SPECIALTY UPDATE What's New in Shoulder and Elbow Surgery

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This annual update on shoulder and elbow surgery is a review of the most pertinent and impactful studies published from January 2012 through December 2012. 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*, *The American Journal of Sports Medicine*, and *Arthroscopy: The Journal of Arthroscopic and Related Surgery*. The level of evidence (when known) is indicated at the end of each review; particular attention should be paid to the Level-I and Level-II studies, as they represent randomized controlled investigations.

Shoulder

General

Regional anesthesia is being used more frequently during operative procedures of the shoulder, both with ambulatory and hospitalized patients. In a prospective study of 1319 patients undergoing arthroscopic shoulder surgery, Singh and colleagues¹ evaluated the safety, efficacy, and patient satisfaction associated with ultrasound-guided interscalene block anesthesia. The interscalene block was deemed successful in 99.6% of cases, with a 2.88% rate of adverse events. At latest follow-up, three patients (0.23%) had permanent sequelae. Overall, 99.06% of patients were satisfied with the block, and 97.8% stated that they would elect to have it again for another procedure.

Rotator Cuff

Impingement Syndrome

The nonoperative treatment of rotator cuff inflammation and pain often includes subacromial injections of corticosteroid or

Specialty Update has been developed in collaboration with the Board of Specialty Societies (BOS) of the American Academy of Orthopaedic Surgeons. other medication. Marder et al.² examined the best approach for subacromial injections. In their prospective randomized study of seventy-five consecutive patients with rotator cuff disease, the accuracy of anterior, lateral, and posterior approaches to the injection was analyzed. Injections contained corticosteroid, anesthetic, and radiopaque contrast, and radiographs were used to determine if the injection was properly located. The accuracy of injection was lower in women than in men. In men, there was no difference in injection accuracy among routes. Overall, the posterior route was significantly less accurate (56% accuracy) compared with the anterior route (84%) and lateral route (92%) (p < 0.006), especially in female patients, in whom a posterior injection was accurate only 38% of the time. The authors concluded that, while any route yields similar accuracy in male patients, the posterior approach is least accurate in women.

While many clinicians advocate the use of corticosteroid injections to relieve subacromial pain, other injections may provide benefit too. Min and colleagues³, in a double-blinded randomized controlled clinical trial, investigated the effects of subacromial injection of 40 mg of triamcinolone (fifteen patients) as compared with the effects of injection of 60 mg of ketorolac (seventeen patients) for the treatment of impingement syndrome. Both groups showed an improvement in their University of California, Los Angeles (UCLA) scores and pain scores at four weeks following injection. However, the patients who received a ketorolac injection demonstrated significantly greater improvement in forward flexion strength and patient satisfaction as compared with the improvement seen in the steroid group (151° versus 134°, respectively; p = 0.03). The authors concluded that while both triamcinolone and ketorolac are effective in the treatment of isolated subacromial impingement, ketorolac appears to have equivalent if not superior efficacy.

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Partial-Thickness Tears

The management of partial-thickness rotator cuff tears remains controversial, with little consensus on the indications for surgery or the optimal repair construct. In a randomized trial of forty-eight patients, Shin⁴ compared two methods of arthroscopic surgical treatment for articular-sided partial tears of the rotator cuff. Forty-eight patients with partial tears involving greater than 50% of the footprint, who had failed nonoperative management, were randomly selected to have a trans-tendon repair, with preservation of the intact bursal fibers or completion of the tear and traditional repair. All patients underwent a standard postoperative rehabilitation program and had a magnetic resonance imaging (MRI) scan six months following surgery to evaluation tendon integrity. Both groups demonstrated significantly improved American Shoulder and Elbow Surgeons (ASES) and Constant scores after repair at a mean follow-up time of thirty-one months. The trans-tendon repair was associated with a slower recovery, greater pain at three months, and lower Constant (57.9 versus 70.8, p = 0.019) and ASES (54.9 versus 64.6, p = 0.037) scores, compared with the tear completion group. In the tear completion cohort there were two retears, as compared with none in the trans-tendon repair group. While both techniques may yield good outcomes, tear completion can enable a faster recovery but may carry the risk of tendon retear (Level-II evidence).

