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Magnetic Resonance Imaging of Glenohumeral Instability

Thomas J. Fischbach, M.D., and Leanne L. Seeger, M.D.

Summary: Glenohumeral instability refers to subluxation or dislocation of the glenohumeral joint. This painful disorder is particularly common in the athletic population, and the individual with instability may present with a variety of clinical complaints. This paper addresses current theories regarding the pathophysiology of glenohumeral instability and illustrates magnetic resonance findings that can assist in diagnosis and treatment planning. **Key Words:** Glenohumeral instability—Glenohumeral joint—Impingement syndrome.

In order to allow the hand to be positioned in space, the glenohumeral joint has evolved into the most mobile joint in the human body. This wide range of motion, however, both renders the glenohumeral articulation inherently unstable and precludes the use of bony configuration as found in the hip or tightly restraining ligaments as present in the knee for stability. Glenohumeral stability is largely dependent on a dynamic interaction of the surrounding soft tissues, and imaging the unstable shoulder must rely on modalities that can accurately display these structures. The ability of magnetic resonance imaging (MRI) to delineate the complex anatomy of the shoulder has rendered it an important tool in determining the site and extent of shoulder pathology.

Most studies evaluating the ability of MRI to demonstrate soft tissue and bony changes associated with glenohumeral instability have shown a high sensitivity and specificity (1-11). This is, however, not universally the case (12). Although controversy continues, MRI is emerging as a clinically useful method for evaluating suspected or documented glenohumeral instability and assisting in therapeutic planning.

IMAGING TECHNIQUE

Several different imaging techniques have been proposed for the MR evaluation of the glenohumeral

joint and supporting soft tissues. While specifics may vary, scan acquisition should include a minimum of imaging in the axial plane and along an axis perpendicular to the bony glenoid (the coronal oblique plane). Axial images will allow evaluation of the anterior and posterior labrum and capsule, and coronal oblique images will depict the superior and inferior labrocapsular complex. Because instability may be associated with impingement syndrome, imaging should always include evaluation of the supraspinatus tendon and the supraspinatus outlet, structures also seen in the coronal oblique plane.

Pulse sequences should be chosen that will clearly demonstrate fluid and allow differentiation of fluid from fat. Most centers use conventional double-echo spin-echo scanning, but gradient-echo imaging is also widely used (13). Newer "fast" spin-echo techniques may also be used, but these may be more susceptible to motion degradation and marrow abnormalities may be more difficult to image. Radial imaging has been proposed for a more detailed depiction of the glenoid labrum (14). This, however, is usually not necessary since the majority of the pathology associated with instability is well depicted with the combination of axial and coronal oblique imaging.

NORMAL ANATOMY RELEVANT TO GLENOHUMERAL STABILITY

The proximal humerus is composed of the greater and lesser tuberosity and the humeral head articular surface (Figs. 1 and 2). In cross-sectional images, the superior humeral head appears round. More inferi-

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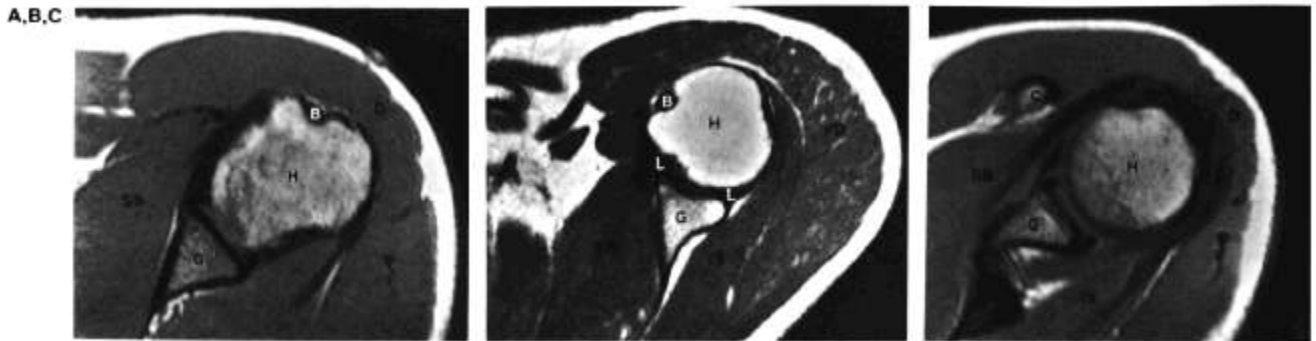


