CHAPTER 41

Tendinopathy of the Rotator Cuff and Proximal Biceps

Jeffrey E. Budoff

The anatomy and function of the rotator cuff were discussed in Chapter 40. The rotator cuff is the most common source of shoulder pain and disability. Most rotator cuff injuries occur without a history of trauma and result from overuse.

Etiology

Classic Teaching (Primary Extrinsic Coracoacromial Arch Impingement)

- Congenital variations in acromial morphology exist. Some acromions are flatter, whereas others have inferior subacromial spurs or hooks on them. With repetitive arm elevation, these subacromial spurs mechanically abrade or cut into the rotator cuff, progressively leading to tendon injury.
- In his classic 1972 article, Neer\(^1\) implicated the anterior acromion and its “spurs” in the etiology of rotator cuff injuries. Subacromial abrasion caused rotator cuff inflammation, which progressed to partial-thickness tears and later full-thickness tears.\(^1\)
- In 1986, Bigliani, Morrison, and April\(^2\) characterized acromial morphology as type I (flat), type II curved (parallel to the humeral head), or type III hooked (converging on the humeral head). They found that full-thickness rotator cuff tears were associated with type III acromions and anterior undersurface spurs.\(^2\)
- The classic theory of the etiology of rotator cuff pathology has been challenged.

Primary Intrinsic Degenerative Tendinopathy (Tendinosis)

- The rotator cuff fails from tensile, not compressive, overload. Pathoetiology and mechanism are identical to tendon pathology in many other areas of the body (i.e., tennis elbow, patellar tendinosis, Achilles tendinosis). Evidence strongly suggests that most rotator cuff symptoms are caused by primary intrinsic degeneration, not extrinsic subacromial compression.\(^3\)–\(^5\)
- Histologic studies of symptomatic rotator cuff disease have repeatedly noted an absence of acute inflammatory cells. These studies have consistently noted the changes of degenerative tendinopathy, for which the pathologic name is angiofibroblastic hyperplasia.
- The term impingement syndrome has been used to describe symptoms related to the rotator cuff in the absence of a full-thickness tear. Commonly used synonyms include bursitis and tendinitis. However, use of the term tendinosis is now recommended in lieu of the histologically inaccurate term tendinitis, because it more accurately describes the true pathology.\(^3\)
- Clinical and cadaveric studies have noted that more than 90% of partial-thickness rotator cuff tears occur on the articular side, away from the acromion.\(^3\)\(^,\)\(^4\)
- Degeneration begins on the articular sides of the supraspinatus and infraspinatus tendon insertions rather than the bursal sides probably because of their poor blood supply.\(^3\)
Acromial spurs form with age and are degenerative. The type III acromion is rare (2%–4%) in young, asymptomatic athletes. A higher incidence of type III acromions is seen in older populations.6

Cadaveric studies have demonstrated that rotator cuff pathology predates that of the acromion.3,5

Spur reformation has been noted following subacromial decompression.7

A study using mineral apposition analysis and quantitative cytochemical techniques demonstrated active bone formation at the acromial insertion of the coracoacromial (CA) ligament, supporting the concept that spur formation is a secondary phenomenon. Thus the spur is actually an enthesophyte (bone growth) at the CA ligament's acromial insertion, probably in response to dynamic loading.8

Nonoperative management has been reported to successfully treat most full-thickness rotator cuff tears. Because therapy cannot modify pathologic osseous prominences, another etiology is implied.9

Pathomechanics

Tissue damage occurs when the stresses placed on the rotator cuff exceed its stress tolerance, which is related to its strength. The rotator cuff muscles are small and weak and therefore are vulnerable to overuse. Overuse injuries occur when the rate of tissue damage over time exceeds the body's rate of repair. As a natural part of the aging process, the deltoid retains its strength longer than the smaller rotator cuff. When rotator cuff injury, degeneration, fatigue, or weakness occurs, the rotator cuff is unable to effectively oppose (via concavity-compression) the superior shear stresses imparted by the larger and stronger deltoid muscle. This situation leads to dynamic superior instability of the humeral head with arm elevation. This inappropriate superior migration of the humeral head causes secondary impingement of the rotator cuff against the CA arch, leading to further injury, in a self-perpetuating cycle. Therefore, subacromial impingement is a secondary and not a primary process.3

The CA ligament and undersurface of the acromion function as secondary, static stabilizers of the humeral head against anterosuperior migration. With rotator cuff dysfunction, the CA ligament may experience increased stress and undergo degenerative changes, forming a traction spur at its insertion into the anteromedial corner of the acromion. These acromial changes are the result of rotator cuff injury; they are not the cause.3,5,8 This traction spur often is mistaken for an abnormal acromial hook, or type III acromion.3,8

As rotator cuff dysfunction increases with age, the CA arch may function as a fulcrum for the superiorly migrated humeral head, allowing continued glenohumeral elevation.10

Relationship to instability: In patients with anterior gleno-humeral instability resulting from ligamentous insufficiency, the dynamic stabilizers, including the supraspinatus, infraspinatus, and biceps, compensate with increased activity.11 This overuse may predispose patients to injury.

Diagnosis

The history and physical examination of rotator cuff disorders are discussed in Chapter 40. Concomitant loss of passive motion, instability, and scapulothoracic dysfunction should be noted.

Radiography

Subtle superior migration of the humeral head can be detected by the presence of a “break” in the arch formed by the medial cortex of the humerus and the lateral cortex of the scapula (Figure 41–1).12

Marked elevation of the humeral head with narrowing of the acromiohumeral distance to less than 5 mm is highly suggestive of a large rotator cuff tear.12

Sclerosis, osteophytes, and subchondral cysts of the greater tuberosity are associated with rotator cuff tears.13

Magnetic Resonance Imaging

According to Frost, Andersen, and Lundorf,14 supraspinatus pathology as seen on magnetic resonance imaging (MRI) is related to age, not to symptoms. According to Shuman,15 conventional MRI has not performed well in distinguishing partial-thickness rotator cuff tears from small full-thickness rotator cuff tears or normal tendon. According to Tørstensen and Hollinshead,16 MRI is not an effective or accurate tool for assessing shoulder pathology when the clinical picture is unclear. From 33% to 80% of partial-thickness rotator cuff tears can be missed on MRI.16–19

Figure 41–1:
Model of an anteroposterior radiograph. Normal rotator cuff function presents with a smooth unbroken scapulohumeral arch. Rotator cuff dysfunction leads to superior migration of the humeral head with a broken scapulohumeral arch. (From Burkhart SS: Reconciling the paradox of rotator cuff repair versus debridement: a unified biomechanical rationale for the treatment of rotator cuff tears. Arthroscopy 10:4-19, 1994.)
Nonoperative Management

- MRI is 68% to 92% accurate, 78% to 96% sensitive, and 49% to 94% specific for assessing full-thickness rotator cuff tears. MR arthrography may be more accurate.15,16,18,19
- Studies by Needell et al.,20 Tempelhof, Rupp, and Seil,22 and Sher et al11 demonstrated that between the ages of 40 and 60 years, 24% to 27% of asymptomatic volunteers had partial-thickness rotator cuff tears. Above age 60 years, 27% to 28% of asymptomatic volunteers had full-thickness rotator cuff tears, and another 26% to 27% had partial-thickness rotator cuff tears. Above age 80 years, 51% of asymptomatic volunteers had full-thickness rotator cuff tears.
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  **Pearl:** Because conservative management of full-thickness tears is identical to that for partial-thickness tears, diagnosing the thickness of the tear may be initially irrelevant. Initial treatment in most cases should not be based on the presence or absence of a full-thickness tear because most full-thickness rotator cuff tears are asymptomatic.12
- Decisions regarding operative treatment are best made based on the patient’s symptoms, wishes, and response to nonoperative management and not the presence or absence of a hole in the cuff.

Nonoperative Management

- Rotator cuff and scapulothoracic stabilizer strengthening reportedly was successful in treating 50% to 82% full-thickness rotator cuff tears.9,23–26
- Nonoperative management may be considered if the patient can actively elevate the arm above the horizontal. This ability implies the tear is functional and does not involve the rotator cuff cable (described in Chapter 40).
- No significant relationship exists between the length of preoperative symptoms and the final outcome following repair of nonacute rotator cuff tears. Therefore, no evidence indicates that a “penalty” exists for attempting nonoperative management of nonacute rotator cuff tears.9
- At least 3 months of nonoperative management is recommended in most cases before undertaking operative management.
- Because rotator cuff pathology results from degeneration and weakness, not from inflammation, nonsteroidal antiinflammatory drugs, corticosteroid injections, and modalities should be used only as adjuncts to increase patient comfort and promote effective strengthening given that they have no proven long-term efficacy or curative potential.
- The efficacy of steroid injections has been questioned. A randomized prospective trial found no difference in symptoms between patients (with medial tennis elbow; a disorder with identical histopathology) injected with steroid and lidocaine and those injected with only saline at 3 and 12 months.27 In addition, a meta-analysis performed by the Cochrane Database found that although subacromial steroid injections had a small benefit over placebo in some trials, no benefit of subacromial steroid injections over oral nonsteroidal antiinflammatory drugs was observed.28 Repetitive injections are inappropriate because they may cause cellular death, further tissue weakness, and actually slow the healing process.27
- Any rest should be relative, with activity allowed within the limits of pain to prevent further deconditioning.
- Physical therapists may educate the patient and facilitate this program, but patients must assume responsibility for their own daily exercise program. Once the motivated patient can properly perform the exercises, he or she can perform therapy exclusively at home.
- Acute large traumatic tears
  - Although the patient usually retains nearly full passive motion, the arm cannot be actively elevated above the horizontal, even following a lidocaine injection. The other elements in the differential diagnosis are fracture and dislocation, which are excluded by radiography, and suprascapular and axillary neuropathies, which are uncommon. Conservative management is ineffective in this setting. Early repairs performed within 3 weeks of injury have yielded better results, with greater postoperative motion and function, than repairs performed later.29 Therefore, the diagnosis should be confirmed by MRI and operative management strongly considered.

Treatment Specifics

- The mainstay of nonoperative management is strengthening of the rotator cuff, deltoid, and scapulothoracic stabilizers. Strengthening the rotator cuff may help decrease symptoms for the following reasons:
  - A stronger rotator cuff can better oppose superior translation of the humeral head and avoid subsequent secondary impingement.
  - Muscles are the “shock absorbers” of the musculoskeletal system and protect their tendons from excessive stress. Therefore, muscle strengthening increases the stress tolerance of the myotendinous unit.
  - Strengthening may enhance tendon healing via increased tissue turnover.
- Scapular strengthening may help decrease symptoms by restoring normal scapular motion, which allows the acromion to clear the rotator cuff during arm elevation. Scapulothoracic weakness causes decreased acromial clearance and increased rotator cuff compression, exacerbating symptoms.30
- Rotator cuff and deltoid strengthening exercises include
  - Internal rotation, external rotation, forward flexion, abduction, and extension, and a diagonal proprioceptive
neuromuscular facilitation pattern similar to the motion used to draw a sword (Figures 41–2 and 41–3). In cases of significant weakness, closed chain exercises may be substituted, which create less stress in the rotator cuff.

- Scapulothoracic strengthening exercises include
  - The seated row, pull-downs, the “push-up plus,” the “bench press plus,” and the “press-up plus.” These exercises should be carried out to a “four-count” to avoid substituting biceps and triceps function for scapulothoracic retraction and protraction, respectively (Figures 41–4 through 41–8).
  - The middle and lower trapezius may be strengthened by prone dumbbell flies performed with the shoulder abducted 90 and 135 degrees, respectively. A four-count is not necessary for these exercises (Figure 41–9).
  - An elastic resistance can be used in lieu of a weight.
  - Exercises optimally should be performed until the muscles fatigue, which is when mechanics become abnormal, rather than completing a specified number of sets and repetitions. For deconditioned patients, a rough goal is one set of 10 to 12 repetitions for each exercise, performed once or twice a day, to start. A well-conditioned athlete can begin with a more advanced program.
  - Exercise should not cause pain. If pain occurs during or after exercises, then (1) the resistance should be decreased, (2) the number of repetitions should be decreased, or (3) the patient should restrict the exercise motion to within the pain-free arc.

- The posterior joint capsule and pectoralis minor should be stretched (Figures 41–10 and 41–11). A tight posterior capsule may negatively affect glenohumeral biomechanics, whereas pectoralis minor tightness may exacerbate scapular protraction.

**Surgical Management**

- Pearl: Instability should be ruled out using examination under anesthesia and/or diagnostic arthroscopy. Failure to address underlying glenohumeral instability will compromise the surgical result.

**Subacromial Decompression (Acromioplasty)**

- Subacromial decompression (SAD; acromioplasty) is the most common shoulder procedure performed today. This procedure is designed to alleviate rotator cuff problems caused by subacromial spurs, per the classic theory of extrinsic CA impingement.
- According to the theory of intrinsic degenerative tendinosis, SAD may provide pain relief by removing the CA ligament and acromial undersurface, the sources of secondary impingement, thereby removing pressure from a sensitive tendon.

![Figure 41–2:](image)

● Other plausible explanations include denervation of the CA arch or the institution of relative rest and meaningful postoperative rehabilitation.

● SAD alone does not directly address the primary degenerative tendinosis and, as noted by Weber and Hyvonen, Lohi, and Jalovaara, does not prevent tear progression from rotator cuff tendinosis/partial-thickness tears to full-thickness tears.

● If pathologic reactive subacromial exostoses are seen in combination with a bursal-sided partial-thickness tear, the offending exostosis should be removed. This procedure does not require a formal SAD, because the acromial body itself rarely is abnormal.

● Two common arthroscopic techniques can be used to “check” each other:
  1. Burr lateral/scope posterior: A burr is buried into the anterolateral corner of the acromion to the desired depth, and the anterior border of the acromion is resected at this depth to its medial border. The depth of resection decreases as the burr is brought posteriorly.
  2. Cutting block technique (burr posterior/scope lateral): The posterior acromion is used to guide resection of the anterior acromion to create a flat undersurface.

Results

● Short-term results of arthroscopic SAD (ASAD) are favorable overall, with between 46% and 100% success at a mean 17- to 48-month follow-up. Stephens et al. reported 81% surgical success for ASAD at average follow-up of 8 years 5 months. Of these patients, 34% underwent concomitant rotator cuff debridement.

● Meta-analysis by Checroun, Dennis, and Zuckerman revealed 83.3% surgical success for 698 open subacromial decompressions at 6 to 62 months and 81.4% surgical success for 1237 arthroscopic SADs at 6 to 41 months. At 25-month follow-up, Spangehl et al. found no significant difference between open and ASAD for strength and patient satisfaction, although patients who had open SAD had less pain and better function.
Hyvonen, Lohi, and Jalovaara reported 72% good or excellent results for open SAD for impingement syndrome at mean follow-up of 9 years (range 6–15 years). Stuart reported 73% good to excellent results at minimum 3-year follow-up.

Fukuda reported 93.9% satisfactory results at 4.5-year follow-up of partial-thickness rotator cuff tears treated with open SAD followed by rotator cuff debridement and repair.

In addition to incomplete pain relief, shoulder stiffness, and deltoid weakness, SAD can be complicated by anterosuperior instability of the humeral head. The instability occurs when biomechanically marginally compensated rotator cuff tears rely on the subacromial arch to provide a fulcrum to allow continued elevation. It also can occur with tears that recur and progress despite surgery. This complication may result in total loss of active glenohumeral elevation.

Figure 41–6: Push-up plus.

Figure 41–7: Bench press plus.

Figure 41–8: Press-up plus.
Arthroscopic Rotator Cuff Debridement

- Arthroscopic rotator cuff debridement (ARCD) is an alternative, or complementary procedure to subacromial decompression. ARCD addresses the primary pathology directly without additional iatrogenic injury to the shoulder. Postoperative pain and morbidity are less than experienced with ASAD.

Technique (Figure 41–12)

- ARCD is best performed with the patient in the lateral decubitus position because of the traction applied. ARCD is extremely difficult to perform effectively with the patient in the beach chair position.
- Instability should be ruled out by examination with the patient under anesthesia and/or by diagnostic arthroscopy. Failure to address underlying glenohumeral instability will compromise the surgical result.
- An angled, motorized shaver is used to debride the insertions of the rotator cuff tendons. The area of tendinosis corresponds to the crescent area described by Burkhart,10,12 just lateral to the rotator cuff’s cable. The cable itself is essentially never degenerative.
- Pearl: The deepest layer of soft tissue surrounding any synovial articulation is the joint capsule. Therefore, when the arthroscope is introduced into a relatively...
Figure 41–12:
A, Arthroscopic view of the superior glenohumeral joint. The pathology is hidden behind the superior joint capsule. B, The superior capsule and rotator cuff insertion are challenged with an aggressive motorized shaver. C, The tendinotic tissue is easily removed. Normal tendon, including the cable of Burkhart seen on the far right, is not affected. D, The depth of the defect can be estimated from the size of the newly created bare spot superior to the humeral articular cartilage. E, The subacromial space is free from underhanging pathologic osseous prominences. Debridement of the bursal surface of the rotator cuff usually removes significantly less pathologic tissue compared to debridement of the articular surface.
normal glenohumeral joint and the lens is directed superiorly, the surgeon is viewing the superior joint capsule, not the rotator cuff. To assess the rotator cuff, you need to debride the superior capsule and challenge the rotator cuff insertion with a motorized shaver.

- Normal tendon is composed of white, shiny fibers of parallel orientation. A motorized shaver used in a windshield wiper fashion will not injure normal tendon. However, the more friable tendinosis tissue will be quickly and easily debrided. Debridement is continued until normal tendon is reached, at which point continued debridement becomes ineffective.
- The CA ligament is not released. Pathologic subacromial osteophytes can be debrided if necessary, but the procedure is uncommon. A traditional SAD is not performed.

Results

- Budoff, Nirschl, and Guidi\(^3\) reported 89% good to excellent results at average 53-month follow-up, 93% if workers’ compensation cases were excluded. Long-term results at minimum 5-year follow-up were 81% good to excellent, 86% if workers’ compensation cases were excluded.\(^3\)
- Snyder et al.\(^44\) reported 93% success, with the addition of SAD making no difference.
- Andrews, Broussard, and Carson\(^45\) reported 85% success in treating young athletes.
- Altchek and Carson\(^46\) reported 80% success in throwing athletes, 10% of whom also underwent ASAD. They believed that untreated instability was responsible for the failures.\(^46\)

Rotator Cuff Repair

- Open repairs involve deltoid takedown and reattachment, necessitating more conservative postoperative therapy and predisposing to the devastating complication of deltoid detachment.
- Mini-open repairs split the deltoid without takedown, are versatile, and prevent the potentially devastating complication of deltoid detachment.
- Arthroscopic repairs have benefited from improved techniques, equipment, and experience. Even large tears can be routinely repaired arthroscopically.
- From 84% to 95% satisfactory results at 2.5- to 4-year follow-up have been reported, rates equal to open repair. Less postoperative pain and stiffness have been noted. Postoperative rehabilitation may be less aggressive than following open repair.\(^47\)–\(^49\)
- Common rotator cuff tear patterns:\(^50\):
  - Longitudinal: These longitudinal splits can simply be repaired side to side.
  - Crescent-shaped: Minimally retracted. The tendon is simply repaired back to the greater tuberosity (Figure 41–13).
  - U-shaped: These often extend medially. The longitudinal component should first be repaired in a side-to-side fashion from medial to lateral (margin convergence) to create a crescent-shaped tear, which reduces strain at the cuff edge. The tear then can be repaired back to the greater tuberosity with minimal tension. Attempts to bring the medial margin laterally to the tuberosity will fail (Figure 41–14).
  - L-shaped: This tear is similar to the U-shaped tear, except that one of the cuff’s leaves (usually the posterior leaf) is torn from the greater tuberosity and the adjacent tendon. This leaf is more mobile than the other and is repaired side to side along the longitudinal split then back to the greater tuberosity. It may occasionally be easiest to first repair its free corner back to the greater tuberosity and then sew its free longitudinal edge back to the adjacent rotator cuff tendon (Figure 41–15).
  - Massive: These tears often are chronic and immobile, requiring surgical release(s) to accomplish a minimal
tension repair. Poorly mobilized tears that are repaired under tension have a high propensity to fail.

- Reported results of full-thickness rotator cuff repairs performed with or without SAD demonstrate similar results.
- From 80% to 94% surgical success has been reported for open repair with SAD at 2- to 13.4-year follow-up.\(^{51-53}\)
- Goldberg, Lippitt, and Matsen\(^ {54}\) reported good results and improved function following open repair performed without acromioplasty at average 4-year follow-up.
- Gartsman and O’Connor\(^ {55}\) performed a prospective, randomized study of 92 patients with full-thickness tears of the supraspinatus tendon and a type II acromion undergoing arthroscopic repair. At minimum 1-year follow-up, they noted no significant difference in outcomes whether or not an acromioplasty was performed.

**Mini-Open Rotator Cuff Repair**

- I routinely perform arthroscopy before mini-open repair to avoid missing additional pathology, and to be able to debride the undersurface of the rotator cuff.
  1. A longitudinal incision in Langer lines is performed over the lateral acromion, centered at its anterolateral corner (Figure 41–16). The skin is mobilized from the superficial deltoid fascia and retracted with a Gelpi retractor.
  2. The anterolateral raphe of the deltoid is split (Figure 41–17). The proximal anterolateral raphe often runs

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**Figure 41–14:**

**Figure 41–15:**
3. To avoid injuring the axillary nerve, classic teaching is to not split the deltoid raphe distally more than 5 cm from the acromion. Although the classic teaching is correct, a more accurate technique is to realize that the nerve courses distal to the distal margin of the subacromial bursa. The pouch-like distal extent of the subacromial bursa can be palpated and the deltoid split just short of this level. A Gelpi retractor is used to maintain the deltoid split.

4. The bursa is resected. This procedure exposes the rotator cuff and may partially denervate the subacromial space, potentially relieving pain. To identify the bursa, remember that the bursa does not move with humeral rotation but the rotator cuff does (Figure 41–18).