Full-Thickness Tears: Assessment and Imaging

Slabaugh and colleagues⁵ evaluated the reliability of the use of the Goutallier classification of rotator fatty atrophy on magnetic resonance images as compared with its use on computed tomography (CT) images. With use of a survey administered to thirty members of the American Shoulder and Elbow Surgeons, the intraobserver reliability of thirty-five individual magnetic resonance images was analyzed. Two months later, twenty-eight of the thirty surgeons reassessed the images, enabling an assessment of the intraobserver reliability. There was moderate intraobserver reliability (kappa = 0.56) and interobserver reliability (kappa = 0.43) among reviewers. The authors proposed a simplified classification system (grades 0 and 1 combined, and grades 2 and 3 combined), which improved intraobserver (0.70) and interobserver (0.61) reliability (Level-II evidence).

Single-Row Versus Double-Row Arthroscopic Repair

Currently, controversy exists regarding the optimal repair construct for managing rotator cuff tears, including open or arthroscopic repairs, single-row or double-row repairs, and anchors or bone tunnels. The balance of evidence-based medicine with cost containment and outcomes of surgical repair adds further wrinkles to these controversies. Regardless of approach, the goal of rotator cuff surgery remains a healed tendon repair that relieves pain and improves function. A few recent series examined the controversy of single-row or double-

row rotator cuff repairs. Ma and colleagues6 conducted a randomized trial of single-row or double-row arthroscopic repairs of full-thickness rotator cuff tears. Fifty-three patients with >1 cm full-thickness tears were randomized to either single-row (twenty-seven patients) or double-row (twenty-six patients) repair, all performed by a single surgeon. At a mean follow-up of 33.3 months, the UCLA score, the ASES index, and muscle strength were significantly increased in both groups in comparison with the preoperative status, but there was no significant difference between the two groups. At the two-year follow-up, seventeen patients (63%) in the single-row group and twenty patients (77%) in the double-row group had intact repairs on MRI, but this difference was not significant. In larger tears (>3 cm), strength testing was significantly better in the double-row group. The authors concluded that either repair construct may be used in smaller tears, but that in tears >3 cm a double row results in improved shoulder strength (Level-II evidence).

A similar study was performed by Lapner et al.⁷ in a multicenter prospective randomized trial of ninety consecutive arthroscopic rotator cuff repairs in which either a single-row or double-row repair was performed. Subjects were assessed with use of the Western Ontario Rotator Cuff Index (WORC), the Constant scoring system, and the ASES scoring system as well as with MRI or ultrasound imaging to assess healing rates. There were no differences in outcome measures at any time point between the two groups. However, smaller tears and double-row repair was associated with higher healing rates when MRI or ultrasound imaging were used to assess the repair. While double-row repair may yield improved healing, no significant differences in functional or quality-of-life outcomes were observed between single-row and double-row repairs (Level-I evidence).

A systematic review of the literature by DeHaan and colleagues⁸ demonstrated similar results. In this review, the authors evaluated the functional and radiographic outcomes of single-row and double-row rotator cuff repairs in seven Level-I and II studies. A total of 446 patients (226 single-row repairs, 220 double-row repairs) were included in the analysis. Clinical outcome measures (ASES, Constant, and UCLA scores) and radiographic outcomes including retear rates were analyzed. Outcomes were not stratified by tear size. The functional assessments revealed no difference between single-row and double-row rotator cuff repairs for any individual score or weighted average of all scores. The total retear rate was 43.1% for the single-row repair and 27.2% for the double-row repair (p = 0.057). On the basis of their systematic review, the authors concluded that clinical outcomes from single-row or doublerow repair are equivalent but that there may be a trend toward higher retear rates with single-row repair.

