

SPECIALTY UPDATE

WHAT'S NEW IN SHOULDER
AND ELBOW SURGERY

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Sources

The sources for this annual update on shoulder and elbow surgery were presentations and symposia at meetings of the American Shoulder and Elbow Surgeons (October 8 through 11, 2003, and March 13, 2004), the Arthroscopy Association of North America (November 13 through 16, 2003; March 13, 2004; and April 23 through 25, 2004), the Orthopaedic Research Society (March 6 through 9, 2004), the American Academy of Orthopaedic Surgeons (March 9 through 13, 2004), the American Orthopaedic Society for Sports Medicine (March 13, 2004), and the American Orthopaedic Association (June 23 through 26, 2004).

Shoulder*Rotator Cuff*

Basic Science

Zuckerman discussed the early work on cartilage-derived morphogenetic protein-2 (CDMP-2). Rat tendon repairs that had been treated with CDMP-2 were stronger than untreated repairs at four weeks. Dines discussed his initial investigations involving platelet-derived growth factor (PDGF) and insulin-like growth factor-1 (IGF-1). Studies at his laboratory demonstrated that cultured rat fibroblasts could be transduced with the genes from the growth factors and then seeded onto a polymer scaffold and cultured to form tissue-engineered tendon constructs. Fibroblasts apposed to the tissue engineered constructs containing the IGF gene demonstrated up to a ten-fold stimulation of collagen synthesis compared with constructs with the gene. The author stated that he hopes that this research can lead to the development of biologically active patches capable of accelerating and modulating rotator cuff repair.

Kikugawa reported on the effects of synovial tissue and growth factors on rotator cuff healing. A supraspinatus tendon defect was created in forty-eight rats. In half of the rats, the defect was filled with synovial tissue. Compared with the

specimens without synovial tissue-filled defects, specimens with filled defects appeared to be more mature, with more-intense staining for TGF- α and increased production of type-I and type-III procollagen. These findings suggest that synovial tissue plays an important role in modulating tendon-healing and that expression of TGF- α may influence the synovial tissue in this role.

Sprott investigated the potential for reversal of fatty infiltration following rotator cuff repair in a rabbit model. Fifteen rabbits underwent unilateral detachment of the supraspinatus tendon from the greater tuberosity. Six weeks following detachment, five rabbits were killed to halt the fatty infiltration process and ten underwent repair of the rotator cuff followed by unrestricted activity. The ten rabbits in the repair group were killed at six months. At six weeks following detachment, significant fatty infiltration was demonstrated ($p = 0.001$). At six months following repair, the muscle demonstrated no further increase in fat ($p = 0.03$), suggesting that the process of fatty infiltration associated with chronic rotator cuff detachment can be halted, but not reversed, by repair.

Meyer used computerized tomography and both light and electron microscopy to study fatty muscle changes that occur after a rotator cuff tear in a sheep model. Eight sheep underwent unilateral infraspinatus tendon release and delayed repair. Seventy-five weeks after the repair, significant increases in muscle retraction and pennation angle as well as significant muscle-fiber shortening ($p < 0.0001$) were identified. Interstitial fat and fibrous tissue increased from 4% to 46% of the muscle volume. On the basis of geometric modeling, the authors concluded that the fatty tissue may fill spaces created by the combination of retraction, shortening, and changes in pennation angle. These findings contradict current thinking that the fatty changes represent primarily a degenerative process.

Bishop evaluated the changes in muscle fatty infiltration

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WHAT'S NEW IN SHOULDER AND ELBOW SURGERY

and atrophy following rotator cuff repair. Preoperative and postoperative magnetic resonance imaging was used to grade fatty infiltration on a 5-point scale and muscle atrophy on a 4-point scale. Fatty infiltration and muscle atrophy correlated positively with tear size ($p < 0.0001$, $r = 0.712$). Moreover, American Shoulder and Elbow Surgeons (ASES) and Constant scores as well as strength measurements correlated inversely with fatty infiltration and muscle atrophy ($p < 0.03$). Repeat tear was associated with fatty infiltration of the supraspinatus and weakness in forward flexion, and external rotation was most strongly associated with fatty infiltration of the infraspinatus. However, pain relief was independent of the degrees of fatty infiltration and muscle atrophy.

Cohen reported on the inhibitory effects of traditional nonsteroidal anti-inflammatory drugs and cyclooxygenase-2-selective inhibitors on rotator cuff tendon-healing in a rat model. Following rotator cuff detachment and repair, 180 rats were randomly assigned to receive celecoxib, indomethacin, or no drug. Groups of animals were killed at two, four, and eight weeks postoperatively, and the tendons were subjected to biomechanical and histologic evaluation. The author found that load to failure was significantly lower in the indomethacin and celecoxib groups compared with the control group at two, four, and eight weeks. In contrast to both treatment groups, the control group exhibited improved collagen maturity and organization at the tendon-insertion site. The results demonstrate that both traditional nonsteroidal anti-inflammatory drugs and cyclooxygenase-2 inhibitors significantly impair tendon-to-bone healing in the rat rotator cuff.

Tingart evaluated the effect of suture anchor design and bone density on the pullout strength of suture anchors used for rotator cuff repair. The trabecular and cortical bone mineral density was determined for six regions within the greater tuberosity. Metal screw-type and biodegradable hook-type suture anchors were inserted into each region and were cyclically loaded until failure. Metal anchors failed at an average 66% higher load than bioabsorbable anchors did ($p < 0.01$). For both anchor types, failure loads correlated with bone-mineral density and were significantly higher in the proximal tuberosity ($p < 0.01$).

Meier, in a cadaveric model, used digitization to evaluate the effectiveness of various repair techniques in recreating the rotator cuff footprint. The double-row suture anchor technique reproduced 100% of the original rotator cuff footprint, whereas the single-row suture anchor and transosseous suture techniques reproduced 46% and 71%, respectively. The author suggested that recreating the original footprint enhances the tendon-bone interface, which may accelerate healing.

Glousman studied different suture constructs in a cadaveric model of rotator cuff repair. Two simple sutures were significantly stronger than two mattress sutures at 50% failure when tested with cyclic loading. No difference was detected at 100% failure. The author concluded that the greatest influence on the security of rotator cuff repair may be the number of

knots across the repair site. In turn, the number of knots across the repair site can be maximized by increasing the number of suture anchors used and the number of sutures per anchor and by placing the sutures in a simple configuration.

Ma evaluated a novel arthroscopic rotator cuff stitch consisting of a horizontal loop that is tied first, followed by a simple vertical loop that is placed medial to the horizontal loop. This massive cuff, or MaC, stitch was subjected to cyclical loading followed by loading to failure in a sheep infraspinatus tendon model and was compared with other stitches. The simple and horizontal stitches all failed by tissue pullout, whereas the MaC stitch and the modified Mason-Allen stitch failed by a combination of suture breakage and pullout. The MaC stitch provided an ultimate tensile load that was comparable with that of the modified Mason-Allen stitch and three times greater than that of either the simple or horizontal mattress stitch ($p < 0.05$). However, in contrast to the Mason-Allen stitch, the MaC stitch can easily be implemented arthroscopically.

Impingement

Van Glabbeek reported the five-year results of arthroscopic subacromial decompression for fifty-two patients who were evaluated with use of ASES and Constant scores. The average Constant score improved from 76 to 85 points postoperatively ($p < 0.001$). The ASES score improved from 76 to 86 points, and the ASES score for pain improved from 2.8 to 1.2 points. These findings suggested that most patients had durable improvement and pain relief.

Chin reported the results of open anterior acromioplasty for the treatment of impingement after a minimum duration of follow-up of twenty-one years. Of the sixty-five patients who had been managed between 1975 and 1979, twenty-five were deceased. Of the remaining forty patients, thirty-five patients (thirty-six shoulders) were available for follow-up. The mean elevation was 168° on the involved side, compared with 171° on the untreated side. Overall patient satisfaction, as rated on a 10-point scale, improved from 2.3 to 7 points. The mean Simple Shoulder Test (SST) scores were 8.9 and 9.2 points for the treated and untreated sides, respectively, and the mean ASES scores were 75 and 93 points, respectively. Only three of thirty-six were subsequently revised, and the author concluded that the open acromioplasty is a durable procedure with a relatively low reoperation rate.

Partial-Thickness Tears

Duralde reported on a series of twenty-four patients with high-grade (>50% thickness) articular-sided rotator cuff tears that were treated with acromioplasty and an all-arthroscopic repair without takedown of the intact bursal surface. All patients had had a failure of conservative treatment preoperatively. Additional procedures included distal clavicular excision in thirteen patients, biceps tenotomy in two, and superior labral anterior-posterior (SLAP) lesion repair in

WHAT'S NEW IN SHOULDER AND ELBOW SURGERY

three. After a minimum duration of follow-up of twelve months, the mean ASES score improved from 48 to 87 points and a good or excellent result was reported for twenty-two patients, all of whom were satisfied with the result. The author suggested that this technique is superior to débridement alone and is associated with lower morbidity than is open repair and/or takedown of normal cuff tissue.