FIG. 1. Normal anatomy: axial plane. Anterior is at the top of the image. B = tendon of long head of biceps, C = coracoid tip, D = deltoid muscle, G = glenoid, H = humeral head, IS = infraspinatus muscle, L = labrum, SB = subscapularis muscle. A: Level of the inferior humeral head. Humerus is externally rotated. B: Level of the midhumeral head. Humerus is internally rotated. C: Level of the superior humeral head.

orly, the head is oblong and its posterior surface is flattened where a portion of the infraspinatus and teres minor tendons insert. The exact level of transition from round to oblong varies among individuals, but the head is generally round above the level of the coracoid process. In axial images, the signal intensity of the humeral head bone marrow humeral head is often inhomogenous. This is a reflection of the oblique orientation of the physis and the signal differences between the marrow of the metaphysis and the epiphysis (10).

The rotator cuff is comprised of the supraspinatus, infraspinatus, teres minor, and subscapularis tendons. The corresponding muscles of these tendons serve to abduct, internally rotate, and externally rotate the humerus. The supraspinatus muscle includes two bellies, which originate in the supraspinatus fossa of the scapula and course laterally to insert on the

superior portion of the greater tuberosity. The infraspinatus and teres minor muscles originate from the posterior aspect of the scapula inferior to the scapular spine and insert onto the greater tuberosity posteroinferior to the supraspinatus tendon. The subscapularis muscle originates from the anterior surface of the body of the scapula. It is comprised of multiple muscle slips that converge as the muscle courses anterior to the glenohumeral joint to insert onto the lesser tuberosity.

The supraspinatus outlet is the only location in the human body where a tendon must function between two rigid structures. This anatomic arrangement accounts for the predisposition of the supraspinatus tendon to impingement. The supraspinatus outlet is formed superiorly by the coracoacromial arch, a rigid structure that is comprised of the acromion, acromioclavicular joint, coracoid process, and coracoacromial ligament. Inferiorly, the supraspinatus outlet is

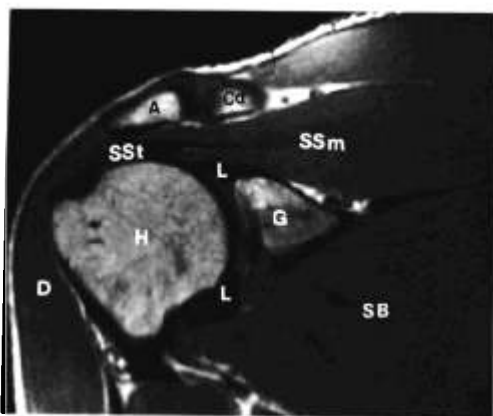


FIG. 2. Normal anatomy: coronal oblique plane (along long axis of supraspinatus muscle). Level of the acromioclavicular joint. A = acromion, C'd = distal clavicle, D = deltoid muscle, G = glenoid, H = humeral head, L = labrum, SB = subscapularis muscle, SSm = supraspinatus muscle, SSt = supraspinatus tendon.

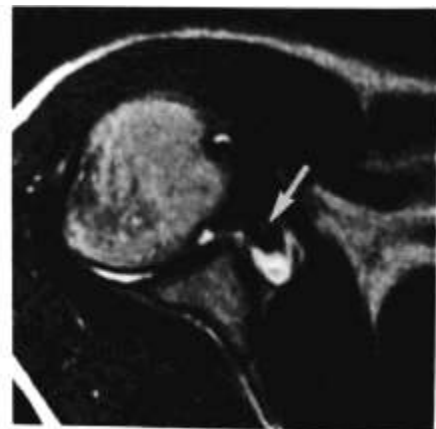
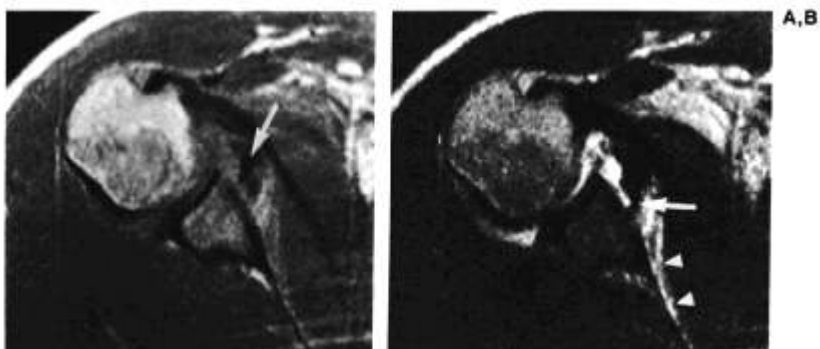


FIG. 3. Bankart lesion. Axial image, SE 2,000/85. The anterior labrum (arrow) is completely detached from the bony glenoid, and is surrounded by joint fluid.

