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Shoulder Arthroplasty

Subscapularis function after total shoulder replacement: results with lesser tuberosity osteotomy. Qureshi S, Hsiao A, Klug RA, Lee E, Braman J, Flatow EL. *J Shoulder Elbow Surg.* 2008;17:68–72.

Context: Traditionally, the subscapularis tendon is incised when performing total shoulder arthroplasties. Yet some authors have reported significant rates of subscapularis dysfunction after TSA as measured by the belly press and lift-off tests when a tenotomy is used. Therefore a lesser tuberosity osteotomy technique was developed in an attempt to mitigate this dysfunction.

Study Design and Results: Twenty-eight patients (30 shoulders) were retrospectively reviewed clinically and radiographically at a minimum of 1 year postoperatively after having a TSA performed via a lesser tuberosity osteotomy. Standard releases were performed. All patients were reported to have normal subscapularis function before surgery. All the osteotomies were reported to be healed by the 6-week postoperative visit. The belly press test was normal in 18 of 30 (60%), and 25 of 30 patients (83%) were able to tuck in a shirt behind the back without difficulty. This was compared with a previous cohort of patients who had tenotomy and in whom the belly press test was normal in only 33% and the ability to tuck in a shirt was normal in only 32%.

Conclusions: Lesser tuberosity osteotomies suggest good rates of healing with favorable subscapularis function.

Comments: The premise of the lesser tuberosity osteotomy approach is that healing is more predictable in a bone-to-bone fashion as compared with a tendon-to-tendon fashion with a tenotomy. Yet studies have reported low correlation between subscapularis integrity and function as measured by the above tests. The current work suggests that the tissue must not only be in continuity (as seen on imaging studies) but firmly adherent to the humerus.

Pearls: Delicate management of the subscapularis by either approach is necessary, as subscapularis rupture after TSA has been correlated with instability and weakness and could lead to early glenoid component failure via an AP “rocking horse” effect. The belly press and lift off tests are frequently positive even when the subscapularis is intact. This might have more to do with preoperative dysfunction (which can be difficult to assess secondary to contractures) and the amount and types of releases with possibly neurapraxias.

A biomechanical evaluation of three surgical techniques for subscapularis repair. Van den Berghe GR, Nguyen B, Patil S, D’Lima DD, Mahar A, Pedowitz R, Hoenecke HR. *J Shoulder Elbow Surg.* 2008;17:156–161.

Context: Subscapularis dysfunction after TSA has been reported by many authors. Reasons for the dysfunction include failure of the repair, change in length of the tendon, and denervation. There are several methods to manage the subscapularis tendon which include tenotomy, releasing the tendon from the lesser tuberosity, and lesser tuberosity osteotomy.

Study Design and Results: Nineteen unmatched human cadaveric shoulders were used to compare three methods of repair. Six shoulders had a tendon-to-tendon repair (Group 1) using four #2 FiberWires placed in a horizontal mattress fashion. Six had a tendon-to-bone repair (Group 2) in

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which the subscapularis was repaired with #2 FiberWires through drill holes at the anatomic neck in a horizontal mattress fashion. Seven others had a lesser tuberosity osteotomy (Group 3) repaired with #2 FiberWires in a mattress fashion through transosseous tunnels and tied over a buttress plate. The repairs were loaded initially to 150 N and cycled 500 times at 1 Hz and those that remained intact subsequently were loaded to 300 N and run for 1500 cycles or until failure. The rate of complete failure for the 150 N load was statistically higher for tendon-to-bone repair compared with the other groups; there was no significant difference between Groups 1 (tendon-to-tendon) and 3 (lesser tuberosity osteotomy). At the 300 N load there was no significant difference between any of the three groups. The change in length of the repaired tendon imposed by the method of repair also was recorded. The tendon-to-tendon repair shortened the tendon by 5.3 mm, whereas the tendon-to-bone repair shortened the repair by 2.6 mm. The bone-to-bone construct did not change in length once it was loaded.

Conclusions: Tendon-to-bone repair of the subscapularis is not as strong as either tendon-to-tendon or lesser tuberosity osteotomy repairs in this fatigue testing model. When the tendon-to-tendon repair is performed in a horizontal mattress fashion the tendon is shortened. Lesser tuberosity osteotomy repairs seem to have a minimal affect on tendon length.

Comments: This study is meaningful only regarding initial changes in length and strength: because it was a cadaver study, no healing could be assessed. In this study, tendon-to-tendon repair seemed better than tendon-to-bone (although the latter may have a higher healing rate. This study seems to support lesser tuberosity osteotomy, in that this technique seems to offer stable length and the healing potential of bone-to-bone repair. Additionally failures of the tendon-to-bone and lesser tuberosity osteotomies were via suture cutting through the bone despite using a cortical augmentation plate.

Pearls: The bone and tendons in elderly patients can be poor. This can be made worse with vigorous posterior retraction of the humeral head to expose the glenoid. Care should be taken when exposing the glenoid to avoid crushing the anterior humeral surface and the stump of the subscapularis (if a tenotomy is used).