Deutsch reported the results of arthroscopic repair of high-grade partial-thickness rotator cuff tears in a study of forty-one patients with a mean age of forty-nine years. Thirty-three patients had an articular-side tear. Repair consisted of acromioplasty (in all patients but two), débridement of degenerative cuff tissue, completion of the tear to full thickness, and reattachment of tendon to bone with use of suture anchors and simple stitches. After a minimum duration of follow-up of twelve months, significant improvements were noted in terms of the mean ASES score (which increased from 42 to 91 points; $p < 0.001$) and the mean pain score (which decreased from 6.5 to 0.8 points; $p < 0.001$). All patients but one were satisfied with the outcome.

Full-Thickness Tears

McCallister reviewed the results of primary open rotator cuff repair, performed through a deltoid split and without acromioplasty, for sixty-one patients with a minimum duration of follow-up of two years. The proportion of shoulders able to perform each of the twelve functions on the Simple Shoulder Test was significantly improved at the time of follow-up ($p < 0.0002$). Improvement in shoulder function was best for shoulders with single-tendon tears (mean improvement, 4.9 functions) and worst for those with three-tendon tears (mean improvement, 3.3 functions). Significant improvements in shoulder function were achieved following rotator cuff repair without acromioplasty with use of a technique similar to that used by Codman seventy years ago.

Gartsman performed a prospective, randomized study of 100 patients with full-thickness supraspinatus tears undergoing arthroscopic repair. One group was managed with acromioplasty and the other was not. At the time of the one-year follow-up, both groups showed nearly identical improvement in the ASES score. The author concluded that arthroscopic subacromial decompression for a type-2 acromion does not appear to change the functional outcome after arthroscopic rotator cuff repair.

Bishop evaluated rotator cuff integrity following both arthroscopic and open rotator cuff repair. Forty patients who had been managed with arthroscopic rotator cuff repair by a single surgeon were followed clinically and with use of magnetic resonance imaging, performed after a minimum duration of follow-up of twelve months. These patients were compared with an earlier group of thirty patients who had been managed with open rotator cuff repair by the same surgeon and followed in a similar fashion. Both groups demonstrated significant functional improvement at the time of

follow-up. Magnetic resonance imaging revealed that 69% of the open repairs and 53% of the arthroscopic repairs were intact. The integrity of the repair was significantly associated with tear size: 74% of the open repairs and 84% of the arthroscopic repairs were intact among shoulders with tears measuring < 3 cm in size, compared with 62% and 24%, respectively, among shoulders with tears measuring > 3 cm in size. Patients with an intact cuff following arthroscopic repair demonstrated greater strength and a significantly higher ASES score.

In the report by Boileau, computerized tomography-arthrography demonstrated complete healing of the supraspinatus tendon in twenty-nine (73%) of forty shoulders after arthroscopic rotator cuff repair. The supraspinatus did not heal to the tuberosity in eight cases, but the remaining tear was smaller than the initial tear in all cases but one. Furthermore, the mean Constant score improved from 52 to 80 points after a minimum duration of follow-up of twelve months and all but four patients reported that they were satisfied with the result. The author concluded that the results of arthroscopic repair of isolated supraspinatus tears appear to be comparable to those of open repair.

Weber reported the results of 126 arthroscopic and 154 mini-open rotator cuff repairs after a mean duration of follow-up of eighty-four and ninety-six months, respectively. In the mini-open group, two manipulations and three reoperations were performed because of the failure of the repair. In the arthroscopic group, two repairs failed shortly after surgery and two failed later. The overall reoperation rate was 3% in the mini-open group and 4% in the arthroscopic group. The final results, as measured with use of the ASES, UCLA, and SST scores, were not significantly different between the two groups, with the numbers available. The author noted that although the long-term anatomic results associated with the two techniques remain unknown, the clinical results remain comparable.

Sperling reported on the long-term results of rotator cuff repair in patients fifty years of age and younger. Significant pain relief was documented after a minimum duration of follow-up of thirteen years ($p < 0.0001$), but no significant improvements were noted in terms of active abduction or external rotation motion. Thirteen of twenty-nine shoulders that were available for evaluation had an unsatisfactory result, and seven shoulders had undergone additional surgery. Three of five revisions that were performed for the treatment of a recurrent rotator cuff tear were done ten years or more after the initial repair. The author concluded that although pain relief following rotator cuff repair is durable, long-term improvement in active motion is lacking. Furthermore, many younger patients remain dissatisfied, perhaps because of persistent high demands and expectations.

Malcarney presented the early results of rotator cuff repair performed with use of a porcine small intestine submucosa implant, which is an acellular, resorbable scaffold that allows for host-cell proliferation. Of the twenty-five patients

WHAT'S NEW IN SHOULDER AND ELBOW SURGERY

who underwent the procedure, four presented with an overt inflammatory reaction at an average of seventeen days postoperatively. At the time of surgical débridement, the implant was not visible and copious amounts of mucinous material communicated between the subacromial space and the glenohumeral joint. Histological analysis revealed inflamed granulation tissue, and neither cultures nor serological testing demonstrated infection. The author recommended caution in the use of these implants and suggested that the failure rate of 16% warranted additional study.

Subscapularis Tears

Edwards presented the results of isolated open repair of subscapularis tears in a study of eighty-four shoulders that were followed for a minimum of two years. Fifty-seven tears were traumatic, and twenty-seven were degenerative. The average interval between the onset of symptoms and surgery was thirteen months. Twenty-three tears involved the upper one-third of the subscapularis, forty-one involved the upper two-thirds of the subscapularis, and twenty were complete subscapularis tears. Fifty-four shoulders had an associated subluxation or dislocation of the long head of the biceps tendon, and ten shoulders had a rupture of the biceps tendon. After a mean duration of follow-up of forty-five months, the mean Constant score had increased significantly from 55 to 80 points ($p < 0.0001$) and seventy-five patients were satisfied or very satisfied. Tenodesis or tenotomy of the biceps tendon, performed in sixty-one shoulders, was associated with an improved outcome, suggesting that one of these procedures should be employed concurrently with subscapularis repair.

Irreparable Tears

Walch reported the results of arthroscopic tenotomy of the long head of the biceps for the treatment of rotator cuff tears in a study of older adults and patients with irreparable tears. Three hundred and seven arthroscopic biceps tenotomies, performed in patients with a mean age of sixty-four years, were evaluated after a mean duration of follow-up of fifty-seven months. The average Constant score increased significantly from 48 to 68 points ($p < 0.0001$), and 87% of the patients were satisfied or very satisfied with the result. During the follow-up period, nine patients underwent additional surgery, the acromiohumeral distance decreased by a mean of 1.3 mm, and the prevalence of glenohumeral arthritis nearly doubled. Tear size and fatty infiltration of the cuff musculature significantly influenced both the functional and the radiographic outcome ($p < 0.0001$). The author concluded that while arthroscopic biceps tenotomy yielded good functional results, it did not alter the progressive radiographic changes associated with chronic rotator cuff tears.

Tendon Transfers

Celli reported the long-term results of teres major transfer for the treatment of irreparable supraspinatus and infraspinatus

rotator cuff tears in a study of twenty patients. The mean age of the patients at the time of the procedure was sixty-one years, and the mean duration of follow-up was thirty-five months. The Constant score improved from 32 to 67 points, and pain relief was satisfactory. Mobility improved from a mean of 90° of active flexion and 7° of active external rotation preoperatively to 147° and 27°, respectively.

Gerber found no difference in outcome between patients managed with pectoralis major tendon transfer for the treatment of irreparable subscapularis tendon tears and patients managed with additional teres major tendon transfer, despite preliminary biomechanical data from a cadaveric study demonstrating that the line of action of the teres major is similar to that of the subscapularis.

Biceps Tendon

Kauffman reported the results of an arthroscopic biceps tenodesis that involved suturing the tenotomized biceps to the rotator cuff and transverse humeral ligament without the use of suture anchors or interference screws. Thirty-seven patients underwent this procedure combined with acromioplasty. In thirty-four patients with an associated rotator cuff tear, the suture that was used was from a suture anchor so that the tenodesis was incorporated into the rotator cuff repair. At the time of the final follow-up, the average UCLA score had improved from 19 to 31 points and the average SST score was 9.4 of 12 points. No patient had development of a serious complication, cosmetic deformity, or arm spasm. Rodosky reported on the use of the same technique for arthroscopic biceps tenodesis. After twenty-five months of follow-up, all patients demonstrated arm symmetry with no biceps deformity or complaints of cramping.

Bertone described a similar technique of arthroscopic biceps tenodesis to the subscapularis tendon. That technique differs from the one described above in that the soft-tissue tenodesis is intra-articular. After the biceps tendon is sutured to the subscapularis, it is tenotomized proximally near its origin. The authors reported excellent results, with a nearly normal return of arm strength, at the time of the most recent follow-up in a group of ninety-two patients.

Mihalko studied the effects of posttraumatic or postoperative biceps scarring within the bicipital groove on glenohumeral motion with use of a cadaveric model. Glenohumeral motion was recorded with use of a motion-tracking system before and after tenodesis of the long head of the biceps tendon, performed without release of the intra-articular portion, with the arm in various positions. A significant decrease in passive glenohumeral flexion occurred following tenodesis ($p < 0.005$), irrespective of arm position.