FIG. 4. Bankart lesion with capsular/periosteal stripping. Axial images. **A:** SE 1,700/15. The labrum (arrow) is lifted off the glenoid. **B:** SE 1,700/70. A band of low signal intensity (arrow) representing periosteum or capsule is seen between the labrum and the scapular neck. Fluid can also be seen dissecting along the anterior body of the scapula (arrowheads).



bounded by the humeral head. As the arm is externally rotated and abducted or internally rotated and elevated, the functional space in which the supraspinatus tendon must glide may be diminished. If reduced sufficiently, the supraspinatus tendon and subacromial bursa are subject to repeated mechanical trauma. Imaging of the unstable glenohumeral joint should always include evaluation of the supraspinatus outlet and the supraspinatus tendon, as glenohumeral instability and impingement syndrome may coexist (see below).

The tendon of the long head of the biceps muscle courses within the intertubercular sulcus (the bicipital groove) of the proximal humerus. In this location, the tendon is surrounded by a synovial sheath, which is continuous with the glenohumeral joint. The tendon is secured within the bicipital groove by the transverse humeral ligament, which passes between the greater and lesser tuberosities and over the synovial sheath. As it exits from the groove proximally, the tendon passes obliquely within the joint beneath the supra-

spinatus tendon and inserts onto the superior glenoid labrum and the glenoid tubercle at the labral base. Within the groove, the tendon is best seen on transverse images as a circular, low-intensity structure. The intra-articular portion of the biceps tendon is generally difficult to image on MRI. The labral insertion of the tendon is generally best appreciated on coronal oblique images. Because the intra-articular portion of the tendon of the long head of the biceps travels beneath the supraspinatus tendon, the former may be involved with impingement syndrome (15-18). Pathology of the proximal attachment of the tendon of the long head of the biceps is seen with the SLAP lesion (see below).

The glenoid labrum is an O-ring that is applied to the rim of the bony glenoid. The labrum is pliable, and its shape may be altered according to the position

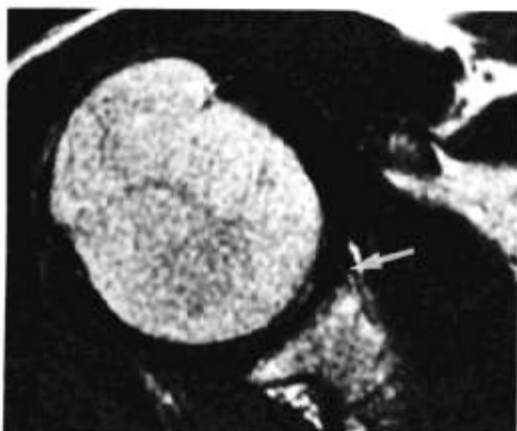


FIG. 5. Labral tear. Axial images, SE 1,500/80. A thin band of fluid (arrow) is seen within the anterior labrum. The labrum is not completely detached, and the capsule is intact.



FIG. 6. Large anterior pouch in a patient with chronic instability. There was no history of dislocation. Axial image, CSFSE 3,000/90. The joint has been distended with saline. The capsule attachment appears to be along the scapular neck, far more medial than normal (arrow). This could represent either a type 3 capsular insertion or alternatively, a capsule that has been stretched but not torn. The labrum is normal and remains attached to the bony glenoid. There was no Bankart lesion at surgery.