5. The tear pattern is recognized and repaired appropriately. Margin convergence (side-to-side repair of the tendon, starting medially and progressing laterally) is used as needed, especially in U-shaped tears (Figure 41–19). Massive tears may require release of the rotator interval (between the supraspinatus and subscapularis), including release of the supraspinatus from the coracohumeral ligament, which tethers it to the base of the coracoid process. Occasionally, a release between the contracted supraspinatus and infraspinatus is also necessary.

6. The tendon should be repaired to bone. A rongeur is used to remove degenerative tendinosis and sclerotic cortex just lateral to the articular cartilage margin. However, the entire cortical thickness does not need to be removed, nor does cancellous bone need to be exposed or a trough created. Doing so may only weaken the suture anchor fixation.

along the anterior margin of the acromion. Extension of the raphe along this margin can compromise the anterior deltoid origin. To avoid this situation, once the anterolateral corner of the acromion is reached, the incision is angled toward the center of the acromion, in a direction 45 degrees from the anterior and lateral acromial border. To maximize exposure, electrocautery should be used to incise the deltoid’s deep fascial origin at the acromion.
7. Suture anchors and/or sutures through drill holes can be used to coapt the tendon to bone. Suture anchors are placed at a 45-degree “dead man’s angle” just lateral to the decorticated bone. I prefer a modified Mason-Allen stitch with no. 2 Fiberwire suture (Arthrex; Naples, FL) (Figure 41–20).

● Postoperatively, early passive and gentle active assisted motion is performed. Active motion is delayed for 4 to 6 weeks and strengthening for 10 to 12 weeks.

Arthroscopic Rotator Cuff Repair

● This particular technique is my preference, but there are many variations, and other surgeons have other excellent techniques. I have no financial interest in any of the products mentioned.

1. The posterior and anterior portals are made more superiorly to provide better angles for suture passage. The anterior portal should be made in the superior and medial extent of the rotator interval, not low on the subscapularis (as would be optimal for a Bankart repair).

2. A complete bursectomy is performed, taking care to remove the posterior wall of the bursa (the “veil of tears”) (Figure 41–21). I prefer using a shaver on forward to prepare the “landing pad” on the greater tuberosity instead of a burr. Sclerotic bone is removed, but a full decortication is not performed.
3. The lateral portal is used for visualization. It is localized with a spinal needle approximately 3 to 4 cm lateral to the lateral border of the acromion, at the anteroposterior center of the rotator cuff tear (Figure 41–22). Before transferring the arthroscope to the lateral portal, any soft tissue around the localizing needle is debrided, otherwise it will obstruct your view once the arthroscope is moved. The anterolateral portal is used to place suture anchors into the greater tuberosity. It is localized with a spinal needle close to the lateral border of the acromion (for a better angle for anchor placement) in line with an axis bisecting the acromioclavicular (AC) joint. Metal anchors can be screwed through needle holes in the skin without the need to create a formal portal. Additional portals can be created as necessary to facilitate the procedure, analogous to extending an open incision. The “safe zone” for portal placement is within 5 cm of the acromial edge in a 180-degree arc lateral to the coracoid, anteriorly and posteriorly.

4. There are four types of tears, in addition to massive tears: longitudinal, U-shaped, L-shaped, and crescent-shaped. Longitudinal tears are repaired side to side and are the easiest to start with. U-shaped tears are repaired by margin convergence (side to side) and then anchored to bone. Following margin convergence, the anterior and posterior leafs of the rotator cuff should lie against the tuberosity without tension. One suture anchor, with two loaded sutures, often is sufficient to anchor both leaves of a U-tear with a “single-row” repair. Crescent tears are repaired by multiple suture anchors, usually proceeding from anterior to posterior. L-shaped supraspinatus tears are repaired by pulling the avulsed corner laterally with a locking grasper and repairing this corner to a suture anchor in the tuberosity. Two anchors (four sutures) often are required to coapt the entire tear to bone. Side-to-side stitches are then placed to repair the longitudinal component of the tear. Alternatively, the side-to-side stitches may be placed before the suture anchor.

5. It is crucial for margin convergence stitch placement to have an unobstructed view of the anterior and posterior cannulas; debride more bursa until this occurs. In my experience, I have found it easiest to pass sutures with the 45-degree Arthrex lasso. After passing the lasso through the posterior cannula, its tip is rotated inferiorly and pushed through the rotator cuff’s posterior leaf. It is important to capture enough tissue (5–10 mm) but not so much that the tendon bunches up excessively when the knot is tied. The lasso then is passed through the anterior leaf of the rotator cuff. It is helpful to use a grasper passed through the anterior cannula, or the anterior cannula itself, to provide “back-pressure” to facilitate penetration of the anterior leaf. The lasso’s suture loop is grasped and pulled out of the anterior cannula, where it is loaded with a free fiber wire (Arthrex) suture (Figures 41–23 and 41–24). The lasso is pulled back out of the posterior cannula, bringing one end of the Fiberwire stitch out with it (Figure 41–25). It is important to pull the metal shaft of the lasso and its suture loop back simultaneously as one unit. If the suture loop is simply pulled through the lasso’s shaft, the fiber wire can be damaged against its sharp tip.

Figure 41–22: Arthroscopic rotator cuff repair: portal placement.
Figure 41–23: Arthroscopic rotator cuff repair: margin convergence stitch placement.

Figure 41–24: Arthroscopic rotator cuff repair: margin convergence stitch placement.

Figure 41–25: Arthroscopic rotator cuff repair: margin convergence stitch placement.
The first end of the fiber wire suture retrieved through the posterior portal is tagged with a hemostat and will be the “post strand” during arthroscopic knot tying. This method ensures that the knot opposes the two rotator cuff leafs to each other and does not become interposed in the repair between them. The grasper is deployed through the posterior cannula, and the other end of the fiber wire suture is grasped close to its exit from the anterior cannula and pulled out of the posterior cannula. An arthroscopic knot is tied through the posterior cannula, as the posterior tendon leaf usually is more mobile than the anterior leaf. I prefer the SMC (Seoul Medical Center) sliding knot, backed up with three half-hitches, but many others work just as well.

6. The suture anchor is placed through the anterolateral portal at a 45-degree “dead man’s angle” just lateral to the decorticated “landing pad (Figure 41–26). The laser markings on the anchor’s inserter correspond to its eyelet and should be oriented medial to lateral to best oppose the tendon to the tuberosity.

Passing the anchor sutures (Figure 41–27): The arthroscope is in the lateral portal. To pass an anchor suture through the posterior leaf of the rotator cuff, first take the medial free end of the suture through the opposite (anterior) portal.

Pearl: Take care that the anchor is not unloaded during this step: Visualize the anchor’s eyelet. If the suture doesn’t move as its free end is shuttled between portals, then the correct end is being pulled. If the suture moves through the eyelet as it is being pulled, then the wrong end is being shuttled, which will result in anchor unloading if the process is continued.

7. I place and tie knots as I go to prevent tangles. To best oppose the tendon to the bone (or to other tissue), the suture end that is passed through the tendon should be your post. Otherwise the knot can become interposed between the tissues that you are trying to oppose.

Postoperative rehabilitation is slightly less aggressive than following mini-open rotator cuff repairs. Passive and gentle active assisted motion is started after 1 to 2 weeks and is limited to 90 degrees of elevation for 3 to 4 weeks. Active motion and return to activities are similar to that following mini-open repair.

**Bicipital Tendinosis**

- In abduction–external rotation, the biceps tendon runs almost perpendicular to the glenoid surface. In this position, it can function as a secondary dynamic stabilizer, increasing compression of the humeral head into the glenoid.
- The biceps tendon assists in preventing superior migration of the humeral head, especially in patients with rotator cuff dysfunction. Symptoms related to the biceps tendon are strongly correlated with rotator cuff disease, possibly because a dysfunctional rotator cuff increases the use of the biceps in this role. Anterior instability leads to even greater biceps activity, especially during the throwing motion.
- Bicipital tendinosis is most commonly (95%) secondary to other pathologic conditions about the shoulder. Most cases are secondary to rotator cuff tendinosis, although bicipital tendinosis also is associated with glenohumeral instability. Failure to address symptomatic bicipital tendinosis may lead to recalcitrant pain following treatment of these other conditions.
- Primary bicipital tendinosis, which accounts for only approximately 5% of cases, most often occurs in younger patients.
Diagnosis

- Bicipital tendinosis is suspected based on its clinical presentation. It causes anterior shoulder pain, often overlapping with symptoms caused by the rotator cuff. Pain of biceps origin often radiates down to the biceps muscle belly.
- Instability of the biceps tendon may present in a young overhead athlete with a painful snapping or clicking, especially in overhead positions, going from internal to external rotation.56
- Tenderness is noted in the bicipital groove. Unlike rotator cuff tenderness, this moves laterally with external humeral rotation and medially with internal humeral rotation. The speed test is discussed in Chapter 40.

- Diagnostic injections may be difficult to interpret, because the biceps sheath communicates with the glenohumeral joint. Consequently, biceps sheath injections may relieve symptoms caused by intraarticular pathology and vice versa.
- If biceps sheath pathology is suspected, MRI can be used to identify biceps tendon instability, tenosynovitis, or other extraarticular tendon pathology. Contrary to common belief, most cases of biceps tendon subluxation do not intermittently reduce with arm motion. Instead, this subluxation appears to be fixed. Biceps tendon instability may be difficult to assess preoperatively.56
- The intraarticular portion of the biceps tendon is best assessed at the time of arthroscopy.
- During arthroscopy, the biceps tendon itself should look shiny and white without significant fraying. As noted by Bennett,59 the tendon in the proximal bicipital groove can be examined by flexing the patient’s elbow and using a probe to pull it into the joint.

Treatment

- Nonoperative management should be directed toward the rotator cuff.56 If nonoperative management fails, surgical treatment for the rotator cuff and biceps tendon can be considered.
- Intraarticular tendinosis most commonly affects the base of the biceps near its origin from the superior labrum. Tendinosis in this area can be debrided similarly to the rotator cuff. Normal biceps tendon will not be injured by a motorized shaver.
- Following debridement, if more than 25% to 50% of the tendon is involved, a tenotomy or tenodesis can be considered.56,60 The superiority of one technique over the other is not completely resolved. However, in higher-demand patients younger than 50 to 60 years, a tenodesis is generally favored. In lower-demand patients, an arthroscopic tenotomy may be just as satisfactory.61 Good or excellent results have been reported in up to 92% of patients following tenodesis.58
- Symptomatic subluxation or dislocation of the biceps is another indication for tenodesis or tenotomy.
- Isolated rupture of the long head of the biceps can be treated nonoperatively. Residual pain or weakness of elbow flexion is uncommon. Supination strength has been noted to decrease 10% to 21% in patients treated nonoperatively and in 8% in patients tenodesed. Although surgical tenodesis may improve cosmesis and possibly supination strength, patients treated nonoperatively may return to work earlier.56

Technique for Open Biceps Tenodesis

- Preoperatively mark the point of the patient’s maximal tenderness, which may locate the proximal end of the biceps stump. In my experience, arthroscopy is routinely performed to evaluate and treat any rotator cuff pathology.
1. If the long biceps tendon is torn, its intraarticular proximal stump is debrided. If it is incompletely torn and a tenodesis is indicated, then, before releasing the biceps tendon, it is marked with cautery just as it enters its groove to guide later tensioning.

2. Once arthroscopy is discontinued, the adducted arm is externally rotated. A longitudinal incision is made over the bicipital groove on the anterior aspect of the shoulder (Figure 41–28). Dissection is carried down via a muscle-splitting approach to the biceps sheath, which is opened and the tendon identified. The incision may have to be extended distally in more chronic situations.

3. Longitudinally incise and elevate the periosteum on either side of the tenodesis site. Use a curette to roughen the bone. Flex the elbow 90 degrees and advance the tendon proximally until it is appropriately tensioned. If the tendon was marked prior to arthroscopic tenotomy, it is tensioned by bringing the cautery mark to the level of the proximal bicipital groove.

4. Place two suture anchors. Weave one end of each suture through the tendon in Bunnell fashion to grasp it firmly. When tying your knot, this end will be your “loop” strand. The other free end goes through the tendon only once so that it slides easily. This sliding end is your “post” strand. This will allow the well-grasped tendon to slide down to the bone when the knot is tied. Place all sutures first, then tie the knots (Figure 41–29).

5. Oversew the tendon into the raised periosteal flaps or other local tissue.

- Postoperatively, keep the elbow flexed 90 degrees for 2 to 3 weeks, then allow active extension and passive flexion. Gradually regain extension. Active flexion is allowed at 4 weeks. Full range of motion should be accomplished by 6 weeks. Light strengthening is allowed at 2 months. Full activity and lifting are allowed at 3 to 4 months.

References


2. Bigliani LU, Morrison DS, April EW: The morphology of the acromion and its relationship to rotator cuff tears. Orthop Trans 10:228, 1986. The authors classified acromions into types I, II, and III. Type III acromions were associated with full-thickness rotator cuff tears.


The authors found that rotator cuff insertional degeneration was more prominent on the articular side compared with the bursal side.


The authors examined cadaveric shoulders and noted that acromial changes are secondary to primary rotator cuff changes.


The type III acromion occurs in only 2% to 4% of young athletes. A higher incidence is seen in older populations, suggesting that the type III acromion is reactive, not congenital.


The authors describe reformation of the subacromial spur following arthroscopic subacromial decompression.


The acromial “spur,” located at the insertion of the CA ligament, demonstrates active bone formation, implying that spur formation is a secondary phenomenon.


Sixty-two percent good or excellent results are reported for treatment of full-thickness rotator cuff tears with nonoperative management at minimum 2-year follow-up.


The author discusses the biomechanics of the rotator cuff cable, force couples, and the fact that not all “successful” rotator cuff repairs have fully healed tendons.


The authors discuss the active and passive stabilizers of the shoulder.


Functional and nonfunctional rotator cuff tears are discussed with reference to the force couples of the shoulder.


Sclerosis, osteophytes, and subchondral cysts of the greater tuberosity are associated with rotator cuff tears.


Supraspinatus pathology as seen on MRI is related to age rather than rotator cuff symptoms.


The author notes that MRI has not performed well in distinguishing normal tendon from partial-thickness or small full-thickness rotator cuff tears. MR angiography has performed better.


MRI is not an effective or accurate tool for assessing shoulder pathology when the clinical picture is not clear.


Eight of 10 arthroscopically proven partial-thickness rotator cuff tears were not seen on MRI.


MRI was reported to be up to 78% sensitive, 83% specific, and 82% accurate for detecting full-thickness rotator cuff tears.


MRI was reported to be 84% sensitive, 94% specific, and 92% accurate for detecting full-thickness rotator cuff tears.


MRI demonstrated a high prevalence of partial-thickness and full-thickness rotator cuff tears in asymptomatic shoulders.


MRI examination revealed that 28% of asymptomatic volunteers older than 60 years had full-thickness rotator cuff tears, and 26% had partial-thickness tears.


The authors report full-thickness rotator cuff tears in asymptomatic volunteers and conclude that these tears can be regarded as “normal” degenerative attrition.


Seventy-four percent success is reported for treatment of full-thickness rotator cuff tears with nonoperative management at
mean 7.6 year follow-up. The program consisted of non-
steroidal anti-inflammatory medications, stretching, strengthening
and occasional steroid injections.

24. Goldberg BA, Nowinski RJ, Matsen FA: Outcome of nonopera-
tive management of full-thickness rotator cuff tears. Clin Orthop
Reports 59% of patients had a significant improvement in
symptoms at mean 2.5 year follow-up of non-operative
management of full-thickness rotator cuff tears. The program was
based on patient education and a home program of strengthening
and stretching.

25. Hawkins HR, Dunlop R: Nonoperative treatment of rotator
Reports 58% of patients were satisfied at mean 3.8 follow-up
of non-operative management of full-thickness rotator cuff
tears. The program was based on rotator cuff strengthening
exercises.

Eight-two percent good or excellent results are reported for
treatment of full-thickness rotator cuff tears with nonoperative
management at mean 3.4 year follow-up. The program con-
sisted of rest, anti-inflammatory medications, local injection of
analgiesa with or without steroid, and motion and strengthen-
ing exercises.

The authors question the efficacy of steroid injections and note
that repetitive injections can cause cellular death, further tissue
weakness, and slow the healing process.

28. Buchbinder R, Green S, Youl JM: Corticosteroid injections for
No benefit of subacromial steroid injection compared with oral
nonsteroidal antiinflammatory drugs was demonstrated; how-
ever a small benefit of subacromial steroid injection compared
with placebo was found in some studies.

29. Bassett RW, Cofield RH: Acute tears of the rotator cuff. The
1983.
For large traumatic rotator cuff tears, early repairs performed
within 3 weeks of injury yielded better results than repairs
performed later.

The author discusses the relationship between scapulothoracic
and glenohumeral pathology and the physical examination and
management of scapulothoracic dysfunction.

31. Burkhart SS, Morgan CD, Kibler WB: The disabled throwing
shoulder: spectrum of pathology part III: The SICK scapula,
scapular dyskinesia, the kinetic chain, and rehabilitation.
Tightness of the postero-inferior glenohumeral capsule may
predispose to glenohumeral pathology, especially SLAP lesions.

32. Soifer TB, Levy HJ, Soifer FM et al: Neurohistology of the sub-
A rich supply of neural elements was identified within the
subacromial bursa.

33. Ryu RK: Arthroscopic subacromial decompression: a clinical
Improvement following ASAD in patients with articular-sided
partial-thickness rotator cuff tears may result from postopera-
tive rest rather than the surgery.

34. Weber SC: Arthroscopic debridement and acromioplasty versus
mini-open repair in the treatment of significant partial-thickness
The author noted that acromioplasty alone does not prevent
rotator cuff tear progression.

35. Hyvonen P, Lohi S, Jalovaara P: Open acromioplasty does not
prevent the progression of an impingement syndrome to a tear.
Nine-year follow-up of 96 cases. J Bone Joint Surg 80B:813-816,
1998.
The authors report 72% good or excellent results at a mean of
9 years following open SAD, with the development of rotator
cuff tears following SAD.

36. Ogata S, Ulahoff HK: Acromial enthesopathy and rotator cuff
tear. A radiologic and histologic postmortem investigation of the
This cadaveric notes that rotator cuff tears likely are not
initiated by impingement; rather, they develop as an intrinsic
degenerative tendinopathy.

acromioplasty: a 6- to 10-year follow-up. Arthroscopy 14:382-
The authors report 81% success at average 8.4-year follow-up.
Thirty-three percent could not return to throwing, and those
who did experienced pain. Fifty percent could not serve a ten-
sis ball.

38. Checroun AJ, Dennis MG, Zuckerman JD: Open versus arthro-
scopic decompression for subacromial impingement. A compre-
nhensive review of the literature from the last 25 years. Bull Hop
Using meta-analysis, the authors report 83.3% surgical success
for 698 open SAD at 6 to 62 months and 81.4% surgical success
for 1237 ASAD at 6 to 41 months.

39. Spanghel MJ, Hawkins RH, McCormack RG, Loomer RL:
Arthroscopic versus open acromioplasty: a prospective, ran-
domized, blinded study. J Shoulder Elbow Surg 11:101-107,
2002.
The authors report no significant difference between open
and arthroscopic subacromial decompression at 25-month
follow-up.

40. Fukuda H: Partial-thickness rotator cuff tears: a modern view on
Open SAD followed by rotator cuff debridement and repair
was performed for partial-thickness rotator cuff tears, leading
to 93.9% satisfactory results at 4.5 years.

41. Lee SB, Itoi E, O’Driscoll SW, An KN: Contact geometry at the
undersurface of the acromion with and without a rotator cuff
Factors other than acromial shape play a significant role in the
pathogenesis of rotator cuff tears.
Four cases of anterosuperior humeral instability are reported following CA ligament division and SAD.

The authors, having reviewed large rotator cuff repairs, note that CA ligament excision leads to a poor result by allowing superior humeral migration, which may stretch the repair.

The authors report 93% good or excellent results for arthroscopic debridement of partial-thickness rotator cuff tears. Results were similar whether or not an SAD was performed.

Arthroscopic rotator cuff debridement was performed on 36 young competitive athletes, 64% of whom were baseball pitchers. Eighty–five percent had good or excellent results.

The authors discuss the rationale for primary rotator cuff dysfunction and weakness leading to superior migration of the humeral head and secondary CA arch impingement. The authors report good results in 80% following arthroscopic rotator cuff debridement.

The authors report 95% good or excellent results at mean 3.5-year follow-up.

The authors report 84% good or excellent results at mean 30-month follow-up.

The authors report 91% good or excellent results using suture anchors.

The authors review rotator cuff tear patterns and strategies for arthroscopic repair.

The authors report 80% satisfactory results following open repair at 13.4-year follow-up.

The authors report 86% good or excellent results following mini-open rotator cuff repair.

The authors report 94% of patients were satisfied following open repair.

The authors report good results for rotator cuff repairs without acromioplasty at 4 years.

No significant difference in outcomes was noted whether or not an acromioplasty was performed with a full-thickness rotator cuff repair.

The authors provide a good review of the topic.

The authors provide a good review of the topic. They note that anterior instability leads to increased biceps activity, especially during the throwing motion.

The authors note that 95% of bicipital tendonitis is secondary to other glenohumeral disorders and report 92% good or excellent results following tenodesis.

The author discusses arthroscopic assessment of the long biceps tendon.

Indications, techniques and results of arthroscopic biceps tenodesis are discussed.

The authors found no difference in cosmetics, pain, or spasm between tenodesis and tenotomy in most patients (average age 58 years).
Glenohumeral Instability, Adhesive Capsulitis, and Superior Labral Anteroposterior Lesions

Jeffrey E. Budoff

Glenohumeral Instability

- The anatomy and function of the glenohumeral ligaments were discussed in Chapter 40. Glenohumeral instability now is understood to comprise a spectrum from frank dislocation to subtle degrees of recurrent subluxation.

