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Arthroscopic treatment of antero-inferior shoulder instability

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The treatment of anterior shoulder instability continues to evolve. Advancements in arthroscopic techniques have led to a recent shift to arthroscopic Bankart repair. This has been coupled with a development of new instrumentation, implants, and techniques. However, to obtain a successful outcome for patients with anterior instability, it is imperative that the surgeon be aware of preoperative, intraoperative, and postoperative factors associated with the recognition and proper treatment of instability pathology. In this chapter, we will present several important techniques, pathologies, and concepts regarding the effective diagnosis and treatment of patients with anterior instability using arthroscopic techniques.

Key words: **Shoulder joint - Arthroscopy - Joint instability.**

Despite advances in the understanding of anterior shoulder instability, failure rates after open and arthroscopic surgery have been reported to be as high as 30%. In general, a successful operative outcome for patients with shoulder instability requires the surgeon to perform a complete preoperative evaluation, a thorough diagnostic arthroscopy to evaluate for concomitant copathology, and implement an effective postoperative therapy program tailored to the repair strategy. In addition to the Bankart lesion, the treating surgeon must be aware of other co-pathologies, such as the HAGL lesion, ALPSA lesion, and SLAP tears, that can occur in concert with capsulolabral injury and present as potential barriers to a successful outcome.

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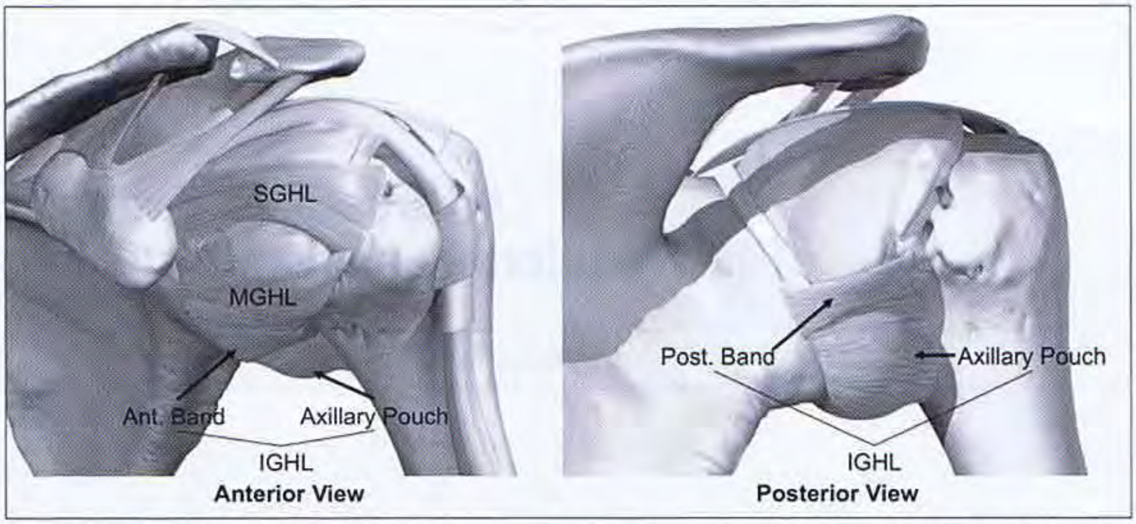

Figure 1.—The anatomic relationship of the static restraints for glenohumeral stability. SGHL: superior glenohumeral ligament; MGHL: middle glenohumeral ligament; IGHL: inferior glenohumeral ligament. Courtesy from Primal Pictures Ltd.

techniques, pathologies, and concepts regarding the effective diagnosis and treatment of patients with anterior instability using arthroscopic techniques.

Anatomy

Improvements in our understanding of the biomechanical and pathoanatomical features of anterior shoulder instability have led to advances in clinical diagnosis and recognition of associated pathology. The stability of the glenohumeral joint is conferred by three major mechanisms:[1]

1) concavity-compression;

2) coordinated contraction of the rotator cuff to permit fluid and complete range of motion of the humeral head onto the glenoid surface;

3) the static contribution of the glenohumeral ligaments.

However, when considering instability, the most pertinent anatomy includes the dynamic and static stabilizers of the shoulder joint. The static stabilizers include the bony anatomy, capsular ligaments (Figure 1), and the rotator interval, whereas the dynamic stabilizers include the rotator cuff and scapular musculature.

Labrum

The labrum contributes in several ways to the overall stability of the shoulder. leFirst, it provides the insertion for the capsule as well as the ligamentous structures, effectively stabilizing them to the glenoid. In fact, in its inferior hemisphere the labrum is attached to the glenoid through a narrow rim of fibrocartilagenous tissue that directly transitions into the glenoid articular cartilage.[2] The superior hemisphere of the labrum is attached more loosely and with considerable variability to the face of the glenoid. This fact leads to several anatomic variants that can be potentially misconstrued as intra-articular pathology. The superior labrum also receives fibers directly from the long head of the biceps tendon that inserts onto the supraglenoid tubercle in close proximity to the superior edge of the glenoid.

Secondly, the labrum increases the concavity of the glenoid and contributes to the concavity-compression stabilization. Previous authors have quantified the contribution of the labrum to a 9 mm deepening in the superoinferior axis and 5 mm in the anteroposterior plane. Consequently, removal of the labrum would decrease glenoid concavity by over 50%.[3] Overall, the labrum is an important structure in the context of shoulder stability for two reasons; it creates the concave-compression relationship and provides the insertion site for other stabilizing structures.

The labrum is the portion of fibrocartilage that is circumferentially attached to the rim of the glenoid. It is critical for the orthopedic surgeon to recognize the normal anatomy and anatomic variants of the labrum to prevent misdiagnoses and inadvertent treatment. The normal superior attachment of the labrum to the glenoid is loose, has tremendous anatomic variation, and is complicated by the attachment of the long head of the biceps tendon as it originates from the supraglenoid tubercle.[4-6] The function of the labrum as it relates to stability of the shoulder joint is threefold. First, the labrum deepens the concavity of the glenoid up to 9 mm in the superior-inferior direction and also doubles the antero-posterior depth to 5 mm.[7] Second, the labrum increases glenohumeral stability by increasing the surface area through which the glenoid contacts the humeral head through an arc of motion. Finally, the labrum is the site of attachment for the various glenohumeral ligaments that confer static stability to the joint.[1]

Glenohumeral ligaments

The glenohumeral capsuloligamentous complex serves to statically restrain the glenohumeral joint against excessive translation. It is composed of multiple structures with different roles based on the position of the arm. The middle glenohumeral ligament (MGHL) is variable in size and appearance (Figure 2). It most commonly originates from the supraglenoid tubercle and anterosuperior labrum in close relation to the SGHL and inserts just anterior to the lesser tuberosity, blending with the fibers of the subscapularis tendon.[8] The MGHL acts to limit anterior and posterior humeral head translation when the arm is abducted between 45° and 75° and limits inferior translation when the arm is adducted.

The inferior glenohumeral ligament (IGHL) has three components: anterior ligament, posterior ligament, and axillary pouch.[9] All originate from the inferior half of the labrum and

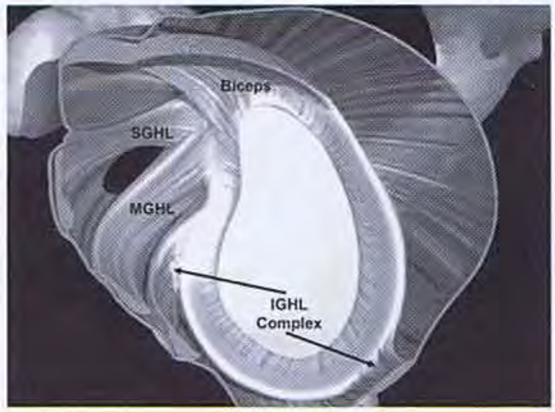

Figure 2.—Glenoid and the glenohumeral ligaments. SGHL: superior glenohumeral ligament; MGHL: middle glenohumeral ligament; IGHL complex: inferior glenohumeral ligament complex. Courtesy from Primal Pictures Ltd.

glenoid neck, and insert on the humerus slightly inferior to the MGHL. However, Ticker *et al.*[10] have suggested that the posterior band has greater variation and is less evident than the other two structures. Furthermore, the IGHL complex is extremely important in the context of shoulder stability, and can represent a common source of instability pathology.

The IGHL provides stability to the shoulder in different planes of motion with the synergy of its three components. With internal rotation, the complex prevents posterior subluxation by shifting posterior. Subsequently, with abduction and external rotation the anterior band provides stability and prevents anterior displacement. The IGHL complex also provides anterior, posterior, and inferior stability when the arm is abducted greater than 60° and is often referred to "the hammock" for the humeral head.

The rotator interval has recently received significant attention regarding its role in shoulder stability. Thus, the anatomy and function of the superior glenohumeral ligament will be discussed in the context of the rotator interval.