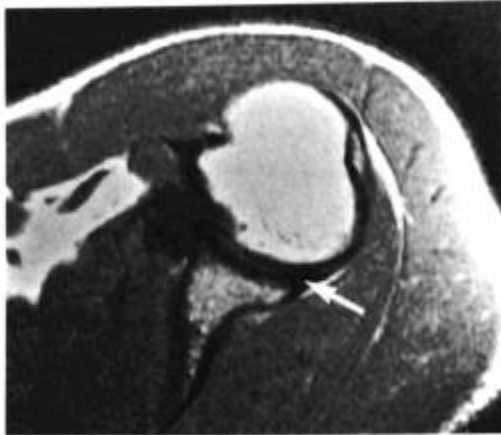


FIG. 7. Severe labral attenuation due to multiple anterior dislocations. Axial image, SE 800/30. The posterior labrum (arrow) is normal. The anterior labrum is absent.

of the humeral head (5, 19). The composition of the labrum is controversial. Some authors have determined that it represents a redundant fold of fibrous joint capsule and that fibrocartilage is present only at the site of attachment to the bony glenoid (19, 20). Others, however, feel that the labrum is composed primarily of fibrocartilage (21). Regardless of its histologic composition, the normal glenoid labrum generally appears as a low signal intensity structure with T1-weighted imaging and low signal intensity with T2-weighting. The anterior and posterior labra and glenoid are best visualized in the axial plane. The superior and inferior labra and glenoid are best seen in the frontal-oblique plane oriented parallel to the long axis of the supraspinatus muscle (which is also perpendicular to the axis of the glenoid).

Like the meniscus in the knee, ill-defined signal may be seen in the labrum in asymptomatic individuals (13, 22–24), and confusion exists as to if these findings reflect normal variations or asymptomatic pathology. Focal linear signal may reflect asymptomatic labral

tears and in the older population, more globular signal may represent mucoid degeneration (22, 25, 26). The glenoid labrum may also show a wide spectrum of shape on MRI (13, 23). In a study of 52 asymptomatic shoulders (23), the most common labral shape was triangular, seen anteriorly in 45% of shoulders and posteriorly, in 73%. The next most common shape was rounded, seen anteriorly in 19% of shoulders and posteriorly in 12%. A cleaved appearance was found anteriorly in 15% of the shoulders studied, and a notched appearance was seen anteriorly in 8%. A flat configuration of the labrum was noted anteriorly in 7%, and posteriorly, in 6%. Nonvisualization of the labrum (and thus presumed absence) was seen in 6% of shoulders anteriorly and in 8% posteriorly (23).

The glenohumeral joint is lined by a synovial membrane and is covered by the joint capsule. The fibrous capsule imparts to the glenohumeral joint a volume that greatly exceeds that of the humeral head, a requirement for normal glenohumeral mobility. In most individuals, the capsule arises from the base of the labrum or the adjacent periosteum of the glenoid and scapula and inserts on the upper portion of the anatomic neck of the humerus (27). The medial attachment of the capsule is, however, quite variable (19, 27).

A classification system for the anteromedial capsular insertion has been proposed by Moseley and Overgaard (19). A type 1 insertion is very near or on the glenoid labrum, a type 2 insertion is found ≤ 1 cm medial to the tip of the labrum, and a type 3 insertion is > 1 cm medial to the tip of the labrum (23). It is currently thought that a type 3 capsular insertion may either predispose one to glenohumeral instability or may represent either stripping of the anterior capsule off of the scapula or capsular stretching resulting from prior injury (19, 27, 28–34).

The frequency of various capsular insertions as seen on MRI has been evaluated (23). A type 1 capsu-

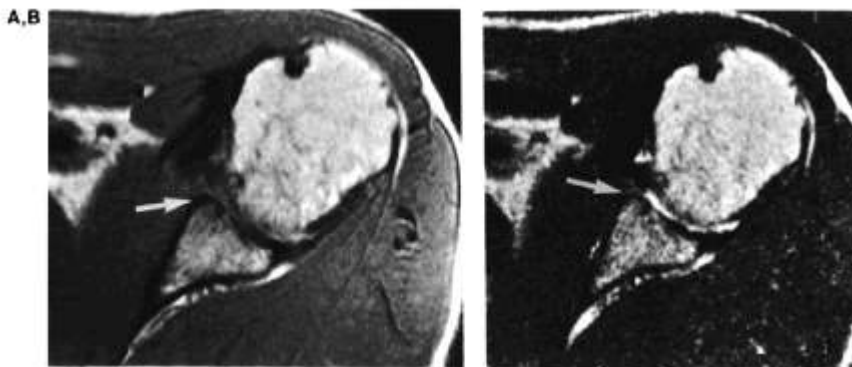


FIG. 8. Bankart lesion, paucity of joint fluid. Axial images. **A:** SE 1,800/15. The anterior labrum shows diffuse abnormal signal on the first echo. Mild truncation of the anterior bony glenoid (arrow) raises the suspicion of a small Bankart fracture that may be associated with a soft tissue Bankart lesion. **B:** SE 1,800/70. A thin band of high signal intensity fluid can be seen separating the labrum from the glenoid (arrow), an indication of a Bankart lesion.