Etiology

- The existence of an “essential lesion” remains controversial.
- A Bankart lesion (avulsion of the anteroinferior labrum and attached ligaments from the glenoid rim) alone leads to only a small increase in translation, not to glenohumeral dislocation (Figure 42–1).1
- Dislocation may require plastic deformation of the capsuloligamentous stabilizers in addition to a Bankart lesion. The amount of plastic deformation may vary with the patient’s body habitus. “Ligamentously loose” individuals may stretch more before failure, whereas “tight-jointed” individuals may avulse their labrum with lesser degrees of permanent ligament stretch. Subsequent episodes of instability can lead to further plastic deformation/elongation.2
- Pathologic glenohumeral subluxation may occur in the absence of labral detachment.
- If surgical treatment is elected, increased capsular volume should be addressed.2

Direction of Instability

- Glenohumeral instability may occur in the anterior direction, posterior direction, or both (multidirectional instability). In addition, ligamentously lax individuals may have a significant degree of inferior hyperlaxity imposed upon their primary instability. This loose ligamentous habitus may be considered a biologic predisposition upon which repetitive or macrotrauma is superimposed.3
- Patients with glenohumeral instability present a spectrum from traumatic instability associated with a capsuloligamentous avulsion (Bankart lesion) to a more atraumatic condition associated with generalized ligamentous laxity, a positive sulcus sign, a patulous capsule, and no Bankart lesion.2 Multidirectional instability is associated with increased capsular volume and inferior glenohumeral hyperlaxity.5

Diagnosis

- Glenohumeral instability is a clinical diagnosis. Its history and physical examination is discussed in Chapter 40. Radiographs should be assessed to determine the presence of an avulsion (Bankart) fracture, Hill-Sachs lesion, posttraumatic arthritis, or a nonconcentric reduction.
- Examination of the anesthetized patient and arthroscopic findings may help confirm the diagnosis in subtle cases.
Arthroscopic findings indicative of instability include Hill-Sachs lesions, Bankart lesions, and anteroinferior labral or chondral injury. According to McFarland et al, a positive drive-through sign, in which the arthroscope is easily placed from a posterior portal between the humeral head and the glenoid into the anterior joint is 92% sensitive but is only 38% specific for instability, as it may be associated with physiologic shoulder laxity.3

Nonoperative Management

Closed Reduction of Anterior Glenohumeral Dislocations

- Relatively contraindicated in the presence of a humeral head, neck, or shaft fracture. If attempted, great care should be taken to avoid fracture displacement.
- Closed reduction should be performed as gently and as early after the dislocation as possible. If closed reduction is not possible without great force, open reduction should be considered.
- Can be facilitated with an intraarticular injection of lidocaine into the vacant glenoid fossa, posterior to the humeral head in lieu of or in addition to intravenous sedation and muscle relaxation.4
- Postreduction radiographs, including an axillary view, are always taken to confirm concentric reduction. Prereduction and postreduction neurovascular checks are routine.
- Author's preferred technique: Scapular manipulation: This technique focuses on repositioning the glenoid and bringing it to the humeral head, instead of bringing the humeral head to the glenoid. The technique is simple, quick, relatively painless, minimally traumatic, and safe. It can be performed with the patient prone or seated.
- Scapular manipulation technique: The patient is placed prone, with the affected arm off the side of the gurney. From 5 to 10 lb traction can be applied to the arm, or an assistant can provide traction (Figure 42–2).
  
  Alternatively, the patient can be seated, with the lateral side of the unaffected shoulder placed firmly against the raised head of the stretcher or the wall. This position prevents the discomfort of assuming the prone position. The assistant provides firm but gentle forward traction by grasping the wrist of the affected side and slowly flexing it 90 degrees, with countertraction provided by placing the palm of his/her other arm against the midclavicle, with his/her elbow extended (Figure 42–3).5,6
- The scapula is manipulated by rotating its inferior angle medially. The other hand stabilizes the superior scapula, pushing it slightly inferolaterally (see Figure 42–2). The physician can stand on the injured or the uninjured side. Standing on the uninjured side may be easier, because the physician’s fingertips can more easily grasp the lateral margin of the scapula and pull its inferior angle toward the midline rather than pushing it from the injured side. The glenohumeral joint often reduces with a palpable pop, but reduction may be subtle.
- Reported 86% to 96% success. No complications have been reported, probably because the reduction can be accomplished with minimal exertion.5,6

Traction-Countertraction Technique

- Excessive force should not be used, especially during humeral rotation, as fracture, brachial plexus, and vascular injuries have been reported. This technique also is effective for posterior dislocations.
The patient is placed in the supine position. The physician wraps a sheet around his/her waist and the forearm of the injured arm just distal to the elbow, which is flexed 90 degrees (elbow flexion relaxes the biceps and neurovascular structures). The assistant wraps a sheet around his/her waist and the patient’s thorax for countertraction. The affected arm is gently abducted and flexed. The surgeon and assistant apply gentle traction-countertraction by leaning back. Gentle but firm traction is gradually increased and maintained. The surgeon gently externally rotates the arm, applies slightly more traction, and then gently internally rotates the arm. Lateral pressure can be applied on the proximal humerus from the axilla (Figure 42–4).

Subacute Management

- Although immobilization has not been shown to decrease recurrence rates, the recommendation is 3 weeks following dislocations in young active patients and 1 week in older individuals more predisposed to developing shoulder stiffness.7,8 Restriction of activity and sports for 6 weeks or more has been shown to decrease the recurrence rate.9
- Magnetic resonance imaging (MRI) studies have shown that following anterior dislocation, immobilization with the shoulder in external rotation more closely approximates the Bankart lesion to the glenoid neck than does the conventional position of internal rotation. Conversely, following posterior dislocation, internal rotation better coaps the posterior labrum to the glenoid rim.10,11
- Rehabilitation should include posterior capsular stretching and rotator cuff and scapulothoracic strengthening (detailed in Chapter 41). Burkhead and Rockwood12 reported 80% good or excellent results in patients with an atraumatic onset of instability associated with ligament laxity, with only 16% good or excellent results in cases of acute unidirectional instability with Bankart lesions.7 Savoie and Field13 reported 90% satisfactory results with 6 months of rehabilitation for patients with multidirectional instability.

Results

- Redislocation rates vary by age and activity, with younger, more active patients having higher rates of recurrent instability. The results reported in the literature vary; noting a 17% to 94% recurrence rate following initial dislocation in patients younger than 20 to 22 years, 37% to 61% for patients between 21 and 30 years, and 9% to 35% in patients older than 30 to 40 years. Recurrent instability is uncommon following initial dislocation in patients older than 40 years.7–9,14
- In older patients, future disability may be more related to traumatic rotator cuff tearing than to recurrent dislocation. Rotator cuff repair alone may be adequate to stabilize the joint in elderly patients, even in the presence of an unrepaired Bankart lesion.15
- Hovelius et al.16 noted a 20% rate of posttraumatic arthritis at 10 years (11% mild and 9% moderate to severe). The risk of damage to capsule, labrum, and cartilage is believed to increase with subsequent dislocations.

Surgical Stabilization

- Surgical stabilization should include repair of any Bankart lesion, repair of any significant rotator interval tear, and treatment of pathologically increased capsular volume as needed. This may be done by open or arthroscopic
technique. Although open stabilizations traditionally have provided more security, improved arthroscopic techniques, equipment, and experience may allow the surgeon to attain excellent results even in high-demand contact athletes with a lower degree of morbidity and stiffness. The capsule can be shifted, capsular volume decreased, and rotator interval repairs performed.

- Rotator interval tears may be responsible for increased inferior or posterior laxity and should be suspected in cases of a sulcus sign that does not reduce with external rotation. Its closure is especially important in patients with posterior or multidirectional instability. In the absence of significant inferior hyperlaxity, rotator interval tightening may limit external rotation.

- Open stabilization may be preferred in young or high-demand patients, contact athletes, or patients with decreased tissue quality (as may occur following multiple dislocations), or for revision of a failed arthroscopic stabilization. It also may be favored in patients with a loose ligamentous habitus. Such patients have less tendency to lose motion and a higher tendency toward recurrent instability. Capsular volume can be significantly decreased by “shifting” the capsular leafs in a superior/inferior direction.

- Although treatment of an initial dislocation traditionally has been nonoperative, arthroscopic treatment of first time dislocations in young, active patients has been advocated by some because of the poor results of nonoperative management in this patient group. Studies comparing nonoperative management to arthroscopic stabilization showed decreased recurrence rates from 47% to 75% to 11% to 16% at follow-up of 24 to 36 months, with improved quality of life and less labral, capsular, and cartilage damage. Compared to nonoperative management, arthroscopic stabilization demonstrated improved overall results and function, with no significant difference in range of motion.17,18

- Arthroscopic stabilization is contraindicated in cases of large bony deficits (>20%–25% loss) of the anterior glenoid, large Hill-Sachs lesions (>25%–35% of the arc), or Hill-Sachs lesions that engage the anterior glenoid rim in abduction–external rotation, poor-quality, attenuated capsulolabral tissue, and avulsion of the capsulolabral tissue from the humerus (“HAGL” lesion).19

- Author’s preferred technique: The particular techniques included in this chapter are my preference, but “there is more than one way to skin a cat,” and other surgeons have other excellent techniques. I have no financial interest in any of the products mentioned. Note that, in the absence of contraindications, I prefer arthroscopic stabilization.

- Open anterior stabilization: I believe that arthroscopy should be performed first, in order to assess and treat any coexisting pathologies.

- I have found open stabilization technically easier to perform with the patient supine, as opposed to the “beach chair” position. I place two folded towels under the scapula to stabilize it.

1. Make a longitudinal incision in the anterior axillary skin fold, starting at the level of the coracoid and extending inferiorly 4 to 5 cm (Figure 42–5). Mobilize the skin.

2. Identify the deltopectoral interval and retract the cephalic vein laterally (Figure 42–6). Release the superior 1 to 2 cm of the pectoralis major tendon. Release the inferior 20% of the coracoacromial (CA) ligament to ease rehabilitation but do not fully transect it. The CA ligament is in the same layer as the conjoined tendon layer. Incise the lateral 30% of the conjoined tendon just below its origin from the coracoid to ease exposure (Figure 42–7).
3. Externally rotate and adduct the shoulder to tension the subscapularis and move the axillary nerve medially. Palpate the axillary nerve as it crosses anterior to the inferior border of the subscapularis. Ligate the anterior humeral circumflex vessels (the “three sisters”).

4. The two options for subscapularis takedown are (1) releasing the subscapularis off of its origin or (2) splitting it. I prefer the former option if more exposure is needed to perform a humeral shift or a rotator cuff interval repair. However, the subscapularis split also works well and is preferred in overhead athletes. The subscapularis split allows adequate exposure for a Bankart repair or a glenoid-sided shift but not a humeral shift.

- A. Subscapularis takedown (Figure 42–8): Use a Bovie to take the subscapularis off its insertion on the lesser tuberosity by cutting vertically at the medial edge of the bicipital groove from the top of the subscapularis (the rotator cuff interval) to its inferior edge (identified by the anterior humeral circumflex vessels). The subscapularis tendon is approximately 7 to 8 mm thick. After cutting to this depth, angle the Bovie and dissect in the coronal plane medially. Alternate using the Bovie to cut and the corner of a ½-inch key elevator to scrape and elevate. Identify and dissect the plane between the joint capsule and the subscapularis. It is easier to find the plane inferiorly and then work superiority. Free up the superolateral and inferolateral corners of the subscapularis to facilitate dissection. Place two no. 2 Ethibond (Ethicon; Sommerville, NJ) tag stitches on the subscapularis to generate tension. The subscapularis is tendinous laterally and muscular medially. The joint capsule is white, smooth, and shiny. Reduce the humeral head with shoulder flexion to increase visualization. If there is no Bankart lesion (as determined at arthroscopy), the subscapularis need only be taken off the capsule to a level 1 cm lateral to the glenoid. If there is a Bankart lesion, dissection should be continued medial to the glenoid. It is important for subscapularis function to free its tendon 360 degrees around. Place a Richardson retractor under the subscapularis for a humeral shift, and three-pronged “pitchfork” retractor on the equator of the glenoid neck for a Bankart repair.

- B. Subscapularis split (Figure 42–9): When the shoulder is externally rotated, the subcapsular nerves enter the muscle more than 2 cm medial to the glenoid rim. Therefore, splitting this tendon over the gleno-humeral joint will not denervate it. Split it at the level of the glenoid’s equator. Start medially in the muscle with a needle-tipped Bovie. Then use a small key
elevator to dissect down to the capsule. Place a Kocher clamp on each leaf of the subscapularis muscle to provide tension. Use a key elevator and then your finger to dissect between the subscapularis muscle and the capsule. Use a scalpel to sharply dissect between the subscapularis tendon and the capsule laterally, followed by a key elevator. Take the time to obtain a generous exposure now because it will be difficult to gain more separation between these two layers once the capsule is cut and tension is lost. The two layers should be separated to a level 1 cm lateral to the glenoid margin to provide enough exposure to place a humeral head retractor in the glenohumeral joint. Place a deep Gelpi retractor between the leaves of the subscapularis, and a three-pronged pitchfork retractor on the equator of the glenoid neck.

5. Taking down the subscapularis allows visualization of any rotator interval tear. The subscapularis split will not allow you to see this, which is a disadvantage of this approach. Pull distally on the arm to make any rotator interval tear obvious, and fix this superior capsular tear before you incise the joint capsule. Have the arm abducted 45 degrees and externally rotated 45 to 60 degrees as you close this interval. Abduct and externally rotate it only 30 degrees for patients with multidirectional instability. Use a running no. 2 Arthrex (Naples, FL) Fiberwire suture from medial to lateral (Figure 42–10). Be careful to not incorporate the biceps tendon into the repair (it is located under the superior capsular leaf).

6A. Humeral shift: This procedure is technically easier than the glenoid-sided shift because the operation takes place in the shallow end of the field. The capsule is taken vertically off its humeral insertion. Avoid injuring the biceps tendon superiorly. An elevator, knife, or Bovie may be needed to mobilize the capsular flaps. Below the 6 o’clock position (6:00), the capsule’s insertion veers medially and superiorly. Flex, adduct, and externally rotate the humerus to bring the inferior capsule into view. Keep the elevator on bone as you dissect inferiorly and posteroinferiorly to prevent injury to the axillary nerve. Do not plunge posteroinferiorly into the neurovascular structures. Stay sutures in the capsule help to tension it. Place a finger in the inferior pouch. Release the inferior capsule from the humerus until tensioning it obliterates the pouch and forces your finger out.

Split the capsule transversely along the glenoid’s equator, with the arm in adduction–external rotation to protect the axillary nerve. Start laterally and work medially. Have an assistant help hold the capsule up while you cut to prevent injury to the underlying articular cartilage (Figure 42–11).

Gently abrade the anterior humeral neck with a curette for 1 cm lateral to the articular margin. Place suture anchors just lateral to the articular margin at 2:00, 3:00, and 5:00. The articular margin runs from inferomedially to superolaterally (Figure 42–12).
Pull up on the superolateral corner of the inferior capsular leaf until the capsular pouch is obliterated. Place the inferior sutures, then the middle sutures, then the superior sutures. When these sutures are tensioned, a finger placed in the axillary pouch should be extruded. Tie the sutures from inferior to superior with the humerus held in 45 degrees abduction and 45 degrees external rotation. Use more abduction-external rotation for throwers and less for those with ligamentous hyperlaxity. Flex the humerus 10 degrees and push its head posteriorly to ensure it is reduced as the stitches are tied. Shift the superior leaf inferiorly and place and tie its sutures from superior to inferior. Do not cut the sutures off the anchors because they will be used to reattach the subscapularis. Oversew the superior and inferior capsular flap to each other. If additional tightening is required, the two flaps can be imbricated using vest-over-pants stitches.

6B. **Bankart repair:** Split the capsule transversely along the glenoid's equator, with the arm in adduction-external rotation to protect the axillary nerve. Start laterally and work medially. Have an assistant help hold the capsule up while you cut to prevent injury to the underlying articular cartilage (Figure 42–13).

- **Pearl:** The glenohumeral capsule has two medial insertions: (1) a synovial insertion onto the labrum and (2) a fibrous insertion onto the glenoid neck. If a glenoid shift with or without a Bankart repair is to be performed, take the synovial insertion coronally off of the labrum for approximately 1 cm superiorly and inferiorly to its equator. Place a tag suture in the capsule at the level of its synovial insertion onto the labrum. Your repair stitches should be at this same mediolateral level to avoid medializing (and overtightening) the anterior capsule. The capsule’s fibrous insertion onto the glenoid neck is left intact.

After carefully placing a narrow double-pronged humeral head retractor in the joint (this requires lateral traction and rotation), gently retract the labrum and abrade the anterior glenoid neck with a curette for 1 cm medial to the articular margin. Place suture anchors in the glenoid at 2:00, 3:00, and 5:00 (Figure 42–14). Place them at the bone–cartilage junction, erring slightly onto the cartilage to ensure the labrum is placed laterally enough to restore normal concavity. At least 50% of the anchor’s hole should be in the articular cartilage. Aim the drill medially and toward the center of the glenoid to get good fixation within bone. Hooking the drill guide over the glenoid lip usually positions the drill appropriately.
Pearl: Visualization and placement of the labral and inferior capsular stitches is significantly easier if the surgeon moves out of the axilla, superior to the shoulder. Take a few seconds to switch positions with your assistant until this step is finished, and then move back into the axilla to place the superior capsular stitches.

Tie the labrum back down onto the glenoid rim anatomically but do not cut the suture ends. You will use these same sutures to tie the medial capsule down to the labrum. Do not make the knot between the labrum and the capsule so bulky that the capsule does not approximate to the labrum.

The inferior capsule may be shifted superiorly (Figure 42–15). Use a traction stitch to tension the inferior capsular leaf in a superior direction; advancement of 1 cm is usually enough. To avoid medialization of the capsule, the anchor’s stitches are placed at the medial-lateral level of the capsule’s synovial attachment to the labrum. Place the inferior sutures, then the middle sutures, then the superior sutures. The stitches are placed and tied with the arm in 30 to 40 degrees abduction, neutral rotation. A small bump of folded towels can be placed under distal humerus to provide slight flexion, keeping the humeral head reduced. The superior capsule is shifted inferiorly as needed; the same anchor sutures are placed from superior to inferior, and then tied. Note that the narrow two-pronged humeral head retractor is removed after the superior capsular stitches are placed but before they are tied. Wider retractors, such as the Fakuda, may need to be removed after the inferior capsular stitches are placed but before they are tied.

Oversew the superior and inferior flap to each other. If additional tightening is required, these two flaps can be imbricated using vest-over-pants stitches.

6C. Glenoid shift: If a glenoid shift is desired in the absence of a Bankart lesion (usually through a subscapularis split), then no suture anchors are needed. The synovial capsular insertion is released as for a Bankart repair, and the capsular leaves are mobilized and shifted superiorly and inferiorly as needed. The capsule is tied down to the intact labrum with no. 2 Fiberwire sutures. Oversew the superior and inferior flap to each other. If additional tightening is required, the two flaps can be imbricated using vest-over-pants stitches.

7. Check motion. Approximately 90 degrees abduction with 60 degrees external rotation should be possible before the capsule is fully tensioned. Under gentle stress, the anterior instability should be eliminated and the sulcus sign reduced. The amount of external rotation that can be obtained postoperatively without stressing the repair is determined.

8. Repair the subscapularis back with suture anchors; for the humeral shift the same anchors that secured the capsule may be used. For glenoid-sided procedures, three anchors can be placed along the subscapularis’ normal insertion. Alternatively, the subscapularis can be initially taken down, leaving a 1-cm lateral cuff of tendon for a soft tissue repair. The deltopectoral interval and skin are routinely closed.

Postoperative

- The protocol varies depending on the patient and the procedure, but early active and active assisted motion can be started, especially in cases performed through a subscapularis split. In cases of subscapularis takedown, active assisted and passive motion can be started early, with active motion allowed after 2 to 3 weeks. Rotator cuff and scapulothoracic strengthening (except internal rotation in cases of subscapularis takedown) can be started early. Motion is gradually advanced so that full motion is obtained by 10 to 12 weeks. The increases in motion often must be individualized. External rotation is limited to the constraints determined intraoperatively for 4 to 6 weeks. Contact sports and throwing can be allowed at 6 months.

- Author’s preferred technique: Arthroscopic anterior stabilization

  The patient is placed in the lateral decubitus position, and an examination with the patient under anesthesia is used to confirm anterior instability.

  1. Make the anterior portal as inferior and as lateral as possible, to give yourself a better angle for glenoid suture anchor placement. Perform diagnostic arthroscopy and debride the rotator cuff insertion to remove any tendinosis.

  2. Create an anterosuperior portal 1 cm anterior to the anterolateral corner of the acromion. Place a cannula through this portal, anterior to the biceps.
3. If an anterior labral periosteal sleeve avulsion (ALPSA) lesion exists (indicating the Bankart healed medially along the glenoid neck), it is mobilized with a shaver or elevator. This is an important step and should not be rushed. The labral tissue is freed until red subscapularis muscle is seen under the freed labrum. The glenoid neck is abraded with a 4-mm oblong burr for 1 to 2 cm medial to its edge. I prefer not to enlarge the Bankart lesion.

4. Three drill holes are made for the Mitek (Norwood, MA) BioKnotless anchors, at 2:00, 3:00, and 5:00 (Figure 42–16). This technique allows the arthroscope to be maintained posteriorly, facilitating orientation. To prevent having the 5:00 hole too close to the anterior rim, leading to a thin anterior wall that predisposes to anchor “breakout,” the 5:00 hole is centered 3 mm onto the glenoid cartilage. The 3:00 and 2:00 holes are centered 2 mm onto the glenoid cartilage. Placing the holes onto the articular cartilage ensures restoration of the glenoid concavity, recreates the labral “bumper,” and allows tensioning of the capsulolabral tissue as the anchors are impacted. Aim the drill 45 degrees into the glenoid; you may have to lever up slightly on the humeral head to obtain the appropriate angle. Note that bioabsorbable devices cannot tolerate the amount of leverage that metal devices can, so the levering must be done gently. The process is easier if your anterior portal was placed more laterally. Press the hypothenar eminence of the hand that is holding the drill guide firmly against the patient’s shoulder to keep the drill from migrating. After each hole is drilled, mark it well by cauterizing the remaining cartilage anterior to the hole and using a biter to clean out the hole so it can be easily found.