Quantitative analysis of glenoid bone loss in osteoarthritis using three-dimensional computed tomography scans. Scalise JJ, Bryan J, Polster J, Brems JJ, Iannotti JP. *J Shoulder Elbow Surg.* 2008;17:328–335.

Context: Osteoarthritis of the shoulder is commonly associated with posterior glenoid bone loss with accompanying alterations in version. Determination of the amount of bone loss and version is difficult on plain

radiographs and two-dimensional (2-D) CT scans owing to patient position and gantry position, respectively.

Study Design and Results: Twelve consecutive patients with clinical and radiographic unilateral arthritis had 3-D CT scans performed of both shoulders. Glenoid bone loss was determined using two methods and these were compared. The nonarthritic glenoid was used as a subject-specific template for glenoid volume. The first method used a custom-designed software package in which a vault implant (a virtual glenoid vault) was scaled to fit the endosteal surfaces of the normal glenoid. A best-fit vault model was implanted into the normal glenoid so as to have as few, if any, voxels (similar to pixels in 2-D images) outside the native glenoid. The same was performed with the arthritic glenoid and the number of voxels outside each glenoid was compared and this difference represented the glenoid bone loss. The second method calculated the 3-D volume of right and left glenoids in each subject, and the arthritic and nonarthritic volumes were compared. It was found that the average glenoid bone loss in the arthritic shoulder as determined using the vault implant model was 15.6%. The amount of bone loss determined by comparing the measured volumes was 14.8% with a correlation coefficient of .99 ($p < .0001$).

Conclusions: The vault model (implanting a virtual glenoid vault into a glenoid cavity) can accurately measure the total the amount of glenoid.

Comment: Determining how much glenoid bone loss and version to correct is difficult. That the vault model accurately measures the total amount of glenoid bone loss suggests that the virtual glenoid accurately depicts the geometry of the bone loss as well. This virtual glenoid then could serve as a template for reconstruction/augmentation.

Pearls: Reaming the high side to balance bone loss can significantly narrow the AP dimension of the glenoid and necessitate a smaller glenoid component and compromise fixation. Also, one must remember that there are compensatory soft tissue adaptations to acquired glenoid bone loss. Thus, giving the patient a “normal” glenoid will not function well, unless the soft tissues are balanced as well. Treating the subluxation which often occurs with the bone loss requires not only correcting the osseous problem but the soft tissue must be balanced.

Revision shoulder arthroplasty for glenoid component loosening. Cheung EV, Sperling JW, Cofield RH. *J Shoulder Elbow Surg.* 2008;17:371–375.

Context: Glenoid component loosening is the most frequent long-term mode of failure of total shoulder arthroplasty. There have been few studies dedicated to the clinical outcomes of operative treatment in patients with painful glenoid loosening after total shoulder arthroplasty. Furthermore, little is known regarding risk factors for an

unsatisfactory result and the rate of failure in this cohort of patients.

Study Design and Results: The authors report a retrospective review of a group of 68 patients (mean age, 65 years) with symptomatic loosening of the glenoid component after total shoulder arthroplasty. The patients were divided into two treatment groups based on intraoperative bone loss and the ability to have a stable glenoid component implanted. Treatment consisted of either revision glenoid placement or allograft cancellous bone grafting of the glenoid defect without glenoid placement. Thirty-three patients underwent glenoid revision placement and were followed for a mean duration of 3.8 years whereas 35 patients were treated with glenoid bone grafting alone and were followed for a mean duration of 6.2 years. Nearly one-third of the patients also underwent repair of a rotator cuff tear. There was significant improvement in pain in both groups, however, 10 of 33 patients with a revised glenoid and 11 of 35 patients after glenoid bone grafting still had moderate to severe pain. Patient satisfaction showed improvement in 24 of 33 shoulders with revised glenoids and 19 of 35 shoulders after bone grafting. Improvement in ROM was seen only with active elevation compared with preoperative scores and there were no differences in ROM between groups. According to the modified Neer score, only nine of 33 shoulders with a revised glenoid and three of 35 shoulders with grafting had good or satisfactory functional outcomes. Seven patients in each group underwent additional revision surgery for various reasons. The survivorship curves for the endpoint of revision surgery at 5 years were similar between groups, 90.7% and 78.1% respectively. However, when survivorship was defined as need for surgery attributable to glenoid revision failure at 10 years, the rate of survival was greater in the glenoid reimplantation group (93.8%) compared with the bone grafting group (69.0%).

Conclusions: The outcomes of revision surgery for glenoid component loosening in the short-term shows modest improvements in pain and patient satisfaction scores but persistent functional deficits and a fairly high need for revision surgery. There is a slight advantage to reimplanting a glenoid component when feasible in the revision setting in terms of risk for glenoid revision failure and patient satisfaction.