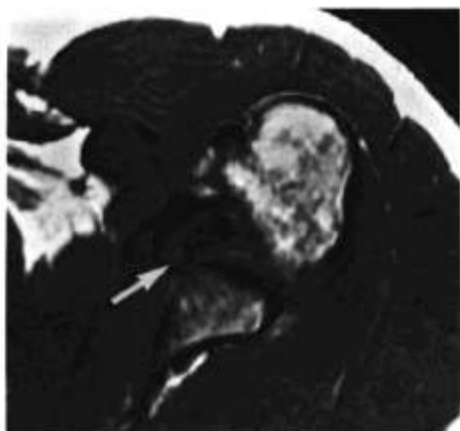


FIG. 9. Bankart fracture. Axial image, SE 2,000/20. The rim of the anterior glenoid (arrow) has been fractured off.

lar insertion was identified in 47% of shoulders, a type 2 insertion was seen in 49%, and a type 3 insertion was seen in 4%. Posterior capsular insertions were identified as type 1 in all asymptomatic shoulders studied. It should be noted that the joint was not distended for this study, and differentiation of the various insertions can be difficult in the absence of intra-articular fluid. It is also often difficult to differentiate a type 3 capsule from a type 1 insertion with a large anterior capsular pouch.

Anteriorly, there are three condensations of the joint capsule: the superior, middle, and inferior glenohumeral ligaments (19). These ligaments serve to prevent instability when the arm is in various degrees of abduction. The superior glenohumeral ligament extends from the supraglenoid tubercle of the scapula near the origin of the tendon of the long head of the biceps to insert near the top of the lesser tuberosity (19, 35). The middle glenohumeral ligament is the most variable of the three and is absent in 30% of shoulders (36). When present, it usually arises from the glenoid just inferior to the supraglenoid tubercle. Its distal half blends with the tendon of the subscapularis and inserts on the lesser tuberosity of the humerus. The middle glenohumeral ligament may also arise from the adjacent anterior labrum or more medially along the neck of the scapula (19, 35). The inferior glenohumeral ligament is a complex of structures consisting of an anterior and posterior band with an intervening axillary pouch (37, 38). It arises from the anteroinferior glenoid and labrum at or adjacent to the origin of the long head of the triceps muscle (19, 35), extends laterally to the medial border of the lesser tuberosity, and inserts on the anatomic neck of the

humerus slightly inferior to the edge of the articular surface of the humeral head (38).

The subacromial bursa is a potential space found between the acromion and the supraspinatus tendon. The normal subacromial bursa is evident on MR images as a thin band of fat-signal intensity, a reflection of the fat both within the synovium and on which the bursa lies (19, 39). The subacromial bursa is continuous with the subdeltoid bursa; this structure is thus often referred to as the subacromial-subdeltoid bursal complex. The subscapular bursa is located between the scapula and the subscapularis muscle and tendon. It is normally in communication with the joint space through an opening between the superior and middle glenohumeral ligaments.

The hyaline cartilage that covers the articular surfaces of the humeral head and glenoid has intermediate signal on spin-echo sequences. At the inner junction of the glenoid and the labrum, there may normally be a margin of hyaline cartilage insinuated under the labrum. This should not be mistaken for a labral tear (24, 40, 41). Intermediate to high-signal intensity between the anterior labrum and the joint capsule and glenohumeral ligaments is thought to represent redundant fat-laden folds of synovium (10, 40).

