scores were all significantly higher in the cuff tear arthropathy group than in the revision group. Scapular notching was seen in twenty-six (68%) of the thirty-eight cases in which radiographic analysis was possible. No glenoid loosening was observed at the time of follow-up, even when the notch extended beyond the inferior screw. The authors concluded that the Grammont reverse total shoulder arthroplasty can improve function and restore active elevation. However, active rotation is usually unchanged because of the absence of anterior and posterior rotator cuff tissue. Results are less predictable and complication and revision rates are higher in patients undergoing revision surgery than in those with cuff tear arthropathy.

The clinical finding of inferior scapular notching following reverse total shoulder arthroplasty has raised concerns about eventual glenoid loosening. Reverse total shoulder arthroplasty with the Delta III prosthesis has been associated with inferior scapular notching. Simovitch et al.²⁷ investigated the predictors of scapular notching in a series of seventy-seven arthroplasties. All sixty-three shoulders that had development of scapular notching did so in the first fourteen months postoperatively. Thirty-four (44%) of the seventy-seven shoulders had inferior scapular notching, twenty-three (30%) had posterior notching, and six (8%) had anterior notching. The angle between the glenosphere and the scapular neck as well as the superior-inferior position of the glenosphere was highly correlated with inferior notching. The height of implantation of the glenosphere had an approximately eight times greater effect on inferior notching than did the prosthesis-scapular neck angle. The authors provided recommendations for ideal glenoid component positioning (Level II).

Studies have demonstrated functional improvement following reverse total shoulder arthroplasty. However, reports have indicated continued functional limitations in external rotation as a result of posterior rotator cuff deficiency or dysfunction. Simovitch et al.²⁸ investigated the impact of fatty

infiltration of the teres minor muscle on the outcome of reverse total shoulder arthroplasty. Preoperative fatty infiltration of the teres minor was assessed according to the method of Goutallier et al. The patients with stage-0, 1, or 2 fatty infiltration of the teres minor (Group 1) had a significantly better ultimate Constant score, a significantly better subjective shoulder value, and significantly greater preoperative-to-postoperative improvement than did the patients with stage-3 or 4 fatty infiltration (Group 2). Group 1 had a net gain of 9° of external rotation with the arm at the side, whereas Group 2 had an average net loss of 7°. The authors concluded that stage-3 or 4 fatty infiltration of the teres minor compromises the clinical outcome of reverse total shoulder arthroplasty in the treatment of cuff tear arthropathy (Level II).

Fractures

Proximal Humeral Fractures

Nonoperative treatment of proximal humeral fractures requires that protected rehabilitation begin at some point. Hodgson et al.²⁹ performed a randomized prospective controlled trial of minimally displaced proximal humeral fractures that were treated with immediate physical therapy or with physical therapy after three weeks of immobilization to determine the effect of immobilization on disability. Disability related to the fracture was measured at one and two years with use of the Croft shoulder disability questionnaire. A significant difference in disability was demonstrated one year after the fracture between patients who had been managed with immediate physical therapy (prevalence of disability, 42.8%) and those who had been managed with three weeks of immobilization (prevalence of disability, 72.5%). By two years, the prevalence of shoulder disability remained unchanged (43.2%) in the immediate therapy group but had improved (59.5%) in patients who had been managed with three weeks of immobilization. However, the difference between the immediate therapy and immobilization groups at two years was not significant. Immediate rehabilitation after a minimally displaced proximal humeral fracture results in faster recovery, with maximum functional benefit being achieved at one year, whereas delaying rehabilitation with three weeks of shoulder immobilization produces a slower recovery, which continues for at least two years after the time of injury.

Clavicular Fractures

Clavicular fractures historically have been treated nonoperatively. However, a growing body of literature supports the surgical treatment of displaced clavicular fractures. The Canadian Orthopaedic Trauma Society³⁰ performed a multicenter prospective randomized trial comparing the outcome of nonoperative treatment and plate fixation of displaced midshaft clavicular fractures. The average time to radiographic union was significantly shorter in the operative group as compared with the nonoperative group (16.4 compared with 28.4 weeks). There were two nonunions and no malunions in

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the operative group, compared with seven nonunions and nine symptomatic malunions in the nonoperative group. Constant scores and DASH scores were significantly improved in the operative group at all time-points measured. This study supports primary plate fixation of completely displaced midshaft clavicular fractures in active adult patients (Level I).