Rehabilitation After Arthroscopic Rotator Cuff Repair The controversies surrounding rotator cuff repair are not isolated to repair construct but also include the optimal

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rehabilitation protocol following repair. The traditional approach of early passive shoulder motion following open rotator cuff repair has recently been challenged by delayed motion following arthroscopic repair due to concerns over tendonhealing and retear rates. Two recent series demonstrate that delayed therapy may be safely used following arthroscopic repair of full-thickness tears as significant postoperative stiffness is unlikely. Cuff and Pupello9 performed a prospective, randomized study of sixty-eight patients who underwent arthroscopic repair of a full-thickness supraspinatus tear with use of a transosseous-equivalent construct. One group began passive motion at two days; the other, at six weeks. ASES and Simple Shoulder Test scores were used as outcomes measures. Rotator cuff integrity was assessed with use of ultrasonography. Both groups demonstrated significant improvements in ASES and Simple Shoulder Test scores following repair. There were no differences between the two groups in terms of outcome scores, shoulder motion, or patient satisfaction at one year after the operation. While there was a trend toward better rotator cuff healing rates in the delayed group (91%) compared with the early motion group (85%), this difference was not significant. The authors concluded that delayed shoulder motion for patients with supraspinatus tears after arthroscopic rotator cuff repair with a transosseous equivalent construct can be delayed until six weeks without compromising ultimate shoulder movement.

In another prospective randomized trial of early or delayed shoulder motion therapy, Kim et al.¹⁰ reported similar results. In their prospective randomized trial of 105 arthroscopic rotator cuff repairs, fifty-six patients underwent early mobilization (group 1) and the other forty-nine patients were treated with delayed passive motion exercises for four to five weeks (group 2). There were no significant differences in shoulder motion, analog pain scales, or clinical outcome measures (Constant and ASES scores) between groups at one year. A similar healing rate was also observed between groups (a 12% retear rate in group 1 and an 18% retear rate in group 2 (p = 0.429) (Level-I evidence). These series highlight the fact that delayed therapy may be safely used following arthroscopic repair of full-thickness rotator cuff repairs without concerns of postoperative stiffness.

Biologic Augmentation of Rotator Cuff Repair

The biologic factors of rotator cuff healing have also been an area of recent interest in the literature, with particular attention placed on augmentation of the tendon-bone healing potential with growth factors, mechanical reinforcement, and other methods. Rodeo and colleagues¹¹ evaluated the effect of platelet-rich fibrin matrix (PRFM), a platelet-rich plasma variant that can deliver cytokines, on tendon-healing in a randomized controlled study. Seventy-nine patients undergoing arthroscopic rotator cuff tendon repair were randomized intraoperatively to receive PRFM at the tendon-bone interface (n = 40) or standard repair with no PRFM (n = 39).

Repair techniques and postoperative rehabilitation were the same for both groups. The primary outcome was tendonhealing as seen on ultrasonography completed at six and twelve weeks postoperatively, completed by blinded ultrasonagraphers. Additionally, ASES scores, L'Insalata scores, and strength testing were assessed at one year postoperatively. There were no differences in tendon-to-bone healing between the PRFM and control groups. At the time of final-follow-up, intact repairs were found in twenty-four of thirty-six (67%) remaining patients in the PRFM group and twenty-five of thirty-one (81%) remaining patients in the control group. Logistic regression analysis demonstrated that PRFM was a significant predictor (p = 0.037) of a tendon defect at twelve weeks, with an odds ratio of 5.8. Both groups showed progressive increases in ASES and L'Insalata scores, but no differences were found in outcomes between the groups. The authors concluded that the addition of PRFM to the repair site had no beneficial effect and may have a negative effect on healing (Level-II evidence).

Barber et al.¹² examined the role of an acellular human dermal matrix graft augmentation on the healing of rotator cuff tears and on the outcome of repair in a prospective randomized clinical trial of forty-two patients who underwent arthroscopic repair of two-tendon tears of the rotator cuff. At an average follow-up of two years, the augmented group (twenty-two patients) demonstrated superior outcomes, including with regard to ASES scores (98.9 versus 94.8, p = 0.35) and Constant scores (91.9 versus 85.3, p = 0.008), compared with the outcomes in the unaugmented group (twenty patients). MRI arthrography of repairs at a minimum of one year postoperatively showed 85% rotator cuff integrity in the augmented group compared with 40% integrity in the unaugmented group (p < 0.01). The authors concluded that in two-tendon tears, augmentation of the repair construct with an acellular graft may improve healing and outcomes (Level-II evidence).