Rotator interval

The rotator is a medially based triangular space in the anterosuperior aspect of the shoulder known as the foramen of Weitbrecht

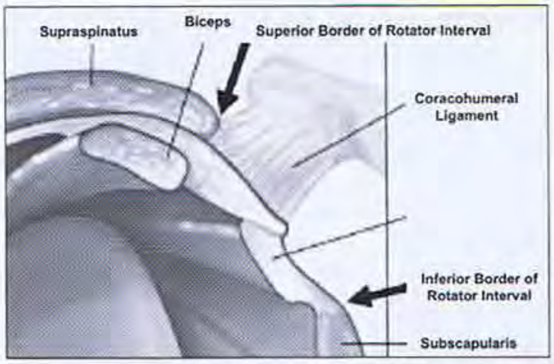

Figure 3.—Rotator interval. A drawing of the glenohumeral joint from the sagittal view that shows the contents of the RI. The contents include the superior glenohumeral ligament, the long head of the biceps tendon, the coracohumeral ligament, and a thin layer of capsule. This area of anatomy can be confusing and changes with sagittal position in the shoulder.[15]

that is bordered superiorly by the anterior border of the supraspinatus, inferiorly by the superior border of the subscapularis, medially by the base of the coracoid, and laterally by the sulcus for the tendon of the long head of the biceps and the transverse humeral ligament.[11-15] The coracohumeral ligament (CHL) is a trapezoid-shaped structure that originates at the base of the coracoid and splits into two bands: one that inserts on the anterior edge of the supraspinatus tendon and greater tuberosity and another band that inserts on the subscapularis, transverse humeral ligament, and the lesser tuberosity (Figure 3). The relatively smaller superior glenohumeral ligament (SGHL) originates from the labrum adjacent to the supraglenoid tubercle, crosses the floor of the rotator interval deep to the CHL, and inserts on the fovea capitis, an area on the superior aspect of the lesser tuberosity.[13] The tendon of the long head of the biceps lies between the CHL and the SGHL (Figure 3).

The capsule of the rotator interval is a very thin structure, measuring between 0.1 and 0.06 mm in cadaveric specimens.[16] The importance of the rotator interval capsular covering is to maintain the negative intra-articular pressure of the shoulder, which helps contribute to the stability of the glenohumeral joint.[17]

The dimensions of the rotator interval varies with arm rotation. The rotator interval decreases in size with internal rotation, emphasizing the concept that if the rotator interval is closed with the upper extremity held internally rotated (or less than 30° of external rotation), significant losses of external rotation may result.[18] The rotator interval dimensions have been investigated in cases with clinical instability and have determined that although the rotator interval size is increased in instability, the distances between the supraspinatus and subscapularis tendons remain unchanged.[19] The main function of the rotator interval is believed to be the prevention of inferior and posterior translation of the glenohumeral joint. However, the role of the rotator interval in maintaining shoulder stability remains controversial.

Some authors have reported the importance of the SGHL in maintaining inferior stability of the shoulder,[20-22] whereas others claim that the CHL is more important and still others explain that the two ligaments work together as a unit to prevent inferior and posterior translation of the humeral head.[23, 24] The CHL has also been cited as an important stabilizer to inferior glenohumeral translation in the adducted arm. In fact, several authors have advocated that the CHL is the most important structure preventing downward translation of the adducted arm.[22, 23, 25] However, the inferior capsule is also an important structure that prevents downward translation of the adducted arm and becomes more important as the glenohumeral joint is abducted. These structures likely act in concert to provide inferior stability of the glenohumeral joint and emphasize the importance of surgical imbrication of the inferior capsule versus the rotator interval structures in cases of anteroinferior, posteroinferior, and multidirectional shoulder instability.

Although the rotator interval capsule is a thin structure, it is important in maintaining the capsular continuity that is vital for maintaining negative intra-articular pressure and concavity compression of the glenohumeral joint. The contribution of the anterior capsule in shoulder stability was described by Mologne *et al.*[26, 27] in their review of failed arthroscopic labral repairs. In their series, 20 patients with recurrent instability after an arthroscopic anterior labral repair were treated with an open stabilization procedure. At the time of revision surgery, 15 patients (75%) were found to have a redundant anterior capsule that indicates an incompetent rotator interval capsule.

Lastly, the rotator cuff musculature and parascapular muscles are critical to the overall function of the glenohumeral joint and confer important dynamic stability to the shoulder. A careful evaluation of the rotator cuff (especially in patients who present with an initial dislocation more than 40-year-old) and scapular function is paramount to ensure that the dynamic stability of the glenohumeral joint is optimized.

Bone stability

The bony anatomy of the glenohumeral joint also plays a major role in anterior shoulder stability. Because of the small size of the glenoid compared with the humeral head, even a small loss of bone, such as a glenoid rim fracture, can compromise stability by decreasing the bony surface area for glenohumeral articulation.[28, 29] Several clinical studies have shown that bone loss of either the humeral head or glenoid surface is the most common cause of failed arthroscopic stabilization procedures and that recurrence of glenohumeral instability is increased with even small amounts of glenoid bone loss, usually between 15% to 20%.[28, 29, 30, 31]

Patient history

Understanding the source and type of instability that patients are experiencing is critical to the ultimate success of surgical treatment. A thorough history should always include type of instability (dislocation, subluxation); direction of instability (anterior, posterior, multidirectional); requirement for medically assisted reduction versus self-reduction; age and amount of time that had elapsed from the first dislocation; activity level, including contact versus non-contact sports; and any treatment that has been rendered to date. Also, if patients experience an initial dislocation at more than 40 years of age, it is imperative to rule out an associated rotator cuff tear.

In addition, the provocative anterior instability position (almost always the abducted externally rotated position) and the amount of trauma necessary for the instability episode to occur has implications in management. Patients whose shoulders slip out during sleep or with simple activities, such as reaching overhead, may have an entirely different diagnosis (*i.e.*, multidirectional instability, glenoid hypoplasia, and so forth) and may require a different surgical plan compared with those who experience instability only with more significant trauma. If patients demonstrate the ability to easily dislocate the shoulder they should be closely evaluated for a volitional component, especially in the absence of glenoid bone loss, glenoid dysplasia, connective tissue disorders, or prior surgery.

Patients with anterior shoulder instability most often present with feelings of impending instability or pain in extremes of motion, and may experience subluxation or even frank dislocation during certain shoulder positions (namely abduction and external rotation and with overhead activities). Although most patients complain of subjective feelings of instability during repetitive overhead activities, such as throwing or swimming, some patients may present with reports of transient sharp pain, numbness, or weakness that usually resolves briefly as their only symptom of instability.

Physical examination

After obtaining the appropriate history, a complete physical examination is integral to making the correct diagnosis and implementing the appropriate treatment plan. Range of motion, neurovascular examination, and overall strength (shoulder girdle and parascapular muscles) should all be normal in the majority of patients with shoulder instability. Specific provocative tests are the hallmark of assessing anterior shoulder instability, including the apprehension, reloca-

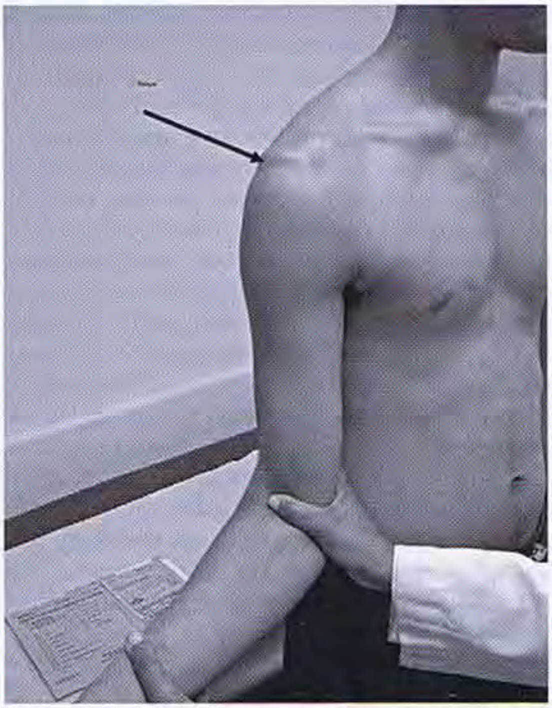

Figure 4.—A test for rotator interval lesion, which is a positive sulcus sign that does not decrease with external rotation at the side.

tion, and anterior release tests. Especially important to investigate is the ease with which the humerus begins to dislocate and engage on the glenoid; if this occurs at 30° of external rotation at the side, for example, it is highly likely that there is a significant engaging Hill-Sachs lesion or associated glenoid bone loss.[29] Patients with engaging Hill-Sachs lesions also usually report a history of shoulder instability in midranges of the shoulder abduction/external rotation.