5. Capsular imbrication is performed by (1) capturing capsule inferior to the anchor it is tied to and (2) folding the lateral capsule to the glenoid anchors (Figure 42–17). For example, for the 5:00 anchor hole, the capsule is captured at 5:30 to 6:00 in order to advance it superiorly. The labrum is captured at 5:00, as it need not be routinely advanced. In my hands, the easiest devices for performing this are the Arthrex 90-degree lasso and the Arthrex corkscrew lasso, using a right-sided corkscrew for right shoulders and a left-sided corkscrew for left shoulders. Although effective, the

![Figure 42–16: Arthroscopic stabilization: anchor hole placement.](image)

![Figure 42–17: Arthroscopic stabilization: capsular shift via suture placement.](image)
90-degree lasso will not allow you to capture capsule as far inferior to the anchor as will the corkscrew. The lasso passes through the capsule from inside-out at 5:30 to 6:00, approximately 1 cm lateral to the labrum and 1 cm inferior to the anchor hole (Figure 42–17, A). It then reenters the joint through the capsule to capture a “tuck” of capsular tissue, which is folded against the labrum (Figure 42–17, B). It is easiest to “pop” the lasso through the capsule at a perpendicular angle. The lasso then is slid underneath the labrum, between it and the glenoid, at 5:00 (Figure 42–17, C and D). The correct amount of capsule to plicate should be individualized.

The lasso’s suture loop is deployed and brought out of the anterosuperior cannula (Figure 42–17, E). A no. 1 Prolene (Ethicon; Sommerville, NJ) shuttle stitch is placed through the lasso, which then is pulled back (Figure 42–17, F). This step brings one end of the Prolene shuttle stitch through the previously captured capsulolabral tissue and out the anteroinferior cannula. Care is taken to pull the lasso’s metal and suture components at the same time. Pulling back on the suture loop without withdrawing its metal component will shear the Prolene suture against the lasso’s sharp tip, damaging it. The Prolene shuttle loop now has one end out of the anterior portal and one end out of the anterosuperior portal, and it goes through the capsulolabral tissue.

If a greater amount of anteroinferior instability is present, necessitating a greater amount of capsular shifting, an inferior capsular split (i.e., the “Tauro tuck”) can be used.20 A narrow biter is used to cut through the anteroinferior labrum and capsule at 5:00 for 5 to 10 mm. This step allows a superior capsulolabral shift of twice the amount of the length of the cut. The axillary nerve is safe as long as the biter stays within 1 cm of the labrum. A tag stitch can be placed through the capsule and taken out through a separate superior stab wound to apply superior traction to the capsule.

6. The Mitek Bioknotless anchor has two prongs that will be used to secure the anchor’s suture loop. There is a green Ethibond anchor loop attached to the anchor, with a longer 2-0 Vicryl utility loop attached to this. Using the free end of the Prolene shuttle stitch coming out of the anterior portal, tie one simple half-hitch around this utility loop and gently pull on the other free end of the Prolene shuttle stitch (the one coming out the anterosuperior portal) to bring the utility loop through the anterior cannula, through the capsulolabral tissue, and out the anterosuperior cannula (Figure 42–18, A). Continue to pull on the utility loop to pass the anchor loop through the capsulolabrous tissue (Figure 42–18, B). Pass the prongs of the anchor around the inferior anchor loop (Figure 42–18, C). Gently place the anchor into the predrilled hole at the appropriate orientation at which it was drilled and gently mallet it into the hole (Figure 42–18, D). The capsulolabral tissue will be brought up onto the anterior glenoid rim as the anchor is malleted in (Figure 42–18, E). Some control of the amount of tensioning is available, but be careful not to mallet the anchor in too far or the anchor’s suture loop may cut through the labrum like a wire through cheese, leaving you in a difficult situation. Of course, the anchor must be malleted in far enough so that it is buried beneath the subchondral bone. Traction may be reduced to 5 lb, the shoulder gently internally rotated, and a posteriorly directed force placed on the humeral head as the anchors are being placed. The utility loop can be pulled to ensure the anchor is secure within the glenoid,

Figure 42–18: Arthroscopic stabilization: Mitek Bioknotless anchor placement.
and then one end of the utility loop is grasped and pulled to remove it from the joint.

7. The 3:00 and 1:00 anchors are similarly placed. Again, these anchors should be placed 2 mm onto the glenoid surface. In my hands, a 45-degree Arthrex lasso is the easiest device to use to capture the capsulolabral tissue at this level. The capsule is captured inferior to the anchor for advancement, and the labrum is captured at the level of the anchor. Less capsular plication should be performed for the superior anchors to prevent loss of external rotation. In general, the middle glenohumeral ligament (MGHL) should be superiorly advanced to the 2:00 anchor.

8. **Rotator interval repair** should be performed for patients with significant inferior (or posterior) hyperlaxity, especially those with a sulcus sign that does not reduce with external rotation.

   Pull the anterior cannula back just outside of the joint capsule. Use a 45-degree lasso through the anterior cannula to penetrate the MGHL, then bring the lasso’s suture loop out of the anterosuperior portal (Figure 42–19). Shuttle a no. 2 Fiberwire stitch back through the MGHL and out the anterior portal (Figure 42–20). Move the extraarticular anterior cannula superiorly, and use an Arthrex 22-degree bird beak grasper, or similar retrieving device, to penetrate the SGHL or tissue in the superior rotator interval. Grasp the superior end of the Fiberwire stitch and bring it back out through the same anterior cannula (Figure 42–21). Tie an extraarticular knot to close down this interval (Figure 42–22). One to two stitches can be placed in the lateral interval, but the medial interval should be left open to prevent loss of external rotation, unless significant tightening is required.

**Capsular Plication**

- In the presence of instability without a Bankart lesion, the capsule and labrum are captured as in arthroscopic anterior stabilization, step 5. The appropriate Lasso device penetrates the capsule from inside-out, then outside-in, then captures the labrum by coming between the labrum...
and the glenoid. The capsule is captured inferior to the labrum to shift it superiorly. However, instead of placing anchors, the suture loop is pulled out through the anterosuperior cannula, and a no. 2 Fiberwire stitch is shuttled back through the capsulolabral tissue. This stitch is tied to secure the folded capsule against the intact labrum. Three to four stitches can be placed as needed (Figure 42–23). The traction should be decreased to 5 lb, the shoulder internally rotated, and a posterior force placed on the humeral head as these knots are tied.

**Postoperative**

- Initially keep the arm “between the nose and toes.” Active and passive motion can be performed below the horizontal. External rotation at the side should be limited to 0 to 30 degrees to protect the repair, depending on the patient’s propensity for stiffness. Deltoid, rotator cuff, and scapulothoracic strengthening can be started early.

At 3 weeks, motion can be increased gradually to obtain full elevation and 50% of external rotation by 6 weeks. A sling is used for 6 weeks when the patient is not performing therapeutic exercises. Abduction-external rotation is avoided for 2 months. Plyometrics may be started to regain full elevation and abduction-external rotation at 10 to 12 weeks. Light throwing can commence at 4 months and overhead and contact athletics at 6 months.

**Results**

- Many still consider open stabilization the “gold standard,” with reported recurrence rates of 4% to 17% (average 7%).
- Much of the criticism leveled at arthroscopic techniques arose from literature reporting results of techniques still “early on the learning curve,” such as absorbable tacks and the transglenoid technique. Although these techniques reported good initial success, results appear to deteriorate with time and increased activity of the patient, leading to a high rate of recurrent instability at long-term follow-up.
- Speer et al. showed 79% good results at mean 42-month follow-up using a bioabsorbable tack for Bankart repair. Manta et al. showed a recurrent instability rate of 60% at minimum 5-year follow-up after transglenoid stabilization.
- Series of arthroscopic suture anchor repairs have reported recurrence rates equal to the rates of open techniques, with less postoperative morbidity, less loss of motion (especially abduction-external rotation), and improved function, especially in overhead-throwing athletes.
- In cases of traumatic anterior instability, arthroscopic suture anchor techniques have reported 92% to 97% good to excellent results at 2- to 5-year follow-up, with 91% returning to the same or a higher level of athletic activity. These results are equivalent to the rates of open repair, even in contact athletes. Abrams et al. reported that 100% of 662 patients regained a minimum of 170 degrees flexion and abduction; at 90 degrees abduction, external rotation averaged 110 degrees. In a prospective comparison study, Kim, Ha, and Kim noted 86.6% good or excellent results for open stabilizations, compared to 91.5% for arthroscopic stabilization at average 39-month follow-up. Residual instability was 10% in the open group and 10.2% in the arthroscopic group. There was no significant difference in loss of external rotation or return to prior activity.
- In cases of bidirectional or multidirectional instability, 88% to 94% success has been reported at 2- to 5-year follow-up, with good return of motion including abduction-external rotation, and 85% of patients returning to athletics. This result is similar to that of open capsular shift, which has 59% to 94% good or excellent results at 4.5 to 8.3 years, with 76% returning to athletics and 57% still active in athletics.
Natural History

- Thermal capsulorraphy/electrothermal shrinkage has been shown to reduce capsular laxity but alters its viscoelastic properties, placing it at risk for recurrent stretching. Reports of early failures and complications, such as axillary nerve injury, severe refractory stiffness, and capsular necrosis, have led many to advocate arthroscopic suture plication techniques instead. Risk factors for early failure include previous surgery and recurrent dislocations.
- From 61% to 96% good or excellent results have been reported for thermal capsulorraphy at 25- to 46-month follow-up. However, studies with longer follow-up tended to have higher recurrence rates. At average 46-month follow-up, Abrams et al. found 45% unsatisfactory results with treatment of multidirectional instability, 32% unsatisfactory results with treatment of recurrent anterior subluxation, and 25% unsatisfactory results with treatment of anterior dislocations. Young athletic females with multidirectional instability had 50% unsatisfactory results.
- In conclusion, thermal capsulorraphy probably should be used only as an adjunct to more traditional arthroscopic stabilizations, if at all.

Adhesive Capsulitis (“Frozen Shoulder”)

Etiology

- The etiology of this disorder is unclear. However, it is an inflammatory disease characterized by acute synovitis. Its origin may be idiopathic or secondary to diabetes mellitus, surgery, or trauma. It has been associated with hyperthyroidism, hypothyroidism, collagen vascular diseases, and crystal arthropathy. It often coexists with rotator cuff pathology, which is not inflammatory.
- Idiopathic and diabetic adhesive capsulitis result mainly from capsular fibrosis, thickening, and contracture, although extraarticular and subacromial adhesions also may exist. Posttraumatic and postsurgical frozen shoulder may have significant extraarticular adhesions in the subacromial, subdeltoid, and subcoracoid spaces in addition to capsular contracture. Tethering of the long head of the biceps in its groove may exacerbate motion loss for adhesive capsulitis of all causes.

Natural History

- Three phases:
  1. The initial freezing phase lasts 3 to 9 months. It presents with painful shoulder stiffness in all planes. During this phase, aggressive attempts at manipulation or surgery may increase the inflammatory response and be counterproductive.
  2. The frozen phase may last 4 to 12 months or more.
  3. The thawing phase lasts 12 to 42 months, during which motion gradually improves. However, complete recovery may not occur. Without treatment, most cases should resolve within 2 to 3 years, with a mean of 30 months before comfort and motion return. However, a significant percentage (7%–42%) may continue to experience chronic motion restriction. Even in cases that may be self-limited, the long duration of morbidity has major implications for patient function and satisfaction.

Diagnosis

- The diagnosis of adhesive capsulitis is clinical and is suspected with decreased passive range of motion. Standard radiographs can rule out posttraumatic deformity and arthritis, which are the other elements in the differential diagnosis.
- Because painful motion can lead to stiffness, secondary stiffness may mask underlying pathology, such as instability, rotator cuff pathology, or even tumors.
- In idiopathic, diabetic, and posttraumatic cases, motion restriction will be global.
- In postsurgical cases, motion restriction may be limited to certain planes.

Nonoperative Management

- The mainstay of nonoperative management is therapeutic stretching, which should not cause undue pain. Overaggressive manipulation is ineffective and may be counterproductive. Although intraarticular steroid injections may be a helpful adjuvant, injections alone will not lead to long-term recovery.
- If strengthening exercises are performed because of concomitant rotator cuff tendinosis, they should be pain-free in order to avoid increasing inflammation.

Operative Management

- Indicated for failure after 3 to 6 months of nonoperative management.
- Gentle manipulation under anesthesia, often followed by arthroscopic debridement or capsular release, has been shown to be effective. Only gentle, “two-finger” force should be used. Forceful manipulation can be complicated by glenohumeral dislocation, humeral fracture, rotator cuff tear, or complete plexus palsy and is not recommended. If manipulation succeeds, the intervention can be stopped or arthroscopic treatment performed as an adjunct.
- If manipulation fails to restore motion, a capsular release should be performed.
- Compared to open release, arthroscopic capsular release has the advantage of not requiring subscapularis takedown and repair, allowing aggressive postoperative therapy. The tight portions of the capsule are released from the labrum with an arthroscopic biter. By staying
adjacent to the labrum and performing extraarticular dissection with the biter in the inferior joint, axillary nerve injury can be reliably avoided. In cases of global loss of motion, the entire 360 degrees of capsule can be incised adjacent to the labrum, in addition to release of the rotator interval. Following arthroscopic capsular release, manipulation is performed to free up unaddressed extraarticular adhesions.39

- Open excision of extraarticular adhesions can be performed in the subacromial space, subcoracoid space, and/or subdeltoid space in cases of posttraumatic or postoperative stiffness. This procedure does not require modification of postoperative rehabilitation.39

- Author’s preferred technique: Arthroscopic capsular release
  1. Use a shaver or blunt dissection to free the subscapularis from the MGHL deep to it, and from the coracohumeral ligament superficial to it.
  2. Use a meniscal biter/basket forceps to open the rotator interval, from the glenoid to the humeral head, from the subscapularis to the biceps tendon.
  3. Use a biter to cut the capsule just lateral to the labrum for 360 degrees around the joint (Figure 42–24). Do not injure the labrum or the biceps tendon. The subscapularis tendon does not have to be cut. Start with the biter in the anterior portal. Cut through the capsule inferiorly. The axillary nerve is located approximately 2 cm lateral to the labrum and is safe if the biter is kept within 1 cm of the labrum. For extra safety, the closed biter can be used to dissect extraarticularly just outside of the capsule, to create a space between the capsule and the extraarticular structures. In my experience, cutting the capsule mechanically may cause less postoperative pain than burning through the capsule with electrocautery, although this has not been proven. Internal rotation relaxes the anterior capsule and may provide more room to work anteriorly. External rotation relaxes the posterior capsule and may provide more room to work posteriorly. The capsule should be cut until rotator cuff muscle is visible through the gap.
  4. An accessory posterior–inferior portal may facilitate cutting the inferior capsule. A spinal needle is placed 2–4 cm inferior and 2–4 cm lateral to the posterior portal and directed to enter the joint. A switching stick or sharp trocar can be inserted along the same path to puncture the capsule and the biter placed through this opening to cut the inferior capsule. A cannula is not routinely necessary.
  5. To cut the superior–posterior capsule, the portals should be reversed with the arthroscope viewing from the anterior portal. If visualization of the posterior–inferior capsule is required, the scope can be placed through an anterosuperior portal, 1 cm anterior to the anterolateral corner of the acromion.
  6. After the capsule has been cut, a motorized shaver should be used to shave the cut edges of the capsule, which widens the gap, and hopefully prevents recurrent contracture. Any inflamed adhesive capsulitis synovitis should then be removed. If this synovectomy is performed earlier, the resultant bleeding can impede visualization.
  7. The subacromial space should be inspected and all adhesions excised.
  8. Methylprednisolone can be injected into the glenohumeral joint, subacromial space and/or intravenously as desired.
  9. In cases of post-fracture or postoperative stiffness, an open release of the shoulder as described by Goldberg, Scarlat, and Harryman39 may be considered to clear adhesions from the subdeltoid, subacromial, and subcoracoid locations.

**Postoperative**

- Begin full active and passive range of motion on postoperative day 1 to 3. A methylprednisolone (Medrol) dose pack can be prescribed for immediate postoperative use.

**Results**

- Manipulation alone has reported satisfactory results in 94% to 97% at a mean 11- to 58-month follow-up, although in one series 8% required a second manipulation to obtain a successful result. Most patients continued to improve with time.40,41
- Manipulation combined with arthroscopy has reported 75% satisfactory results at minimum 1-year follow-up, with normal or near-normal motion and minimal pain.42

![Figure 42–24: Arthroscopic capsular release.](image-url)
Arthroscopic release has been reported to be safe and effective with improved motion and pain relief in 83% at 22-month follow-up. Arthroscopic release may be less traumatic than manipulation. Instability following capsular release is rare, even in patients who developed stiffness following procedures initially performed to treat instability.39,43

Arthroscopic capsular release combined with open extraarticular release as needed has reported 90% surgical success.39

Diabetic frozen shoulder may be more refractory to nonoperative and surgical treatment than the idiopathic variety, although this observation is not universally accepted.

Patients with frozen shoulder because of prior surgery had significantly more pain, less function, and less satisfaction than those with idiopathic or postfracture causes.44

The prognosis is better for patients who have experienced stiffness for less than 6 months.38

Superior Labral Anteroposterior (SLAP) Lesions

Originally described and classified by Snyder et al, this entity refers to injury of the superior labrum about the biceps root. Type 1 refers to labral fraying, type 2 is detachment of the superior labrum from the glenoid, type 3 is a bucket handle tear of the superior labrum without detachment, and type 4 is a bucket handle tear (like type 3) but with extension into the biceps root (Figure 42–25).45

Etiology

The exact mechanism of injury is still debated. Although superior labral anteroposterior (SLAP) lesions originally were thought to be avulsion injuries of the biceps tendon that occurred during the deceleration phase of throwing, Burkhart, Morgan, and Kibler46 showed that SLAP lesions most commonly are caused by “peel back” of the biceps root and attached labrum from the superior glenoid during abduction-external rotation. This process may occur during the acceleration phase of the throwing motion.

A tight posterior-inferior capsule may predispose to SLAP lesions in throwers by causing inappropriate posterosuperior migration of the humeral head as the shoulder moves into full external rotation during the late cocking phase of throwing. This process may overload the posterosuperior labrum as the peel-back mechanism produces maximum torsional force in abduction-external rotation. Posterior capsular stretching appears to help prevent this injury in throwing athletes.47

Pearl: SLAP lesions occur most commonly in the dominant shoulder of young throwing athletes. In other settings, be aware of normal anatomic variants, whose “repair” is not indicated and may lead to complications, especially stiffness.

Type 3 lesions can be treated by surgical resection of the torn labrum, analogous to treatment of bucket handle meniscal tears.45

Type 4 lesions are treated similar to type 3 lesions. In addition, the biceps tendon should be debrided and tenotomized or tenodesed if greater than 30% to 50% is involved.45

Type 4 lesions are treated similar to type 3 lesions. In addition, the biceps tendon should be debrided and tenotomized or tenodesed if greater than 30% to 50% is involved.45

In throwing athletes, posterior capsular stretching should be continued postoperatively throughout their athletic career.47

Author’s preferred technique: SLAP repair
1. Debride the superior glenoid rim with burr or a shaver on forward. A full decortication is not necessary or desirable.
2. Create an anterosuperior portal 1 cm lateral to the anterolateral corner of the acromion; this is in a more lateral location than the portal created for the Bankart repair, in order to obtain a better angle to drill the anchor hole. The portal is localized with a spinal needle, the capsule is penetrated in the rotator interval with a switching stick or sharp obturator, and a cannula is placed. If an anterior anchor is desired, it should be drilled through this cannula. The most biomechanically important stitch is the one placed just posterior to the biceps root. Other anchors are used as needed. The suture anchors are placed and their sutures tied, one at a time.

3. To drill a posterior anchor, the “portal of Wilmington” is optimal. This portal is localized by a spinal needle entering 1 cm inferior and 1 cm anterior to the posterolateral corner of the acromion. Angle the needle toward the coracoid. It may help to adduct the arm in traction so that this portal goes through the rotator cuff muscle instead of its tendon. Because this portal is used for anchor placement only, no cannula is needed.

4. Anchor holes should be drilled at a 45-degree angle into the superior glenoid. Anchors should be placed on the superior aspect of the glenoid; they do not have to come onto the glenoid cartilage (note that this is different than for Bankart repairs). Take care that the eyelet of the anchor (often identified by a laser mark on the anchor) is oriented medial-lateral, to allow the labrum to be easily opposed to the glenoid.

5. Once the anchor is placed, a 45-degree Arthrex bird beak or similar retriever is passed under the labrum to retrieve the medial free end of the anchor suture (Figure 42-26). This is then brought out of the anterosuperior portal (Figure 42-27). When tied with
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Postoperative

- Prevent stiffness by allowing early active and passive motion. However, abduction–external rotation greater than 90 degrees/90 degrees should be avoided for 6 weeks, as should resisted biceps loading. The posteroinferior capsule should be stretched as demonstrated in Chapter 41 for the duration of the patient’s athletic career. Light throwing can begin at 4 months, and overhead and contact sports can resume at 6 to 7 months.

References

   A simulated Bankart lesion resulted in only small increases in anterior glenohumeral translation, with a maximum of only 3.4 mm.

   Reports 84% good or excellent results following a capsular shift for anterior-inferior glenohumeral instability. Discusses the pathoanatomy and surgical technique.

   Reports that a positive drive-through sign is not specific for shoulder instability but may be associated with shoulder laxity.

   Compared to intravenous sedation, intraarticular lidocaine injections showed no significant difference in difficulty of reduction or subjective pain.

   Good description of the technique.

   Good description of the technique.

   Recommends full-time immobilization for at least 3 weeks following primary traumatic dislocation in patients younger than 30 years but only 1 week in older patients.

   Discusses recurrence rates following primary anterior glenohumeral dislocation and notes that immobilization has little effect on recurrence, especially in young patients.