Comments: Although the data from this study are useful, the results and conclusions are hindered by several inherent study design flaws. It appears that the degrees of glenoid bone loss in the groups were different which led to the decision to reimplant or graft the defects. These differences may have affected clinical and radiographic outcomes. Furthermore, the decision to reimplant or bone graft was not standardized but rather based on the surgeon's impression of the defect at the time of surgery. There were

various glenoid designs used in this study including a significant percentage of cemented and uncemented metal-backed implants. Metal-backed implants generally have fallen out of favor owing to the reported higher rates of loosening. In addition, the mean duration of followup between groups was notably different which may influence all measured outcomes.

Pearls: The results of this study highlight the difficulty of successfully managing patients with a painful, loose glenoid after total shoulder arthroplasty. However, it seems that modest pain relief and patient satisfaction can be achieved with either revision glenoid placement or bone grafting of the glenoid in this setting which is very useful in counseling patients before surgery. Additional studies are needed using conventional glenoid implants and newer designs to determine the clinical success and radiographic survivorship of revision glenoid placement.

Young patients with shoulder chondrolysis following arthroscopic shoulder surgery treated with total shoulder arthroplasty. Levy JC, Virani NA, Frankle MA, Cuff D, Pupello DR, Hamelin JA. *J Shoulder Elbow Surg.* 2008;17:380–388.

Context: Chondrolysis is a rare condition complicating various types of arthroscopic shoulder surgeries. This process usually results in end-stage arthritic complaints and severe pain. Treatment of these patients is complicated by the young age of the individuals.

Study Design and Results: The authors retrospectively report on 11 patients with glenohumeral chondrolysis treated with total shoulder arthroplasty. The mean age of the patients was 39 years (range, 16–64 years) and surgery was performed at a mean of 26 months after arthroscopy. Records of the index surgery were available for the majority of patients. Eight of 11 patients had surgery performed for a capsulolabral or SLAP repair. In addition, at least nine of the 11 patients had placement of an intra-articular pain catheter and adjunctive use of thermal probe. At the time of shoulder arthroplasty, severe loss of articular cartilage and erosive bony changes were seen. Acute inflammation was rare on frozen section and final pathology results showed chronic inflammation in three shoulders. Culture specimens were positive for *Propionibacterium acnes* in one patient. After shoulder arthroplasty, significant improvements in pain, ASES score (37 to 77.5), SST score (2.8 to 7.2), and active ROM were seen. Ten of 11 patients had good or excellent satisfaction. Progressive glenoid radiolucencies were seen in three patients and no patient had a deep infection develop.

Conclusion: Total shoulder arthroplasty for treatment of severe glenohumeral chondrolysis produces predictably improved clinical results in these patients in the short-term; however, progressive glenoid radiolucencies may develop.

Comment: The etiology of glenohumeral chondrolysis cannot be determined from this study given the presence of multiple known risk factors in this population. The erosive glenoid changes and osteopenia seen in these patients raise concern of glenoid longevity. The absence of infection in these patients from intraoperative cultures is reassuring.

Pearls: Data regarding the outcomes for surgical management of glenohumeral chondrolysis are sparse, and this series highlights predictably improved clinical outcomes after total shoulder arthroplasty in this young population. However, additional study of this cohort is needed given the presence of progressive glenoid lucencies seen with early followup. The results of this study can serve as a control against other methods of treatment such as hemiresurfacing arthroplasty with or without biologic glenoid resurfacing. Even seemingly benign procedures, such as shoulder arthroscopy for capsulolabral or SLAP repair, can lead to devastating complications.

Comparison of conforming and nonconforming retrieved glenoid components. Nho SJ, Ala OL, Dodson CC, Figgie MP, Wright TM, Craig EV, Warren RF. *J Shoulder Elbow Surg.* 2008;17:914–920.

Context: The rate-limiting step in long-term total shoulder replacement success is glenoid stability. Glenoid designs vary in their conformity and studying these issues regarding wear may allow us to predict long-term glenoid stability rates.

Study Design and Results: Sixty-three retrieved glenoids were evaluated for wear and the nature of their design (nonconforming vs conforming). The study was performed between 1979 to 2006 and the inclusion criterion was only all-polyethylene, keeled glenoid components. Retrospective patient chart review and a thorough radiographic analysis was performed. Classification of glenoid loosening/radiolucency was performed in multiple planes according to the schemes of Mole, Franklin, and Torchia. Microscopic examination of specimens for burnishing, abrasion, scratching, pitting, delamination, focal wear, surface deformation, embedded debris, and fracture was obtained for each of four quadrants. Results showed similar mean patient age, arthritis type, and similar intraoperative findings. The damage score was significantly greater for nonconforming glenoid implants. Conforming glenoid implants had significantly greater abrasion and delamination scores. Rim damage was common in both groups, however, the wear pattern differed with edge abrasion greater in the conforming group and surface delamination greater in the nonconforming group. Radiographically, no significant difference was observed on the AP view, however on the axillary views the conforming group had more radiolucent lines in all three zones. Conforming glenoid

implants had greater loosening and lucency scores on both views.