BIOMECHANICS OF GLENOHUMERAL INSTABILITY

Interest in shoulder instability has been present since the late 5th century B.C. when Hippocrates recommended cautery of the anterior joint with a hot

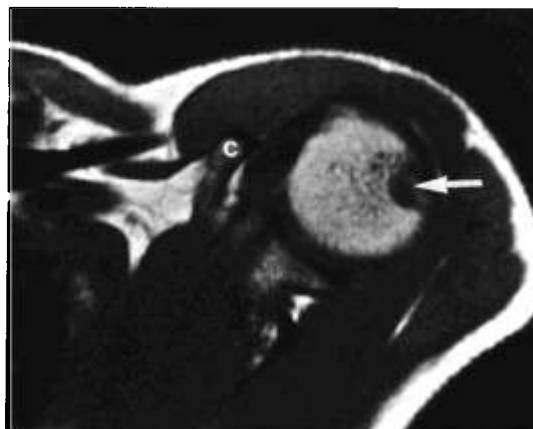


FIG. 10. Hill-Sachs fracture. Axial image, SE 800/30. The large defect in the posterolateral aspect of the superior humeral head (arrow) represents an impaction fracture. At the level of the coracoid tip (C), the head should be relatively round.

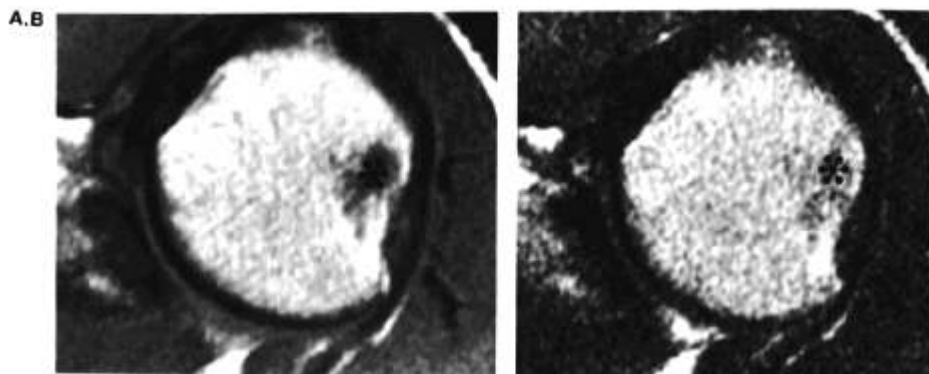


FIG. 11. Hill-Sachs fracture in a patient with a history of multiple anterior dislocations. Axial images. The posterolateral aspect of the humeral head is abnormally flat. A: SE 1,500/15. The marrow beneath the cortical depression (*) is low to intermediate in signal intensity. B: SE 1,500/80. With T2-weighting, a portion of the marrow increases in signal intensity (*) while other portions remain low signal. This reflects a combination of relatively acute marrow trauma superimposed on more remote trauma.

iron and immobilization in adduction and internal rotation as treatment (42). Clearly, management options have significantly changed since that time. The underlying anatomic pathophysiology and mechanics of glenohumeral instability, however, remain controversial.

Although no consensus exists as to precisely which structures are responsible for glenohumeral stability, a significant portion is most likely obtained from the so-called "capsular mechanism" (19, 32, 33). The anterior capsular mechanism consists of the anterior synovial membrane and capsule, the subscapular bursa, the three glenohumeral ligaments, the glenoid labrum and scapular periosteum, and the subscapularis muscle and tendon (19, 32, 33). The posterior capsular mechanism consists of the posterior synovial membrane, capsule, glenoid labrum and periosteum, the posterior recesses, and the posterior and superior rotator cuff, including portions of the supraspinatus, and the infraspinatus, and the teres minor.

The contribution of bony structures to stability of

the shoulder is minimal. The glenoid is shallow, and it has a radius of curvature larger than that of the humeral head. Consequently, there is no substantial surface contact between the two. The glenoid fossa is slightly deepened by the glenoid labrum, which may impart a small additional degree of stability, but its role is most likely minor.

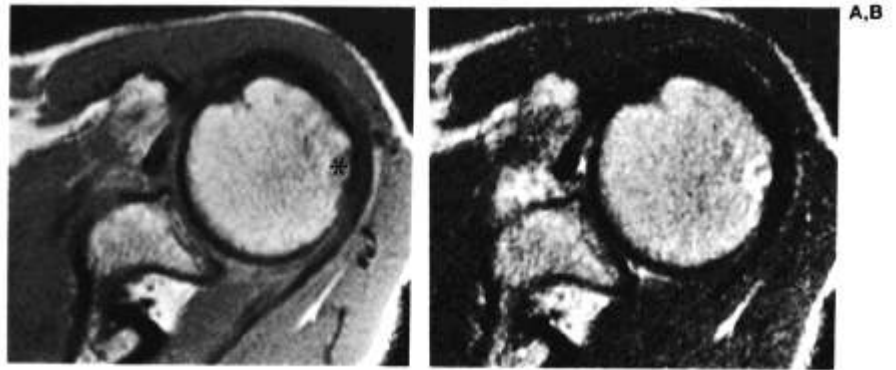
Negative pressure within the glenohumeral joint has also been suggested as a factor contributing to glenohumeral stability (43). Cadaveric studies have shown that loss of the normal negative pressure results in inferior subluxation of the humeral head out of the glenoid fossa (43). This situation, however, is not routinely encountered in double contrast shoulder arthrography in which negative pressure is lost as air is introduced into the joint.