15. Itoi E, Tabata S: Rotator cuff tears in anterior dislocation of the shoulder. *Int Orthop* 16:240-244, 1992. Following traumatic anterior dislocation, rotator cuff repair is sufficient to stabilize the shoulder in elderly patients, even when the Bankart lesion is not repaired.


28. Abrams JS, Savoie FH III, Tauro JC, Bradley JP: Recent advances in the evaluation and treatment of shoulder instability: anterior, posterior, and multidirectional. *Arthroscopy* 18(suppl 2):1-13, 2002. The authors recommend that thermal devices be used solely to augment arthroscopic suture stabilizations, not as a primary means of shoulder stabilization.

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Reports 93% stable shoulders following arthroscopic repair of traumatic anterior glenohumeral instability in a high-demand patient population.


37. Lyons TR, Griffith PL, Savoie FH 3rd, Field LD: Laser-assisted capsulorrhaphy for multidirectional instability of the shoulder. Arthroscopy 17:25-30, 2001. Reports that 96% shoulders were stable and asymptomatic at minimum 2-year follow-up after laser-assisted capsulorrhaphy for multidirectional instability.


47. Burkhardt SS, Parten PM: Dead arm syndrome: torsional SLAP lesions versus internal impingement. Tech Shoulder Elbow Surg 2:74-84, 2001. SLAP lesions are predisposed to by a tight posterior/inferior capsule, result from a “peel-back” mechanism during external rotation, lead to the “dead arm” syndrome, and produce “pseudo-laxity.” Definitive diagnosis often only can be made arthroscopically.

48. Burkhardt SS, Morgan CD, Ben Kibler W: The disabled throwing shoulder: spectrum of pathology part III: the SICK scapula,

Symptoms of SLAP lesions may include pain or the “dead arm” syndrome in throwers (loss of velocity and control because of pain and unease).


Reports MRI was 92% specific but only 42% sensitive for detecting SLAP lesions. Clinical testing was not accurate in predicting SLAP lesions.


MRI had 65% sensitivity and 74% to 84% specificity in detecting type 2, 3, or 4 SLAP lesions.


MR arthrography had 89% sensitivity, 91% specificity, and 90% accuracy in detecting SLAP lesions.


MR arthrography had 84% to 92% sensitivity, 69% to 84% specificity, and 74% to 86% accuracy in detecting SLAP lesions.


The “kissing lesions” of undersurface rotator cuff tears and posterosuperior labral damage may be explained by mechanisms other than “internal impingement.”


Reports 82.3% good or excellent results, with 53% of patients returning to their preinjury level of sporting activities following SLAP repair with a bioabsorbable tack.


Reports 71% good or excellent results at an average of 3.7 years following SLAP repair with a bioabsorbable tack.
Fractures About the Shoulder

David P. Barei*, Lisa A. Taitsman†, and Sean E. Nork‡

Fractures of the Proximal Humerus

Introduction

• Fractures of the proximal humerus are commonly encountered and represent approximately 5% of all fractures.1
• Fractures that occur in the elderly usually result from a low-energy fall. Younger patients with these injuries more likely are involved in high-energy trauma and present with significant associated injuries.2

Anatomy

• Four main osseous structures are surgically relevant when managing fractures of the proximal humerus: the humeral head, greater tuberosity, lesser tuberosity, and humeral shaft.
• When viewed in the frontal plane, the humeral neck-shaft angle is approximately 130 to 150 degrees. When viewed in the sagittal plane, the humeral head appears retroverted relative to the humeral shaft approximately 20 to 40 degrees. Although there is significant variation among patients, individuals tend to be symmetrical bilaterally.
• The subscapularis, supraspinatus, infraspinatus, and teres minor compose the rotator cuff muscles. The latter three insert into the greater tuberosity, whereas the subscapularis inserts into the lesser tuberosity. The tuberosities are anatomically separated by the bicipital groove, which contains the tendinous portion of the long head of the biceps muscle. The attachments of the rotator cuff play a role in determining fracture displacement.
• Humeral head vascularity mainly comes from the anterior branch of the anterior humeral circumflex artery. This branch ascends within the bicipital groove and terminates as the arcuate artery, which penetrates the cortex of the proximal humerus. Lesser contributions arise from the posterior humeral circumflex artery as it terminates into numerous penetrating branches along the posterior aspect of the proximal humerus. Additional vascularity is provided by the attachment of the rotator cuff tendons into their respective tuberosities.
• After an acute fracture, the remaining soft tissue attachments to the humeral head, particularly those from the capsule and medial periosteal vessels, play a predominant role in preserving vascularity to the head.3,4

Physical Examination

• The initial physical examination should identify associated injuries and, in conjunction with a full history, begin to ascertain the patient’s functional status. The functional evaluation of the patient often has a significant influence on management decisions and patient expectations.
A focused examination of the involved shoulder region and ipsilateral upper extremity begins with the identification of deformity, areas of tenderness, swelling, and the presence of open wounds. Open injuries are exceptionally uncommon around the proximal humerus because of the surrounding muscle bulk. They usually occur in patients involved in high-energy trauma. Less commonly, cachectic elderly patients present with open injuries after lesser degrees of trauma.

The clinical diagnosis of associated nerve injuries in fractures of the proximal humerus is exceptionally inaccurate and significantly understimates their presence. Electromyographic studies have identified nerve lesions in approximately 82% of displaced proximal humerus fractures. A lesser incidence (59%) was identified in undisplaced fractures. The axillary nerve, followed by the suprascapular nerve, are most commonly injured.\textsuperscript{5}

The difficulty in clinical diagnosis, particularly of the axillary and suprascapular nerves, is not surprising given the associated pain and swelling in the region being tested.

Major arterial injury is a rare, but devastating, complication of these fractures.\textsuperscript{6} Age greater than 50 years and the presence of a brachial plexus injury are associated factors. Almost 90% of these cases involve the third part of the axillary artery. Diminished distal pulses, altered skin temperature, and altered digital sensation are indications for prompt further investigation.

### Radiographic Examination

- The standard trauma series radiographs obtained for suspected fractures about the glenohumeral joint include the anteroposterior (AP) and lateral images, both obtained in the plane of the scapula. In addition, the axillary view is essential to the diagnosis of an associated glenohumeral dislocation. Obtaining an axillary lateral view may be difficult because of the pain involved in appropriately positioning the upper extremity. An alternative technique is the Velpeau axillary lateral view.\textsuperscript{7} While wearing a sling or Velpeau bandage, the patient leans backward 30 to 45 degrees over the x-ray table. The x-ray tube is placed above the shoulder, and the beam is projected vertically down through the shoulder onto the underlying cassette (see Figure 40–28).

- A study demonstrated the effect of arm position on the accuracy of the axillary projection in determining fracture angulation in simulated fractures of the proximal humerus.\textsuperscript{8} Increased apparent angulation is encountered with decreasing amounts of abduction, with 30 degrees abduction creating the most apparent angulation. This same increased apparent angulation effect occurs with increasing shoulder extension, whereas shoulder flexion decreases the apparent angulation. Because of pain, a technically sound axillary lateral projection (90 degrees abduction, neutral flexion/extension, neutral rotation) is rarely obtained in the emergency room setting. Although still useful for diagnosis of glenohumeral dislocations, accurate assessment of fracture angulation on nonstandardized axillary projections is questionable.\textsuperscript{8}

- The vast majority of clinical decision making is based upon information obtained from the plain radiographs.

- Computerized tomography (CT) allows improved definition of fracture fragments and their relative relationships.\textsuperscript{9,10} Articular injuries of the humeral head, such as head-splitting fractures and impaction injuries, are easily identified and quantified. CT scanning is not routinely used but is beneficial in situations of fracture-dislocations or when associated humeral head injuries are suspected.

- Magnetic resonance imaging or ultrasound imaging is rarely indicated in fractures of the proximal humerus.

### Classification

#### Neer

- The Neer classification was introduced in 1970 and remains the most commonly used classification system for the diagnosis and treatment of proximal humerus fractures (Figure 43–1).\textsuperscript{11,12}

- The key to the Neer classification system is the identification that the proximal humerus reproducibly fractures into two, three, or four major segments. These segments are the humeral head, greater tuberosity, lesser tuberosity, and humeral shaft.

- Displaced fractures are classified as two-part, three-part, or four-part fractures. They can be further classified into fracture-dislocations, depending on the presence of an associated dislocation. To be considered displaced, however, at least 1 cm or at least 45 degrees of angulation must be present between one anatomic segment compared to the others on biplanar radiographs. Fractures with less than this displacement are termed minimally displaced fractures.

- Articular injuries of the humeral head, such as head-splitting or impaction injuries, are grouped as fracture-dislocations because the resultant head deformity often has significant impact on glenohumeral stability.

- Increasing vascular isolation of the humeral head segment occurs as the number of displaced fracture fragments or “parts” occurs.

#### AO/ASIF

- The AO/ASIF (Arbeitsgemeinschaft für Osteosynthesefragen/Association for the Study of Internal Fixation) is a comprehensive alphanumeric classification system that, like the Neer system, emphasizes the remaining vascular supply to the humeral head segment (Figure 43–2).\textsuperscript{13,14}

- Types A, B, and C are the three main categories. The system groups the injuries according to increasing...
severity and likelihood of avascular necrosis of the humeral head. All three types are extensively subdivided to include the vast majority of fracture patterns. With this system, type C injuries are associated with the highest risk of osteonecrosis.

- Although more commonly used for periarticular fractures throughout the appendicular skeleton, the AO/ASIF classification is less commonly used to guide treatment decisions. However, the system will be increasingly referred to in the proximal humeral fracture literature.

**Limitations**

- Like many other classification systems, the Neer and AO/ASIF systems demonstrate poor intraobserver and interobserver variability.\(^{15-17}\)
- Other shortcomings include the inability to classify all fracture types.\(^{2}\) Furthermore, despite being heavily based on the predictability of osteonecrosis of the humeral head, variable avascular necrosis rates have been noted within groups.
- This finding suggests that the vascular viability of the humeral head is more complex than simply the number of fragments present. Factors such as the orientation of the humeral head in multifragmentary fractures may have a significant effect on the presence or absence of soft tissue attachments remaining to the humeral head.\(^{3,18}\)
- The Neer classification provides guidelines, not rules, for fracture management. Whereas 5 mm of displacement may be well tolerated in a two-part fracture at the surgical neck of the humerus in an older individual, this degree of displacement in a young, active patient with a superiorly displaced greater tuberosity fracture may be an indication for surgical management.\(^{19}\)

**Emergency Room Management**

- After obtaining a thorough history and performing a physical examination, the shoulder trauma series of
Hand, Elbow & Shoulder: Core Knowledge in Orthopaedics

Radiographs should be obtained and reviewed. Most fractures without dislocations can be initially placed in a sling or a collar-and-cuff immobilizer (Box 43–1).

- Patients with an anterior glenohumeral dislocation with an associated greater tuberosity fracture or those with a posterior dislocation with lesser tuberosity fracture may benefit from an attempt at closed reduction under satisfactory sedation.
- Patients with glenohumeral dislocations and associated surgical neck fractures likely will not be reduced by closed means. Attempts at closed reduction in patients with this injury complex may displace the fracture and are best performed in the operating room under general anesthesia to allow maximal muscle relaxation. Failure of gentle attempts at closed reduction then allows rapid conversion to open methods.

**Treatment**

- Though commonly used in the therapeutic decision-making process, the final management decision should not be based solely on the presence of the number of fracture fragments as dictated by the classification schemes.

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<table>
<thead>
<tr>
<th>Groups:</th>
<th>Humerus, Proximal Segment, Extraarticular Unifocal (11-A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Avulsion of Tuberosity (11-A1)</td>
<td>Humerus, Proximal Segment, Extraarticular, Bifocal (11-B)</td>
</tr>
<tr>
<td>2. Impacted Metaphysis (11-A2)</td>
<td>1. With Metaphyseal Impaction (11-B1)</td>
</tr>
<tr>
<td>3. Non-Impacted Metaphysis Fracture (11-A3)</td>
<td>2. Without Metaphyseal Impaction (11-B2)</td>
</tr>
<tr>
<td></td>
<td>2. Articular Fracture Impacted with Marked Displacement (11-C2)</td>
</tr>
<tr>
<td></td>
<td>3. With Glenohumeral Dislocation (11-B3)</td>
</tr>
<tr>
<td></td>
<td>3. Articular Fracture with Glenohumeral Dislocation (11-C3)</td>
</tr>
</tbody>
</table>

**Figure 43–2:**
AO/ASIF classification of proximal humerus fractures. (Courtesy Orthopaedic Trauma Association.)
Displaced Fractures

Minimally Displaced Fractures

- The vast majority of proximal humerus fractures (80%–85%) reported are minimally displaced, according to the criteria described by Neer, and can be managed nonoperatively.
- As pain subsides, patients are instructed on a supervised physical therapy program to restore glenohumeral motion. Range of motion exercises are started once the clinical stability of the fracture is assessed. Impacted fractures typically are stable at first presentation and are immediately started on pendulum and passive range of motion exercises. Active assisted motion is instituted as union and comfort progress.
- Unimpacted and unstable proximal humeral fractures are treated with a 1- to 2-week period of shoulder immobilization. After this period, physical examination should demonstrate that gentle passive rotation of the humeral shaft is accompanied by palpable, synchronous humeral head motion. This finding ensures that gentle passive motion can be started, because the majority of motion now is occurring at the glenohumeral joint and not at the fracture site. Range of motion may be slowly progressed as tolerated.
- Even in unstable fractures, a supervised physical therapy program should be instituted within 2 weeks of injury. Koval et al. reviewed 104 patients with minimally displaced proximal humerus fractures managed with a standardized protocol. At a minimum 1-year follow-up, 77% of their patients obtained a good or excellent result. Ninety percent of patients had minimal or no residual pain with functional recovery greater than 90%. Final recovery of forward elevation, external rotation, and internal rotation approached 90% of the contralateral uninjured extremity.

Displaced Fractures

- The best treatment for proximal humerus fractures remains controversial and elusive.
- Published literature is inadequate to make evidence-based recommendations for treatment of these complex injuries. What seems apparent is that open methods of treatment for displaced fractures appear to result in superior pain relief with improved return of a functional arc of motion compared to patients managed nonoperatively.
- Because of these deficiencies in the literature, treatment should be individualized until high-quality studies can better guide treatment decisions.
- An important first step in managing these injuries is in differentiating “physiologically active” patients from “physiologically inactive” or “low-demand” individuals. It is important to note that this definition should not be based simply on the patient’s age, as an increasing number of older individuals remain independent, active, and functional members of the community.

Displaced Fractures in Physiologically Active Patients

- The goal of surgical treatment of proximal humerus fractures is to:
  1. Restore anatomic alignment of the neck and shaft in the coronal, sagittal, and transverse planes.
  2. Anatomically reduce and secure the greater and lesser tuberosities, if involved.
  3. Maintain reduction with sufficient stability to allow early range of motion without the need for postoperative immobilization.
- The most common operative techniques include open reduction and internal fixation (ORIF), intramedullary nailing, closed reduction, and percutaneous pin fixation.
- Studies that compare these operative techniques in a randomly assigned method among similar fracture groups are lacking. Studies have failed to demonstrate any significant advantages in patient outcomes with one technique compared to others. Understanding the relative advantages, disadvantages, and rationale for use of these techniques allows the surgeon to manage the spectrum of fracture types that occur in disparate patient populations.

Surgical Procedures

- Open Reduction and Internal Fixation
  - ORIF allows direct visualization and stabilization of critical fracture fragments, namely, the humeral head, humeral shaft, and the greater and lesser tuberosities. The major concern with open techniques is the potential for further devitalization of fracture fragments, leading to delayed union, nonunion, and avascular necrosis.
  - The selection of stabilizing implants is variable and has ranged from conventional screw/plate devices, cerclage wires, blade plates, suture fixation, and newer locking screw/plate devices (Figure 43–3).
  - The choice of implant should be tailored to the specific fracture pattern, bone quality, and anticipated time to union, with the goal of achieving rigid fracture fixation that allows unrestricted range of motion. For example, standard screw/plate devices typically demonstrate poor...
fixation ability in osteoporotic bone. Alternatives such as locking screw/plate implants or blade plate fixation are better choices. Similarly, comminuted tuberosity fragments often are better secured with suture techniques rather than screws.

- Patients usually are given a general anesthetic and positioned in the beach chair or supine position.

- The vast majority of multifragmentary proximal humeral fractures are approached using the deltopectoral interval via an anterior skin incision. The incision begins at the region of the coracoid process and proceeds distally toward the deltoid insertion. The cephalic vein marks the deltopectoral interval and is mobilized, allowing it to be retracted, usually with the

Figure 43-3:
A, B, Anteroposterior and axillary lateral images show a three-part fracture-dislocation of the proximal humerus in a 28-year-old man involved in a motorcycle collision. Associated injuries included an open unstable pelvic ring disruption and a moderate closed head injury. C, D, Postoperative anteroposterior and lateral radiographs show satisfactory reduction and fixation with a screw/plate construct using a deltopectoral approach.
Intramedullary Nailing

Patients are placed supine on a radiolucent table, and a Potential benefits of intramedullary nailing of proximal Locked intramedullary devices specifically designed for using proper soft tissue handling, satisfactory results have been demonstrated.

• Initial reduction of the head/neck relationship subsequently makes “space” available for reduction of the greater and lesser tuberosities. This is particularly important when treating proximal humeral fractures with valgus angulation of the head/neck region.

• Temporary fixation is performed with small Kirschner (K) wires and should be placed out of the way of the anticipated definitive implants.

• Plates are placed along the lateral aspect of the proximal humerus and are distal to the tip of the greater tuberosity to prevent impingement during shoulder flexion and abduction. Conventional screws directed into the humeral head should be placed as subchondral and central as possible because bone quality typically is best in this region.

• Tuberosity fixation can be achieved with screws, provided the bone quality is excellent and the fragment is of sufficient size, which frequently is not the case. In these situations, suturing the tendinous portion of the rotator cuff insertion to the adjacent bone or plate provides satisfactory stability of the tuberosities.

• At the conclusion of the procedure, the adequacy of reduction and the position of the implants are assessed radiographically. The shoulder is placed through a range of motion, and fracture stability is assured.

• Using proper soft tissue handling, satisfactory results have been demonstrated.

• Intramedullary Nailing

Locked intramedullary devices specifically designed for fractures of the proximal humerus have been developed and are commercially available. Several multiplanar screws can be placed through the nail and into the humeral head, creating control of the proximal segment (Figure 43–4).

Standard humeral nail systems are not designed for these fractures because of the relatively low proximal interlocking location.

Potential benefits of intramedullary nailing of proximal humeral fractures include the ability to independently capture greater and lesser tuberosity fragments with the proximal interlocking screws, a minimally invasive insertion technique, load-sharing ability of the implant, and management of fractures with associated humeral shaft extension.

Patients are placed supine on a radiolucent table, and a small incision is made distally from the lateral border of the acromion. The deltoit muscle is split in line with its fibers, and the rotator cuff is incised in line with its fibers and retracted. Avoid excessive distal dissection of the deltoit muscle, which may injure the anterior branch of the axillary nerve.

• Fractures typically are reduced with closed manipulative or percutaneous techniques, and the nail is inserted medial to the greater tuberosity. At the conclusion of the procedure, careful attention is paid to proper closure of the rotator cuff tendon with nonabsorbable suture.

• Despite satisfactory early results demonstrated in two-, three-, and four-part fractures, care must be taken when considering this technique for highly comminuted fractures of the proximal humerus. The main indication for use of locked intramedullary nailing of proximal humerus fractures is for treatment of combined surgical neck and shaft fractures.

• Rehabilitation After Open Reduction and Internal Fixation or Intramedullary Nailing

Patients are started immediately on pendulum and gravity assisted range of motion exercises. Motion restrictions do not need to be imposed, provided stable and secure fixation is obtained in the operating room. Active assisted and pulley exercises are instituted gradually, and the importance of physical therapy is reinforced.

• At 6 weeks, active range of motion is introduced gradually. At this point, radiographs are obtained and fracture union should be progressing.

• At 12 weeks, radiographs are repeated. Fracture union should be complete to the point that stretching and strengthening exercises can be initiated. Strengthening and rehabilitation of the rotator cuff are performed prior to strengthening the major shoulder motors (deltoit, pectoralis, latissimus).

• Percutaneous Pinning

Because this technique is performed using closed manipulation, the most significant theoretical benefit is maximal preservation of soft tissue attachments to the proximal humeral fragments (Figure 43–5).

The patient is placed supine on a radiolucent table. Image intensification (anteroposterior and axillary lateral) is necessary during both closed reduction and pinning of these fractures.

Several multiplanar 2.5-mm Schanz pins are placed from the lateral cortex of the humerus to the subchondral bone of the humeral head in a divergent pattern to maximize fixation. Additional pins are placed to secure the greater and lesser tuberosity fragments if required.

This technique has been most frequently described in two-part fractures, although three-part fractures, four-part fractures, and fracture dislocations can be managed successfully.

Understanding the location of the axillary and musculocutaneous nerves, cephalic vein, and posterior humeral circumflex artery is critical for safe use of this technique.
Contrary to the basic concept of rigid fixation that allows early range of motion, percutaneous pin fixation typically results in the transfixation of some amount of the surrounding soft tissue envelope that hampers early, unrestricted range of motion. It is important to recognize how this technique differs from modern fracture fixation ideas. Despite this difference, patients appear to ultimately achieve satisfactory shoulder range of motion.

At 3 weeks, lesser tuberosity pins are removed in the clinic, and patients are allowed to increase their range of motion as comfort allows. Of the three main pin clusters (lesser tuberosity, greater tuberosity, humeral...
At 6 weeks, the greater tuberosity pins are removed. Commonly, this procedure improves patient comfort, allowing increased forward elevation, abduction, and external rotation.

Depending on radiographic union, typically at 8 to 12 weeks, the remainder of the pins can be removed and patients started on a stretching and strengthening program as described for ORIF and intramedullary nailing.