Conclusions: The conformity of the glenoid component on retrieved specimens contributed to differences in radiographic lucencies and wear patterns. These differences were relatively consistent and thus conformity may contribute to glenoid loosening.

Comments: This study, although large with respect to retrieved studies, has many confounding variables. A major issue with its applicability is the relatively low use of keeled glenoid implants in today's market. This issue has to be studied as well as multiple peg, inline peg, and ongrowth/ingrowth pegged glenoid implants usually are used in current practices. Furthermore, the underlying etiology of failed/loose glenoid implants is often multifactorial. All of the glenoid implants examined by the authors failed for one reason or another, and unless one knows the rate of implantation of each type, one cannot guess which type is better. This study serves only as a source of useful observational data.

Pearls: A nonconforming implant has a mismatch between the radii of curvature of the humeral head and glenoid. Conforming means the radii of curvature are identical. Understanding this is essential for surgeons performing total shoulder replacement. The numerous implants on the market are variable in their conforming or nonconforming nature and matching the glenoid implant to the disorder is paramount and seems to be a requirement for long-term stability.

Hemiarthroplasty and total shoulder arthroplasty for avascular necrosis of the humeral head. Feeley BT, Fealy S, Dines DM, Warren RF, Craig EV. *J Shoulder Elbow Surg.* 2008;17:689–694.

Context: Avascular necrosis (AVN) of the shoulder often is treated surgically with arthroplasty. This study aimed to show whether hemiarthroplasty (HA) or total shoulder replacement produced better results. ROM, pain relief, and outcomes were studied.

Study Design and Results: This was a retrospective large case cohort study of the patients of four surgeons. Sixty-four shoulders were followed for a mean of 4.8 years (range, 2–7.2 years). There were 38 men and 26 women with a mean age of 57 years (range, 46–77 years). The most common etiology for AVN was corticosteroid use (31) followed by trauma (17). Thirty-seven patients underwent HA and 27 were treated with total shoulder arthroplasty (TSA). The same prosthesis was used in every patient with a slightly older population in the TSA group (71 versus 59 years). Glenoid components were cemented and used in cases of extensive glenoid wear. Average ASES and L'Insalata scores were 67 and 64.7, respectively. Average forward flexion was 127°, external rotation 49°,

and internal rotation to L1. Sixty-three of 64 patients were satisfied with their surgery and would repeat it. Posttraumatic patients had less motion compared with patients in the other groups. The average ASES/L'Insalata scores were not significantly different between HA and TSA shoulders. TSA shoulders had less flexion but similar external and internal rotation. In the largest subgroup based on etiology (corticosteroid use), ASES and L'Insalata scores were higher in the HA group along with greater measurements for flexion. There were two (5%) reoperations in the HA groups for glenoid wear whereas there were substantially more reoperations in the TSA groups (six, 22%); four were for loose glenoid implants.

Conclusions: HA and TSA provide good results for patients affected by humeral head avascular necrosis. Patients with posttraumatic AVN had the worst results. Glenoid wear was the main indication for total shoulder replacement.

Comments: Shoulder arthroplasty for avascular necrosis leads to successful outcomes for all etiologies of humeral avascular necrosis. A significant weakness of this study is the lack of sophisticated grading of glenoid wear for patients undergoing HA compared with TSA. Patients with severe Grade V erosion should have a TSA, however, which of the procedures patients with lower grades of erosion should have remains controversial. Also, without preoperative functional scores, improvements cannot be truly measured. Without standardized radiographs obtained at followup, the glenoid with and without glenoid implants cannot be evaluated. Despite these issues the common theme of improved function and diminished pain is true with either prosthesis.

Pearls: AVN of the humeral head, by definition, initially spares the glenoid, but with time asymmetries of the head will damage the glenoid too. Thus all patients with avascular necrosis should be evaluated clinically and radiographically for glenoid damage. TSA should be considered for patients with affected glenoids.

Reverse Total Shoulder Arthroplasty

Factors affecting fixation of the glenoid component of a reverse total shoulder prosthesis. Chebli C, Huber P, Watling J, Bertelsen A, Bicknell RT, Matsen F 3rd. *J Shoulder Elbow Surg.* 2008;17:323–327.

Context: Failure of the glenoid component in reverse total shoulder arthroplasties is one of the most common complications with this procedure. This has been related to several factors including baseplate design and center of rotation, but few studies have evaluated screw placement.

Study Design and Results: Glenoid component fixation was tested mechanically by loading a common prosthesis

that uses two locking and two nonlocking screws (DePuy Delta, Warsaw, IN). The baseplates were fixed to blocks of rigid polyurethane foam to simulate normal cancellous bone and osteopenic bone. Loads were applied through the humeral component in 50° abduction (such that the polyethylene cup of the humeral component did not contact the foam block) collinear to the screws. Components were loaded to failure at 30 mm/second. All failures occurred catastrophically, with screw pullout with the screw closest to the point of the applied load pulling out first. Loading collinear to the locking screws (load being applied from an inferior direction) resulted in failure at 2811 N $\pm$ 75 N which decreased by 23% in osteopenic bone. Loading collinear to the nonlocking screws (AP) resulted in failure at 1832 N $\pm$ 35 N for osteopenic bone. Regarding contribution of each screw, the collinear locking load was decreased by 16% if the superior locking screw was omitted, 28% if either of the nonlocking screws were omitted, and 35% if the inferior locking screw was omitted.