Fractures of the distal part of the clavicle are classified on the basis of the integrity of the coracoclavicular ligaments. In type-II distal clavicular fractures, the coracoclavicular ligaments are incompetent, rendering the medial fragment unstable. Haidar et al.³¹ reported the results for patients in whom type-II distal clavicular fractures had been treated with hook-plate fixation. One patient failed to achieve union of the fracture. One patient had a delayed fibrous union that ultimately healed 5.5 months following plate removal. Four complications were encountered, including fixation failure in two patients, skin breakdown over the plate in one patient, and a new clavicular fracture at the medial aspect of the plate in one patient. None of these complications had an effect on fracture-healing. Plate removal was a planned part of treatment and was performed in all but one patient, who refused. Nineteen patients were satisfied with the final outcome. This study supports hook-plate fixation as an acceptable method for the treatment of type-II fractures of the distal part of the clavicle.

Elbow

Lateral Epicondylitis

Effective treatments for lateral epicondylitis are not well established in the literature. Very little evidence-based research has proved one treatment method to be superior to another. Bisset et al.³² conducted a randomized clinical trial to evaluate the efficacy of physical therapy as compared with expectant management or corticosteroid injection. The results were assessed at the initiation of treatment, at six weeks, and at fifty-two weeks. The corticosteroid treatment group showed significantly better results at six weeks as compared with the physical therapy group but had a high recurrence rate and significantly poorer outcomes at fifty-two weeks. Physical therapy was better than expectant management at six weeks but was no different at fifty-two weeks, when most patients in both groups reported a successful outcome. The significant short-term benefits of corticosteroid injection do not last beyond six weeks and appear to have a detrimental effect in the long term. Physical therapy provides short-term benefit but no long-term benefit greater than that of expectant management (Level I).

A systematic review of randomized controlled trials with use of Cochrane Collaboration methodology was performed by Buchbinder et al.³³ to establish the efficacy of extracorporeal shock wave therapy in the treatment of lateral epicondylitis. Nine placebo-controlled trials and one trial in which extracorporeal shock wave therapy was compared with steroid injection were included in the review. The nine placebo-controlled trials had conflicting results. With the data available,

thirteen pooled analyses were performed. Many of the benefits that were demonstrated in the individual studies were lost when the data were pooled. No significant benefit of extracorporeal shock wave therapy over placebo was demonstrated in eleven of the thirteen pooled analyses. Two pooled results favored extracorporeal shock wave therapy. However, this finding was not supported by the results of four other trials that were unable to be pooled. Minimal adverse effects of extracorporeal shock wave therapy were reported. On the basis of a systematic review of the nine placebo-controlled trials, there is strong evidence that extracorporeal shock wave therapy provides little or no benefit in terms of pain and function in patients with lateral elbow pain. There is some evidence, based on one trial, that steroid injection may be more effective than extracorporeal shock wave therapy (Level II).

A prospective, placebo-controlled, double-blinded trial was performed by Placzek et al.³⁴ to evaluate the efficacy of a single injection of botulinum toxin A in the treatment of lateral epicondylitis. Follow-up evaluation was performed at two, six, twelve, and eighteen weeks with use of a novel clinical pain score and with a visual analog pain scale. The strength of the third finger and wrist extension were evaluated, as was grip strength. The clinical findings and subjective general assessment significantly improved for the botulinum toxin A group as compared with the placebo group. No significant difference between the groups was noted in terms of grip strength measures. The results of this study demonstrate the short-term beneficial effect of botulinum toxin A for the treatment of lateral epicondylitis. However, this study does not answer the question of the long-term efficacy of this treatment (Level I).

Distal Biceps

The functional anatomy of the distal biceps tendon and aponeurosis is not well understood. Eames et al.³⁵ performed dissections of the distal biceps tendon and aponeurosis in cadavers. In most specimens, the distal biceps tendon was made up of two distinct parts, each a continuation of the long and short heads of the muscle. In the other specimens, there was interconnection of the short and long heads of the muscle. The tendon insertion on the tuberosity was investigated as an indication of its function. The short head inserted distal to the radial tuberosity, where it acted more as a flexor of the elbow, whereas the long head inserted on the tuberosity away from the axis of rotation of the forearm, where it acted more as a supinator. The bicipital aponeurosis consisted of three layers that completely encircled the ulnar forearm flexor muscles. This study highlights the potential independent function of each portion of the biceps muscle and raises the question of their separate function at the elbow.