Acromioclavicular Joint

Rodosky used a cadaveric model to study the sequence of coracoclavicular ligament injury during acromioclavicular joint dislocation. A materials-testing machine was used to displace

WHAT'S NEW IN SHOULDER AND ELBOW SURGERY

the clavicle superiorly until failure of the coracoclavicular ligaments occurred, and the injury pattern was determined with use of visual inspection and video analysis. In all specimens, failure through the midsubstance of the conoid ligament was followed by failure of the trapezoid ligament at its clavicular insertion. Overall, the coracoclavicular ligament injury propagated in an inferomedial-to-superolateral direction. The findings of the study suggested that disruption of the acromioclavicular ligaments and conoid ligament may occur without disruption of the trapezoid, corresponding to a type-II injury with partial coracoclavicular ligament disruption.

Lee employed a cadaveric model to determine the forces across the coracoclavicular ligaments with the arm in various positions. A suture placed around the coracoid and through the clavicle was attached to a transducer that measured forces continuously as glenohumeral joint position was varied. The study demonstrated that shoulder extension produced forces across the coracoclavicular ligaments that exceeded the ultimate tensile strength of a Weaver-Dunn reconstruction. Placement of the arm in internal and external rotation produced lower forces approaching those obtained by placing the arm in a sling.

Glenohumeral Instability

Basic Science

Alberta arthroscopically performed a 10-mm anterior-inferior capsular plication in a cadaver and measured the changes in capsulolabral depth and glenohumeral kinematics. The plication increased the depth of the capsulolabral bumper from 3 to 6 mm ($p < 0.001$) and caused a 12° loss of external rotation ($p < 0.05$) as well as a decrease in anterior and posterior humeral head translation. Moreover, plication shifted the humeral head posteriorly and inferiorly throughout the arc of motion, underscoring the need to attend to the amount of tissue included in the plication.

Mihata investigated the association of SLAP lesions with shoulder laxity in a study of six cadaveric shoulders. First, the shoulders were stretched beyond maximum external rotation at 60° of glenohumeral abduction to detach the superior labrum. Next, the SLAP lesions that had been created were repaired arthroscopically with use of two suture anchors that were placed anterior and posterior to the biceps anchor. After stretching of the shoulder, both anterior and inferior translation increased. After repair of the SLAP lesion, external rotation and glenohumeral translation diminished slightly, but only with the arm in certain positions. The author concluded that SLAP lesions associated with anterior capsular laxity result in increased external rotation and glenohumeral translation. Because the increased translation persists following isolated SLAP repair, addressing capsular laxity concurrently may be necessary. The same group of investigators also reported the results of a similar study in which type-II SLAP lesions were created surgically without capsular stretching. Subtle increases in external rotation, range of motion, and gle-

nohumeral translation were noted following the creation of these tears. Subsequent repair of these lesions with use of two suture anchors restored normal glenohumeral rotation and translation.

Kelly evaluated the healing response following capsular plication in an ovine shoulder model. Twenty-six animals were randomized to undergo either capsular plication, performed without capsular disruption to simulate an arthroscopic procedure, or open shift. At six weeks, the animals were killed for analysis of both operatively and nonoperatively treated limbs. Capsular healing responses were evaluated histologically through an assessment of fibrosis, granuloma formation, and vascularity. The investigator noted no difference between the two groups on the basis of these criteria, and both the capsular plication and the open shift groups demonstrated healing by fibrosis.

Anterior Instability

Itoi presented an interim report regarding an ongoing prospective, multicenter study on immobilization in external rotation after dislocation of the shoulder. Ninety-six patients were randomized to immobilization of the shoulder in either internal rotation or external rotation for three weeks, followed by routine rehabilitation and return to normal use. With the exclusion of patients with associated humeral fractures and patients who had not had immobilization within three days after the injury, eighty patients (including sixteen patients with recurrent dislocations) were available for analysis. The overall recurrence rate was twelve (30%) of forty in the internal rotation group and four (10%) of forty in the external rotation group ($p < 0.05$). Among patients younger than twenty-nine years old, the recurrence rate was 37% in the internal rotation group and 11% in the external rotation group ($p < 0.05$).

Warner reported the results of arthroscopic Bankart repair performed with use of a knotless anchor. Thirty-six patients with traumatic anterior shoulder instability and a mean age of thirty-four years underwent repair of the Bankart lesion and capsular tensioning with one standard suture anchor that was placed inferiorly at the five o'clock position and two knotless suture anchors that were placed at the four and three o'clock positions. After an average duration of follow-up of thirty-seven months, the average ASES score improved from 40 to 83 points ($p < 0.001$) and the average pain score improved from 6.9 to 1.7 points. Thirty-two patients had a good or excellent result, and twenty-seven returned to their preinjury level of sporting activity. Two patients required arthroscopic capsular release because of stiffness, and four patients had recurrent instability following reinjury. Three of the four patients with recurrent instability required revision.

Gill, in a study of twelve patients, presented the results of glenoid reconstruction with use of a tricortical iliac-crest bone graft for the treatment of recurrent posttraumatic anterior shoulder dislocation associated with substantial glenoid

WHAT'S NEW IN SHOULDER AND ELBOW SURGERY

bone loss that precluded soft-tissue reconstruction. The mean age of the patients was thirty-five years, and eight patients had undergone an average of nearly two previous operations. In all patients, an intra-articular iliac-crest autograft was fixed with cannulated screws to reestablish the normal glenoid concavity. After a minimum duration of follow-up of twenty-four months, no patient reported recurrent instability and the mean ASES score was 78 points (range, 45 to 100 points). Modest side-to-side motion deficits in flexion, external rotation in abduction, and internal rotation were identified, but all patients stated that they would undergo the procedure again.

In the study by Miniaci, eighteen patients who had had a failed operation for the treatment of instability and a large Hill-Sachs lesion encompassing >25% of the humeral head surface were managed with an irradiated humeral head allograft. After a mean duration of follow-up of fifty months, the mean Constant score was 87 points and the patients reported dramatic pain relief. No patient had recurrent instability, and all patients stated that they would undergo the procedure again. Two patients had partial collapse of the bone graft and required screw removal.

Posterior Instability

Wolf, in a study of forty-eight consecutive shoulders, evaluated the results of open posterior stabilization for the treatment of recurrent posterior glenohumeral instability. Forty-four shoulders in forty-one patients were available for evaluation after 1.8 to 22.5 years of follow-up. Posterior instability recurred in eight shoulders (18%), the mean L'Insalata score was 81 points, and 84% of the patients were satisfied with the current status of the shoulder. No progressive signs of glenohumeral arthritis were observed. An age of more than thirty-seven years and the presence of a chondral defect at the time of stabilization were predictors of poorer satisfaction and lower outcome scores.

Weber retrospectively reviewed the results of both open and arthroscopic procedures for the treatment of recurrent posterior instability. Voluntary instability was a significant risk factor for recurrence in both groups. After a mean duration of follow-up of forty months, the outcomes in both groups were comparable. There were fewer recurrences in the arthroscopic group (prevalence, 10%) than in the open group (prevalence, 18%), but this difference was not significant.

Arciero compared the results of open and arthroscopic stabilization for the treatment of posterior instability in a study of thirty-four shoulders with reverse Bankart or related capsulolabral lesions. Eleven shoulders underwent open stabilization, and twenty-three shoulders underwent arthroscopic repair with use of suture anchors (seventeen shoulders) or bioabsorbable tacks. After a mean duration of follow-up of twenty-seven months, the overall group had mean Rowe and SST scores of 87 and 11 points, respectively. The mean Rowe score was 90 points in the arthroscopic group and 83 points in

the open group, but this difference was not significant, with the numbers available. The authors concluded that the arthroscopic technique involving the use of suture anchors, nonabsorbable suture, and capsular plication mirrors the technical features of the open technique and is associated with comparable outcomes and reduced morbidity.

Multidirectional Instability

Kim reported on the results of arthroscopic capsular and labral reconstruction for the treatment of multidirectional instability. The author described a spectrum of labral lesions, including incomplete labral detachments (both visible and concealed), chondrolabral erosions, and flap tears, along with variable capsular stretching. After a mean duration of follow-up of fifty-one months, twenty-one of the thirty-one patients had an excellent result, nine had a good result, and one had a fair result. Modest deficits in internal and external rotation were noted, but most patients returned nearly to their previous level of activity and only one patient had recurrent instability.

Complications

Five years ago, thermal capsulorrhaphy merited an entire symposium at the American Shoulder and Elbow Surgeons Annual Specialty Day; this year, the only presentations on the subject were about its complications. Park reported the results of revision procedures that had been performed in fourteen patients in whom thermal capsulorrhaphy had failed at a mean of 7.5 months postoperatively. Nine patients had had the index procedure elsewhere. Diagnostic arthroscopy revealed that the capsule was thin in five patients and ablated in one. Furthermore, four of six patients with a previous Bankart repair had a recurrent tear. All patients underwent open stabilization with use of a glenoid-based capsular shift, performed through a subscapularis split. In the one patient who had an ablated capsule, the inferior capsule could be advanced adequately to enable repair without the need for supplemental tissue.