Conclusions: Load to failure decreases in osteopenic bone regardless of the direction of applied load. The load to failure was less when loaded collinear to the nonlocking screws. The inferior screw seems to be the most important when loaded collinear to the locking screws.

Comments: Many of the patients are osteopenic which emphasizes the need for good baseplate fixation. The inferior location of the baseplate can make it difficult to place the important inferior screw contained in bone. Careful inferior dissection may help with the inferior screw placement.

Pearls: Screw placement is critical and can be especially difficult in revision cases. There are different morphologic features of the scapula especially regarding neck shape. If the glenoid has a long neck, one might need to place the baseplate a little higher to capture good bone. Also using an image intensifier can assist in determining the best position for the baseplate and ensure good screw placement.

Scapular notching in reverse shoulder arthroplasty. Lévigne C, Boileau P, Favard L, Garaud P, Mole' D, Sirveaux F, Walch G. *J Shoulder Elbow Surg.* 2008;17: 925–935.

Context: Scapular notching, a mechanical erosion of the inferior scapula behind the glenoid baseplate, has the potential to lead to mechanical failure in reverse shoulder arthroplasty. The medial rim of the humeral prosthesis may impinge against the lateral scapular neck in adduction. This has raised concerns regarding longevity of the implant.

Study Design and Results: Between December 1991 and June 2003, 457 consecutive reverse shoulder arthroplasties (RSA) were performed in four shoulder centers. After

exclusion criteria were met, 337 shoulders in 326 patients were studied retrospectively with prospectively gathered data. Preoperative clinical and radiographic data were obtained for multiple fundamental parameters. All surgeries were performed by a well-established shoulder surgeon. Seventy of the RSAs were placed via a superolateral approach and the other 267 through a deltopectoral approach. Either a 36-mm (320) or 42-mm (17) diameter glenosphere was used. Implant parameters also were documented. The postoperative protocol was similar for all patients. Radiographs (true AP and axillary) were obtained at 6 weeks, and at 1, 2, and 3 years. Notching was classified according to Sirveaux. Multiple statistical analyses were obtained for notching on preoperative, postoperative, and intraoperative variables. Followup averaged 47 months (range, 24–120 months). Notching was present in 62% of shoulders at last followup; 22% had Grade 1 notching, 18% had Grade 2, 14% had Grade 3, and 8% had Grade 4. Notching was present in 10% at 6 weeks and 42% at 1 year. The highest frequency was seen in patients with cuff tear arthropathy (76%) and the lowest frequency was in patients with posttraumatic shoulders (38%). Active patients had more notching than inactive. Preoperative Constant-Murley scores and ROM did not correlate with notching. Interestingly, deltopectoral (56%) versus superolateral (86%) surgical approach was significant. Grades 3 and 4 notching initially were most likely to enlarge with time. Clinical outcome was not affected by the notch. There was no correlation between ROM and Constant-Murley scores. There was an increasingly greater correlation with radiolucency around the glenoid implant with higher grades of notching.

Conclusions: In a large multicenter study, scapular notching was present in a significant number of postoperative RSA shoulders. Yet notching stage had no effect on clinical outcomes to date.

Comments: This study provides important information on scapular notching and parameters that may involve its creation and its clinical outcomes. The inclusion of patients from multiple centers adds to its credibility as the results are relatively unbiased. This information provides essential data to use in all studies regarding scapular notching, especially to follow patients longitudinally at multiple times. Notching appears to occur early but not always and progresses with time. Also, the deltopectoral approach was associated with a lower incidence of notching, perhaps by allowing lower, more proper placement of the glenoid baseplate.

Pearls: The RSA has come under tremendous debate as the issue of scapular notching and glenoid failure becomes more prevalent. Design changes, as in lateral offset and higher more vertical neck shaft angles, may assist surgeons

in lower notching rates and thus improve the longevity of the glenoid baseplate. Notching seems to be common with RSA, yet concern over notching must be balanced with the other aspects of the successful RSA such as stability, ROM, and pain relief. RSA addresses disorders that might not have any other surgical solution.

Rotator Cuff

The relationship between greater tuberosity osteopenia and the chronicity of rotator cuff tears. Cadet ER, Hsu JW, Levine WN, Bigliani LU. *J Shoulder Elbow Surg.* 2008;17:73–77.

Context: High retear rates for larger more chronic rotator cuff repairs are well documented in many studies. Some have postulated that there is an osseous component to this retear rate. It was shown in a rat model that bone loss occurs in a chronic rotator cuff repair model.