It is imperative that the surgeon discerns between laxity and instability. Instability is generally regarded as symptomatic laxity and is the perception *by patients* experiencing the shoulder subluxation or dislocation event. Laxity is a normal finding of the glenohumeral joint, because the humerus needs to have a minimum obligate translation on the glenoid for normal shoulder function.[32, 33] The amount of laxity and instability are both assessed with translation testing for laxity (anterior, posterior, and inferior sulcus) and symptomatic directional laxity, which is a critical diagnostic indicator of shoulder instability. A positive sulcus sign that does not decrease with external rotation at the side indicates a pathologic rotator interval (Figure 4). Increased generalized ligamentous laxity should also be assessed, including thumb to forearm, elbow recurvatum, metacarpophalangeal hyperextension, and increased external rotation in the abducted position.

Physical examination must always begin with both shoulders exposed for visual inspection. Visual inspection of the back during active shoulder forward flexion with the examiner positioned behind the patient can detect subtle scapulothoracic dyskinesia or scapular winging. Active and passive range of motion should be assessed and compared with the unaffected extremity. Deficits with internal rotation can suggest posterior capsule contractures that are common in the throwing athlete with internal impingement. Extreme deficits with internal and external rotation can be seen in the setting of unrecognized anterior and posterior dislocations, respectively. An assessment of generalized laxity (*e.g.*, hypermobile patella, hyperextension of elbows, metacarpopha- langeal joints, and the ability to reach the ipsilateral forearm with the abducted thumb) must be performed.

The physical examination for shoulder instability can be divided into two main groups: 1) tests for the assessment of glenohumeral laxity and 2) provocative, or instability, tests.

Laxity testing

ANTERIOR DRAWER TEST

This test attempts to quantify anterior translation of the humeral head on the face of the glenoid. The test should be performed with the patient lying supine. The examiner stands at the ipsilateral side of the affected extremity. The shoulder is in 80° to 120° of abduction, 0° to 20° of forward flexion, and 0° to 30° of external rotation. One of the examiner's hands is used to stabilize the scapula by placing the fingers on the scapular spine and the thumb on the coracoid. The other hand grasps the proximal humeral shaft. An anterior force is applied to the proximal humerus and the amount of translation is quantified.

ANTERIOR AND POSTERIOR LOAD AND SHIFT TEST

The patient can be in either a supine or seated position. In the supine position, the arm is placed in 20° of abduction, 20° of forward flexion, and neutral rotation. If in the upright position, the examiner stands behind the patient on the ipsilateral side of the examined extremity. Assuming the right shoulder is being examined, the examiner places his or her left hand on the scapula to stabilize scapular motion. The examiner grasps the humeral head with his or her right hand and applies an axial load perpendicular to the articular surface of the glenoid. Anterior or posterior-directed forces are then applied the humeral head and translation relative to the glenoid is measured.

Instability testing

APPREHENSION TEST

The test can be performed with the patient in the supine or upright position. The affected shoulder is passively moved to abduction and maximum external rotation. At the same time, a gentle anterior force is placed on the posterior humeral head. A test is positive when the patient becomes "apprehensive" and experiences pain.

APPREHENSION-RELOCATION TEST

The first part of the examination incorporates the apprehension test. The relocation part is performed by applying a posterior-directed force to the anterior humeral head with a relief of pain experienced by the patient.

Radiographic evaluation

Upon initial evaluation of patients with a traumatic shoulder dislocation, routine radiographs should be obtained, including true anteroposterior, axillary lateral, and scapular-Y views. In patients with a history of recurrent anterior instability, or if a bone defect is suspected, further radiographic imaging is warranted, including the apical oblique, West Point view, or Didiee views. For humeral head defects, such as a Hill-Sachs injury, the Stryker Notch view and a true anteroposterior in internal rotation should be obtained. Hill-Sachs injuries may be well demonstrated on anteroposterior internal rotation views (Figure 5).

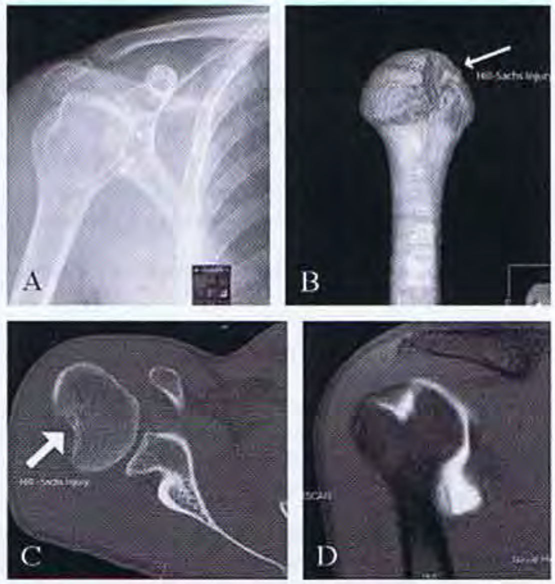

Figure 5.—A Hill-Sachs injury is identified on several different images. The internal rotation anteroposterior view (A); a three-dimensional CT scan with the glenoid and scapula digitally subtracted that demonstrates the hatchet- type injury of the humerus (B); the same image on the axial CT scan (C); and a coronal MR arthrogram demonstrating the injury adjacent to the rotator cuff posterolaterally (D).

Evaluation of glenoid and humeral head bone loss

In evaluating patients with glenohumeral instability, it is essential that the surgeon assess for patient demographic and examination factors associated with glenoid and humeral head bone loss (Table I). Patients with high energy trauma to the shoulder leading to dislocation should be evaluated for glenoid bone loss. The position when instability of the shoulder is first experienced should be carefully assessed on examination to determine if the instability is present in midranges of motion (suggestive of bone loss). Also, patients that present with numerous instabil-

TABLE I.—*Factors suggesting the presence of glenoid or humeral head bone loss.*

Patient's history and examination
- Initial shoulder dislocation caused by a high-energy traumatic event
- Multiple instability events
- Recurrent anterior instability extending over several years or occurring as a single event several years after the initial instability
- Progressive ease of instability (decreasing level of activity required)
- Instability in the mid ranges of motion (45°-60° abduction, with 45° of external rotation)

Imaging
- Bone loss seen on axillary lateral radiograph
- Anteroinferior glenoid loss (on cortical rim or outline) seen on AP or true AP radiograph
- Bone loss seen on sagittal oblique MRI or magnetic resonance arthrogram
- Bone loss seen on CT, especially three-dimensional reconstruction with the humeral head digitally subtracted

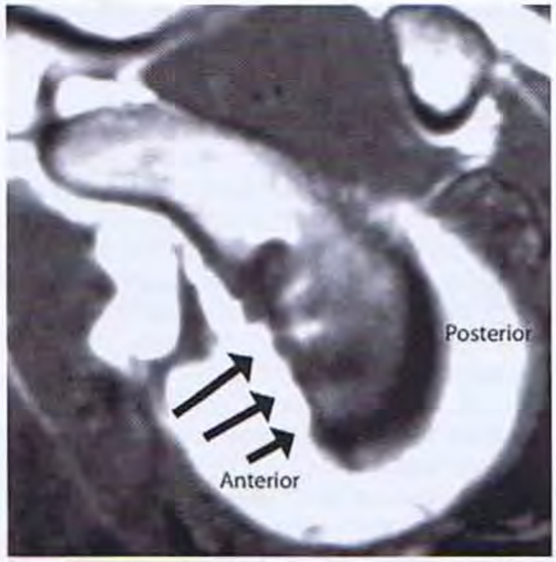

Figure 6.—MR arthrogram demonstrating glenoid bone loss on the sagittal oblique image. Arrow points to bone defect, which is about 30% of the glenoid in this example.

ity episodes, a long history of instability, or progressive ease of instability symptoms suggests a larger anatomic problem, namely glenoid or humeral head bone loss.

For a comprehensive evaluation of glenoid bone loss, advanced imaging is necessary. A magnetic resonance imaging (MRI) and a magnetic resonance arthrogram (MRA), although helpful in diagnosis of soft-tissue pathology, may also be used to assess the degree of bone loss by evaluating the most lateral glenoid cut on sagittal oblique images (Figure 6). However, the most accurate method to measure glenoid bone loss is a three-dimensional CT scan with digital subtraction of the humeral head on sagittal oblique imaging. The humeral head may also be isolated in three-dimensional reconstruction to assess the size, depth, and orientation of the Hill-Sachs defect.