Burkhead reported on five patients (mean age, nineteen years) who had focal osteonecrosis and severe chondrolysis following arthroscopic thermal capsulorrhaphy. All patients underwent arthroscopic capsular release for the treatment of arthrofibrosis; additional procedures included closed manipulation, biologic resurfacing, and glenohumeral arthrodesis. Range of motion remained poor in all patients, and pain relief was incomplete at best. The author observed that the rates of subchondral collapse, deformity, and pain appeared to be much greater than those associated with typical osteonecrosis and concluded that thermal capsulorrhaphy should be avoided.

Watson reported on six young patients who had glenohumeral joint chondrolysis following thermal capsulorrhaphy. The presenting symptoms, which included increased pain, crepitus, and stiffness, were noted at a mean of seven months postoperatively. Arthroscopy revealed global chondrolysis and

WHAT'S NEW IN SHOULDER AND ELBOW SURGERY

extensive arthrofibrosis in two patients. Andrews reported on three teenage throwing athletes who had glenohumeral joint chondrolysis after shoulder arthroscopy. All patients had development of severe glenohumeral joint-space narrowing on radiographs within five months after the index procedure. Two of the three patients had undergone thermal treatment, one for thermal capsulorrhaphy and one for ablation of a labral tear. The pathogenesis of this condition does not appear to be understood, and no specific treatment for glenohumeral chondrolysis has been proposed.

Glenohumeral Arthritis

Basic Science

Spencer, in a cadaveric study, evaluated the effects of humeral component anteversion on stability when the glenoid component is retroverted in order to treat posterior glenoid bone loss as is commonly seen in patients with osteoarthritis. The author found that compensatory humeral component anteversion did not increase the stability of a shoulder replacement with a retroverted glenoid component. Consequently, the glenoid should be reamed eccentrically so that the glenoid component can be placed in anatomic version.

Shapiro also evaluated the effects of glenoid component retroversion on glenohumeral joint forces and joint-contact pressures in a cadaveric model. The glenoid component was implanted both in anatomic version and in 15° of retroversion. Glenohumeral joint forces were measured with use of a load-cell, and glenohumeral joint-contact pressures were measured with use of pressure-sensitive film. Significantly decreased posterior and inferior joint forces ($p < 0.05$) were noted during arm adduction when the glenoid component was implanted in retroversion, suggesting increased load-sharing by the posterior capsule, which may contribute to posterior instability.

Gramstad evaluated the effects of cement pressurization on prosthetic micromotion in a study of five matched pairs of fresh-frozen scapulae that were implanted with a pegged glenoid component. One glenoid component was cemented with thumb-packing, and the other was cemented with sponge pressurization. The components were then loaded centrally, and total micromotion was recorded along the anterior, posterior, and superior edges. The volume of cement that had been injected was found to be significantly greater in the glenoids that had been treated with pressurization ($p < 0.05$). In addition, cement pressurization decreased total prosthetic micromotion by an average of 31% for all loading positions, suggesting that implant stability can be improved by cement pressurization.

Nonprosthetic Treatment

Glenoid resurfacing with use of nonprosthetic techniques is slowly gaining popularity. The use of a meniscal allograft has recently been championed because of evidence of synovial-based healing and improved structural characteristics com-

pared with alternatives such as Achilles tendon or fascia lata. In addition, a wedge-shaped graft can be used to compensate for glenoid wear. Wirth described a glenoid resurfacing procedure in which meniscal allograft interposition is performed with use of a parachute technique similar to that used during heart valve surgery. The meniscal tissue is fashioned into an oval, is sutured directly over the prepared glenoid with use of sutures passed from the glenoid, and then is transported down those sutures until it rests on the glenoid. Six patients were evaluated at a mean of twenty-three months after hemiarthroplasty and glenoid resurfacing. Significant improvements were noted in the visual analog scores for pain, function, and quality of life, and radiographs demonstrated improvement in the glenohumeral joint space.

Krishnan reported on the treatment of cuff-tear arthropathy involving conventional hemiarthroplasty coupled with biologic resurfacing of the glenoid and the undersurface of the acromion with use of an Achilles tendon allograft or a fascia lata autograft. Fourteen patients with a mean age of seventy years underwent this procedure and were followed for an average of three years. Pain relief was reliable, and the mean active forward elevation improved from 35° to 95°. According to Neer's limited goals criteria, ten results were rated as excellent, three were rated as good, and one was rated as fair. These results compare favorably with the results of other treatments for cuff-tear arthropathy.

Basmania reported on pressure localization and core decompression for the treatment of humeral head osteonecrosis. The author hypothesized that foci of osteonecrosis could be identified intraoperatively with use of intramedullary pressure monitoring. Twelve shoulders in ten patients with stage-II or III osteonecrosis underwent arthroscopy followed by intramedullary pressure measurements with use of a biopsy needle that was connected to an arterial pressure transducer. The needle was advanced into the area of highest intramedullary pressure under fluoroscopic guidance, and this area was then decompressed with use of a cannulated reamer. All but one patient reported substantial pain relief, with the mean visual analog pain score improving from 9.5 to 1.5 postoperatively.

Conventional Prosthetic Arthroplasty

Kleppe studied radiolucent lines in the glenoid following sixty-nine total shoulder arthroplasties. Radiolucent lines measuring >1 mm were noted in seven of twenty-eight shoulders in which a keeled glenoid component had been cemented with use of a manual packing technique, compared with one of sixteen shoulders in which a keeled component had been cemented with use of instrumented pressurization techniques. None of the twenty-five shoulders in which a pegged glenoid component had been inserted with use of instrumented pressurization techniques demonstrated radiolucent lines measuring >1 mm.

Levine reported the long-term results of total shoulder arthroplasty for the treatment of primary osteoarthritis in a

WHAT'S NEW IN SHOULDER AND ELBOW SURGERY

study of twenty-eight patients who had a mean age of sixty-one years. All procedures had been performed between 1982 and 1992 with use of a first-generation implant (Neer II). Eleven patients died and three were lost to follow-up, leaving fourteen patients (fifteen shoulders) available for evaluation at a mean of 13.2 years after the arthroplasty. The implant survival rate was 87%, the mean ASES score was 87 points, and eleven shoulders were rated as excellent according to Neer's criteria. All patients were satisfied with the result and stated that they would undergo the procedure again. Two shoulders were revised because of late glenoid loosening, and one was revised because of posterior instability in the early postoperative period.

Maale reported on thirteen patients (mean age, sixty-six years) in whom septic arthritis of the shoulder was treated with use of delayed-exchange arthroplasty. In seven patients, the septic arthritis had developed postoperatively. All patients were managed with débridement, exchange hemiarthroplasty with antibiotic-impregnated cement, and long-term antibiotic therapy. All patients but one underwent a two-stage exchange. Seven patients underwent additional grafting for soft-tissue coverage, and two patients required a proximal humeral allograft. After a mean duration of follow-up of six years, the mean forward elevation was 86° and the mean abduction was 74°. Overall, seven patients were very satisfied and two patients were satisfied. Infection recurred in one patient, nearly seven years after hemiarthroplasty.

Rockwood reported on eighty-eight patients with cuff-tear arthropathy in whom a hemiarthroplasty had been performed with use of a prosthesis that was designed to replace both the greater tuberosity and the humeral head in order to enable a smooth articulation with the acromial undersurface. After a minimum duration of follow-up of sixteen months, the mean forward elevation improved from 65° to 128° and eighty-one patients rated the result as good or excellent.

Constrained Prosthetic Arthroplasty

Frankle evaluated the results associated with the use of a reverse ball-and-socket prosthesis and compared them with the results of conventional hemiarthroplasty for the treatment of cuff-tear arthropathy. The reverse-prosthesis group included twenty-six patients (thirty shoulders) who had undergone the index procedure at a mean age of seventy-four years. The historical control group included seventeen patients (twenty-one shoulders) in whom the index procedure had been performed at a mean age of seventy-eight years. All procedures had been performed by the author. The mean duration of follow-up was thirty-one months in the reverse-prosthesis group and seventy-three months in the hemiarthroplasty group. Patients in the reverse-prosthesis group had significant improvement in the ASES pain score (from 17 to 39 points; $p < 0.05$), in the total ASES score (from 34 to 70 points; $p < 0.05$), and in the arc of forward flexion (from 71° to 121°; $p < 0.05$). Patients in the hemiarthroplasty group had improvement in the ASES pain

score (from 11 to 26 points) but had no improvements in active motion or function. Moreover, six patients in the hemiarthroplasty group had development of severe pain that necessitated revision to a reverse prosthesis at a mean of forty months postoperatively.

Gilbart reported on a series of 113 shoulders that were treated with implantation of a reverse ball-and-socket prosthesis; 64% of the procedures were revisions. Overall, thirty-nine patients experienced at least one complication, including hematoma and dislocation, and thirteen patients (12%) underwent subsequent revision of the prosthesis.

Complications and Revisions

Cascio studied discharge data from all hospitals in the state of Maryland over a seven-year period in order to compare shoulder arthroplasty with hip and knee arthroplasty in terms of in-hospital morbidity, mortality, and economic impact. After 15,414 hip arthroplasties, 34,471 knee arthroplasties, and 994 shoulder arthroplasties, there had been twenty-seven, fifty-four, and zero deaths, respectively. Shoulder arthroplasties were one-sixth as likely as hip or knee arthroplasties to be followed by a hospital stay of more than six days and one-tenth as likely to be associated with hospital charges exceeding \$15,000. The risk of at least one complication following shoulder arthroplasty was one-half that following hip or knee arthroplasty. The author concluded that shoulder arthroplasty is as safe as, or safer than, other commonly performed major joint arthroplasties.