### Displaced Fractures in the Physiologically Elderly

- Critical to the successful management of displaced proximal humerus fractures in this population is accurate assessment of the patient’s functionality and bone quality. The best treatment remains controversial.
- Three studies have demonstrated satisfactory results with nonoperative management of translated two-part surgical neck fractures and three-part valgus impacted fractures in the physiologically elderly population.34,35
Indications for nonoperative management include two-part fractures with translation of less than approximately two thirds the diameter of the proximal humeral metaphysis and valgus-impacted three-part injuries without significant angulation. We prefer to manage widely displaced two-part fractures and unstable three- and four-part fractures operatively, provided the patient has reasonable cognitive and functional capabilities.

Reasonable options for obtaining satisfactory fracture stability in osteoporotic bone include locking screw/plate implants, blade plate implants, or tension band fixation with supplemental intramedullary Ender nails. In functional patients with significant osteoporosis, we preferentially manage two- and three-part fractures with locking screw/plate devices, because these devices appear to demonstrate improved fracture stability in osteoporotic bone (see Figure 43–3, C and D). The procedure is performed via the deltopectoral approach with the reduction and fixation strategies outlined in the section on open reduction and internal fixation. If stable fixation cannot be achieved, then hemiarthroplasty should be performed.

Displaced three-part fracture-dislocations and four-part fractures are managed with hemiarthroplasty.

Hemiarthroplasty

The goals of hemiarthroplasty are (1) stable replacement of the humeral head, (2) restoration of proximal humeral length and retroversion, (3) secure and stable fixation of the tuberosities, (4) repair of the rotator cuff, and (5) institution of early motion (Figure 43–6).

A deltopectoral approach is performed. The humeral head is removed, and the cancellous bone is used for supplemental bone graft around the tuberosities. The bicipital groove and transepicondylar axis of the distal humerus are intraoperative landmarks that can be used to determine the appropriate retroversion of the prosthesis. The height of the prosthesis often is difficult to accurately assess in the fracture situation but is critical to obtaining a satisfactory outcome (Box 43–2). A small amount of bone cement is used at the proximal portion of the stem to secure height and rotational control of the prosthesis. The tuberosities are anatomically repaired to the humeral shaft and to the prosthesis using heavy nonabsorbable suture. Cerclage wire is used less often because of its comparatively poor handling characteristics and potential for crowding the subacromial space.

In a prospective, multicenter study, Boileau et al. demonstrated that the functional results after hemiarthroplasty for three- and four-part proximal humerus fractures appeared to be directly correlated with satisfactory reduction and union of the greater tuberosity. Complications associated with the greater tuberosity, such as malposition and migration, led to unsatisfactory results. To decrease these complications, attention should be directed at obtaining appropriate prosthesis height and retroversion as well as anatomic and secure fixation of the greater tuberosity.

Figure 43–6:
A, 70-year-old man sustained a comminuted four-part fracture of the proximal humerus after he was involved in a motorcycle collision. B, The postoperative anteroposterior radiograph shows satisfactory position of a cemented hemiarthroplasty.
Complications

- Fractures of the Clavicle
  - Can be secondary to low- or high-energy injury.43
  - Clavicle fractures represent 2% to 5% of all fractures.43
  - Posttraumatic shoulder stiffness remains a difficult therapeutic problem. Physical therapy is the mainstay of treatment. Operative procedures include open or arthroscopic mobilization of the glenohumeral articulation, subacromial space, and scapulothoracic region. Surgical success is greatly dependent upon aggressive and consistent postoperative physical therapy.

## Fractures of the Clavicle

### Introduction

- Clavicle fractures represent 2% to 5% of all fractures and 25% to 40% of all shoulder girdle fractures.43
- Can be secondary to low- or high-energy injury.43
- Can occur as an isolated fracture or in the polytraumatized patient.

- Commonly result from a fall on the shoulder and less often from a fall on the outstretched arm.44
- Most clavicle fractures are managed nonoperatively. The majority occur in the middle third and heal without complications.43
- Nonunion rates of 0.1% to 5% are reported, with significantly higher nonunion rates (>10% in some series) in operatively treated patients.45
- Poor technique and suboptimal fixation devices likely played an important role in these nonunion cases.
- Several studies showed hemiarthroplasty is a satisfactory method for achieving a relatively painless shoulder, but patients should be informed of the expected restrictions in forward elevation, strength, and functional activity.12,26,39,40
- Most patients will obtain between 90 and 120 degrees of forward elevation, 25 degrees of external rotation, and internal rotation to the first lumbar vertebrae.

## Anatomy

- The clavicle is an S-shaped bone that varies in thickness when viewed from its superior and anterior aspects. It presents a subcutaneous anterosuperior border along its entire length.
- It articulates with the sternum (sternoclavicular joint) and the acromion (acromioclavicular joint) at its proximal and distal extents, respectively. Biomechanically, the clavicle serves as a strut between the shoulder and the chest wall, allowing the shoulder to function at a distance from the center of the body. Clavicle fractures with significant shortening allow the shoulder to displace anteriorly and centrally, potentially compromising normal glenohumeral and scapulothoracic function.
- The stability of the sternoclavicular joint is secondary to its stout ligamentous connections, particularly the posterior contributions. The acromioclavicular joint is secured via numerous ligamentous attachments distally:
  - The superiorly located acromioclavicular ligament surrounds the joint capsule and provides minor support.
  - The coracoclavicular ligaments maintain the relationship of the clavicle to the coracoid. This relationship indirectly maintains the stability of the acromioclavicular joint. The coracoclavicular ligaments are composed of two major contributions: the conoid ligament (medial) and the stronger of the two) and the trapezoid ligament (lateral).
- The major muscle attachments include the deltoid, trapezius, pectoralis major, and sternocleidomastoid. Fracture displacement is related to muscle attachments. Midshaft fractures typically result in superior displacement of the medial portion secondary to pull of the sternocleidomastoid and trapezius. Similarly, the weight of the arm displaces the distal segment inferiorly.
- The subclavian artery and vein and the brachial plexus are important structures that lie immediately below the clavicle. The subclavian artery and vein and the brachial plexus are important structures that lie immediately below the clavicle.

### Box 43–2 Clinical Pearl

- The humeral head should translate approximately 50% of the glenoid surface, yet allow stable, anatomic repair of the tuberosities.38
- Inferior traction should translate the humeral head approximately 50% of the glenoid surface.
- With gentle traction and the arm held in neutral rotation, match the height of the humeral head prosthesis with the native glenoid. Specifically, the superior aspect of the humeral head should match the superior aspect of the glenoid.
- With slight abduction, the superior aspect of the greater tuberosity should be approximately 5 to 8 mm inferior to the superior aspect of the prosthetic humeral head.

- Several studies showed hemiarthroplasty is a satisfactory method for achieving a relatively painless shoulder, but patients should be informed of the expected restrictions in forward elevation, strength, and functional activity.12,26,39,40
- Most patients will obtain between 90 and 120 degrees of forward elevation, 25 degrees of external rotation, and internal rotation to the first lumbar vertebrae.

## Complications

- The most common complications after fractures of the proximal humerus are nonunion, malunion, stiffness, and avascular necrosis.
- Most nonunions occur at the surgical neck and can be managed successfully with plate fixation and bone grafting. Fixed-angled devices, such as blade plates, give improved fixation in the often osteopenic humeral head.41,42
- Avascular necrosis with associated collapse frequently is responsible for poor outcomes in displaced four-part fractures.2,24,25 Prosthetic replacement may be indicated when nonsurgical methods fail to provide satisfactory results.46–48 High-energy injuries with comminution and substantial shortening (2–3 cm) appear to have lower functional results secondary to the inevitable malunion that occurs with nonoperative treatment. This finding has prompted recommendations for surgical management of some of these high-energy injuries.
clavicle. They can be injured at the time of fracture, during surgical fixation, or in a delayed fashion secondary to excessive callus formation. The supraclavicular nerves cross the anterior aspect of the clavicle and innervate the skin of the anterior, superior portion of the chest wall. They can be injured during surgical exposure of the clavicle.

**Physical Examination**

- Examine the skin. Most of these fractures result from direct injury to the shoulder, so abrasions are common whereas open fractures are rare.
- Neurovascular evaluation must be comprehensive and well documented.
- Pneumothorax must be considered in patients with isolated fractures and more commonly in polytraumatized patients. It is reported in up to 3% of patients with clavicle fractures.

**Radiographic Examination**

- Most clavicle fractures can be identified on an AP chest x-ray film. Shoulder films are useful for assessing fractures of the distal clavicle and associated shoulder/scapular injuries.
- In addition to an AP view, a 20- to 45-degree cephalad tilt view of the fractured clavicle is obtained to better assess the anteroposterior relationship of the main clavicle fragments.
- A posteroanterior view with 15 degrees caudal tilt has been described as beneficial in assessing the clavicle shaft for length/shortening.
- The 45-degree anterior and posterior oblique views (off the coronal plane) can assist in demonstrating displacement of distal one-third clavicle fractures.
- Weighted views can be useful in evaluating distal clavicle fractures if concern about fracture stability and potential displacement exists. This radiograph is taken as a standard AP view with a weight (often 10 lb) strapped to the patient’s affected extremity. Comparison is made to a similar unweighted view. True displacement may be potentially altered, however, because several shoulder girdle muscles may be recruited to support the weight.
- The “serendipity view” of the sternoclavicular joints is taken with 40 to 45 degrees cephalad tilt. This view should be centered on the manubrium and should include both sternoclavicular joints for comparison.
- CT scan can be useful in evaluating very medial fractures or sternoclavicular dislocations.

**Classification**

- Most fractures are characterized descriptively by location, comminution, and displacement.
- Allman classified clavicle fractures into three groups (Figure 43–7):
  - Group I: middle third diaphyseal fractures. Most common location (approximately 80%). Fracture is medial to coracoclavicular ligament insertions.
  - Group II: lateral (distal) third fractures. Less common (approximately 12%–15%).
  - Group III: medial third fractures. Least common (approximately 5%–8%). They often result from a direct blow and usually are minimally displaced because of the stout costoclavicular ligaments.
- Neer subclassified distal clavicle fractures (Figure 43–8) as follows:
  - Type I distal fracture, coracoclavicular ligaments intact, minimal displacement (stable)
  - Type II: distal fracture with conoid (and possibly part of trapezoid) ligament disrupted from shaft, usually significant displacement (unstable)
- Additional classification has been added:
  - Type III: distal fracture involving the acromioclavicular joint
  - Type IV: physeal separation

**Treatment**

- The vast majority of clavicle fractures can be managed nonoperatively.
- Performing a closed manipulation is of limited use because reduction is difficult to achieve and maintain.
- Nonoperative treatment focuses on patient comfort and early functional rehabilitation of the shoulder. Initially, the injured arm is placed in a sling for comfort, and the patient is encouraged to remove the sling for hygiene, personal care, and elbow range of motion.
- Pendulum exercises are started immediately, with passive and active assisted exercises beginning once the acute pain has improved.
Follow-up should begin within the first 1 to 2 weeks after injury to reinforce the benefits of early motion and to reassure the patient who may be anxious about pain and motion at the fracture site. It is reasonable at this time to discuss the residual cosmetic effect that may persist after union.

By the 6- to 8-week mark, the fracture should demonstrate clinical union and substantially less pain with palpation. Motion should be approaching full range. At this time, patients may be concerned about the mass (healing callus) that develops at the site of the fracture and should be reassured that this is a common occurrence that will regress as the fracture remodels. Strengthening activities are instituted in a progressive fashion and are guided by pain. A return to contact sports should be avoided for a minimum of 3 months to allow for solid union and muscle rehabilitation to a competitive level.

Figure-of-eight splints applied in an effort to minimize excessive shortening were recommended in the past; however, functional and cosmetic results are similar to simple sling management.54

**Indications for Operative Management**

- The majority of clavicle fractures can be successfully managed with nonoperative means, but several relative indications for surgical management exist. The indications continue to evolve.

**Open Fractures**

- Open fractures are rare and usually result from high-energy trauma.
- In addition to a thorough surgical debridement and irrigation, fracture stabilization often is beneficial, particularly in allowing soft tissue recovery.

**Skin at Risk**

- Displaced clavicle fractures can place skin at risk for necrosis with delayed presentation of an open wound. Significant superior-anterior displacement can result in tenting of the skin with ischemic changes. Blanched skin that is no longer mobile over the fracture site can result from a fragment of bone that penetrated the dermis or a severely displaced fragment. In these unusual situations, the fracture is operatively reduced and stabilized to prevent skin necrosis and to allow soft tissue recovery.

**Scapulothoracic Dissociation**

- **Pearl:** Because of normal muscle forces, the majority of clavicle fractures demonstrate shortening of the clavicle through the fracture. Patients that demonstrate distraction of a clavicle fracture should raise suspicion for traction-type mechanisms and suggest a scapulothoracic dissociation (Figure 43–9).
- This rare injury often is accompanied by devastating neurovascular injury, with the clinical picture often

![Figure 43–8](image)

Group 2 distal clavicle fractures are subdivided according to their relationship with the coracoclavicular ligaments. Type I distal clavicle fractures are nondisplaced and do not have disruption of these ligaments. Type II fractures are just medial to the coracoclavicular ligaments and often are unstable, with a higher risk of nonunion. Type III fractures are distal to the coracoclavicular ligaments and involve the articular surface of the distal clavicle at the acromioclavicular (AC) joint.

![Figure 43–9](image)

Anteroposterior chest radiograph of a 38-year-old man who was severely injured after he was struck by a car while riding his bicycle. Note the distracted appearance of the clavicle fracture, associated rib fractures, and lateral displacement of the scapula relative to the chest wall. In addition to this scapulothoracic dissociation, the patient had a significant brachial plexus injury and an open wound along the lateral base of the neck.
demonstrating some degree of paralysis of the upper extremity (secondary to brachial plexus injury) and/or a dysvascular limb. Despite limited literature support, we advocate fracture fixation, especially in cases of significant displacement and/or associated vascular disruption requiring surgical repair.

**Floating Shoulder**
- Clavicle fractures with ipsilateral scapular neck fractures create a glenohumeral articulation that is no longer in continuity with the axial skeleton. This combination injury is commonly referred to as a floating shoulder.
- Stabilization of the clavicular component has been advocated in the past to allow improved shoulder function (Figure 43–10). Contemporary clinical and biomechanical literature questions this concept, suggesting that satisfactory results can be obtained with nonoperative treatment. At present, management of this injury complex should be individualized and dependent on the displacement of the clavicle and scapular neck fractures.
- When nonoperative treatment is selected, routine x-ray films obtained during the first few weeks are important to ensure that unacceptable displacement does not occur.

**Neurovascular Injury**
- Repair of the clavicle should be considered with concomitant vascular injury requiring repair to protect against further bony injury. Likewise, if a brachial plexus repair is performed, clavicle fixation may be prudent to avoid disruption by bony fragments.

**Distal Clavicle Fractures**
- A controversial and relative indication.
- Significantly displaced distal fractures (type II) have a higher rate of nonunion and functional problems and may benefit from operative fixation.
- Careful consideration is needed because fixation of these fractures can be particularly challenging.

**Special Situations**
- A relative indication for fixation of clavicle fractures are patients with neuromuscular conditions, such as Parkinson’s disease, where immobilization is difficult.
- Polytrauma, bilateral fractures, and elite athlete status of the patient have been described as relative indications for operative treatment.

**Surgical Procedures**

**Open Reduction Internal Fixation**
- Open reduction and plate osteosynthesis is our preferred technique for operative management.
- Patients are placed in the supine or beach chair position on a radiolucent table. A small towel bump is placed between the scapula, allowing the involved shoulder to be relatively extended.
- The surgical incision parallels the clavicle and is placed just inferior to the prominent anterosuperior border. Care is taken to preserve supraclavicular nerve branches.
- Contoured 2.7-mm dynamic compression plates or 3.5-mm limited contact dynamic compression plates are used, with supplemental lag screws when possible. Reconstruction plates also can be used. Adequate plate length is critical, as many prior studies of nonunion following ORIF attribute failure to technical errors such as inadequate plate length (Figure 43–11).
- Plates can be applied superiorly or anteroinferiorly. Mechanical studies suggest that superior plate placement
offers increased fracture stability, but clinical studies of anteroinferior placement demonstrate comparable union rates, with substantially less complications related to implant prominence. For these reasons, we prefer anteroinferior plate placement.

External Fixation
- Described in the literature as effective for management of acute fractures and nonunions but is used infrequently.
- Patient comfort is the biggest drawback of this technique.

Intramedullary Implants
- K-wires, threaded Steinman pins, intramedullary screws, rush rods, elastic nails, and other devices all have been described for successful fixation of clavicle fractures.
- Despite successful reports, K-wire stabilization is associated with implant migration and is not used at our institution for management of these fractures. Implants have been found within numerous organ systems, including the lung, heart, and spinal canal. Smooth wires, rather than threaded pins, appear to be particularly problematic.

Rehabilitation
- Patients are started on immediate pendulum exercises with their sling still in place. Gravity assisted and passive range of motion are subsequently started. The sling should be worn for the majority of the day, except during physical therapy. Until early fracture union occurs, the weight of the arm presents a significant displacing force after fixation, so the arm needs to be supported with the sling.
- Progressive strengthening exercises usually can begin at approximately 8 weeks, depending on radiographic stability and union.

Complications

Malunion
- Symptomatic malunions of the clavicle can lead to patient dissatisfaction. McKee, Wild, and Schemitsch reviewed 15 patients who underwent corrective osteotomy for clavicular malunion. Preoperative symptoms included weakness, pain, neurologic/thoracic outlet symptoms, and appearance concerns (“droopy” shoulder, with other symptoms). Fourteen of the 15 patients subsequently achieved union and significant symptom improvement.
- Shortening of 2 cm or more is the most consistent risk factor for symptomatic malunion.

Nonunion
- More common in operatively treated fractures, especially in older studies. Overall, nonunion rates of less than 1% to greater than 10% have been reported.
- Most common in distal third fractures, but functional results appear to be satisfactory.
- Operative management includes stabilization and the addition of bone graft (see Figure 43–11). Satisfactory results have been reported with both plate fixation and intramedullary devices.
- Midshaft fractures with more than 2 cm of shortening and lateral third fractures appear to be at higher risk for nonunion.

Fractures of the Scapula and Glenoid

Introduction
- Scapula and glenoid fractures occur uncommonly.
- Frequently result from high-energy trauma.
- Scapular body fractures typically occur after a direct blow to the thorax or shoulder girdle after vehicular accidents or a fall from significant height. Associated skeletal and soft tissue injuries occur commonly.
- Intraarticular glenoid fractures occur in 20% to 30% of scapula fractures and are associated with similar violent trauma and associated injuries. The exception is the glenoid rim fracture, which may occur in association with an anterior glenohumeral dislocation.
Anatomy

- The scapula is encased in muscle and is minimally constrained by osseous attachments to the axial skeleton.
- This generous muscular coverage of the majority of the scapula imparts rapid healing but makes surgical access difficult, except to the palpable subcutaneous portions such as the scapular spine, acromion process, and medial scapular border.
- The osseous anatomy is complex, with significant variability in cortical thickness from the central body to the borders and processes.
- The portions of the scapula useful for screw purchase include the glenoid neck, acromion process, coracoid process, scapular spine, and medial and lateral borders.
- The glenoid articular surface is small and relatively flat, making the glenohumeral joint poorly constrained.
- Shoulder joint stability results primarily from the dynamic muscular forces acting across the glenohumeral articulation.
- Important articulations include the glenohumeral joint, acromioclavicular joint, and scapulothoracic articulation.
- Thorough understanding of the location of the primary muscular attachments, nerve supply, and vascular supply of the anterior and posterior scapula is necessary for a complete assessment and treatment plan.
- For posterior approaches to the shoulder, the interval between the teres minor and the infraspinatus allows safe access to the shoulder joint.
- The axillary nerve is located between the teres minor and the teres major.
- The circumflex scapular artery crosses the lateral border of the scapula near the glenoid neck and requires identification in posterior approaches that expose the lateral border.
- The deltopectoral interval is used for anterior access to the shoulder for anterior glenoid fractures.
- The muscular and ligamentous attachments to the coracoid process include the coracoacromial ligament, coracooacromial ligament, pectoralis minor, coracobrachialis, and short head of the biceps brachii. The displacement patterns of glenoid articular fractures involving the anterosuperior portion of the joint are determined by the relative integrity of these attachments.

Physical Examination

- Associated shoulder girdle injuries, such as those to the clavicle, acromioclavicular joint, and proximal humerus, occur commonly and should be identified.
- Although open fractures of the scapula and glenoid are rare, a careful assessment of the skin integrity should be performed.
- An accurate upper extremity neurologic examination should include assessment of the entire brachial plexus because associated nerve injuries are common.
- Special attention should be directed to assessment of the axillary, suprascapular, and musculocutaneous nerves.
- To adequately assess the vascular supply of the upper extremity, the presence and quality of pulses and the ankle-brachial index should be documented.

Radiographic Examination

- Radiographic studies include AP and lateral shoulder views in the plane of the scapula (true AP and lateral), a true AP of the entire scapula (frequently lacking on a true AP shoulder view), and an axillary lateral shoulder view. The glenoid articular surface is best visualized on the scapular (true) AP and the axillary lateral. Glenohumeral subluxations and dislocations are most evident on the axillary lateral view.
- Comparison views of the contralateral shoulder frequently are helpful in determining angulatory and translational deformities of glenoid neck and fossa injuries.
- In most glenoid articular fractures, radiographic evaluation with CT is important in fracture pattern comprehension, preoperative planning, and determination of the surgical approach. Three-dimensional reconstructions may enhance planning of some difficult patterns.
- The role of CT scans in scapular body fractures is poorly defined and limited because surgical indications are unusual.
- Angiographic studies are warranted in patients with altered upper extremity blood flow, as predicted by physical examination and ankle-brachial indices. Further evaluation of the brachial plexus may be indicated in patients demonstrating associated extensive neurologic upper extremity impairment.