Study Design and Results: Greater tuberosity osteopenia scores were retrospectively calculated for 28 shoulders with rotator cuff tears using standard AP radiographs. Thirteen tears were classified as minimally or mildly retracted (retracted to a level lateral to the articular edge) and 15 were moderately or severely retracted (retracted medial to the articular edge). Ages of the patients were not statistically different. The greater tuberosity osteopenia scores (as determined by NIH digital imaging software) were significantly more severe in the larger more retracted tears (0.48) compared with the minimally retracted tears (0.58). In addition six of the 13 minimally retracted tears were deemed acute (less than 6 months of symptoms) and six of the 15 severely retracted tears were deemed chronic (greater than 6 months of symptoms). The chronic tears had significantly more severe scores (0.48) compared with the acute group (0.64).

Conclusions: There was significantly greater tuberosity osteopenia in the chronic more severely retracted tears.

Comments: These results are consistent with Wolff's law. With the loss of load from the cuff, the greater tuberosity loses bone mass and strength. The degree of greater tuberosity osteopenia in the chronic tears can affect the fixation strength of bone anchors and bone tunnels. In addition this osteopenic bone may have a decreased ability to heal.

Pearls: Most of the vascularity and healing cells come from the bone. If the bone is osteopenic this might significantly affect healing. There might be a role for the use of biologic stimulants in these cases. The degree of greater tuberosity osteopenia in chronic tears can affect the fixation strength of bone anchors and bone tunnels.

A novel lesion of the infraspinatus characterized by musculotendinous disruption, edema, and late fatty infiltration. Lunn JV, Castellanos-Rosas J, Tavernier T, Barthelemy R, Walch G. *J Shoulder Elbow Surg.* 2008;17:546–553.

Context: The authors describe a novel cause of shoulder pain associated with an isolated rupture of the infraspinatus associated with acute muscular edema and retraction which later progresses to advanced fatty infiltration of the infraspinatus muscle.

Study Design and Results: This is a retrospective review of 19 patients (mean age, 47.7 years) presenting for evaluation of shoulder pain who had an isolated injury to the infraspinatus. Fifteen patients were females. The authors report a detailed description of the clinical presentation and clinical and radiographic workup for these patients. Only two patients had a history of distinct trauma whereas the remaining patients had chronic pain in the shoulder, 15 of whom had a minor acute on chronic event with worsening of symptoms. A previous steroid injection in two patients and needle aspiration of a calcific deposit in three patients resulted in an acute worsening of symptoms. Evidence of calcific tendinitis was seen in 13 patients. All patients had MRI on presentation which showed disruption of the infraspinatus at the level of the tendon or the myotendinous junction. In addition, all subjects characteristically had edema in the infraspinatus muscle. No spinoglenoid cysts were evident on MRI and the remaining cuff tendons were healthy. EMG analysis was performed on 15 patients and was normal in all instances. Fourteen patients were treated conservatively with activity modification, physical therapy, and steroid injections, and five underwent surgical repair of the infraspinatus. All patients were followed for a mean duration of 50 months. The Constant-Murley score improved from 24 to 79 points. Operatively treated patients had similar outcomes as patients managed conservatively. Of the six patients receiving workers compensation, all had worse Constant-Murley scores, decreasing an average of 10.6 points. There were slight ROM deficits at final followup compared with the opposite shoulder and external rotation strength was significantly lower (3.2 vs 6.0 kg). Repeat MRI was performed for all patients with Grade IV fatty infiltration of the infraspinatus.

Conclusions: The authors describe a novel condition affecting the infraspinatus with an unknown cause; however, female gender and the presence of calcific tendinitis are apparent risk factors. Characteristic appearance of edema in the infraspinatus seen on MR images should clue the clinician to this unique process. Good clinical outcomes can be expected with conservative management despite the progression of fatty infiltration with time.

Comments: This study provides an excellent description of the history, clinical presentation, and results of a

thorough workup of a unique injury of the infraspinatus. The etiology of this problem remains unknown.

Pearls: The infraspinatus shares function with the teres minor (external humeral rotation). Thus an isolated infraspinatus is hard to detect on examination; MRI would be necessary to make this diagnosis.

Repair integrity and clinical outcome after arthroscopic rotator cuff repair using single-row anchor fixation: a prospective study of single-tendon and two-tendon tears. Deutsch A, Kroll DG, Hasapes J, Staewen RS, Pham C, Tait C. *J Shoulder Elbow Surg.* 2008;17:845–852.

Context: This study aimed to determine the prospective results of arthroscopic single-row rotator cuff repairs. Determining healing rates and outcomes are discussed.