Fractures and Dislocations

Distal Part of the Humerus

Complex fractures of the distal part of the humerus can be difficult to characterize on the basis of conventional radio-

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graphic techniques. Doornberg et al.³⁶ evaluated the use of three-dimensional computed tomography reconstructions to improve fracture characterization, classification, and treatment decisions in comparison with plain radiographs and two-dimensional computed tomography. Plain radiographs and two-dimensional computed tomography scans were initially evaluated. Two weeks later, a second evaluation was performed with use of three-dimensional computed tomography reconstructions. Five fracture characteristics were evaluated with each assessment: the presence of a fracture line in the coronal plane; articular comminution; metaphyseal comminution; the presence of separate, entirely articular fragments; and impaction of the articular surface. Fractures were also classified according to the AO/ASIF Comprehensive Classification of Fractures and the classification system of Mehne and Matta. Intraobserver and interobserver reliability of both classification systems was improved with the use of three-dimensional computed tomography reconstructions. Additionally, the level of intraobserver agreement for all fracture characteristics was improved from moderate to substantial. The authors concluded that three-dimensional computed tomography reconstructions were a helpful tool for preoperative planning in cases of distal humeral fractures.

The surgical treatment of complex distal humeral fractures can be complicated by severe comminution, bone loss, and osteopenia. Anatomic plate designs, a better understanding of the biomechanics of these injuries, and the adoption of a principle-based surgical technique have improved the treatment of these injuries. Sanchez-Sotelo et al.³⁷ evaluated a group of patients with complex distal humeral fractures that were fixed with parallel plates. The technical goals of surgery were (1) to maximize fixation in the distal fragments and (2) to gain stability at the supracondylar level through screw fixation in the distal segment. Applying this principle-based approach, the authors were able to obtain union of all but one of the fractures after the initial operation. One patient required bone-grafting to achieve union. Postoperative stiffness requiring contracture release occurred in five patients. Functional range of motion was achieved in most patients, and the final outcome was satisfactory in twenty-seven of thirty-four patients. This study demonstrates the ability to achieve predictable results with use of the principle-based surgical technique (Level IV).

Radial Head

Displaced two-part fractures of the radial head are increasingly treated with open reduction and internal fixation. The natural history of nonoperative treatment of displaced two-part fractures has been poorly understood. Recently, Akesson et al.³⁸ evaluated the results of nonoperative treatment of forty-nine of these fractures at an average of nineteen years. Initial nonoperative treatment included either early mobilization or cast immobilization for an average of two weeks. Six patients required a delayed radial head excision because of an unsatis-

factory primary result. Forty of the forty-nine patients had no subjective complaints, eight were slightly impaired as the result of occasional elbow pain, and one had daily pain. Flexion, extension, and pronation were slightly impaired in the injured elbow as compared with the uninjured elbow. Degenerative changes were noted in 82% of the injured elbows, compared with 21% of the uninjured elbows. The authors concluded that the results of nonoperative treatment were generally satisfactory, especially if a delayed radial head excision is performed in the few cases in which the early outcome is unsatisfactory (Level IV).

Complex Instability

The results of fixation of comminuted radial head fractures with associated injuries have been disappointing. Grewal et al.³⁹ presented the short-term outcomes for a group of patients who were managed with modular metallic radial head replacement for the treatment of comminuted radial head fractures. Associated injuries included isolated dislocation or dislocation associated with a fracture of the coronoid process. The patients demonstrated significant decreases in impairments over time, with the majority of the recovery occurring by six months. There were slight-to-moderate deficits in range of motion and strength on the affected side as compared with the unaffected side. The level of patient satisfaction was high at three months and remained high at two years. All elbow joints remained stable, and no implant-related issues requiring revision occurred. Mild osteoarthritis was seen in five (19%) of the twenty-six patients, and the authors concluded that modular metallic radial head replacement for comminuted radial head fractures with associated injuries is an effective treatment option (Level IV).

Monteggia Fracture-Dislocations

The long-term results of Monteggia fractures are not well documented in the literature. Konrad et al.⁴⁰ performed a retrospective review after an average duration of follow-up of 8.7 years in order to correlate the Bado and Jupiter classifications with long-term results after operative treatment. Satisfactory results were achieved in thirty-four of forty-seven patients. The factors that were correlated with a poor clinical outcome were posterior Monteggia fracture-dislocations (Bado type II), fractures involving the olecranon and coronoid (Jupiter type IIa), fractures of the radial head, coronoid fractures, and complications requiring further surgery.

Stiffness

The intermediate-term results following open contracture release for the treatment of posttraumatic stiffness of the elbow were reported by Sharma and Rymaszewski⁴¹. Surgery involved release of the contracted capsule, removal of any impinging osseous abnormalities (coronoid and olecranon tip osteophytes and osteophytes in the radial and olecranon fossae), and release of intra-articular adhesions as necessary.