Classification

- Classification of scapula fractures is primarily descriptive and based on the anatomic location of the primary injury pattern. Key anatomic locations for classification purposes include the acromion, scapular spine, glenoid neck, glenoid articular surface, and scapular body.
- Glenoid articular fractures have been further classified according the anatomic location of the primary fracture lines as follows (Figure 43-12): fractures of the glenoid rim (type I), inferior lateral partial articular injuries (type II), superior partial articular injuries (type III), transverse fractures extending to the medial scapular border (type IV), combined patterns involving the entire fossa (type V), and severely comminuted fractures (type VI).
Emergency Room Management

- Most scapular and glenoid articular injuries can be initially managed with a sling for comfort. Open scapula fractures are surgical emergencies and require early debridement and irrigation. Fixation may be required, depending on the particular skeletal and soft tissue injury. Associated vascular injuries require a coordinated approach with an appropriate vascular consultant.

Treatment

- The vast majority of scapular body fractures heal rapidly with nonoperative management. Following an initial sling for comfort, early and unrestricted active and passive shoulder range of motion exercises can be instituted.
- Scapular neck and glenoid articular fractures that are treated nonoperatively are initially managed with a sling for comfort. Early passive range of motion exercises can be initiated based upon patient comfort. Resistive exercises should be restricted for 6 weeks in patients with neck fractures and 12 weeks in those with articular fractures.
- Indications for fixation of acromial fractures are poorly described. Significant displacement and associated shoulder girdle injuries are relative indications. The approach is directed by the fracture configuration. Fractures of the lateral acromial process usually can be approached posteriorly along the posterior border, carefully elevating the deltoid origin. Fixation frequently is difficult because of the complex anatomy and limited scapular bone stock.
- Surgical indications for fractures confined to the scapular body are unusual. Even open scapular bodies do not necessarily require fixation after an appropriate and timely debridement and irrigation.
- Surgical indications for glenoid neck fractures are not well described. Significant displacement, translation, and angulation of the entire glenohumeral joint relative to the scapular body may affect shoulder joint motion and the mechanical advantage of the rotator cuff and shoulder girdle muscles, producing a surgical indication. The exact displacement, translation, and angulation that produce functional abnormalities are unknown, so treatment must be individualized (Figure 43–13). Associated clavicle fractures create the so-called floating shoulder injury and have been identified as a strong indication for fixation of the glenoid neck and/or clavicle fracture. Clinical and biomechanical studies have questioned this condition as a surgical indication.
- Surgical indications for operative fixation of glenoid fractures include displacement of 3 to 5 mm and/or humeral head subluxation (Figure 43–14). The amount (percentage) of articular surface involved and the fracture location also influence the treatment decision.
- Anterior rim fractures may represent labral avulsion fractures in patients with an associated dislocation. Treatment decisions parallel glenohumeral instability without an anterior rim fracture.

Surgical Management

Exposures

Anterior

- For anterior glenoid rim or articular fractures, the deltopectoral approach is used. These fracture patterns are unusual and represent the exception.

Posterior

- The majority of glenoid articular fractures and all scapular neck fractures are approached posteriorly. Positioning can be either lateral or prone.
- The lateral position allows simultaneous access to the coracoid for manipulation of fractures involving the

Figure 43–12: Modified Ideberg classification system of glenoid fractures.
Figure 43–13:
A, B, Injury anteroposterior and scapular Y radiographs of the right shoulder of a 38-year-old man after he slipped and fell down a flight of stairs. Note the marked inferior displacement of the glenoid fossa. C, Three-dimensional CT reconstruction was obtained to improve the comprehension of the fracture pattern. The anterior view of the right scapula is shown. D, E, F: Using a posterior surgical exposure, multiple minifragment scapular body plates and a single one-third tubular antiglide plate placed along the inferior glenoid neck were used for fixation. Anteroposterior, axillary, and scapular Y radiographs show satisfactory union 4 months later. An excellent functional result was obtained.
entire articular surface. However, intraoperative fluoroscopic imaging is limited.

- Prone positioning allows intraoperative fluoroscopic images but limits manipulation of anterior fracture fragments.
- For combined glenoid articular and scapular body fractures, one approach consists of a modification of a posterior approach to the shoulder combined with aspects of the posterior (Judet) approach to the scapula.86,97

**Technique**

- An incision is made along the spine of the scapula extending from the lateral acromion to the medial scapular border. The incision curves distally and parallels the medial scapular border along the scapular length. A full-thickness flap of the skin and subcutaneous tissues is developed, exposing the overlying fascia of the deltoid and the shoulder external rotators.
- The deltoid muscle belly, with its investing fascia, is reflected off the underlying infraspinatus muscle and the scapular spine. With the deltoid retracted laterally, the interval between the teres minor and the infraspinatus is identified and developed, exposing the lateral border of the scapula and the posterior joint capsule. Care is taken to identify the circumflex scapular artery at the lateral scapular border and to avoid dissection inferior to the teres minor (axillary nerve) (Box 43–3).
- Exposure of the scapular spine and medial scapular border is important in fractures with extensions to these locations. In fractures not involving the medial or lateral scapular borders (types II and III), further exposure in these locations for reduction and plate applications is not necessary. The shoulder joint can then be exposed. The interval between the infraspinatus and the teres minor can be extended laterally to uncover the posterior joint capsule. Typically, the posterior exit of an intraarticular fracture component produces a capsular disruption that can be used to view the articular surface and the subsequent reduction. The capsular and labral attachments to the posterior glenoid rim should be left intact. However, a vertical capsular incision can be extended to improve the exposure. For fractures of the scapular neck, lateral exposure to the joint capsule is unnecessary.
- The suprascapular nerve and vessels at the spinoglenoid notch should be protected throughout.
Figure 43–14:
A, B, Injury anteroposterior plain radiograph and three-dimensional CT reconstruction show a type IV glenoid fossa fracture in a 42-year-old man involved in a motorcycle collision. Marked articular congruity of the glenoid articular surface is seen. C, Intraoperative anteroposterior fluorograph shows satisfactory reduction and stabilization via a posterior exposure. D, E, Anteroposterior and axillary radiographs show satisfactory union.
Fixation Strategies

- The choice of implant for fixation is governed by the cortical thickness, complex scapular geometry, and limited space for plate application.
- Scapular neck fractures can be stabilized with a plate placed along the lateral aspect of the lateral border of the scapula.
- Glenoid articular fractures require a more comprehensive surgical approach.
- Smaller (2.0, 2.4, or 2.7 mm) plates combine adequate stiffness, flexibility, and contouring characteristics for the medial scapular border and scapular spine. Plates spanning the thinner, frequently unicortical scapular body usually are 2.0 mm; the maximum screw length in this location usually is 6 to 8 mm. One-quarter tubular, one-third tubular, or 2.7-mm reconstruction plates can be easily contoured to stabilize the glenoid neck.
- The most important location for fixation of type Va, Vc, and VI fractures usually is at the lateral scapular border, extending to inferior articular margin. One-quarter tubular and one-third tubular plates can be placed on the lateral aspect of the lateral border (see Figure 43–13, D and E). This step allows fixation through the plate and into the coracoid process, supporting both the inferior articular fracture and the caudal scapular body component. It should be understood that the coracoid process base actually is lateral and cephalad in location relative to the lateral border.
- The medial border fracture (in type IV, V, and VI patterns) usually is stabilized prior to the articular reduction in glenoid articular fractures. Although fixation of the medial border of the scapula is not needed for stability, scapular body reduction facilitates articular reduction.

Rehabilitation

- Postoperatively, immediate, unrestricted passive range of motion exercises are encouraged. Active shoulder exercises are delayed for 6 weeks to allow for healing of the repaired deltoid origin.
- Resistive exercises are instituted beginning at 12 weeks.
- Radiographic evaluation includes scapular anteroposterior and axillary lateral views postoperatively and at 6, 12, and 24 weeks.

Complications

- Infections are unusual given the generous vascular supply to the scapula.
- Healing complications after scapular body fractures are rare. Union is predictable and rapid because of the abundant vascular supply.
- Glenoid neck fractures heal predictably, but the impact of significant angular or translational deformities is unknown. Glenohumeral stiffness after a glenoid neck or articular fracture occurs commonly but can be managed with early, aggressive physical therapy.
- Traumatic peripheral nerve injuries occur relatively frequently, and their management usually is expectant.
- Iatrogenic intraoperative nerve injuries, especially to the axillary and suprascapular nerves, usually can be prevented by understanding the surgical anatomy and safe planes of dissection and implant placement.

References


17. Bernstein J, Adler LM, Blank JE et al: Evaluation of the Neer system of classification of proximal humeral fractures with computerized tomographic scans and plain radiographs. J Bone Joint Surg Am 78:1371-1375, 1996. The classification of proximal humeral fractures remains difficult because of the lack of uniform agreement about which fragments are fractured. Intraobserver reliability was marginally improved with CT scanning, but interobserver reproducibility was not.


Results of percutaneous pinning were comparable or superior to those obtained in previously described operative methods for treatment of these fractures.


In this cadaveric model, the authors describe the proximity of neurovascular structures to the pin location in percutaneous techniques for fracture stabilization of the proximal humerus.


Patients with two-part translated fractures of the surgical neck tended to be independent and relatively fit, even though their mean age was 72 years. Outcome was determined by the age of each patient and the degree of translation on the initial anteroposterior radiograph.


This study reported 80.6% of patients with an impacted valgus fracture treated nonsurgically had a good or excellent result, the quality of which depended on the age of the patient and the degree of displacement. Operative fixation of these fractures is not necessary.


Satisfactory tuberosity position and union correlated with the success or failure of hemicraithroplasty for treatment of displaced fractures of the proximal humerus.


Fracture severity and timing of the operation did not appear to have a bearing on the outcome. Technical problems at surgery, greater tuberosity displacement, late rotator cuff rupture, and poorly motivated patients were the main reasons for failure.


Blade plates and autograft were used to repair ununited fractures of the proximal humerus. A 92% rate of healing and 80% good or excellent results with few complications were reported.


Clavicle fractures represented 2.6% of all fractures and 44% of those in the shoulder girdle. Fractures of the middle third were most common (81%), whereas fractures of the medial third were the least common (2%).


Study reported that 94% of patients fractured their clavicle from a direct blow on the shoulder; only 6% had fallen on an outstretched hand.


Unsatisfactory results were reported by 16 of 52 patients with displaced, midshaft clavicle fractures. Shortening of 2 cm or more was highly correlated with nonunion and unsatisfactory results.


Corrective osteotomy was performed for 15 patients with clavicle midshaft malunion; 14 of 15 healed. Satisfaction and function improved significantly in all patients.


Midshaft clavicle fractures with shortening greater than 2 cm are predisposed to nonunion. ORIF should be undertaken in symptomatic patients if no signs of healing are observed after 6 weeks.


The authors describe the advantage of obtaining a posteroanterior 15-degree caudal view in assessing clavicle fractures and evaluating shortening.


Distal clavicle fractures are reviewed. A classification with division into two types as related to stability is described.


A review of clavicle fractures, acromioclavicular and sternoclavicular sprains. Classifications are defined. Evaluation protocols and treatment options are described.


Treatment with a simple sling caused less discomfort and perhaps fewer complications than a figure-of-eight bandage, with identical functional and cosmetic results.


Good results may be seen both with and without operative treatment for patients with a displaced fracture of the glenoid neck and an ipsilateral clavicular fracture or acromioclavicular separation.


Twenty patients with a floating shoulder were treated nonoperatively. Nineteen fractures united; one clavicular nonunion resulted. The majority of patients had excellent shoulder motion and functioning scores.


Ipsilateral clavicle and scapula fractures are not inherently unstable. In the absence of caudal dislocation of the glenoid, nonoperative treatment leads to good outcomes.


A review article evaluating the controversies involving the management of distal clavicle fractures.


Most distal clavicle fractures do not require surgical intervention.


Nonoperative treatment of most displaced lateral clavicle fractures results in good functional outcomes.


The authors describe their technique of using a Dacron arterial graft as a sling around the clavicle and coracoacromial process to treat distal clavicle fractures. All fractures healed.


Eleven Neer type II distal clavicle fractures were treated by open reduction internal fixation with a Bosworth-type screw. All fractures healed within 10 weeks.


Clavicles plated superiorly exhibit significantly greater stability than those plated anteriorly. Limited contact dynamic compression (LCDC) plates provide greater stability than reconstruction and dynamic compression (DC) plates.


The authors describe their technique for open reduction internal fixation of clavicular nonunion with anteroinferior placement of a 3.5-mm reconstruction plate.


Fifteen patients with clavicle fractures and five patients with nonunions were treated with external fixation. All fractures united with shoulder function and minimal complications.


The authors describe a technique for fixation of displaced midshaft clavicle fractures with flexible titanium nails, leading to healing in 57 of 58 fractures.


Fourteen years after nonoperative treatment for scapula fractures, the majority of patients had satisfactory outcomes, but half with residual deformity had slight or moderate shoulder disability.


An extensive review of intraarticular glenoid fractures and their management. The classification system is further elucidated.


Good outcomes were obtained following ORIF of displaced glenoid fossa fractures.


The superior shoulder suspensory complex is described. Surgical reconstruction and stabilization of injuries to this complex is recommended.


Based on a limited experience, the authors recommend nonoperative treatment for most displaced intraarticular fractures of the glenoid.
   At an average of almost 2.5 years after operative fixation of displaced glenoid articular fractures, good results were obtained in 14 patients.

   Good results were obtained in patients that did not have a deep infection or an associated brachial plexus palsy. The surgical approach and reduction of displaced glenoid fractures are described in detail.

   A posterior surgical approach and reduction maneuvers are described.

   The suprascapular nerve is located an average of 1.4 cm from the glenoid rim. The circumflex scapular artery is an average of 2.8 cm from the inferior glenoid margin.
CHAPTER 44

Shoulder Arthritis

Phani K. Dantuluri

Introduction

- Normal shoulder function depends on the humeral head and glenoid smoothly articulating via congruent, well-lubricated joint surfaces. When these surfaces are damaged, this normally congruent relationship deteriorates, leading to pain, stiffness, and loss of function.
- Glenohumeral arthritis of the shoulder is a relatively common condition, although it occurs less frequently than arthritis of the hip and knee.
- In addition to rotator cuff disease, it is one of the most common causes of shoulder pain and functional loss in elderly patients.
- Incidence of osteoarthritis of the shoulder seems to increase with age, with patients typically presenting in the sixth and seventh decades of life.
- Treatment of symptomatic arthritis of the shoulder is nonoperative in the majority of patients. Surgical intervention may become necessary in advanced cases with significant degenerative change and loss of range of motion leading to functional loss.
- The degree of degenerative change, patient age, and functional demands of the patient help determine the most appropriate treatment plan. With the improvement of biomaterials and the modularity of prosthetic replacement, glenohumeral arthroplasty is becoming an increasingly viable option in properly indicated patients.

Clinical Etiologies of Glenohumeral Arthritis

- A number of different etiologies can lead to arthritic changes of the shoulder joint.

Primary Degenerative Arthritis

- Primary degenerative arthritis or osteoarthritis typically presents with increased posterior wear of the glenoid cartilage and subchondral bone. Significant central wearing of the humeral head cartilage with a rim of residual cartilage and peripheral osteophytes is seen. Osteophytes are common inferiorly and posteriorly along the glenoid and the anterior, inferior, and posterior aspects of the humeral head, leading to a flattened appearance. Subchondral sclerosis and degenerative cystic changes may be present in the humeral head or glenoid (Figure 44–1). In addition to significant posterior glenoid wear, there often is posterior humeral subluxation and tightness of the anterior capsular structures. Often there is an enlarged inferior capsule with laxity of posterior structures. Loose bodies are often seen in the glenohumeral joint, but rotator cuff pathology is rare.

Secondary Degenerative Arthritis

- Arthritic changes result from posttraumatic alterations, recurrent instability, prior surgery, or other conditions leading to secondary degenerative changes. Fracture...
leading to malunion can result in altered joint congruity precipitating significant cartilage erosion (Figure 44–2). Prosthetic arthroplasty in malunion cases show that satisfactory long-term pain relief and function can result in 75% of cases, but with a relatively high complication rate. Dislocation can lead to instability, which also disrupts normal glenohumeral motion, leading to wear. Radiographic patterns in secondary degenerative arthritis are generally similar to primary degenerative arthritis with subchondral sclerosis, osteophytes, and joint space narrowing.

### Inflammatory Arthritis
- Most commonly rheumatoid arthritis. Rheumatoid arthritis typically presents with even cartilage destruction across joint surfaces (Figure 44–3). Glenoid erosion typically is medial and central as opposed to the posterior erosion seen in osteoarthritis. Significant marginal erosions can be present along the humeral head. Osteopenia is present, and there usually is significant involvement of the soft tissues, including the rotator cuff. Significant soft tissue swelling, weakness, and contractures often are present. Ipsilateral upper extremity rheumatoid involvement of the sternoclavicular and acromioclavicular joints, hand, wrist, and elbow can lead to significant loss of function. Other inflammatory and crystalline arthropathies, such as pigmented villonodular synovitis, gout, and pseudogout, can present similarly.

### Rotator Cuff Tear Arthropathy
- Degenerative changes are the result of a chronic large rotator cuff defect that allows superior migration of the humerus, leading to arthritic change superiorly and erosion of the coracoacromial arch. Glenoid wear

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**Figure 44–1:**
Osteoarthritis of the shoulder. A, Stereotypical radiographic, pathoanatomic appearance. The humeral head is somewhat enlarged and flattened. Peripheral osteophytes are particularly prominent inferiorly. There is flattening of the humeral head with subchondral sclerosis, best seen centrally and central-superiorly. Interosseous cysts may be present and are best seen on the axillary projection. B, In the axillary view, asymmetric glenoid wear with slightly greater wear of the posterior aspect of the glenoid is seen. This radiographic appearance of the glenoid is typical of that of a biconcave glenoid that, unless otherwise contraindicated, is best treated by implanting a glenoid component. (From Matsen FA, Rockwood CA, Wirth MA, Lippitt SB: Glenohumeral arthritis and its management. In Rockwood CA, Matsen FA, editors: The shoulder, ed 2. Philadelphia, 1998, WB Saunders.)

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typically is superior as well. The resulting superior instability resulting from cuff deficiency makes glenoid replacement a poor option, because lack of glenohumeral stability leads to eccentric loading forces on the glenoid component and early loosening. Radiographic changes are notable for the “femoralization” of the proximal humerus and the “acetabularization” of the coracoacromial arch as the incompetent rotator cuff allows the superior migration of the proximal humerus and this new pathologic articulation (Figure 44–4).²

Capsulorrhaphy Arthropathy

- Capsulorrhaphy arthropathy is a secondary degenerative process caused by prior surgery performed for recurrent instability. It typically is seen in shoulders that underwent prior anterior surgical procedures to tighten the anterior capsule for recurrent dislocations. If overtightening is done, posterior subluxation and posterior wear of the glenohumeral joint can occur. Similarly, excessive posterior capsular tightening can lead to anterior translation, wear, and subsequent degenerative changes. It may also be seen secondary to surgical structural alteration of the glenohumeral joint or to surgical implants left in the joint, such as screws or staples. It is a common cause of glenohumeral arthritis in the younger demographic group.

Avascular Necrosis

- Avascular necrosis of the humeral head can lead to collapse and irregularity of the humeral head. This irregular humeral head causes wear of the glenoid and
leads to secondary degenerative changes. Causes of avascular necrosis are numerous. Steroids, vascular causes, dysbaric conditions, alcoholism, transplantation, Gaucher’s disease, radiation, lipid metabolism disorders, cytotoxic drugs, sickle cell disease, and idiopathic etiologies all have been implicated as causal factors. Pathologic changes can be detected in the early stages by magnetic resonance imaging (MRI), but radiographic changes occur later in the process. Relative osteopenia or osteosclerosis and eventual subchondral fracture leading to the classic crescent sign can be seen (Figure 44–5). End-stage changes occur on both sides of the joint and involve the humeral head and the glenoid.

**Clinical Presentation**

**History**
- The history is critically important in making the proper diagnosis when dealing with patients having shoulder pathology. Obtaining the chief complaint, age, extremity dominance, occupation, activities, trauma history, and functional demands are critical in determining the etiology, presentation, and treatment plan in patients with glenohumeral arthritis. Symptoms can vary, depending on the extent of articular involvement, but typically patients present with pain, stiffness, and loss of function that are refractory to rest, nonsteroidal antiinflammatory drugs, and exercise. Important prognostic factors include the presence of systemic disease and the etiology of the degenerative changes.

**Physical Examination**
- Careful examination of the deltoid and rotator cuff should be performed because these areas are important factors in surgical decision making.
- A complete neurovascular examination including isometric testing is essential.
- Examination of the ipsilateral wrist, elbow, and hand to evaluate the impact of surgical intervention is beneficial.
- Careful examination of overall body function is crucial. The findings may affect surgical timing because patients may also present with significant lower body involvement. Lower extremity involvement may influence the timing of shoulder surgery because upper extremity weight bearing cannot be considered until 4 to 6 months after arthroplasty.

**Findings on Physical Examination**
- Limited joint range of motion. Loss of external rotation and forward flexion is typical of advanced stages. In patients with capsulorrhaphy arthropathy, this loss of external rotation can be severe, and symptoms of instability can still be present.
- Pain can be elicited, depending on the location of arthritic change, by placing the arm in a provocative position.
- Patients who have loose bodies or osteophytes may experience locking or popping during range of motion.
- Crepitus may be felt through passive range of motion of the shoulder.
Figure 44–5: Osteonecrosis of the proximal humerus. There is an osteochondral fracture with minimal distortion of the articular surface of the humerus, best seen in the anteroposterior view (A). In the axillary view (B), a crescent sign in the anterocentral part of the humeral head is seen. (From Matsen FA, Rockwood CA, Wirth MA, Lippitt SB: Glenohumeral arthritis and its management. In Rockwood CA, Matsen FA, editors: The shoulder, ed 2. Philadelphia, 1998, WB Saunders.)

Figure 44–6: Neuropathic arthritis. Occasionally, neuropathic arthritis can be confused with the more common forms of glenohumeral arthritis. A, Fragmentation of the proximal humerus with bone debris scattered throughout the joint region. B, Bone fragmentation is seen, but this predominantly sclerotic response is associated with neuropathic arthritis. The underlying condition in both of these patients was syringomyelia of the cervical portion of the spinal cord. (From Matsen FA, Rockwood CA, Wirth MA, Lippitt SB: Glenohumeral arthritis and its management. In Rockwood CA, Matsen FA, editors: The shoulder, ed 2. Philadelphia, 1998, WB Saunders.)
Muscle wasting can be seen around the glenohumeral joint, depending on the severity and duration of involvement.