Of the three glenohumeral ligaments, the inferior ligament is thought to be most crucial for anterior and posterior joint stability (15, 19, 33, 38, 41, 43, 44). This ligament comes under tension as the shoulder is in external rotation and abducted past 90°, the classical position for anterior instability (32, 33, 38). The histologically discrete anterior and posterior bands of the inferior glenohumeral ligament come under varying stress depending on the position of the humerus (38). When the humerus is in external rotation, the anterior band restricts anterior subluxation and the posterior band restricts inferior movement. With internal rotation of the humeral head, the orientation of both bands is changed such that the anterior band limits inferior movement and the posterior band restricts posterior subluxation. The superior glenohumeral ligament acts as a primary restraint to inferior displacement of the adducted shoulder (45) and provides secondary restraint to posterior dislocation (46). The role of the middle glenohumeral ligament in maintaining shoulder stability is not entirely clear, but it appears to act as a secondary restraint to anterior dislocation and limit external rotation at 45° of



FIG. 12. Remote Bankart fracture. Axial image, SE 2,000/80. On a T2-weighted image, low signal intensity in the anterior glenoid rim (arrow) indicates a healed Bankart fracture.

FIG. 13. Trabecular infraction without frank Hill-Sachs fracture. Axial images. **A:** SE 1,800/15. The contour of the humeral head is normal, but there is a subtle focus of ill-defined intermediate signal intensity in the subchondral marrow in the expected region of a Hill-Sachs fracture. **B:** SE 1,800/70. With T2-weighting, the abnormal marrow signal increases in signal intensity. This indicates a relatively acute injury.



abduction (33). The subscapularis tendon also contributes to anterior stability.

While it may be reasonably assumed that the anterior capsule and its condensations provide the majority of restraint for anterior instability and the posterior capsule provides the majority of support to avoid posterior instability, research has shown that complete transection of the posterior aspects of the capsule does not allow posterior instability. Rather, it is only with severing the anterior capsule that posterior instability can be demonstrated (36, 47). Additional studies involving removal of the anterior labrum from a posterior approach showed that anterior dislocation could not be produced unless damage to the anterior capsular complex was produced (32). Most likely, both anterior and posterior stability require a complex interaction between both the anterior and posterior capsular mechanism, and the relative role of each component depends on the strength of the activity and the location of the arm in space.

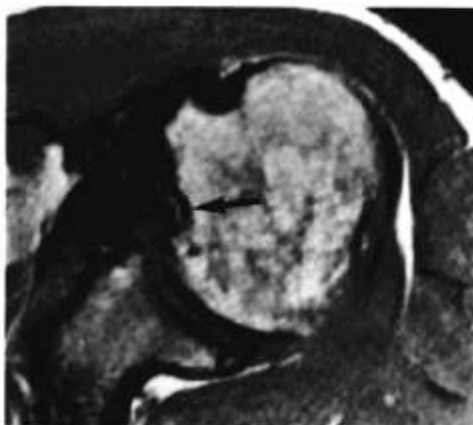


FIG. 14. Reverse Hill-Sachs. Axial image, SE 1,500/15. The patient had a history of both anterior and posterior dislocations. The defect (arrow) in the anteromedial aspect of the inferior humeral head represents a fracture from a prior posterior dislocation.

PATHOLOGY OF INSTABILITY

The classic pathology associated with anterior instability is the Bankart lesion: detachment of the labrum and/or joint capsule, usually at the level of the inferior glenohumeral ligament (48) (Fig. 3). Especially in cases of traumatic dislocation, the periosteum may be stripped from the underlying scapula at the junction of the labral-capsular complex (Fig. 4). Less often, the glenoid labrum may be torn in the absence of capsular pathology (Fig. 5), or the capsule may simply stretch, leaving a large anterior pouch that can easily accommodate the humeral head (Fig. 6). Although usually associated with instability, labral tears may be seen in the clinically stable shoulder and can be found in association with labral degeneration (19, 25, 31, 49). Multiple dislocations may lead to severe attenuation of the labrum as it is gradually eroded away (Fig. 7).