Glenohumeral Instability

Arthroscopic Stabilization

The role of surgical repair for the first instance of traumatic anterior shoulder dislocation remains controversial. Chahal and colleagues¹³ performed a systematic review of four studies, comprising 228 patients, that compared anatomic Bankart repair to either rehabilitation or arthroscopic lavage (but no repair). Two studies compared repair to sling immobilization while the other two compared repair to arthroscopic lavage. The risk of recurrent instability after repair was approximately one-fifth the risk following the other forms of treatment (risk ratio, 0.18; 95% confidence interval, 0.10 to 0.33). Western Ontario Shoulder Instability scores were better in the group that had anatomic Bankart repair than they were in the other groups, and anatomic repair improved disease-specific quality of life over a short-term period (two to six years). The authors concluded that the use of anatomic Bankart repair in young THE JOURNAL OF BONE & JOINT SURGERY 'JBJS.ORG VOLUME 95-A · NUMBER 20 · OCTOBER 16, 2013 WHAT'S NEW IN SHOULDER AND ELBOW SURGERY

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patients with first-time shoulder dislocation can lower the rate of recurrent instability over the long term and improve shortterm quality of life (Level-II evidence).

Crall and colleagues¹⁴ evaluated the cost-effectiveness of arthroscopic stabilization for first-time traumatic dislocations as compared with nonoperative treatment. Using a Markov model of 1000 patients over a fifteen-year period, they evaluated six possible scenarios in female and male patients who were fifteen, twenty-five, or thirty-five years of age. After a firsttime traumatic dislocation, patients were treated nonoperatively or with arthroscopic repair. In the nonoperative group there were two outcomes: success (i.e., no recurrence), and recurrence. After operative treatment, four possible outcomes were considered: success, recurrence, infection, and stiffness. To determine outcome probabilities, weighted averages from a comprehensive literature search were used. Costs for each possible event in the model were considered from the payer perspective and were tabulated from Medicare Current Procedural Terminology data, as well as hospital and office billing records. Surgery was more effective in all scenarios and was more cost-effective in fifteen-year-olds (either sex) and in twenty-five-year-old men. After one recurrence, surgery was more effective and less costly in all subgroups. The authors concluded that surgery is a clinically effective and cost-effective treatment for first-time anterior shoulder dislocations (Level-II evidence).

Superior Labrum Anterior Posterior (SLAP) Tears

The diagnosis and optimal management of superior labrum anterior posterior (SLAP) tears remains controversial. Although considered a relatively rare pathologic entity by many surgeons, Weber and colleagues¹⁵ found that the rate of SLAP tears being repaired may be increasing and is greater than the reported incidence of SLAP tears in the literature. In their analysis, they reviewed the surgical rates for SLAP tears that had been reported on the American Board of Orthopaedic Surgery Part II database from 2003 to 2008. They identified 4975 SLAP repairs, representing 9.4% of all shoulder cases. The volume increased to 10.1% in 2008, representing a volume that was three times greater than the reported incidence of SLAP tears. SLAP repairs were most commonly reported by sports medicine specialists (12.4% of cases). Mean age of patients was 36.4 years, with a maximum age of eighty-five years. The authors concluded that the alarming rate of repairs, as well as those performed in middle-age and older patients, warrants education of young orthopaedic surgeons on the recognition and optimal management of symptomatic SLAP lesions (Level-III evidence).