Huysmans *et al.*[34] have described the inferior two thirds of the glenoid as a well-conserved circle, and deficiencies within this circle are used to quantify the amount of glenoid bone loss (Figure 7). A best-fit circle is drawn on the inferior two thirds of the *en face* sagittal image, and is well conserved for normal glenoid geometry.[34] The amount of bone missing is determined by assessing surface area losses from the anteroinferior part of

Figure 7.—CT evaluation of a sagittal oblique glenoid en face view demonstrating the best-fit circle as a gold standard to determine the amount of glenoid bone loss.

the circle. The reason for the precision of bone loss measurement is that the glenoid bone stock from anterior to posterior is only about 24 to 28 mm and varies from patient to patient.[35] In addition, for approximately each 1.5 to 1.7 mm of glenoid bone loss, this corresponds to a 5% increase in loss of glenoid bone stock. Of note, glenoid bone loss of

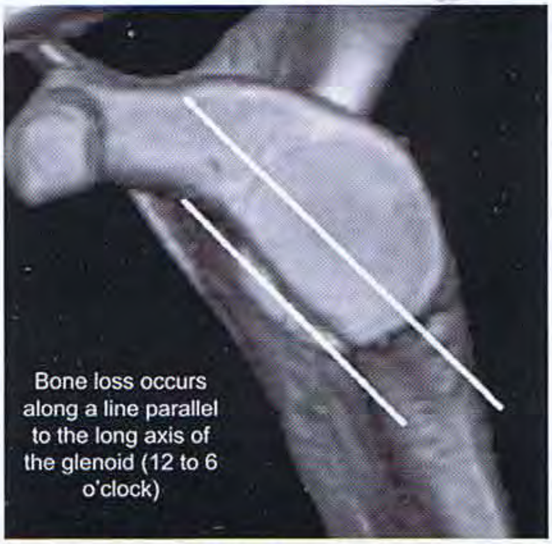

Figure 8.—A sagittal oblique CT image demonstrating the typical location and manner in which glenoid bone loss occurs; along a line parallel with the long axis of the glenoid (12 o'clock–6 o'clock).

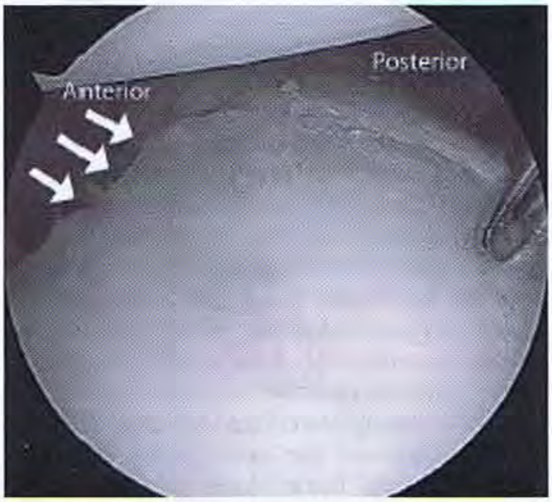

Figure 9.—Arthroscopic image from the anterosuperior portal demonstrating an inverted pear glenoid with significant (>20–25%) glenoid bone loss.

between 6 to 8 mm indicates an approximately 20% to 25% bone stock loss of the glenoid from anterior to posterior and may necessitate a change in surgical strategy (*i.e.*, soft-tissue procedure to bone augmentation). Glenoid bone loss occurs along a line parallel to the long axis of the glenoid (parallel to the 12- to 6-o'clock line) [36, 37] (Figure 8). Glenoid bone loss greater than 20% to 25% can lead to the glenoid taking on the shape of an inverted pear when viewed arthroscopically from the anterosuperior portal (Figure 9).[26, 35] Although a Hill-Sachs lesion is present in up to 80% to 100% of patients with anterior instability, it is usually insignificant.[29] However, in patients with glenoid bone loss, it is now well appreciated that a Hill-Sachs lesion can become more significant and engage the glenoid with much less force and anterior translation than those without glenoid bone loss.[37, 38] Thus, one should look at glenoid and humeral head bone loss as a bipolar problem, and make informed decisions regarding treatment based upon the amount of bone loss, patient expectations, and associated recurrent instability risk factors.

Ideally, the amount of glenoid and humeral head bone loss is determined preoperatively in order to have an informed discussion with patients regarding treatment options and expected outcomes of arthroscopic versus bone augmentation repair. However, if the presence of bone loss is not evaluated preoperatively, the glenoid bone stock may be assessed arthroscopically. The bare spot of the glenoid is a well-described landmark for assessing glenoid bone loss *via* a calibrated probe inserted from the posterior shoulder while the arthroscope is in the anterosuperior portal. Lo *et al.*[35] have described a method of quantifying glenoid bone loss by measuring the anterior-posterior width of the defect at the level of the bare spot. A calibrated probe is inserted from the posterior portal to measure the distance from the anterior and posterior rims to the bare spot. The difference between the anterior and posterior radii can be determined and referenced as a percentage of the diameter of the normal inferior glenoid using the following equation:

Distance from the bare spot to the posterior rim percent bone loss=distance from the bare spot to the anterior rim)/2× distance from the bare spot to the posterior rim × 100.

The arthroscopic determination of glenoid bone loss remains a well-accepted technique and has been validated clinically [35, 39] and in the laboratory setting.[36]

Historically, arthroscopic treatment of glenoid bone defects have had a high recurrence rate (from 61-67%).[29] Mologne *et al.*[26] demonstrated a 14% recurrence rate in patients with a mean loss of 25% glenoid bone loss treated arthroscopically, and noted that all of their failures (three total) were in patients deemed to have attritional bone loss and no glenoid bone fragment to incorporate into the repair. In another study, Sugaya *et al.*[40] demonstrated only an 8% recurrence rate in patients with a mean 25% bone loss treated arthroscopically when the bony fragment was incorporated into the repair. These studies illustrate the importance of maintaining glenoid bone stock for the success of arthroscopic instability repair.

The management of patients with humeral bone loss is less well quantified, owing to the difficulty in determining when a Hill-Sachs lesion is clinically important. Burkhart *et al.*[29] defined a Hill-Sachs lesion as "engaging" when the posterolateral humeral head engages the anterior glenoid with the arm in abduction and externally rotation. Yamamoto *et al.*[41] demonstrated in a cadaveric model that the engagement phenomenon is potentiated in the setting of glenoid bone loss (*i.e.*, the humeral head engages the glenoid easier if the anterior glenoid has a bone deficiency present). However, in the presence of humeral head engagement, or for sizable Hill-Sachs defects (usually >5-7 mm in depth), the typical solution is glenoid bone augmentation. In rare circumstances, there are a variety of surgical management options for a Hill-Sachs injury that range from soft-tissue augmentation (Remplissage), glenoid-based bone augmentation, humeral-head options, and occasionally both.

Treatment

Non-operative

The natural history of acute anterior instability events has been evaluated through numerous prospective studies with age at the time of initial dislocation being the most significant prognostic factor for future instability events. Active patients less than 30 years of age treated with a supervised physical therapy program instead of surgically have had reported recurrence rates of 17% to 96%, whereas those treated with arthroscopic repair had failure rates ranging from 4% to 22%.[42, 43] This data indicates early arthroscopic repair following first-time dislocation is applicable for young, highly active patients or those engaged in activities involving overhead use of their arms. Operative intervention should also be considered in patients with recurrent episodes of instability after a course of conservative management.

Non-operative treatment for anterior shoulder instability consists of physical therapy tailored toward the acuity and mechanism of instability. Immobilization is only necessary until pain control is achieved, which is typically one to three weeks. Although controversial, immobilization in external rotation after an initial instability event decreases recurrence rates in some populations.[44-46]

Operative

Normal variants

Although the various anatomic structures all have a defined role in maintaining shoulder stability, there are many variations in normal anatomy that must be recognized at arthroscopy so they are not mistaken for pathologic lesions.

Sublabral foramen and the Buford complex

As described previously, the superior half of the labrum is more loosely and variably attached to the glenoid than the inferior hemisphere. The result can be the presence of a sublabral foramen, either in isolation or in conjunction with other variant anatomy (Figure 10). The anterosuperior quadrant is the most common location for a sublabral foramen, with an incidence of 11.9% to 18.5% in shoulders undergoing arthroscopy.[47, 48] These observational studies found that sublabral foramens do not contribute to instability and should not be "repaired" in the majority of cases. This is especially true if they exist in the superior half of the glenoid.

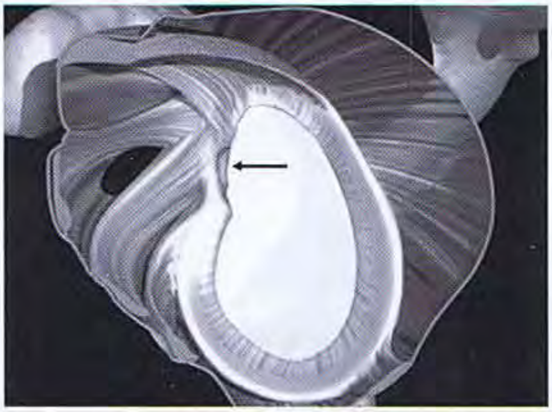

Figure 10.—Sublabral foramen – A sublabral foramen is an antero-superior glenoid labrum normal variant characterized by detachment of the labrum from the underlying glenoid. This should not be confused with a pathologic disruption. Courtesy from Primal Pictures Ltd.