**Diagnostic Imaging**

- Careful assessment of the shoulder via various imaging studies can provide a better understanding of the extent of disease and guide treatment. Many imaging studies are available. Each has its advantages and disadvantages and provides different information.
- As in all surgical interventions, careful preoperative planning can allow a successful result and help prevent unexpected surprises. Imaging studies can aid in this preoperative planning.

**Radiographic Evaluation**

- Radiography is always the starting point for diagnostic evaluation of the glenohumeral joint. Tremendous amounts of information can be determined from careful examination of plain films. Understanding the three-dimensional orientation of the glenohumeral joint is necessary to understand the radiographs and to acquire the appropriate views. Standard views include a scapular anteroposterior (AP) view and a true axillary view (Figure 44–7). These views can allow the examiner to evaluate unexpected surprises.

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**Figure 44–7:**
Radiographic series for a stiff shoulder. A, The anteroposterior view in the plane of the scapula is obtained by orienting the beam perpendicular to the plane of the scapula and centering it on the coracoid tip while the film is parallel to the plane of the scapula. B, The resultant radiograph should clearly reveal the radiographic joint space between the humeral head and the glenoid. C, The axillary view is obtained by centering the beam between the coracoid tip and the posterior angle of the acromion. D, The resultant radiograph should project the glenoid midway between the coracoid and the acromion, providing a clear view of the joint space. (From Matsen FA, Rockwood CA, Wirth MA, Lippitt SB: Glenohumeral arthritis and its management. In Rockwood CA, Matsen FA, editors: The shoulder, ed 2. Philadelphia, 1998, WB Saunders.)
bony architecture, relative cartilage thickness, humeral head position in relation to the glenoid, degree of osteopenia or osteosclerosis, presence and location of osteophytes, and extent of deformity present. Furthermore, internal and external rotation views of the humerus can aid in preoperative arthroplasty planning by allowing a truer understanding of the anatomy of the proximal humerus. Superior displacement of the humeral head on the scapular AP view can be suggestive of rotator cuff deficiency. An AP radiograph taken with the arm in 45 degrees abduction can help demonstrate central humeral head cartilage loss, which may not be apparent on the standard scapular AP view. The glenoid can be well visualized on the axillary view, allowing careful evaluation of posterior erosion, subluxation of the humeral head, and available bone stock for glenoid resurfacing.

**Computed Tomography**

- Glenoid morphology and version can be better visualized with the three-dimensional information available through computed tomography (CT). Three-dimensional reconstructions also can provide an excellent idea of bony architecture and help determine reconstructive options. Both shoulders should be included in the scan in order to allow comparison. Preoperative CT scans can help prevent shoulder arthroplasty malposition and subsequent failure because of unrecognized posterior glenoid wear. A CT scan is recommended prior to shoulder arthroplasty if there is significantly decreased external rotation or a history of prior surgery, or if the plain radiographs are suggestive of posterior subluxation of the humeral head or significant posterior glenoid erosion (Figure 44–8).² Furthermore, a CT arthrogram can provide additional information on the pathologic joint changes present.

**Magnetic Resonance Imaging**

- MRI provides excellent visualization of the soft tissues surrounding the glenohumeral joint, allowing careful evaluation of the rotator cuff and surrounding musculature. MRI also can provide information on labral and capsular pathology, and MRI arthrography may be superior to CT arthrography in assessing labral pathology. Furthermore, in patients in whom osteonecrosis is suspected, early changes may be visualized on MRI before any radiographic changes are apparent. Although MRI can provide excellent visualization of the soft tissues, CT scans may allow better evaluation of the bony architecture and aid in preoperative planning of cases where shoulder arthroplasty is considered.

**Management**

**Nonoperative Management**

- Treatment of early glenohumeral arthritis should always be nonoperative before surgical intervention is considered.

**Physical Therapy and Range of Motion Exercises**

- A proper physical therapy and rehabilitation protocol can be greatly beneficial in improving range of motion and strength. Passive and active ranges of motion exercises are important in increasing the flexibility and pliability of the soft tissues around the shoulder in order to improve function. Furthermore, scapulothoracic strengthening may improve the biomechanics of the shoulder joint complex. Strengthening the muscles around the shoulder girdle, including the rotator cuff and deltoid, can lead to significant functional gains and allow improvements in the activities of daily living while decreasing concomitant pain from possible coexisting rotator cuff pathology.

**Nonsteroidal Antiinflammatory Drugs**

- Nonsteroidal medications can be effective because of their analgesic and antiinflammatory effects. Care must be taken to take a safe, effective NSAID based on one’s general medical condition and comorbidities.

**Pain Medications**

- Pain medications should be used judiciously and only on a short-term basis if necessary because of the great potential for abuse.
Steroid Injections

- Steroid injections have been beneficial in relieving symptoms of the arthritic glenohumeral joint, particularly in patients with an inflammatory component to their arthritis. However, care should be taken when administering steroid injections to diabetic or immunocompromised patients. Repeat steroid injections may cause additional damage to the soft tissues within and around the glenohumeral joint.

General Surgical Indications

- Surgery should be considered only after nonoperative management has failed. Patients must be made fully aware of the risks, complications, limitations, and expectations of the proposed surgical procedure. Patient selection is one of the most important determinants to achieving a successful surgical outcome. The patient’s age, comorbidities, and functional demands also dictate surgical options. Surgical options include synovectomy, arthroscopic debridement, capsular release, resection arthroplasty, interpositional arthroplasty, arthrodesis, corrective osteotomies, and prosthetic arthroplasty.

Synovectomy

- Synovectomy is most often indicated in patients with inflammatory arthropathies, including rheumatoid arthritis, with intact articular surfaces. Patients with severe synovitis and significant soft tissue swelling that is unresponsive to nonoperative treatment may be candidates for synovectomy. Synovectomy can be performed either arthroscopically or via an open approach, but in both cases great care must be taken to avoid iatrogenic nerve injury because abundant inflamed synovium and soft tissues can alter the normal anatomy.

Arthroscopic Debridement

- Arthritis of the glenohumeral joint may include a degenerative labrum, loose bodies, articular defects, and osteophytes. Arthroscopic debridement may be a reasonable treatment in patients after nonoperative methods have been unsuccessful and when prosthetic arthroplasty is not desired. However, this procedure is best indicated when severe arthritic change has not occurred, as little benefit is seen in patients with advanced disease. Long-term studies are needed to clearly evaluate this treatment option. Capsular release often is performed as part of the procedure, and should also be considered in patients with early capsulorrhaphy arthropathy. It can be performed either open or arthroscopically.

Resection Arthroplasty

- Resection arthroplasty is indicated primarily as a salvage procedure. It can be useful in septic arthropathy with significant involvement of the humeral head and glenoid. It also is used in the setting of an infected prosthetic arthroplasty or component failure. Typically postoperative instability is seen initially, but stiffness usually develops over time. Weakness often is present because of the lack of bony stability and mechanical advantage. Pain relief can be variable.

Arthrodesis

- Indications for arthrodesis have become rare. It can be used in patients with strenuous physical demands, such as heavy manual laborers who are not candidates for prosthetic arthroplasty. It also is a treatment option for patients with multiple failed surgeries. Other indications include patients with septic arthritis, loss of deltoid and rotator cuff function, and refractory instability.

Interpositional Arthroplasty

- Interpositional arthroplasty has relatively few indications but can be an option in younger patients with severe rheumatoid arthritis. Interposition has been performed in a variety of ways using local capsular tissue, fascia lata autograft, Achilles tendon allograft, and lateral meniscal allograft. Results are less favorable than prosthetic arthroplasty and can be highly variable. However, the combination of biologic resurfacing of the glenoid and hemiarthroplasty of the shoulder is a viable option in younger patients.

Corrective Osteotomies

- Opening wedge osteotomies of the glenoid have been used in patients with fixed posterior subluxation of the humeral head and posterior glenoid wear, but the technique is reserved for selected cases. Varus/valgus and derotational osteotomies of the humerus can rarely be considered in posttraumatic deformity, but indications are limited and corrective osteotomy should be performed before significant arthritic changes occur.

Prosthetic Arthroplasty

- Main indications for prosthetic arthroplasty of the glenohumeral joint are pain, severe loss of function, and end-stage arthritic change of the joint refractory to conservative measures. The different causes leading to end-stage disease influence surgical management and present unique considerations that must be addressed. Common contraindications to prosthetic arthroplasty include the presence of infection, deltoid and rotator cuff insufficiency, neuropathic arthropathy, and intractable
instability. Relative contraindications may include patients who are younger, patients with inadequate bone stock for glenoid replacement, and patients with rotator cuff defects that cannot be repaired.

**Unique Disease Considerations in Prosthetic Arthroplasty**

**Osteoarthritis**

- Prosthetic replacement has led to consistently good results in most reports. Prospective long-term studies of total shoulder arthroplasty have shown good survivorships at 10 to 15 years and have shown that total shoulder arthroplasty has yielded better results than hemiarthroplasty alone. Hemiarthroplasty can be considered without glenoid resurfacing if the articular surface of the glenoid is preserved, but the glenoid often will need to be resurfaced at a later date if glenoid wear continues. Hemiarthroplasty also is preferred in cases of avascular necrosis or proximal humeral fracture, or in revisions with poor glenoid bone stock. Hemiarthroplasty in combination with an interpositional allograft, such as the lateral meniscal allograft, may be a reasonable option in younger patients. Hemiarthroplasty is contraindicated in cases where posterior humeral subluxation and subsequent posterior wear have resulted in formation of a biconcave glenoid. Long-term posterior subluxation of the humeral head may lead to posterior capsular laxity, which may require plication in some cases. Rotator cuff pathology is relatively uncommon in osteoarthritis patients compared to rheumatoid patients.

**Rheumatoid Arthritis**

- Rotator cuff pathology and more soft tissue involvement is common in patients with rheumatoid arthritis. Functional improvement after arthroplasty may be less predictable. Most reports show better outcomes with total shoulder arthroplasty, provided good soft tissues and viable rotator cuff function are present. Careful examination of an AP radiograph demonstrating the lack of superior humeral head migration may indicate a balanced rotator cuff force couple, suggesting that a glenoid component may be placed. However, as glenoid erosion is central and more osteopenia is present, inadequate bone stock may preclude glenoid fixation, and a hemiarthroplasty may be indicated. A deficient or irreparable rotator cuff is another indication for a hemiarthroplasty.

**Rotator Cuff Arthropathy**

- In rotator cuff arthropathy where the rotator cuff is not functional, glenoid resurfacing is generally not indicated because the lack of a functioning rotator cuff leads to eccentric loading on the glenoid component and early component loosening. Hemiarthroplasty often is the treatment of choice with a prosthetic head roughly the same size as the native humeral head. Use of a humeral head prosthesis that is too large may overstuff the joint and lead to pain, decreased range of motion, and early failure. Preserving the integrity of the coracoacromial arch is crucial in these patients to prevent anterosuperior instability, as patients who previously underwent subacromial decompression with coracoacromial ligament compromise have demonstrated significant anterosuperior instability with subsequent loss of active elevation. Some surgeons have considered further retroverting the humeral head in cases involving loss of integrity of the coracoacromial arch. New directions in dealing with patients with rotator cuff arthropathy are on the horizon. A newly developed reverse ball and socket prosthesis, which effectively reverses the ball and socket in the shoulder joint (Figure 44–9), uses the deltoid to achieve active elevation. This prosthesis has just received US Food

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**Figure 44–9:**
This newly developed prosthesis reverses the ball and socket locations, allowing for stability of the implant without relying on the rotator cuff. This prosthesis may be a treatment option for patients with rotator cuff arthropathy.
Capsulorrhaphy Arthropathy

- Several factors are relevant in these patients, including the younger age demographic, soft tissue contractures, and potential bony deficiencies. A long-term study reviewing the results of arthroplasty in this patient group demonstrated that arthroplasty provides pain relief and improved motion but is associated with higher rates of revision surgery and unsatisfactory results because of component failure, instability, and pain caused by arthritic change of the glenoid.8

Proximal Humeral Malunions

- A study evaluating patients who had undergone arthroplasty after they developed posttraumatic arthritis demonstrated satisfactory pain relief and function in 75% of cases, but with a high rate of complications.9 Patients who were treated operatively at the time of initial injury and patients who had tuberosity osteotomy at the time of arthroplasty were at risk for a poor result.

Prosthetic Arthroplasty

(Box 44–1, and Figures 44–10 through 44–24).

Box 44–1 Surgical Pearls for Prosthetic Arthroplasty

- I prefer to place the patient in a modified beach chair position with the head of table flexed approximately 20 to 30 degrees and a small folded towel placed under the scapula.
- The upper extremity typically is prepped and draped, ensuring complete access to the entire shoulder girdle region and allowing full passive range of motion of the shoulder.
- A number of surgical approaches have been described, but the long anterior deltopectoral approach is the most commonly used.
- When exposing the glenohumeral joint, the superior portion of the pectoralis major tendon insertion can be released to improve exposure.
- Superiorly, a portion of the coracoacromial ligament can be released, but the structural integrity of the ligament should be maintained because it may become important in preventing anterosuperior instability.
- Measuring preoperative external rotation allows determination of whether effective lengthening of the subscapularis is necessary to increase postoperative external rotation.
- A 360-degree release of all adhesions around the subscapularis should be performed after release from the humerus to provide more external rotation and prevent postoperative scarring and loss of range of motion.
- Great care must be taken when removing the humeral head articular surface to ensure the humeral cut is at the correct angle and to avoid injuring the posterior rotator cuff.
- The correct starting point for humeral reaming must be determined to avoid humeral component malposition. Varus malalignment of the humeral prosthesis may lead to overstuffing of the joint, which can result in pain, loss of motion, and early failure.
- Pay close attention to determining the correct amount of version before broaching the humeral canal.
- Leave the humeral broach in place when exposing the glenoid to prevent iatrogenic injury or fracture to the proximal humerus from vigorous retraction.
- Be aware of posterior glenoid wear and determine if preferential anterior reaming can correct this deformity or if posterior bone grafting is necessary. Typically, approximately 1 cm of preferential anterior reaming can be performed to correct the glenoid version to neutral, but this step depends on the amount of glenoid bone stock available.
- Posterior bone grafting should rarely be performed because this procedure can be technically demanding and is associated with higher complication rates. Many advocate accepting almost 15 degrees retroversion of the glenoid after anterior reaming rather than performing posterior bone grafting. If the retroversion of the glenoid appears to be greater than 15 degrees after reaming, posterior bone grafting may be necessary. Some commonly used bone graft choices include bone grafts fashioned from the resected humeral head or grafts taken from the iliac crest. My preference is tricortical iliac crest bone grafts with screw fixation. Some have advocated using less retroversion of the humeral component to address this problem, but my preference is to correct the retroversion of the glenoid with bone grafting if greater than 15 degrees glenoid retroversion exists even after preferential anterior reaming.
- Determining the central axis of the glenoid is critical before reaming the glenoid to avoid component malposition. This can be accomplished by placing a finger along the anterior surface of the scapula medial to the glenoid and then reaming the glenoid with the tip of the reamer aimed toward the finger along the anterior surface of the scapula.
- In cases where a glenoid component is contraindicated, as in rotator cuff arthropathy or rheumatoid arthritis with an irreparable rotator cuff tear, I do not routinely ream the glenoid if the glenoid surface is not too irregular and relatively congruent. If the surface is too irregular, I do a very gentle ream to provide a smooth congruent surface for the humeral head to articulate with.
- Do not overstuff the joint with components that are too large, as doing so can lead to pain, decreased motion, and early component loosening.
- Above all, realize that total shoulder arthroplasty is an operation where proper balancing of the soft tissues is critically important, as the components are not as constrained as in total hip and total knee arthroplasties.
Complications of Arthroplasty

- Two series have examined the long-term outcome and results of shoulder arthroplasty and noted the complications associated with glenohumeral arthroplasty.\(^\text{10}\)
- Common complications include glenoid component wear and loosening, glenohumeral instability, intraoperative humeral fractures, neurologic injury, rotator cuff tears, infection, humeral component subsidence or loosening, and deltoid dysfunction.

Rehabilitation after Prosthetic Arthroplasty

- Intraoperative range of motion should be recorded after implant fixation and subscapularis repair to help guide postoperative protocols.
Typically, pendulum and passive range of motion exercises are started on postoperative day 1. Limits on range of motion depend on intraoperative measurements and the quality of soft tissue repairs. External rotation limits are noted in the operating room.

Two weeks postoperatively, additional assisted range of motion exercises and isometric strengthening can be added.

Six weeks postoperatively, assisted motion in all planes is started, and light resistive exercises can be added in all planes.

Twelve weeks postoperatively, more resistance and stretching are added. Final outcomes typically are seen 6 to 8 months after surgery.
Figure 44–14: Humeral head exposure. A, The capsule should be released from the neck of the humerus from top to bottom. Failure to release the capsule all the way inferiorly leads to difficulty in displacing the head of the humerus up and out of the glenoid fossa. B, With Darrach retractors in the shoulder as a skid, a bone hook can be used to gently lift the head of the humerus out of the glenoid fossa while the arm is externally rotated and extended off the edge of the table. (From Matsen FA, Rockwood CA, Wirth MA, Lippitt SB: Glenohumeral arthritis and its management. In Rockwood CA, Matsen FA, editors: The shoulder, ed 2. Philadelphia, 1998, WB Saunders.)

Figure 44–15: Humeral head resection. A, The template should be used to determine the proper angle of humeral head resection. B–D, Failure to use the template when removing the head may lead to insufficient bony support for the neck of the prosthesis. (From Matsen FA, Rockwood CA, Wirth MA, Lippitt SB: Glenohumeral arthritis and its management. In Rockwood CA, Matsen FA, editors: The shoulder, ed 2. Philadelphia, 1998, WB Saunders.)
Failed Shoulder Arthroplasty

- Shoulder pain and stiffness are the most common complaints of patients who are dissatisfied with the results of shoulder arthroplasty.\(^\text{11}\)
- Evaluation of the painful shoulder arthroplasty can be a diagnostic challenge. Serial radiographs, physical examination, arthrography, CT, and MRI all have been used to provide information, but the presence of implants can make interpreting diagnostic studies difficult. MRI studies in patients with painful shoulder arthroplasties showed that further evaluation may be possible, as special technique MRIs correctly predicted rotator cuff tears in 10 of 11 patients, correctly predicted the absence of tears in 8 of 10 patients, and correctly predicted glenoid wear in 8 of 9 patients.\(^\text{12}\)
- Diagnostic arthroscopy can be considered in patients in whom no cause is found with less invasive investigations.
- Revision shoulder arthroplasty can be considered in selected patients with failed shoulder arthroplasty. An assessment must be made of available bone stock, the integrity and function of the soft tissues, and the functional demands and expectations of the patient before revision is considered. Patients must be advised of the higher complication rates and worse outcomes that can result compared to primary arthroplasty.

Conclusions

- Shoulder arthroplasty generally results in excellent pain relief, improved range of motion, and functional gains in patients with advanced glenohumeral arthritis.
- Nonoperative modalities, including rest, physical therapy, activity modification, medications, and careful use of steroid injections, should be considered before surgical intervention is contemplated.
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Figure 44–18:
Glenoid exposure. When resurfacing the glenoid fossa and placing a glenoid component, various types of humeral head retractors can be gently used to expose the glenoid fossa. (From Matsen FA, Rockwood CA, Wirth MA, Lippitt SB: Glenohumeral arthritis and its management. In Rockwood CA, Matsen FA, editors: The shoulder, ed 2. Philadelphia, 1998, WB Saunders.)

Figure 44–19:
Location of the glenoid center. After the center of the glenoid fossa is located, a central hole is placed in the glenoid fossa using a punch or an air burr. (From Matsen FA, Rockwood CA, Wirth MA, Lippitt SB: Glenohumeral arthritis and its management. In Rockwood CA, Matsen FA, editors: The shoulder, ed 2. Philadelphia, 1998, WB Saunders.)

Figure 44–20:
Glenoid preparation. The hub of the glenoid reamer can be placed into the central hole. Reaming of the glenoid should be performed until the glenoid fossa is perfectly smooth and matches the back surface of the glenoid component. (From Matsen FA, Rockwood CA, Wirth MA, Lippitt SB: Glenohumeral arthritis and its management. In Rockwood CA, Matsen FA, editors: The shoulder, ed 2. Philadelphia, 1998, WB Saunders.)

Figure 44–21:
Careful preoperative planning is crucial prior to any surgical procedure. Evaluation of rotator cuff and deltoid function and the neurovascular status of the upper extremity are critical. Discussions with the patient must include expected surgical outcomes and functional gains.

Results of shoulder arthroplasty are affected by the underlying disease, concomitant comorbidities, and the age and demands of the patient. A wide armamentarium of treatment options is available for patients with glenohumeral arthritis. As advances are made in biomaterials, prosthetics, and our understanding of arthritic disease, the science of arthroplasty will continue to evolve.

References


5. Iannotti JP, Norris TR: Influence of preoperative factors on outcome of shoulder arthroplasty for glenohumeral osteoarthritis. *J Bone Joint Surg* 85A:251-258, 2003. Patients with less than 10 degrees of preoperative passive external rotation had significantly less postoperative external rotation, a repairable rotator cuff tear was not a contraindication to glenoid replacement, patients with glenoid erosion should have a glenoid component placed, and humeral head subluxation preoperatively was associated with a poor result regardless of whether hemiarthroplasty or total shoulder arthroplasty was performed.


10. Hasan SS, Leith JM, Campbell B et al: Characteristics of unsatisfactory shoulder arthroplasties. *J Shoulder Elbow Surg* 11:431-441, 2002. Shoulder pain and stiffness were the most common complaints, but instability, rotator cuff tears, and glenoid erosions in shoulders with a hemiarthroplasty and glenoid polyethylene wear and loosening in patients with total shoulder arthroplasty were commonly seen.