Study Design and Results: This was a prospective study of single- and two-tendon cuff repairs performed by one surgeon (AD). Forty-eight patients met the inclusion criteria and 39 were available for final followup and MRI to determine cuff integrity. Twenty-one patients had single-tendon tears and 18 had tears involving the supraspinatus (SS) and infraspinatus (IS) tendons. Tears were classified according to size and retraction. Morphologic features of the tears also were documented. All patients had similar demographics, with 24 men and 15 women with a mean age of 54 years (range, 32–71 years). Minimum followup was 38 months (range, 24–60 months). A trial of conservative management failed in all patients. Outcomes were measured using the ASES score, with strength measured using a handheld dynamometer. Cuff integrity was measured at 1 year using MRI. Average time to MRI was 23 months (range, 12–40 months) after repair. Specific criteria for a recurrent tear on MRI were stated. Arthroscopic repairs were performed in standard fashion with the patient in the beach chair position under general anesthesia and concomitant interscalene block. Standard arthroscopic cuff releases were performed along with side-to-side repairs when indicated. Direct repair with anchor fixation (nonabsorbable simple suture fashion) was performed to the tuberosity with the arm at the side and no medialization of repair. The tuberosity was prepared with light decortication and anchors placed lateral to the footprint. All patients underwent an acromioplasty, 13 had a distal clavicle resection, six had biceps tenodesis, five had biceps debridement, and one had a tenotomy. Postoperatively patients wore a sling and began a standardized rehabilitation protocol from passive stretching to active ROM and resistance at 3 months for single-tendon and 4 months for two-tendon repairs. Both groups had improvement of ROM, pain scores, ASES scores, strength, and satisfaction. Postoperative MRI showed 19 of 21 (90%) intact cuffs in the single-tendon group versus 15 of 18 (83%) in the two-tendon group. Recurrent tears were commonly associated

with asymmetric retraction; four of five recurrent tears had an L-shaped configuration. Complications included anchor failure, stiffness, and suture breakage during repair.

Conclusions: Arthroscopic rotator cuff repairs lead to successful outcomes in single- and two-tendon rotator cuff tears. Strict adherence to surgical technique and rehabilitation are crucial to good, reproducible results. Asymmetric tear patterns had the most difficulty healing at latest followup.

Comments: This prospective study provides important information for the orthopaedist regarding the success of well-performed single- and two-tendon cuff repairs. The strengths of this study are its prospective nature, inclusion criteria, reproducible surgical technique, and standardized rehabilitation program; its major weakness is the small population of patients.

Pearls: Studies assessing cuff healing suggest an imperfect correlation between healing and function. It is possible to have a good outcome despite tendon failure seen on postoperative imaging and vice versa.

Tendon Transfers

Latissimus dorsi transfer for irreparable rotator cuff tears: a longitudinal study. Irlenbusch U, Bracht M, Ganssen HK, Lorenz U, Thiel J. *J Shoulder Elbow Surg.* 2008;17:527–534.

Context: Irreparable tears of the posterior rotator cuff can be difficult to manage. Latissimus dorsi tendon transfer has been advocated for management of irreparable rotator cuff tears in selected patients with variable clinical results.

Study Design and Results: The authors report a longitudinal series of 52 patients (mean age, 60.1 years) with irreparable tears of the posterior cuff treated with isolated latissimus dorsi tendon transfer. Patients were seen at three times after surgery (mean, 11, 36, and 50 months) and the results were broken down according to several patient-specific factors: primary surgery ($n = 35$), revision surgery ($n = 17$), and involvement of the subscapularis tendon ($n = 19$). A subgroup of 19 patients meeting ideal indications for latissimus dorsi transfer as described by Gerber (isolated posterior cuff tear, healthy subscapularis, no instability, normal deltoid muscle, and no prior operations) was identified. The clinical results included measures of pain, Constant-Murley score, abduction strength, and patient satisfaction. Radiographic outcomes included grading of glenohumeral arthritis and acromiohumeral interval. Overall, the Constant-Murley score improved from 32 to 68 points, abduction motion improved from 69° to 143°, flexion motion improved from 79° to 153°, external rotation improved from 18° to 23°, and pain scores improved from 1.7 to 11.5 points (0–15 scale). Better Constant-Murley

scores were seen in primary (71) versus revision surgeries (60) and the best results were seen in Gerber's ideal indications (77) group. Eleven patients were rated as having unsatisfactory results with Constant-Murley scores of 33 to 44 points (three shoulders were revised). Pain relief was achieved by greater than 90% of patients at all three followups. Glenohumeral arthritis progressed slightly and the acromiohumeral interval diminished by 1 mm as a whole.

Conclusions: Latissimus dorsi tendon transfer can be used to successfully manage patients with irreparable tears of the posterior rotator cuff across multiple clinical scenarios. The clinical results and level of pain relief are more predictable for patients with an isolated posterior cuff tear, an intact subscapularis, no instability, normal deltoid muscle, and no previous surgeries. Latissimus dorsi tendon transfer does not prevent the progression of glenohumeral arthritis or proximal humeral migration.

Comment: Significant patient attrition occurred among patients in the revision surgery and concomitant subscapularis tear groups (greater than 50% in both groups). The authors admit that the patients returning for examination from these groups at 36 and 50 months were mostly satisfied and had good clinical outcomes. This significantly skews the data toward a better clinical result. Furthermore, the clinical followups were not performed by independent examiners which raises the concern for observer bias.