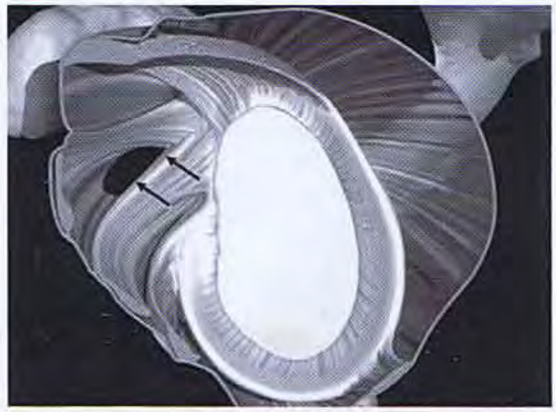

Figure 11.—Buford Complex – note the deficiency of the anterosuperior labrum. The Buford Complex is a normal variation of the labroligamentous sleeve of the glenoid with a cord-like middle glenohumeral ligament and an absence of the anterosuperior labrum. Courtesy from Primal Pictures Ltd.

The Buford complex a recognized normal variant defined by a large deficiency of the anterosuperior labrum in conjunction with a thickened, cordlike MGHL (Figure 11). The Buford complex can be mistaken for an anterior labral avulsion or superior labral tear when interpreted on magnetic resonance imaging (MRI), but is recognizable during arthroscopy due to its characteristic appearance. The prevalence has been reported to be between 1.3% and 10%.[20, 48-50]

SUPERIOR LABRAL VARIANTS

The superior labrum can have great anatomic variability owing to its loose glenoid attachment and its relationship with the long head of the biceps. Several variants of the attachment of the long head of the biceps have been reported.[51] Thus, the presence of a recess between the biceps and the superior labrum does not always represent a SLAP tear. This should be fully evaluated arthroscopically to determine if there is a solid biceps attachment.

Pathology associated with instability

There are several intra-articular lesions associated with anterior instability and include a superior labral anterior posterior lesion, which is a detachment of the glenoid labrum at the insertion of the long head of the biceps tendon; a medial displacement of the labrum and periosteal sleeve of the anterior glenoid labrum and capsule (anterior labral periosteal sleeve avulsion, ALPSA); and the humeral avulsion of the glenohumeral ligament or detachment of the capsuloligamentous structures off the humeral head (HAGL lesion). The presence of these lesions can lead to recurrent instability and future subluxation events if not properly addressed.

Humeral avulsion of the glenohumeral ligaments

The HAGL lesion is a humeral avulsion of the inferior glenohumeral ligaments and capsule (Figure 12). Bach *et al.*[52] first described the presence of this humeral-sided ligament and capsular disruption in patients with recurrent dislocation. They suggested that this potential pathology should be evaluated in shoulders with recurrent instability and no lesion evident in the labrum or glenoid.

Anterior labroligamentous periosteal sleeve avulsion

The ALPSA lesion represents a soft-tissue or bony Bankart injury that has occurred and

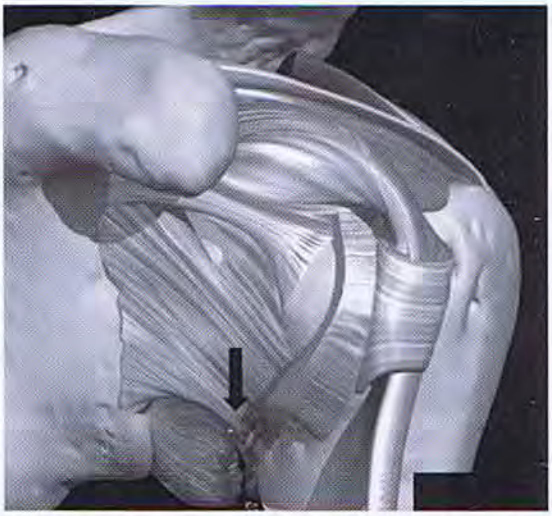

Figure 12.—HAGL lesion – The Humeral Avulsion of the Glenohumeral Ligaments (HAGL) occurs when the inferior glenohumeral ligament is disrupted at its humeral origin. Courtesy from Primal Pictures Ltd.

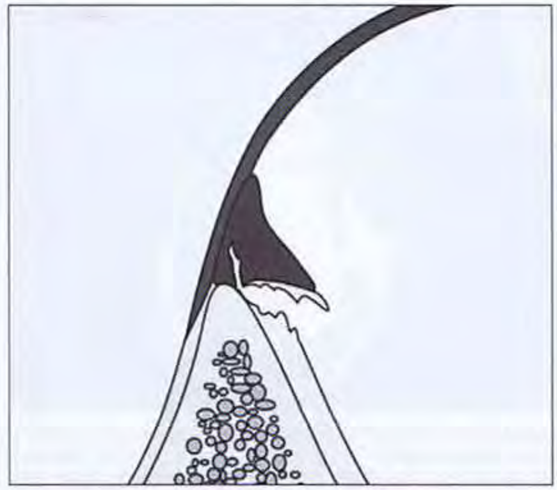

Figure 13.—GLAD Lesion. A glenolabral articular disruption (GLAD) lesion can be caused by a forced adduction injury to the shoulder from an abducted and external rotated position. Courtesy from Primal Pictures Ltd.

healed in a medially displaced position on the glenoid neck. This was first described by Neviaser *et al.*[53] in 1993. The ALPSA lesion is slightly different than the similar Bankart injury due to the intact sleeve of scapular periosteum. This sleeve then translates inferior and medially becomes adherent to the glenoid neck creating an anterior potential space. Often, this space can be defined by a crease between the glenoid border and the fibrosed labrum that represents the starting point for arthroscopic dissection.[8] We have determined that the ALPSA lesion is associated with an increased chance to have glenoid bone loss, and thus, a potentially higher chance for failure after arthroscopic stabilization.

Glenoid labrum articular disruption

The GLAD lesion represents an articular cartilage injury of the anteroinferior glenoid (Figure 13). Labral tears on MRI are common associated findings. However, some patients will not present with instability, but rather anterior shoulder pain. This is due to the fact that some of the deep fibers of the IGHL will remain attached with an adjacent injury to the articular cartilage. This injury can extend to the subchondral bone in severe cases. Arthroscopic debridement is a successful treatment for these patients with good relief of pain, although the long-term sequelae of GLAD lesions remains unclear.

Bankart injuries

Bankart injuries consist of two variants; the bony injury and the soft tissue lesion (Figures 14, 15). Bankart *et al.*[55] reported his observation that labral detachment in 4 patients led to recurrent instability. He termed this the "essential lesion". In contemporary orthopedics the Bankart lesion refers to the detachment of the anteroinferior labrum with the anterior band of the IGHL. This pathology can be present in up to 90% of patients with a traumatic anterior shoulder dislocation.[56] Bony Bankart injuries can involve a significant portion of the anteroinferior glenoid and treatment should be based on the amount of glenoid involved. Thus, it is important to be clear when distinguishing a Bankart injury as either soft tissue only or also involving a bony fragment.

However, capsular stretch is also a fundamental injury of almost any anterior instability and should be addressed in order to have a successful outcome during a Bankart repair.

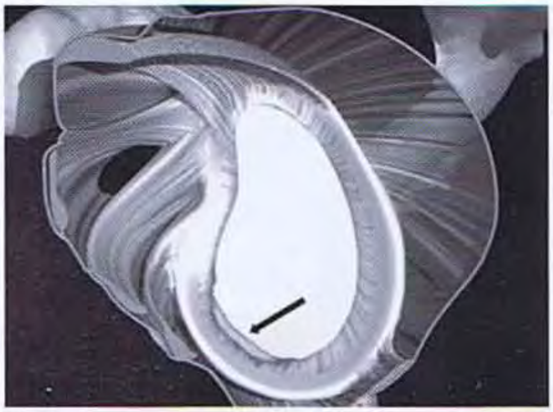

Figure 14.—Bankart lesion. The Bankart lesion refers to the detachment of the anteroinferior labrum with the anterior band of the IGHL and leads to recurrent instability. Courtesy from Primal Pictures Ltd.

Bankart *et al.*[55] reported his observation that labral detachment in four patients led to recurrent instability. He termed this the "essential lesion". This pathology can be present in up to 90% of patients with a traumatic anterior shoulder dislocation.[56] Bony Bankart injuries can involve a significant portion of the anteroinferior glenoid and treatment should be based on the amount of glenoid involved.

Operative techniques

Overview

1. Appropriate preoperative evaluation: evaluate for glenoid/humeral head bone loss.

2. Evaluation under anesthesia: this evaluation should confirm the preoperative plan and assist with amount of capsular shift to perform.