Martin retrospectively evaluated the clinical and radiographic results of revision shoulder arthroplasty. The modes of failure of primary total shoulder arthroplasty included aseptic loosening in fifty-nine shoulders, polyethylene wear in eight, periprosthetic fracture in two, and glenoid tray fracture in two. Twelve shoulders required glenoid bone-grafting, and five required a bulk allograft of the humerus. Twenty-one shoulders had revision to a hemiarthroplasty, four had revision of the humeral stem, and forty-six had revision of both the stem and the glenoid component. After a mean duration of follow-up of 7.8 years, the mean ASES score had improved from 18 to 59 points. Pain was minimal or absent in thirty-seven shoulders, mild in fifteen, moderate in thirteen, and severe in six. Patients who had undergone glenoid reimplantation had better pain relief than patients who had not, but function was comparable in both groups. The overall complication rate was 41%, compared with 14% following primary total shoulder arthroplasty. Complications included subscapularis rupture (six shoulders), chronic anterior instability (three), and deep infection (two); in addition, four shoulders required a second revision.

Topolski reported on the outcomes of seventy-five revision shoulder arthroplasties in patients with positive intraoperative cultures. Routine blood tests (determination of the white blood-cell count and the erythrocyte sedimentation rate) often had revealed normal findings in these patients pre-

WHAT'S NEW IN SHOULDER AND ELBOW SURGERY

operatively. Sixty-seven of seventy-three histologic evaluations revealed negative findings. The most common pathogen was *Propionibacterium acnes*, which grew on culture of specimens obtained from forty-five of seventy-five patients. Ten shoulders required subsequent surgery in order to improve comfort or function. The remaining patients received either intravenous antibiotic therapy followed by oral therapy, oral therapy alone, or no further treatment.

Sperling reported on periprosthetic fractures following shoulder arthroplasty. Among 3091 patients who had undergone shoulder arthroplasty at the Mayo Clinic, nineteen sustained a periprosthetic fracture at an average of forty-nine months postoperatively. Twelve fractures were centered at the tip of the prosthesis, and six of these fractures extended proximally. Overall, six fractures healed after an average of six months of nonoperative treatment. Ten fractures required surgery, but five of these fractures had failed to heal after an average of four months of nonoperative treatment before surgery. All fractures eventually went on to eventual union, but one patient required multiple operations, including a free fibular transfer. The author concluded that fractures distal to the tip of the prosthesis can be treated conservatively but that fractures at or proximal to the tip of the prosthesis require surgery, including the use of autogenous bone graft.

Adhesive Capsulitis

Unterhauser reported on the detection of myofibroblasts in patients with adhesive capsulitis. Tissue samples were taken from the posterior capsule of five patients with idiopathic adhesive capsulitis and five asymptomatic individuals. Sections were stained with anti-alpha-smooth muscle actin to determine the expression of myofibroblasts. Overall, the expression of myofibroblasts was significantly higher in the study group than in the control group ($p < 0.001$), suggesting a tenfold upregulation. The total cell count and the vessel cross-sectional area were also higher in the study group. The study demonstrated that adhesive capsulitis is an intense inflammatory process and that myofibroblasts may play an important role in the contraction of the joint capsule and subsequent loss of motion. Because certain agents are known to suppress myofibroblast expression, it is thought that these cells may become a target of therapeutic modalities in the future.

Fractures

Proximal Humeral Fractures

Gerber described a new method for obtaining correct prosthetic height during replacement surgery for the treatment of comminuted proximal humeral fractures. The method involves using the distance from the edge of the pectoralis major tendon to the top of the humeral head. Normative values for the pectoralis-to-head height were determined by using three-dimensional digitization to analyze fifty cadaveric proximal humeral specimens in which the pectoralis major tendon had been dissected. The mean value was then used clinically to

guide intraoperative positioning of the humeral prosthesis in the treatment of seven fractures. The average difference in length between the reconstructed humerus and the contralateral humerus was only 4 mm, suggesting that this measure is practical and reliable.

Clavicular Fractures

Arrington reported on the use of Hagie pin fixation for the repair of acute, displaced, middle-third fractures of the shaft of the clavicle in a study of thirty-seven patients. The mechanism of injury was military or athletic training or a fall from a height in all patients but two. All fractures healed after surgery, and the pins were removed at a mean of fourteen weeks. After a minimum duration of follow-up of twelve months, all patients had returned to their preinjury level of function.

McKee examined the influence of time to repair on patient-reported outcomes following open reduction and internal fixation of clavicular fracture nonunions. The study population comprised thirty-eight patients who underwent operative treatment of a clavicular nonunion at a mean of 1.8 years after the fracture. All patients underwent plate fixation, and 64% of the patients had adjunctive iliac-crest bone-grafting. Thirty-six of the thirty-eight fractures healed. The mean DASH score was 12.5 of 100 points (with 100 points indicating complete disability), and the SF-36 scores were within the range for normal controls. There was no significant difference in the DASH or SF-36 scores between patients who had had fixation within six months after the fracture and those who had had fixation afterward. The author concluded that patient satisfaction following repair for clavicular nonunion was high, irrespective of time to repair.

McKee also reported on objectively measured strength deficits in a study of twenty-five patients who had had a mean of fifty-four months of conservative treatment of a midshaft clavicular fracture. The strength of the injured shoulder ranged from 66% to 86% of that of the uninjured shoulder in terms of peak and endurance flexion, abduction, and rotation. Patients with >2 cm of shortening had significantly worse DASH scores than did those with less shortening. The study demonstrated notable residual deficits in shoulder strength and function following conservative treatment of displaced midshaft clavicular fractures, especially those that heal with considerable shortening.

Neurologic Injuries

Caltoun presented the results of surgical treatment of an isolated complete axillary nerve lesion in a study of ten patients. Seven patients underwent sural nerve-grafting with use of two cable grafts, and three patients underwent scar decompression and neurolysis. The mean interval between the injury and surgery was six months. The mean arc of forward flexion improved from 8° preoperatively to 120° postoperatively, and the mean arc of abduction improved from 50° preoperatively to 110° postoperatively. The mean postoperative ASES score was

WHAT'S NEW IN SHOULDER AND ELBOW SURGERY

75 points, and the mean abduction strength improved to grade 3. The author concluded that significant improvement in activities of daily living and satisfactory ASES scores can be achieved when surgery is performed within the first three to six months after the injury.

Miscellaneous

Williams described the arthroscopic treatment of internal rotation contractures in children with residual brachial plexus birth palsy. Arthroscopic release of the contracted rotator interval, and anterior and inferior capsule, allowed reduction of the dysplastic glenohumeral joint. Preoperative and postoperative magnetic resonance imaging revealed improvements in humeral head position, glenoid version, and glenohumeral joint congruency.

Westerheide reported the results of arthroscopic treatment of spinoglenoid ganglion cysts causing suprascapular nerve palsy. Fourteen patients were evaluated at a mean of fifty-one months after arthroscopic cyst decompression and labral repair or débridement. The mean SST score was 11.5 points, and the mean Constant-Murley score was 94 points. No recurrences or complications were noted. Twelve patients rated their activity level as at or above the preoperative level, and all patients reported that their overall level of satisfaction was excellent.

Schneeberger reported on his experience with ten patients in whom a low-grade infection was identified as an unusual cause of pain following shoulder surgery. All patients were afebrile and had normal findings on C-reactive protein studies. Biopsy was required for diagnosis. Seven of the ten patients had a positive culture for *Propionibacterium acnes*. Treatment consisted of six to nine months of oral antibiotic therapy. Nine of the ten patients continued to have moderate to severe pain and were considered to have an unsatisfactory outcome.

Yian investigated normal values for the Constant score by computing the score for 1620 patients who were seen in the clinic over an eight-year period. Male patients achieved higher Constant scores than female patients did, and an age-related decline in the Constant score was noted among patients who were more than forty years of age. Women who were more than forty years old and men who were more than sixty years old had higher Constant scores than the normal values established by Constant in 1986. Consequently, age-adjusted scores with use of Constant's normative data may overestimate shoulder function in women who are more than forty years old and in men who are more than sixty years old.

Elbow

Instability

Basic Science

Alcid investigated the effects of olecranon resection on elbow laxity and medial collateral ligament strain. A three-dimensional digitizing system was used to measure elbow laxity and

bone-ligament-bone strain in six cadaveric elbows. The amount of olecranon resection did not affect medial collateral ligament strain. Valgus angulation and varus-valgus laxity increased proportionately with the amount of olecranon resection. At 90° of elbow flexion and 3 N-m of applied torque, olecranon resections of 0, 4, and 8 mm produced varus-valgus laxity of 14°, 15°, and 18°, respectively. The author concluded that resections of the medial part of the olecranon for the treatment of posteromedial olecranon impingement in the throwing athlete should be limited to the osteophytes alone.