Pearls: Patients who lack more than one of the predictors of a good outcome (isolated posterior cuff tear, an intact subscapularis, no instability, normal deltoid muscle, and no previous surgeries) should be considered for reverse shoulder arthroplasty.

Physical Therapy

The role of anterior deltoid reeducation in patients with massive irreparable degenerative rotator cuff tears. Levy O, Mullett H, Roberts S, Copeland S. *J Shoulder Elbow Surg.* 2008;17:863–870.

Context: The patient with the massive, irreparable rotator cuff tear needs an effective therapy program. Therapy aimed at strengthening and reeducating the anterior deltoid may assist some patients in regaining and/or improving their function.

Study Design and Results: Seventeen elderly patients with an average age of 80 years were diagnosed with massive irreparable rotator cuff tears. All patients had pseudoparalysis and full passive ROM before treatment. They were treated with subacromial corticosteroid injections and encouraged to take oral nonsteroidal antiinflammatory drugs. Radiographs revealed extensive changes of cuff tear arthropathy (Hamada Classes 3–5) in 12 patients. MRI/ultrasound revealed massive retracted, atrophic rotator cuff

tears including the subscapularis in all patients. All patients had concomitant medical comorbidities which would add to their surgical risk. Patients were videotaped before and after the rehabilitation program. Deltoid reeducation consisted of supine elevation exercises with resisted deltoid isometrics through a full arc of motion. First, the exercises are done with just the weight of the arm progressing to light weights. Exercises are performed 3 to 5 times per day for the first 6 weeks. The goal is to increase the weight, excursion, and level against gravity to a semisitting and then standing positions. The exercises were continued for 12 weeks and the patients were evaluated at 6 weeks, 12 weeks, 6 months, and 9 months. Minimum followup was 9 months. Mean Constant-Murley scores improved from 26 (range, 8–41) to 63 (range, 43–77). Mean strength scores did not improve. Mean forward elevation improved from 40° (range, 30°–60°) to 160° (range, 150°–180°). Three patients did not significantly improve. One underwent a reverse shoulder replacement and the other had an arthroscopic decompression. Patients who improved (14) were all comfortable, regained good motion, and did not require pain medication.

Conclusions: Anterior deltoid reeducation can help in the treatment of massive irreparable rotator cuff tears.

Comments: This prospective study is ground breaking. The importance of a program in which a painful, dysfunctional shoulder can become useful and comfortable again cannot be understated. This rehabilitation protocol should become a substantial instrument in not only the shoulder surgeons thought process but should be an initial program for all patients with painful pseudoparalysis associated with a massive rotator cuff tear.

Pearls: Selecting patients with intact anterior deltoids without denervation or neurologic compromise is essential. One cannot compensate for an irreparably torn cuff with an equally irreparable deltoid.

Throwing Shoulder

Relationships between ball velocity and throwing mechanics in collegiate baseball pitchers. Werner SL, Suri M, Guido JA Jr, Meister K, Jones DG. *J Shoulder Elbow Surg.* 2008;17:905–908.

Context: Pitching fastballs places great stress on the shoulder. Injuries among throwing athletes are common. A

better understanding of the subtle mechanics of throwing may enable pitchers to become more efficient regarding positioning and kinematics of the shoulder and elbow and may lead to a reduction in stresses to these joints and subsequently less injury.

Study Design and Results: The authors used high-speed (240 Hz) 3-D videography to determine what kinematic parameters are essential in maximizing efficiency in the throwing motion. Video data were collected on fastballs from 54 collegiate baseball pitchers. Ten pitching trials were obtained for each pitcher at 240 Hz by all six cameras for a wide cinematic view while pitching at 15 m to a regulation strike zone. Multiple linear regression analysis was used to relate ball velocity and pitching mechanics. Ball velocity averaged 35 m/second (79 mph) for all pitchers. Body mass and nine temporal and kinematic parameters related to pitching mechanics—such as maximal shoulder angular velocity or maximal external rotation flexion—combine to account for 68% of the difference in ball velocity for a group of college pitchers. These variables can be manipulated via mechanical changes and sports-specific training to affect ball velocity. The results of the study can be used to increase ball velocity while minimizing stresses on the throwing arm, elbow, and shoulder. Improved training programs can be developed based on these data.

Conclusions: This study reveals that body weight and nine temporal and kinematic parameters that may be controlled account for 68% of the difference in ball velocity in this collegiate pitching group. Clinicians, trainers, and therapists may have the ability to influence changes in mechanics to adjust and improve efficiency and velocity while lowering the stress on related joints.

Comments: This study offers a unique design to study pitching motion and provides beneficial data to maximize throwing motion and improve ball velocity. Obviously it may be difficult to introduce changes in motion, stride position, weight distribution, and trunk rotation without changing the nature of a pitcher's motion and resultant product.

Pearls: Ball velocity is prized among pitchers but is just one of many parameters that affect performance: simply improving velocity may not improve consistency or accuracy. Nonetheless, throwing faster should lead to better performance.