3. Patient positioning: although it is surgeon preference, the lateral decubitus provides for ease of access to the superior, posterior, inferior, and anterior labrum and capsule (Figure 16).

4. Anterosuperior portal: always view the pathology from the anterosuperior portal to avoid missing ALPSA lesions, it is better to evaluate anteroinferior glenoid bone loss and to assess extent of tear posteriorly, as well as any inferior or posteroinferior pathology.

5. Glenoid preparation: make sure that the soft tissue is removed from the intended repair site and that there is a bleeding bed of bone to enhance healing. Visualization of the posterior subscapularis muscle fibers indicates an adequate preparation of the labrum and capsular attachments to the glenoid and allows for sufficient mobilization for repair

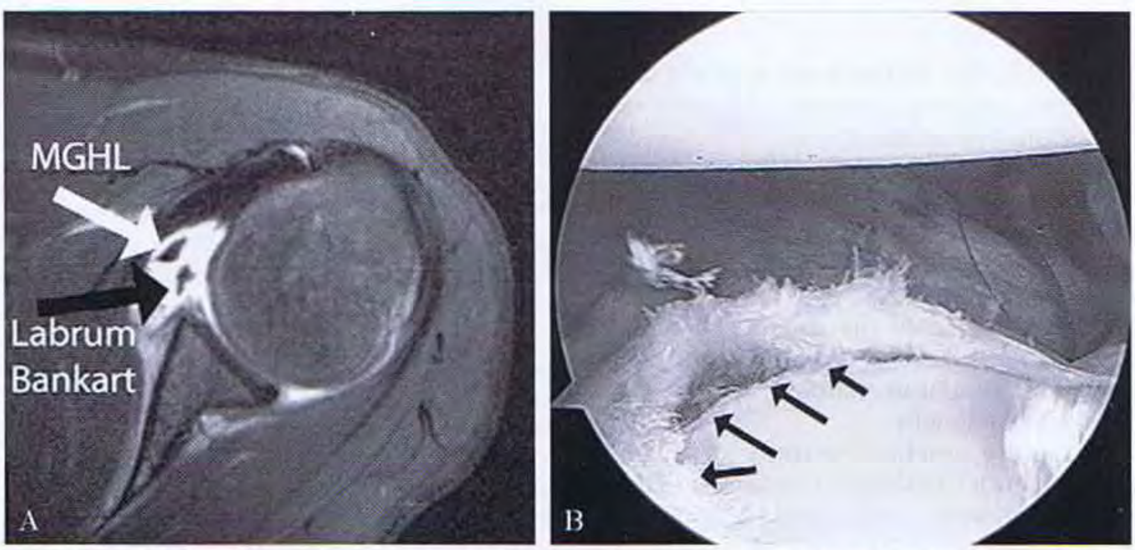

Figure 15.—A) MRA axial image of a soft-tissue Bankart tear anteriorly. Arrow points to anteroinferior labrum; B) corresponding arthroscopic image of the anterior Bankart soft-tissue only tear. Posterior view of glenohumeral joint with probe on anteroinferior labrum.[54]

Figure 16.—Lateral decubitus setup for arthroscopic instability procedure. Arrow points to lateral arm traction. Care should be taken to ensure that the lateral traction strap is placed around a cushion or foam sleeve.

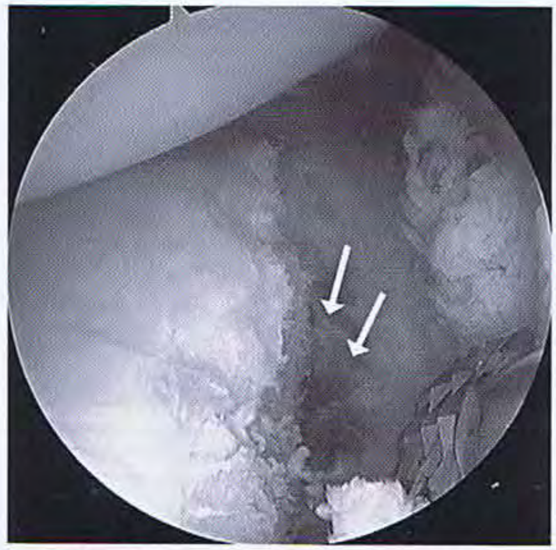

Figure 17.—Arthroscopic image of an adequately prepared anterior glenoid labrum. The posterior subscapularis fibers (arrows) are just visualized and the labrum and capsule easily float up to the glenoid face indicating adequate preparation.

(Figure 17). The axillary nerve is closest at the 6-o'clock position, between 12.5 to 15 mm, and should be avoided.

6. Labral preparation: Use an elevator device and ensure labrum is visible, release subperiosteally to prepare the glenoid and allow the capsulolabral tissue to easily float up to the glenoid face.

7. Suture anchor placement: Make sure anchors are placed at the articular cartilage margin to avoid non-anatomic medial scapular neck placement.

8. Suture anchor quantity: For most anteroinferior labral tears a minimum of three suture anchors should be used (3-6 o'clock on a right shoulder; 6-9 o'clock on a left shoulder). A standard repair is three anchors below 3 o'clock (the equator).

9. Capsular plication: abrasion of the capsule should be performed to enhance healing to the labrum. The plication can be performed to an intact labrum if there is robust labral tissue. If there is any question, a suture anchor is preferred.

Specifics

Patient set-up in the operating room

Based on the preference of the surgical team and patient, shoulder arthroscopy can be performed with general anesthesia, interscalene block or a combination of the two. The authors prefer regional anesthesia supplemented with a light general anesthetic to facilitate lateral decubitus positioning in the outpatient setting.

With regard to set-up for patients undergoing arthroscopic anterior shoulder instability repair, patients can be placed in either the lateral decubitus or beach-chair position. The beach-chair position affords several advantages, including ease of access, ability to see the anterosuperior, inferior and anterior aspect of the glenohumeral joint, and ability to easily convert to an open procedure if indicated.

For cases of shoulder instability, however, the authors prefer to place patients in the lateral decubitus position because it allows ease of access and visualization of the entire capsulolabral complex. With the ability to provide longitudinal and direct lateral suspension, the lateral position affords greater distension of the glenohumeral joint and better ability to make the necessary passes with instrumentation for optimal repair. One of the pitfalls of lateral decubitus positioning is the difficulty in achieving rotational control during instability repair. For instance, proper tensioning of the capsule and inferior glenohumeral ligament is particularly challenging in the lateral decubitus position and can lead to postoperative stiffness and decreased external rotation. In addition, subscapularis repair in athletes with shoulder instability and rotator interval closure are ideally done in 30° to 45° of external rotation, which can be difficult to achieve in patients in the lateral position.

Lastly, the examination under anesthesia is an important component to any instability repair. It is used to confirm what is known preoperatively about patients, including direction of instability, symptoms, and associated findings. Furthermore, the EUA can offer information about the amount of translation in the anterior, posterior, and inferior directions, and can serve to tailor specific operative planning, such as how much capsular plication to perform.

Portals

Proper portal placement is pivotal in performing an accurate diagnostic arthroscopy and complete Bankart repair while providing facile soft-tissue mobilization and accurate anchor placement. After patient positioning, the standard posterior and anterior-superior portals (high in the rotator interval,directly adjacent to the long head of the biceps) are made and a full diagnostic arthroscopy is performed. The initial posterior portal in the lateral decubitus position is made in line with the lateral edge of the acromion and 1 cm inferior to the posterior tip. This position allows the posterior portal to have a slightly downward trajectory on the glenoid surface to facilitate ease of instrumentation during the case.

Once a Bankart lesion has been identified, an anterior mid-glenoid portal can be established in line with the 3-o'clock position on the glenoid using an 18-G needle for localization just superior to the subscapularis tendon. Although accurate portal placement is essential for labral preparation and anchor placement for anteroinferior labral defects, the 4- to 6-o'clock labral pathology can prove to be increasingly difficult to appropriately repair through these standard portals. A 7-o'clock portal can be established approximately 3 to 4 cm directly lateral to the posterolateral corner of the acromion and provides excellent access to the inferior glenoid and may be used to percutaneously place suture anchors in the most inferior aspect of the glenoid (Figure 18). This can be performed percutaneously with only the anchor inserter device, or a small-diameter plastic cannula may be utilized.

Labrum preparation

Proper labral preparation is a critical portion of anterior shoulder instability repair as inadequate labral preparation can lead to insufficient capsulolabral plication and symptoms of recurrent instability. It is imperative that the surgeon spend time preparing and mobilizing the labrum-bone interface before anchor insertion and fixation. The authors prefer to use an elevator device to peel the labrum from the glenoid neck while viewing the labral pathology from the anterosuperior portal.

Labral preparation should be completed before preparing the glenoid for anchor placement and special care should be taken to preserve the remaining labrum for plication. With either the shaver or small bone-cutting shaver on forward or the burr on reverse, the glenoid can be prepared, allowing for adequate bone preservation during glenoid preparation.