Murthi investigated the use of a split anconeus fascia transfer to reconstruct the lateral collateral ligament complex of the elbow in a cadaveric model. All specimens had a positive manual pivot shift and varus instability after sectioning of the lateral collateral ligament complex. A strip of anconeus fascia was detached from its origin and was split in line with its fibers down to its ulnar insertion. The superior segment was passed under the annular ligament to reconstruct the proper radial collateral ligament while the inferior segment was used to reconstruct the lateral ulnar collateral ligament. A docking technique was used to secure the fascia to the isometric point on the lateral epicondyle. All specimens had a negative manual pivot shift, stability to varus stress, and a full range of motion following reconstruction. The author concluded that local graft can be used for anatomic reconstruction without the morbidity of tendon harvest, especially when instability arises during surgery.

Beingessner studied the effect of coronoid fractures on elbow joint kinematics and stability in a cadaveric model. Each elbow was tested under various conditions (with the medial collateral ligament intact and deficient, after radial head excision, and after metallic radial head replacement) and under four coronoid states (intact, 10% avulsion, 50% removal, and 80% removal). The study demonstrated decreased elbow stability with increasing coronoid fracture size. When combined with even a small coronoid fracture, radial head excision caused increased varus-valgus laxity. These findings support the fixation of even small coronoid fragments when possible and the need to restore lateral-column stability with use of either a radial head replacement or internal fixation.

Clinical

Van Riet reported on the use of osteochondral bone graft for coronoid reconstruction in a study of ten patients who had chronic posterior elbow subluxation at a mean of eight months after the original injury. All patients had a Regan-Morrey type-II or III coronoid fracture, and eight patients had had at least one previous operation. After a mean duration of follow-up of forty-two months, four patients had little or no pain but two had had a failure because of residual contracture. Five patients had a good or excellent Mayo elbow-performance score, and four patients had complete graft resorption on follow-up radiographs. The author stressed the unpredictable outcome following this salvage procedure.

WHAT'S NEW IN SHOULDER AND ELBOW SURGERY

Ring reported on the treatment of acute traumatic elbow instability without medial collateral ligament repair. Patients underwent repair of ulnar shaft and coronoid fractures, repair or replacement of the radial head, and repair of the lateral collateral ligament complex. Repair of the medial collateral ligament and external fixation was reserved for elbows that remained unstable after these interventions. In all thirty-four patients, the lateral collateral ligament was avulsed from the lateral epicondyle. One patient underwent medial collateral ligament repair because of persistent intraoperative instability, and another underwent revision surgery because of a malpositioned radial implant. After a mean duration of follow-up of twenty-one months, a stable articulation was restored in all patients and the mean flexion-extension arc was 101°. Five patients underwent additional surgery for the treatment of contracture or heterotopic ossification. The author suggested that medial collateral ligament repair is rarely required.

Tendon Injuries**Basic Science**

Mihalko compared the strength of bone tunnel, suture anchor, Endobutton (Smith and Nephew, Andover, Massachusetts), and interference screw repair techniques for the treatment of distal biceps tendon ruptures in a cadaveric model. Native tendon pullout strengths were evaluated with the elbow in both 45° and 90° of flexion, and the subsequent repairs were loaded to tensile failure with the elbow in 90° of flexion. The study demonstrated lower distal biceps tendon pullout strength at 45° of elbow flexion, which correlates with the clinical observation that these injuries commonly occur with the elbow near full extension. The average pullout strength for the repairs ranged from 127 to 269 N, compared with 459 N for the intact state. Bone tunnel repairs and suture anchor repairs demonstrated lower strengths, which the authors attributed to suture abrasion against either cortical bone or the edge of the suture anchor eyelet.

Clinical

Ruland described the use of a biceps squeeze test for the diagnosis of distal biceps tendon injuries in a study of sixty-five otherwise normal patients with a biceps injury. The response to biceps compression was forearm supination. The squeeze test correctly demonstrated the presence or absence of a complete distal biceps tendon rupture in twenty-two of twenty-three extremities with a suspected rupture; thus, the positive predictive value was 95% and the sensitivity was 100%. The biceps squeeze test is a simple and reproducible method for the clinical diagnosis of distal biceps tendon ruptures and is of particular value when magnetic resonance imaging is difficult to obtain.

Ross reported on the use of the flexion initiation test to improve the clinical diagnosis of distal biceps tendon ruptures. The inability to flex against resistance from a fully ex-

tended position, with the wrist supinated, signifies a positive flexion initiation test. Twenty-one consecutive patients with a suspected distal biceps tendon rupture were tested, and the results were confirmed at the time of surgery or with use of magnetic resonance imaging. All but one of the patients were noted to have a positive flexion initiation test; the remaining patient retained the ability to perform the test despite obvious asymmetric weakness.

Dunham studied the efficacy and safety of extracorporeal shock wave therapy for the treatment of chronic lateral epicondylitis in a multicenter, prospective, randomized, placebo-controlled trial involving 225 patients who had had a failure after a minimum of six months of conservative treatment. Patients were unblinded after eight weeks of treatment so that any failures in either the placebo group or the active-treatment group could receive additional treatment and be included in a second-phase open-label study. The success of treatment was defined by the lack of point tenderness on examination, by self-assessment of pain, and by infrequent analgesic use. All criteria for a successful result were met by 41% of the patients in the active-treatment group and by 24% of those in the placebo group. After twelve months of follow-up, the criteria for a successful result were met by 87% of the patients in the active-treatment group as well as by 94% of the patients in the initial placebo group who subsequently crossed over to active treatment.

McCall also explored the use of extracorporeal shock wave therapy in a randomized, double-blind study of 114 patients with a minimum six-month history of lateral epicondylitis. Patients received either three weekly shock wave treatments or a placebo treatment. Of the 114 patients in the study, 108 patients completed the treatment and were followed for as long as twelve weeks. Sixty-one patients completed the one-year follow-up, while thirty-four patients in the placebo group crossed over to receive active treatment and were then followed for twelve weeks. A significant difference in pain reduction was observed at twelve weeks, with 61% of the patients in the active-treatment group and 29% of those in the placebo group showing at least 50% improvement in pain ($p = 0.001$). The improvement was maintained at one year, and functional activity scores, activity-specific evaluation, and overall patient satisfaction improved as well. Crossover patients also showed improvement, with 56% demonstrating at least 50% improvement in pain. The authors concluded that extracorporeal shock wave therapy is effective and represents a viable noninvasive method for the treatment of chronic lateral epicondylitis.

Fractures and Dislocations

Ring characterized coronoid fractures on the basis of specific fragment characteristics and the overall injury pattern rather than on the basis of fragment size. Forty-one surgically repaired coronoid fractures in forty patients were studied. Twenty of twenty-two olecranon fracture-dislocations in-

WHAT'S NEW IN SHOULDER AND ELBOW SURGERY

involved >50% of the coronoid height. In this group of twenty fractures, nine had a single coronoid fragment and an additional eight had three fragments consisting of the anteromedial facet and central and lesser sigmoid notch portions. The presence of an anteromedial fragment often required a medial exposure. All sixteen patients with so-called terrible triad injuries had coronoid fractures involving <50% of the coronoid height along with a lateral collateral ligament injury. Forthman added to this study by reviewing fifty-eight consecutive elbow fracture-dislocations. Anterior olecranon fracture-dislocations were rarely associated with radial head fracture, and only the most high-energy injuries had an associated ligamentous injury. Posterior olecranon fracture-dislocations typically were associated with radial head and coronoid fractures along with lateral collateral ligament avulsions from the lateral epicondyle.

Ring discussed the use of hinged external fixation in a study of thirteen patients who had persistent instability two or more weeks after an elbow fracture-dislocation. Seven patients had a terrible triad injury pattern, and six had a posterior olecranon fracture-dislocation. All patients had sustained a radial head fracture, and ten had sustained a coronoid fracture. The patients were managed with temporary hinged external fixation following coronoid and lateral collateral ligament repair or reconstruction. After an average duration of follow-up of fifty-seven months, the average arc of ulnohumeral motion was 99°. All patients had a stable elbow, the average DASH score was 15 points, and the average Mayo elbow-performance score was 84 points. Ten patients had a good or excellent result. Six patients, including five of the six who had sustained an olecranon fracture-dislocation, had radiographic signs of arthrosis of the elbow.

Ring also reported on the use of dorsal contoured plating for the treatment of loss of alignment following surgery in patients with posterior Monteggia fractures. Seventeen patients with malalignment, twelve of whom had development of associated ulnohumeral subluxation or dislocation, were managed with realignment of the ulna and fixation with a 3.5-mm limited-contact dynamic compression plate that was applied to the dorsum of the ulna and was contoured to wrap around the olecranon process. After an average duration of follow-up of fifty-nine months, the fracture was healed and the ulnohumeral joint was concentrically reduced in all patients. The average arc of elbow motion was 108°, and the average arc of forearm rotation was 134°. The average ASES elbow evaluation score was 87 points, and fourteen patients had a good or excellent result according to the Broberg and Morrey scale.

LaPorte presented the results of semiconstrained total elbow arthroplasty for the treatment of distal humeral nonunion. Twelve patients with a long-standing painful nonunion that initially had been treated with attempts at rigid internal fixation with or without bone-grafting underwent arthroplasty at a mean of twenty-eight months after the injury. At a mean of sixty-three months after the arthroplasty, seven pa-

tients had no pain, four patients had occasional pain with activity, and one patient had pain with infection at the site of the arthroplasty. With the exception of the one patient who had an infection, all patients believed that the procedure had provided excellent pain relief and substantial functional gains. The mean arc of elbow motion was from 18° to 134°. There were four cases of extensor mechanism failure after olecranon osteotomy, supporting the use of a triceps-sparing approach during initial fracture fixation.