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In a series of twenty-five patients, the average arc of motion improved from 55° to 105° at one year after surgery. This improvement was maintained over the follow-up period (mean, 7.8 years). Pain, function, and patient satisfaction were improved in twenty-three of twenty-five patients. The authors demonstrated that the results of open release for posttraumatic stiffness of the elbow are durable at least through the intermediate term.

The functional outcomes following arthroscopic capsular release of the stiff elbow in twenty-two patients were reported by Nguyen et al.⁴². Capsular release and gutter débridement were performed, but the posterior bundle of the medial collateral ligament was not addressed. The average end points of extension and flexion significantly improved to 19° and 141°, respectively. The average improvement in the arc of motion was 38°. All patients had improved elbow function, and most were satisfied with the results of the procedure. The authors believed that the results of arthroscopic débridement and capsulectomy of the stiff elbow are comparable with those described in previous reports on open and arthroscopic treatment (Level IV).

Arthritis

General

Nonoperative treatment of the arthritic elbow should be attempted before operative treatment is considered. Viscosupplementation has been utilized to treat arthritic conditions of the knee. However, its effectiveness in the elbow has not been established. Van Brakel and Eygendaal⁴³ performed a series of three injections of sodium hyaluronate within a four-week period for the treatment of posttraumatic osteoarthritis of the elbow in eighteen patients. Patients were evaluated with regard to pain and function before the initial injection and at three and six months after injection. Viscosupplementation resulted in slight, short-term pain relief and a very limited decrease in activity impairment at evaluation after three months. After six months, no beneficial effects were noted. On the basis of the results of this nonrandomized study, the authors did not recommend viscosupplementation for the treatment of posttraumatic osteoarthritis of the elbow (Level IV).

Total Elbow Arthroplasty

Component fracture following total elbow arthroplasty is an uncommon complication but is difficult to treat. Athwal and Morrey⁴⁴ reviewed the Mayo Clinic experience with this complication. When the bone-cement interface was intact, the implant was cemented into the preserved cement mantle. However, when the bone-cement interface was loose, the implant was recemented into the bone after it was prepared with traditional techniques. The Mayo Elbow Performance Score (MEPS) was satisfactory for thirteen of twenty-one patients at an average of 5.1 years. Outcomes were generally better for patients who were managed with a cement-in-cement revision as compared with those who were managed with traditional

revision methods. Nineteen complications occurred in fourteen patients. Risk factors for component fracture include component notching, component design, and high stresses due to bone deficiency (Level IV).

The presence of an olecranon fracture or nonunion can create technical challenges during total elbow arthroplasty. Marra et al.⁴⁵ reported their experience with these cases. The goal of treatment was to maintain the integrity of the triceps mechanism. During arthroplasty, the olecranon was fixed with a tension band in sixteen elbows, was excised in four, and was sutured in two. A stable fibrous union was present in three patients and was not disrupted at the time of surgery. Union was achieved in nine of eighteen patients in whom fixation of the olecranon fragment was attempted. A stable fibrous union did not appear to affect the final outcome. After an average duration of follow-up of 5.5 years, twenty-one of twenty-five patients had a satisfactory result. There was a significant improvement in the Mayo Elbow Performance Score, from 42 points preoperatively to 86 points postoperatively.

Upcoming Meetings and Events

There are several upcoming courses sponsored by the AAOS or jointly between the AAOS and ASES.

1. Sixth Biennial Combined AAOS/ASES Shoulder and Elbow: Current Techniques and Controversies (Course #3215); April 3 through 6, 2008; Orlando, Florida.
2. AAOS/ASES Arthroscopic Management of Rotator Cuff Disease and Instability (Course #3206); July 18 and 19, 2008; Rosemont, Illinois.
3. AAOS/ASES Management of the Unstable Shoulder: Arthroscopic and Open Repairs (Course #3208); October 3 and 4, 2008; Rosemont, Illinois.
4. AAOS/ASES Shoulder Arthroplasty: Surgical Indications and Techniques (Course #3236); November 21 and 22, 2008; Rosemont, Illinois.
5. AAOS Elbow Reconstruction: Arthroscopy, Instability and Arthroplasty (Course #3213); December 12 and 13, 2008; Rosemont, Illinois.

In addition, the ASES Annual Open Meeting will be held on Specialty Day at the Annual Meeting of the AAOS (March 8, 2008), in San Francisco, California.

Shoulder and Elbow Fellowships

Fellowships in shoulder and elbow surgery continue to gain in popularity. There are currently nineteen shoulder and elbow fellowships available. There is now a formalized match process that includes the majority of the fellowships. The match process allows the fellowship applicants to interview at a number of programs without being pressured to make a choice prior to completing the interview process. Hopefully, all programs can be encouraged to participate in the match process moving forward.

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