Besides bone loss, the most frequent reasons for failure after instability repair include unaddressed capsular laxity (especially inferiorly), improper anchor positioning, and

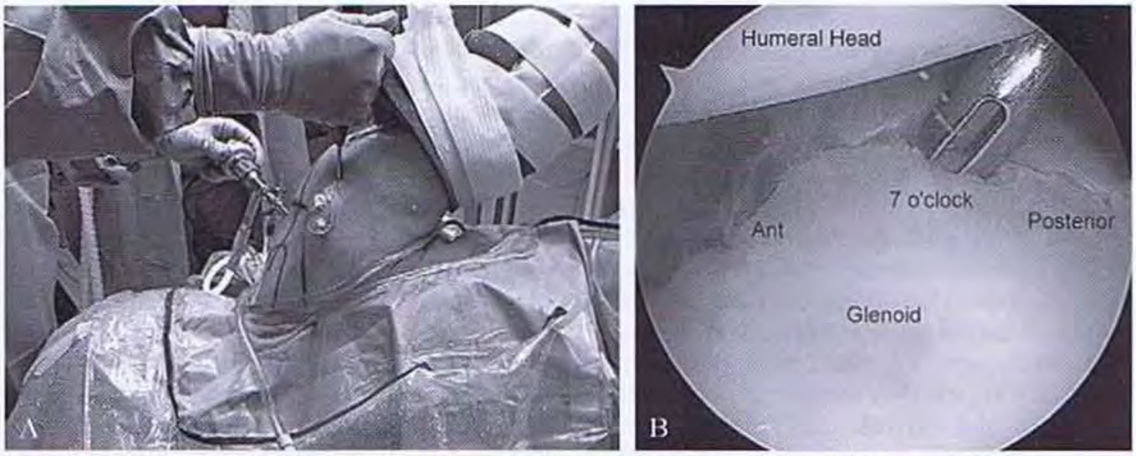

Figure 18.—The posterolateral 7-o'clock portal as viewed from outside (A) and inside (B) the shoulder demonstrating ease of access and anchor placement in the inferior aspects of the glenoid.

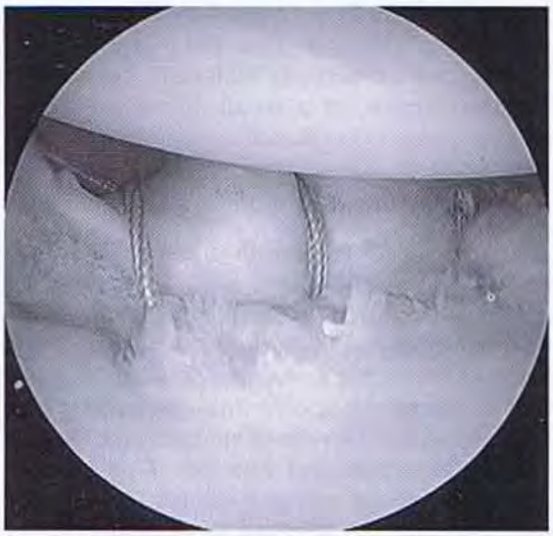

Figure 19.—Posterior viewing portal of the final anteroinferior labral repair with anatomic restoration of the labral-ligamentous complex.

recurrent trauma in an otherwise well-done reconstruction. Accurate positioning of suture anchors on the glenoid with penetration at the margin of the articular surface allows recreation of the glenoid concavity during repair and avoids repairing the labrum complex too medially down the glenoid neck. Boileau *et al.*[57] recommend at least four suture anchors, because less than three suture anchors in their study was associated with failure after instability repair. Their study finding speaks to well-placed suture anchors that correctly address the pathology of instability. Lastly, asymmetric tensioning during open or arthroscopic capsulorrhaphy can also create instability in the opposite direction.

Anchors

The standard arthroscopic Bankart repair typically uses three anchors placed below 3 o'clock with ideal anchor placement on the glenoid rim at a 45° angle relative to the glenoid surface 2 to 3 mm inside the anterior glenoid rim (Figure 19). Additional anchors are placed approximately 7 mm apart depending on the size and extent of the labral defect. Some have advocated a balanced repair, which includes repair of the anterior tear and posterior plication sutures to the intact posterior labrum.[58] The posterior labrum may not always be intact and may present as an extension of the anterior tear posteriorly. In this case, suture anchors are used to repair the labrum and perform plication of the capsule as necessary. However, if a balanced repair is desired and the posterior labrum is intact, it has been shown biomechanically that an intact labrum provides similar fixation strength to a suture anchor.[59] In performing adequate capsulolabral tensioning, the surgeon can use knots from a suture anchor or knotless anchors for fixation of the labrum to the glenoid.

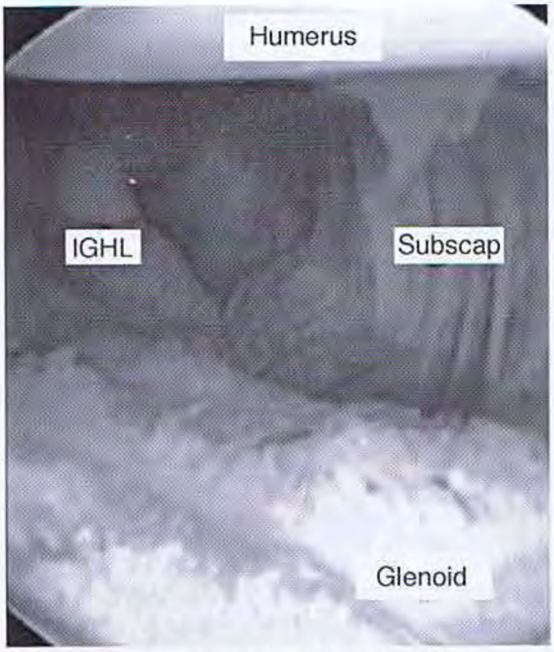

Figure 20.—Arthroscopic view of left shoulder from posterior portal with 70° scope. The free edge of the avulsed inferior glenohumeral (IGHL) complex can be seen in this anterior HAGL lesion. Subscapularis muscle is seen superior and anterior to free edge of ligaments.

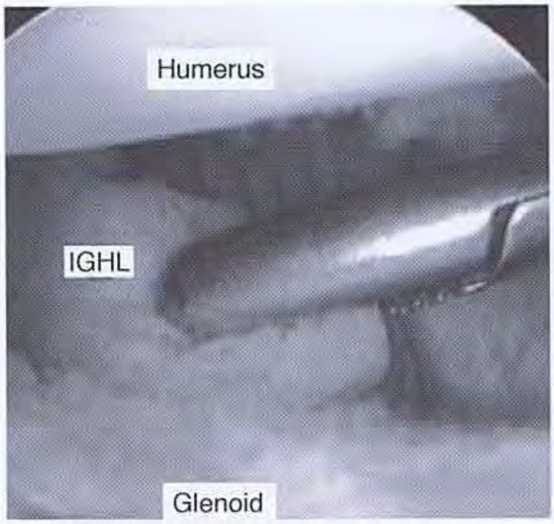

Figure 21.—In this arthroscopic view of left shoulder from the posterior portal with a 70° scope, the grasper has been placed through the anterior midlateral portal to reduce the capsular tissue to the humeral neck.

Of note:

— tension the capsulolabral structures with the arm in slight external rotation;

— use a minimum of three suture anchors;

— the anchors should be placed 2 mm onto the glenoid rim and not medially on the glenoid neck;

— pull on sutures before knot tying and after the capsulolabral repair stitch has been placed to visualize capsular plication and to ensure that adequate capsular tissue has been incorporated;

— a balanced repair may be performed if there is significant posterior laxity and capsular volume with either plication stitches (if labrum intact) or suture anchor repair after an anterior instability repair.

HAGL Lesion

Once the portals are established, the humeral avulsion of the glenohumeral ligaments pathology is further clarified. The anterior glenohumeral ligaments are inspected from their glenoid/labral origin to their attachment on the humeral neck. In a humeral avulsion of the glenohumeral ligaments lesion, all or part of the middle and inferior glenohumeral ligament complexes are avulsed from their humeral insertion. The humeral insertion is best visualized with a 70° scope in the posterior portal or with a 30° scope placed in the anterosuperior portal (Figure 20).

The capsular tissue avulsed off the humeral head is identified and reduced to the humeral neck with an arthroscopic grasper (Figure 21). If a labral tear is identified, the humeral avulsion of the glenohumeral ligaments lesion is repaired first and then the labral tear is addressed. This avoids overtightening of the capsule medially, which may prevent or impair lateral repair. In order to prepare the bony bed, the original humeral insertion site of the inferior glenohumeral ligament complex is gently debrided using a burr on reverse from the anterior mid- glenoid portal to complete a light decortication and obtain a bleeding surface. An 18-G needle is used under direct visualization to establish the correct path for suture anchor placement onto the medial humeral neck. The approximate placement of this path is

Figure 22.—Arthroscopic view of the left shoulder from the posterior portal using a 70° scope. When the sutures were brought up through the anterior portal, the glenohumeral ligament complex was anatomically reduced onto the anterior aspect of the humeral head.

between the standard posterior portal and the accessory posterolateral portal (7 o' clock). This is obtained in a percutaneous fashion with the anchor inserting device and drill.