Stiffness

Park reported on the open treatment of posttraumatic elbow contracture in a study of forty-seven patients. The operative procedure consisted of partial excision of the olecranon tip and excision of scar tissue followed by gentle manipulation and anterior release with excision of coronoid osteophytes when necessary. Ulnar nerve transposition was performed in twenty-two patients with a tardy ulnar nerve palsy. After a mean duration of follow-up of forty-nine months, extension improved from 35° to 12° and flexion improved from 101° to 123°. Three patients with myositis ossificans and pain had a poor result, but the overall results of open débridement and manipulation appeared to be good.

Mader evaluated the effectiveness of a dynamic external fixator for the treatment of posttraumatic elbow stiffness. Twenty patients with a mean preoperative arc of total motion of 36° were managed with intraoperative distraction followed by a subsequent relaxation phase and then by mobilization under distraction for seven weeks with use of the dynamic external fixator. After a minimum duration of follow-up of five years, there were seven excellent results, twelve good results, and one fair result. The mean arc of total motion was 105°, and the mean Mayo elbow-performance score was 91 points. All but one of the patients had a stable elbow, and two patients had development of moderate ulnohumeral degenerative changes.

Arthritis

Morrey reported on his experience with revision total elbow arthroplasty in the setting of bone deficiency. A variety of techniques were employed, including cancellous impaction grafting, humeral strut-grafting, ulnar strut-grafting, and reconstruction with an allograft-prosthesis composite. Eleven of twelve patients managed with impaction grafting had incorporation of the graft, and ten had a satisfactory result. Ten of twelve patients managed with humeral strut-grafting had incorporation of the graft and a satisfactory clinical result, and eighteen of twenty-two patients managed with ulnar strut-grafting had incorporation of the graft. Two revisions were performed because of implant loosening following strut-grafting. Six of thirteen patients who had undergone reconstruction with use of an allograft-prosthesis composite had a clinical failure, and four of these failures were due to nonunion. Consequently, the author has abandoned the use

WHAT'S NEW IN SHOULDER AND ELBOW SURGERY

of the allograft-prosthesis composite.

In a retrospective review of 887 total elbow arthroplasties, Celli identified sixteen elbows that had required subsequent triceps reconstruction (with exclusion of procedures performed because of infection). The mean interval between the arthroplasty and the triceps reconstruction was thirty-nine months, and the mean duration of follow-up was sixty-six months. The operative procedure consisted of direct tendon-to-bone repair in nine elbows, reconstruction with use of an Achilles tendon allograft in four, and reconstruction with use of an anconeus rotation flap in three. A good or excellent result was reported for fourteen of sixteen elbows.

Arthroscopy

O'Driscoll reported on the arthroscopic release of elbow contractures in a study of twenty-one patients with a loss of terminal extension of $<30^\circ$. The diagnosis underlying the loss of extension was primary osteoarthritis in seventeen patients and posttraumatic contracture in four. After a mean duration of follow-up of twenty-two months, the mean extension had improved from 23° to 5° (range, 0° to 20°) and the mean flexion had improved from 123° to 134° . The functional result was satisfactory in nineteen patients, and thirteen of these patients reported having "a normal elbow."

Steinmann reported on the arthroscopic treatment of primary osteoarthritis of the elbow. Twenty-nine patients underwent arthroscopic loose-body removal, resection of osteophytes, and capsulectomy followed by continuous passive motion for three to six weeks. At the time of the final follow-up, the mean loss of extension improved from 24° to 9° and the mean flexion increased from 116° to 130° . All but two of the patients had little or no pain postoperatively.

Krishnan reported on the use of all-arthroscopic ulnohumeral arthroplasty for the treatment of degenerative arthritis of the elbow in a study of eleven patients who were less than fifty years old. After a mean duration of follow-up of twenty-two months, the mean flexion had improved from 100° to 140° and the mean extension had improved from 40° to 7° . In addition, the mean subjective pain score had improved from 9.2 to 1.7 and the mean patient satisfaction score had improved from 1.8 to 9. The author cautioned that the durability of this procedure remains unknown.

Evidence-Based Orthopaedics

During 2004, the editorial staff of *The Journal* reviewed a large number of 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, seven level-I articles were identified that were relevant to the shoulder and elbow. 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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Upcoming Meetings

AAOS/ASES Surgical Techniques and Management of the Shoulder and Elbow. January 28-30, 2005. Ramsey ML and Galatz LM, course directors. Rosemont, Illinois. Contact: Nancy Cocalis. E-mail address: cocalis@aaos.org

Arthroscopic Glenohumeral Reconstruction. April 1-2, 2005; November 18-19, 2005. Gartsman GM, course chairman. King Orthopedic Institute, Houston, Texas. Contact: Brenda Cockerham. E-mail address: info@jwkoi.com

AAOS/ASES Open and Arthroscopic Techniques in Shoulder Surgery. April 1-3, 2005. Weber SC and Nicholson GP course directors. Rosemont, Illinois. Contact: Nancy Cocalis. E-mail address: cocalis@aaos.org

Advanced Shoulder Arthroplasty. April 22-23, 2005; October 28-29, 2005. Gartsman GM and Edwards TB, course chairmen. King Orthopedic Institute, Houston, Texas. Contact: Brenda Cockerham. E-mail address: info@jwkoi.com

Third International Conference on Shoulder Arthroplasty. April 29-30, 2005. Paris, France. Contact: Dominique Gazielly, MD. E-mail address: d.gazielly@gsante.fr

AAOS/ASES The Shoulder and Elbow: A Comprehensive Update. Williams GR, Cuomo F, Norris TR, and Tibone JE, course directors. May 12-15, 2005. Hilton Head, South Carolina. Contact: Nancy Cocalis. E-mail address: cocalis@aaos.org

Arthroscopic Rotator Cuff Repair. May 20-21, 2005; September 30-October 1, 2005. Gartsman GM, course chairman. J.W. King Orthopedic Institute, Houston, Texas. Contact: Brenda Cockerham. E-mail address: info@jwkoi.com

San Diego Shoulder Arthroscopy: Twenty-second Annual Meeting. June 22-25, 2005. San Diego, California. Esch J, course director. E-mail address: jesch@shoulder.com

AAOS/ASES The Shoulder Arthroscopic Techniques. September 9-10, 2005. Green A and Marra G, course directors. Rosemont, Illinois. Contact: Nancy Cocalis. E-mail address: cocalis@aaos.org

Shoulder Surgery Controversies. October 1-3, 2005. Laguna Hills, California. Contact: Wesley Nottage, MD. E-mail address: TSCWMN@aol.com

Recent Publications of Interest Related to the Shoulder

Rotator Cuff

Basic Science

Ziegler DW. The use of in-office, orthopaedist-performed ultrasound of the shoulder to evaluate and manage rotator cuff disorders. *J Shoulder Elbow Surg.* 2004;13:291-7.

Impingement

Mura N, O'Driscoll SW, Zobitz ME, Heers G, An KN. Biomechanical effect of patch graft for large rotator cuff tears: a cadaver study. *Clin Orthop.* 2003;415:131-8.

WHAT'S NEW IN SHOULDER AND ELBOW SURGERY

Tendon Tears

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.

Scheibel M, Lichtenberg S, Habermeyer P. Reversed arthroscopic subacromial decompression for massive rotator cuff tears. *J Shoulder Elbow Surg.* 2004;13:272-8.

Wolf EM, Pennington WT, Agrawal V. Arthroscopic rotator cuff repair: 4- to 10-year results. *Arthroscopy.* 2004;20:5-12.

Instability

Basic Science

Mihata T, Lee Y, McGarry MH, Abe M, Lee TQ. Excessive humeral external rotation results in increased shoulder laxity. *Am J Sports Med.* 2004;32:1278-85.

McMahon PJ, Burkart A, Musahl V, Debski RE. Glenohumeral translations are increased after a type II superior labrum anterior-posterior lesion: a cadaveric study of severity of passive stabilizer injury. *J Shoulder Elbow Surg.* 2004;13:39-44.

Werner CM, Nyffeler RW, Jacob HA, Gerber C. The effect of capsular tightening on humeral head translations. *J Orthop Res.* 2004;22:194-201.

Lo IK, Parten PM, Burkhart SS. The inverted pear glenoid: an indicator of significant glenoid bone loss. *Arthroscopy.* 2004;20:169-74.

Anterior Instability

Enad JG, ElAttrache NS, Tibone JE, Yocum LA. Isolated electrothermal capsulorrhaphy in overhand athletes. *J Shoulder Elbow Surg.* 2004;13:133-7.

Barber FA, Snyder SJ, Abrams JS, Fanelli GC, Savoie FH 3rd. Arthroscopic Bankart reconstruction with a bioabsorbable anchor. *J Shoulder Elbow Surg.* 2003;12:535-8.

Kim SH, Ha KI, Jung MW, Lim MS, Kim YM, Park JH. Accelerated rehabilitation after arthroscopic Bankart repair for selected cases: a prospective randomized clinical study. *Arthroscopy.* 2003;19:722-31.