Latarjet Reconstruction for Recurrent Instability

The Latarjet coracoid transfer has gained considerable popularity in the management of the recurrently unstable shoulder with associated glenoid bone deficiency. Ljungquist and colleagues¹⁶ evaluated the relationship between the thickness of the coracoid process and the diameter of the glenoid face in an effort to better define the reconstructive volume of the transferred coracoid in unstable shoulders with glenoid deficiency. In their evaluation of 100 paired scapulae (fifty male, fifty female), the coracoid thickness represents approximately 35% of the glenoid width in normal specimens, thereby indicating that patients with greater than 35% glenoid bone loss may not be optimal candidates for a coracoid transfer.

Glenohumeral Arthritis Subscapularis Management

A variety of techniques of subscapularis tendon takedown during total shoulder arthroplasty are currently utilized, including tenotomy, a subperiosteal release or "peel," and a lesser tuberosity osteotomy. Giuseffi et al.¹⁷ performed a biomechanical study of tenotomy compared with osteotomy in a cadaver model. Using twenty matched paired shoulders from ten cadavers, the shoulders underwent lesser tuberosity osteotomy or subscapularis tenotomy during implantation of uncemented anatomic total shoulder prostheses. Matched pairs were compared, which provided optimal internal control for bone density and musculotendinous strength. The subscapularis tenotomy group showed significantly less cyclic displacement than that seen in the osteotomy group. The maximum load to failure was slightly higher for the osteotomy group but was not significantly different. Failure in the tenotomy group occurred by suture pull-out in all instances. In the osteotomy group, the sutures typically tore through the osteotomized wafer of bone. The authors believe that their results call into question the biomechanical superiority of lesser tuberosity osteotomy repair.

In a prospective, randomized controlled trial of ninetyseven patients, Lapner and colleagues¹⁸ compared tuberosity osteotomy (forty-three patients) to subscapularis peel (fortyfour patients) in anatomic shoulder arthroplasty. Patients and the independent observer who collected the data were blinded to the surgical technique used. All patients underwent a standard postoperative rehabilitation protocol. Subscapularis muscle strength at two years postoperatively revealed no significant difference (p = 0.131) between the groups. Similarly, no significant differences were observed on Western Ontario Osteoarthritis of the Shoulder (WOOS) index scores or ASES scores between the groups at any time point. Two patients in the osteotomy group had radiographic nonunion but were asymptomatic, and no patient required revision for problems related to the subscapularis. On the basis of these results, the authors concluded that neither technique held significant advantages over the other (Level-I evidence).

Infection and Shoulder Arthroplasty

Infection following shoulder arthroplasty remains a rare complication. However, infection following reverse shoulder

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arthroplasty may be higher than with anatomic arthroplasty, in part due to the more common role of the reverse implant in revision arthroplasty. In a multinational, multi-institutional retrospective review by Nowinski et al.¹⁹, infection rates between two cohorts of 501 patients undergoing primary reverse shoulder arthroplasty were analyzed. One group received antibiotic-impregnated cement during humeral implant fixation (236 shoulders), and the other received cement without antibiotics (265 shoulders). Antibiotics were used on the basis of surgeon preference, and multiple types of antibiotic were used. The mean follow-up was thirty-seven months. The authors found a significantly higher rate of infection in the group that did not receive antibiotic cement (3.0% compared with 0%, p < 0.001), leading them to conclude that antibioticimpregnated bone cement is effective in the prevention of postoperative deep infection after primary reverse total shoulder arthroplasty during the short-term follow-up period.

Reverse Shoulder Arthroplasty

Glenoid baseplate fixation and positioning is a critical step of reverse shoulder arthroplasty. Most surgeons agree that the optimal positioning of the baseplate is low on the glenoid face, to minimize the chance of scapular notching. Many surgeons also advocate asymmetric inferior reaming of the glenoid rim to produce an "inferior tilt" to the baseplate to neutralize shear forces. Edwards and colleagues²⁰, in a prospective, randomized trial of fifty-two shoulders undergoing reverse shoulder arthroplasty with use of a classic Grammont-style prosthesis, evaluated the effect of inferior tilt of the baseplate on scapular notching. One group had 10° of inferior tilt on the glenosphere, while the other did not. Radiographic follow-up at one year was performed to determine if there was a difference in the rates of scapular notching. Scapular notching was very common in both groups (75% of the inferior tilt group, and 86% of the control group). There was no significant difference between the groups. It appears that inferior tilt of the glenosphere does not change the high rate of scapular notching in a Grammont-style prosthesis.