Once the appropriate trajectory is established, a 3.0-mm bioabsorbable suture anchor is placed. One of the suture limbs is retrieved with a crochet hook out the anterosuperior portal. The remaining suture limb is left posteriorly outside the skin. A straight suture repair device is advanced through the 8.25-mm cannula in the 7-o' clock portal and passed through the inferior/lateral capsule just inside of the avulsion borders. A #1 monofilament suture is advanced into the joint through the suture repair device and retrieved through the anterosuperior portal. The monofilament is tied to the previously passed suture limb and shuttled back through the 7-o' clock portal through the capsuloligamentous complex. This can be repeated, and a mattress suture is then tied through the 7-o' clock portal with a knot pusher.

As the repair continues anteriorly, an accessory low anterior portal is required for correct anchor placement. This portal is created in a trans-subscapularis fashion, staying lateral to the humerus to minimize risk of axillary nerve injury. This portal can be used to place an anchor percutaneously, or a small 5-mm cannula can be used. It is important to use the rotation of the humerus to help controlling the access to all areas of the humeral capsular avulsion site. Once the anchor is in place, sutures are passed through the torn capsule in a similar fashion as described above using a corkscrew suture-passing device. The sutures are shuttled and brought out the anterior midglenoid portal. In general, sutures are passed in a mattress fashion allowing the knot to be placed outside the capsule (Figure 22).

Rotator interval

Surgical repair of the rotator interval remains a controversial subject (Figures 23, 24). Based on the latest biomechanical and clinical studies, there is relatively strong evidence that an arthroscopic RI closure improves anterior stability.[15, 19, 20, 27] Indications for surgical rotator interval repair remain poorly defined; however, there is a growing body of evidence that rotator interval closure should be considered in:

1) patients with anterior instability and a rotator interval lesion (incompetent sulcus);

2) patients with symptomatic shoulder instability and laxity in the inferior direction (positive sulcus) that does not tighten in external rotation with the arm at the side;

3) patients who have significant laxity and a large sulcus finding in the setting of multidirectional instability.

For arthroscopic rotator interval closure, the authors prefer a modification to the method described by Taverna *et al.*[21] This "all-inside" technique allows direct visualization of the extent of the repair and preservation of the deltoid. The patient can either be in the beach-chair or lateral decubitus position and the position of the glenohumeral joint is adjusted to 30° of external rotation with an assistant positioning the arm holder. A 5 to 7-mm cannula is placed back into the middle aspect of the rotator interval and then backed out such that it is just anterior to the capsule. A sharp crescent hook device is

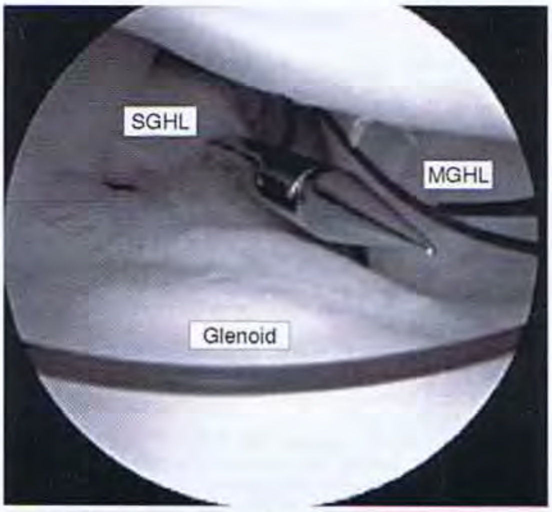

Figure 23.—A penetrator device is inserted through the superior glenohumeral ligament in the superior aspect of the rotator interval and grasps the monofilament suture that has been passed through the middle glenohumeral ligament.

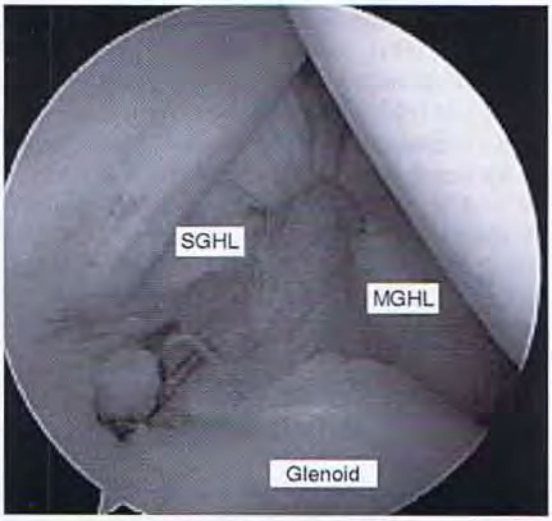

Figure 24.—Two stitch rotator interval closure – the final repair.

loaded with a no. 1 monofilament suture. This is brought in though the cannula, and then the tissue adjacent to the MGHL is penetrated with the sharp crescent needle. If the MGHL is small, the superior aspect of the subscapularis or other tissues just superior to the subscapularis can be grasped. The first stitch is placed medially, near the level of the glenoid face; one additional stitch will be placed more laterally if necessary. The n. 1 monofilament suture is shuttled into the joint and then the crescent hook removed. The cannula is maintained in a position just anterior to the capsule but is shifted slightly superior so that a sharp penetrator device can pierce the SGHL and tissues immediately inferior to the supraspinatus, again a few millimeters lateral to the glenoid face. The penetrator retrieves the n. 1 monofilament suture and is brought out through the cannula. This is changed to a n. 2 non-absorbable suture although absorbable sutures may also be used. The n. 2 non-absorbable suture is taken outside the cannula, and then the cannula is removed and replaced such that the sutures are now external to the cannula. A second stitch that is more laterally placed in the tissues may be passed at this point in a similar fashion.

The cannula is then replaced, just anterior to the capsule after the two medially based sutures are placed inside the cannula while it is external to the body. Once down on the capsule, a knot pusher is used to tie a non-sliding knot while watching the closure in an "all-inside" technique to ensure adequate plication. The arm is then released from 30° of external rotation, and stability and postoperative range of motion are assessed.

Rehabilitation

Proper postoperative rehabilitation begins with thorough preoperative patient counseling combined with the intraoperative findings. Factors to consider are type of pathology (traumatic *vs.* atraumatic); direction of instability (anterior, posterior, multidirectional); integrity of tissue at time of repair; comfort level with quality of repair; and possible associated findings and treatment (*i.e.*, biceps tendon tear, rotator cuff tear). Routine postoperative immobilization varies based on the procedures performed. The authors recommend an abduction sling for most anterior instability repairs (this type of sling keeps the shoulder in a neutral position).

Physical therapy typically starts 7 to 10 days following most routine instability repairs. Unidirectional instability repair will progress with passive and active-assisted range of motion for the first 4 weeks (forward elevation [FE] to 130°; external rotation [ER] to 30°). From 4 to 6 weeks these ranges will be increased to FE 130° to180° and ER 30° to 60°. Active range of motion exercises progress thereafter with resistive strengthening from 8 to 12 weeks and the return to full sports and activities at 4 to 6 months in most cases.

Conclusions

The successful management of patients with anterior shoulder instability can be a significant challenge and is predicated on the accurate assessment and treatment of the offending pathologies. It is essential that the surgeon have an understanding of the pathoanatomy of recurrent anterior shoulder instability and to recognize the associated conditions. With a thorough understanding of the principles of arthroscopic instability repair, the pearls provided should allow a comprehensive approach to patients with shoulder instability with the hope of continued improvement in patient outcomes.

Riassunto

Trattamento artroscopico dell'instabilità antero-inferiore della spalla

Il trattamento dell'instabilità anteriore della spalla è in continua evoluzione. Progressi nell'ambito delle tecniche artroscopiche hanno permesso di sviluppare recentemente la riparazione artroscopica di Bankart. Ciò si associa allo sviluppo di nuovi strumenti, impianti, e tecniche. Tuttavia, per ottenere buoni risultati nei pazienti con instabilità anteriore, è fondamentale che il chirurgo sia a conoscenza dei fattori preoperatori, intraoperatori e postoperatori in associazione con il riconoscimento e il corretto trattamento della patologia relativa all'instabilità. In questo capitolo, gli autori presentano diverse e importati tecniche, patologie e concetti relativi alla corretta diagnosi e trattamento dei pazienti con instabilità anteriore impiegando tecniche artroscopiche.

Parole chiave: Spalla, articolazione – Artroscopia – Articolazione, instabilità.

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