Multidirectional Instability

Kim SH, Kim HK, Sun JI, Park JS, Oh I. Arthroscopic capsulolabroplasty for posteroinferior multidirectional instability of the shoulder. *Am J Sports Med.* 2004;32:594-607.

D'Alessandro DF, Bradley JP, Fleischli JE, Connor PM. Prospective evaluation of thermal capsulorrhaphy for shoulder instability: indications and results, two- to five-year follow-up. *Am J Sports Med.* 2004;32:21-33.

Complications

Petty DH, Jazrawi LM, Estrada LS, Andrews JR. Glenohumeral chondrolysis after shoulder arthroscopy: case reports and review of the literature. *Am J Sports Med.* 2004;32:509-15.

Freehill MQ, Harms DJ, Huber SM, Atlihan D, Buss DD. Poly-L-lactic acid tack synovitis after arthroscopic stabilization of the shoulder. *Am J Sports Med.* 2003;31:643-7.

Glenohumeral Arthritis

Clinical

Garreau De Loubresse C, Norton MR, Piriou P, Walch G. Replacement arthroplasty in the weight-bearing shoulder of paraplegic patients. *J Shoulder Elbow Surg.* 2004;13:369-72.

Complications and Revisions

Hacker SA, Boorman RS, Lippitt SB, Matsen FA 3rd. Impaction grafting improves the fit of uncemented humeral arthroplasty. *J Shoulder Elbow Surg.* 2003;12:431-5.

Fractures

Proximal Humerus Fractures

Mansat P, Guity MR, Bellumore Y, Mansat M. Shoulder arthroplasty for late sequelae of proximal humeral fractures. *J Shoulder Elbow Surg.* 2004;13:305-12.

Clavicle Fractures

Mighell MA, Kolm GP, Collinge CA, Frankle MA. Outcomes of hemiarthroplasty for fractures of the proximal humerus. *J Shoulder Elbow Surg.* 2003;12:569-77.

Miscellaneous

Tokish JM, Decker MJ, Ellis HB, Torry MR, Hawkins RJ. The belly-press test for the physical examination of the subscapularis muscle: electromyographic validation and comparison to the lift-off test. *J Shoulder Elbow Surg.* 2003;12:427-30.

Recent Publications of Interest Related to the Elbow

Instability

Basic Science

Armstrong AD, Ferreira LM, Dunning CE, Johnson JA, King GJ. The medial collateral ligament of the elbow is not isometric: an in vitro biomechanical study. *Am J Sports Med.* 2004;32:85-90.

Clinical

Levin JS, Zheng N, Dugas J, Cain EL, Andrews JR. Posterior olecranon resection and ulnar collateral ligament strain. *J Shoulder Elbow Surg.* 2004;13:66-71.

Tendon Injuries

Lemos SE, Ebramzadeh E, Kvitne RS. A new technique: in vitro suture anchor fixation has superior yield strength to bone tunnel fixation for distal biceps tendon repair. *Am J Sports Med.* 2004;32:406-10.

Greenberg JA, Fernandez JJ, Wang T, Turner C. EndoButton-assisted repair of distal biceps tendon ruptures. *J Shoulder Elbow Surg.* 2003;12:484-90.

Arthritis

Clinical

Sarris I, Riano FA, Goebel F, Goitz RJ, Sotereanos DG. Ulnohumeral arthroplasty: results in primary degenerative arthritis of the elbow. *Clin Orthop.* 2004;420:190-3.

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

Shoulder

Rubenthaler F, Ludwig J, Wiese M, Wittenberg RH. Prospective randomized surgical treatments for calcifying tendinopathy. *Clin Orthop.* 2003;410:278-84.

Thirty-eight patients with chronic calcifying tendinopathy of the shoulder were prospectively randomized to treatment with arthroscopic decompression (nineteen patients) or open decompression (nineteen patients). Clinical and ultrasound examinations were performed at the time of follow-up. The average duration of follow-up was sixteen months. Both groups demonstrated equivalent results with regard to the Patte score and the Constant score. The authors concluded that the arthroscopic and open operations were equally effective for the treatment of chronic calcifying tendinopathy of the shoulder. Surgeons may select either the arthroscopic approach or the open approach on the basis of their personal training and preferences.

Gerdemeyer L, Wagenpfeil S, Haake M, Maier M, Loew M, Wortler K, Lampe R, Sell R, Handle G, Gassel S, Rompe JD. Extracorporeal shock wave therapy for the treatment of chronic calcifying tendinitis of the rotator cuff: a randomized controlled trial. *JAMA.* 2003;290:2573-80.

The authors performed a double-blind, randomized, placebo-controlled trial comparing three treatments: high-energy extracorporeal shock wave therapy, low-energy extracorporeal shock wave therapy, and placebo (sham treatment). Forty-four patients were included in each treatment group, and the primary end-point was the change in the mean Constant score. At the time of the six-month evaluation, both high-energy and low-energy extracorporeal shock wave therapy appeared to provide beneficial effects in terms of shoulder function, self-reported pain, and the size of calcifications when compared with placebo. High-energy extracorporeal shock wave therapy appeared to be superior to low-energy extracorporeal shock wave therapy. Shock wave therapy is more common in Europe than in the United States. It appears to pro-

WHAT'S NEW IN SHOULDER AND ELBOW SURGERY

vide an option for patients who do not desire operative treatment.

Slaa RL, Wijffels MP, Brand R, Marti RK. The prognosis following acute primary glenohumeral dislocation. *J Bone Joint Surg Br.* 2004;86:58-64.

The authors prospectively studied 107 shoulders in 105 patients with acute, primary dislocations of the glenohumeral joint after a mean duration of follow-up of seventy-one months. The overall probability of recurrence within four years was 26%. The recurrence rate was 64% among patients who were less than twenty years old and 6% among those who were more than forty years old. There was no significant difference in the recurrence rate between patients who were active in sports and those who were not. No patient with a concomitant fracture of the greater tuberosity had a recurrent dislocation. Age at the time of the initial dislocation was again shown to be the most important predictor of recurrence, although it is difficult to separate age from activity level.

Husby T, Haugstvedt JR, Brandt M, Holm I, Steen H. Open versus arthroscopic subacromial decompression: a prospective, randomized study of 34 patients followed for 8 years. *Acta Orthop Scand.* 2003;74:408-14.

In this prospective study, the fifteen patients were randomized to arthroscopic subacromial decompression and nineteen were randomized to open subacromial decompression for the treatment of Neer grade-2 chronic impingement syndrome of the shoulder. The UCLA Shoulder Rating Scale, visual analog scales for pain and satisfaction, and isokinetic dynamometer testing for strength were employed. The authors found essentially no differences between the two groups during the eight-year follow-up period. This is one of the few studies to compare the results of arthroscopic and open treatment after long-term follow-up.

Elbow

Paoloni JA, Appleyard RC, Nelson J, Murrell GA. Topical nitric oxide application in the treatment of chronic extensor tendinosis at the elbow: a randomized, double-blinded, placebo-controlled clinical trial. *Am J Sports Med.* 2003;31:915-20.

The authors studied the effects of topical nitric oxide in this prospective, randomized, double-blind clinical trial. Eighty-six patients were divided into two

equal groups, both of which were instructed to perform a standard tendon-rehabilitation program. One group received an active glyceryl trinitrate transdermal patch, and the other group received a placebo patch. Patients in the glyceryl trinitrate group had significantly reduced elbow pain with activity at two weeks. At six months, 81% of the treated patients were asymptomatic with activities of daily living, compared with 60% of patients who had had tendon rehabilitation alone. This study and the two studies dealing with lateral epicondylitis that are discussed below illustrate the difficulty of evaluating a condition whose natural history demonstrates improvement with or without treatment. The results of this study on a novel topical treatment await corroboration from other centers.

Melikyan EY, Shahin E, Miles J, Bainbridge LC. Extracorporeal shock-wave treatment for tennis elbow. A randomized double-blind study. *J Bone Joint Surg Br.* 2003;85:852-5.

Seventy-four patients with lateral epicondylitis were entered into a randomized, double-blind study, and outcomes were assessed with use of the DASH questionnaire. The authors studied grip strength, pain, analgesic usage, and the rate of progression to operation. None of the outcome measures demonstrated a significant difference between the treatment and control groups. All patients had significant improvement over time, regardless of treatment. Since other studies have demonstrated significant differences in association with shock wave treatment, the exact role of this modality remains unclear.

Nirschl RP, Rodin DM, Ochiai DH, Maartmann-Moe C; DEX-AHE-01-99 Study Group. Iontophoretic administration of dexamethasone sodium phosphate for acute epicondylitis. A randomized, double-blinded, placebo-controlled study. *Am J Sports Med.* 2003;31:189-95.

The authors evaluated 199 patients with lateral or medial epicondylitis in a randomized, double-blind, placebo-controlled study. Patients received six treatments, one to three days apart, within fifteen days. The 100-mm visual analog scale for pain demonstrated significantly more improvement in the Dexamethasone group than in the placebo group at two days (average improvement, 23 mm compared with 14 mm) and at one month (average improvement, 24 mm compared with 19 mm). The results of this study await corroboration from other centers.