Elbow

Distal Biceps Tendon Repair

A distal biceps tendon rupture is often managed with early surgical repair to optimize functional outcome in active patients. Currently, two popular approaches are widely used to repair the ruptured tendon to the radial tuberosity: an anterior single incision with anchors or an EndoButton (Smith & Nephew, Andover, Massachusetts), or an anterior-posterior two-incision technique that makes use of bone tunnels. In a prospective randomized trial of ninety-one patients, Grewal et al.²¹ evaluated the outcome of distal biceps ruptures treated with either a single incision technique that made use of suture anchors (forty-seven patients) or a two-incision technique that made use of transosseous drill holes (forty-four patients). At the two-year follow-up, no difference in outcome with regard to ASES, Disabilities of the Arm, Shoulder and Hand (DASH), or Patient-Rated Elbow Evaluation (PREE) scores was seen between the groups. A 10% increase in isometric flexion strength was observed in the two-incision group (104% versus 94%; p = 0.01), but no increase was seen with regard to supination strength. Further, the single-incision group had a higher rate of transient neurapraxia of the lateral antebrachial cutaneous nerve (40% versus 7%; p < 0.001). On the basis of these results, the authors concluded that the two-incision technique can yield increased flexion strength and a lower prevalence of transient neurapraxia of the lateral antebrachial cutaneous nerve as compared with a single-incision technique that makes use of suture anchors, but subjective outcome was similar between approaches.

Elbow Arthroscopy

Nerve injury remains a rare but potentially devastating complication of elbow arthroscopy. All three major nerves of the arm (median, radial, and ulnar) are at risk, and an understanding of the three-dimensional anatomy of the elbow is critical to protecting these structures during arthroscopic procedures. In a recent cadaveric study, Omid and colleagues²² examined the course of the radial nerve as it relates to arthroscopic anatomy. In their study of twenty-four cadaveric elbows, the radial nerve coursed medial to the capitellum at the level of the joint line anteriorly. Proximal to the joint line, the brachialis muscle lay between the radial nerve and the capsule in all specimens. More distally, however, at the level of the radial neck, the nerve was in direct contact with the anterior aspect of the capsule in eleven of twenty-four specimens (46%). The anatomic study demonstrates that the radial nerve is more medial than previously described, and the authors recommend that any dissection for capsular release of the elbow be performed at or proximal to the level of the radiocapitellar joint to protect the radial nerve.

Total Elbow Arthroplasty

Optimal positioning of the humeral and ulnar components is a critical aspect of successful total elbow arthroplasty. However, in some severe pathologic states, the normal osseous landmarks, such as the flexion-extension axis and the epicondylar axis, may be altered or absent due to bone loss or deformity. In these situations, the humeral anatomy, specifically the flat posterior surface of the humeral cortex proximal to the olecranon fossa, may be utilized as a guide to the appropriate rotation of the humeral component. In an anatomic study, Sabo et al.²³ examined the accuracy of the posterior humeral cortex as a landmark for humeral component rotational orientation. With use of CT scans of fifty cadaveric elbows, the relationship between the flexion-extension axis and the posterior humeral cortical line was determined as it related to the transepicondylar axis. On the average, the posterior humeral cortical line was externally rotated by a

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mean and standard deviation of $14.0^{\circ} \pm 4.2^{\circ}$ relative to the flexion-extension axis. The transepicondylar axis was less externally rotated (mean, $2.8^{\circ} \pm 3.5^{\circ}$) relative to the flexion-extension axis. Although the posterior humeral cortex can be used as a secondary landmark for determination of humeral component position, its position is externally rotated relative to the flexion-extension axis, and the surgeon should be aware of this phenomenon and the potential need for internal rotation correction. This is especially important when there is loss of the primary epicondylar landmarks that enable assessment of the transepicondylar axis.

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