The Bankart lesion is most conspicuous in the axial plane where it is evident as displacement of the labrum off the underlying glenoid. In the acute setting, fluid may be seen dissecting along the anterior border of the scapula or into the subscapularis musculotendinous unit. If the dislocation is remote or the patient with glenohumeral instability has never experienced a frank dislocation, the labrum may be separated but will lie immediately adjacent to the glenoid. Identification of the Bankart lesion can be difficult in this setting (Fig. 8). Labral tears are identified as linear increased signal within the substance of the labrum, which extends to the joint surface (5, 20, 40, 41). The labrum, however, remains attached to the glenoid.

Traumatic anterior dislocations may be associated with trauma to the subscapularis tendon or muscle (50). With complete rupture of the subscapularis tendon, the musculotendinous junction will retract medially. Abnormal increased signal within the muscle on T1-weighted images is indicative of fatty replacement of normal muscle fibers, and may be seen with a

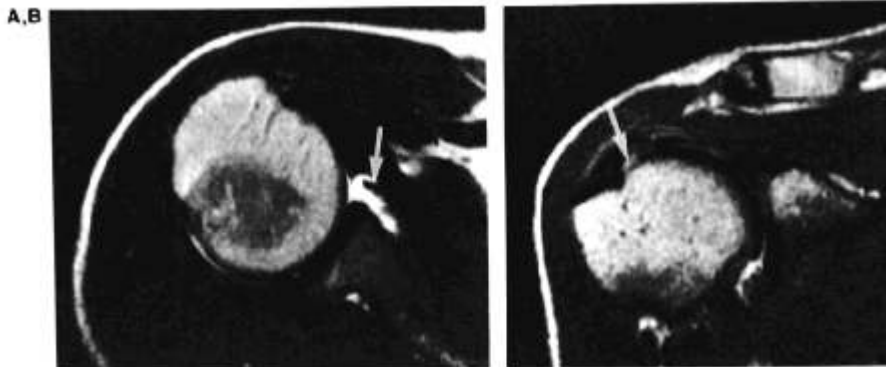


FIG. 15. Secondary impingement syndrome. Although the patient's complaints were primarily referable to impingement, the pathology requiring surgical attention was instability. **A:** Axial image, CSFSE 3,000/90. A Bankart lesion is present, evident as separation of the labrum (arrow) from the glenoid. **B:** Coronal oblique image, SE 1,800/70. A focal fluid collection is present in the supraspinatus tendon (arrow). Surgery confirmed that this represented a partial-thickness undersurface rotator cuff tear.

remote tear of the subscapularis tendon (10). Additional findings that may be associated with instability include thickening of the inferior capsular insertion, an irregular outline of the capsule, and periosteal reaction with new bone formation at the glenoid margin (26, 29, 31, 40).

The bony abnormalities associated with anterior instability include fracture of the anterior glenoid rim (the Bankart fracture, Fig. 9) and depression fracture of the posterolateral aspect of the superior humeral head (the Hill-Sachs fracture, Fig. 10) (51). The Bankart fracture results from anterior displacement of the humeral head onto the bony glenoid and should not be confused with the soft tissue Bankart lesion. In his original description of anterior instability, Bankart specifically indicated that none of the soft-tissue lesions he encountered in the unstable shoulder were associated with fracture of the glenoid or humeral head (48). The Hill-Sachs fracture reflects impaction of the humeral head onto the glenoid.

In the acute setting, both the Bankart fracture and

the Hill-Sachs fracture will be associated with marrow changes of intermediate signal intensity in T1-weighted images and high-signal intensity in T2-weighted images (Fig. 11). With time, this pattern of marrow edema and hemorrhage will either resolve (leaving only the contour abnormality) or will become low-signal intensity in both T1- and T2-weighted images indicating callous (Fig. 12). In the absence of frank fracture with cortical interruption, MRI may only show marrow changes of edema similar to the trabecular infraction seen in the knee (Fig. 13).

Pathology associated with posterior instability includes the posterior Bankart lesion (tear of the posterior labrum or joint capsule), reverse Bankart fracture (fracture of the posterior glenoid rim), and reverse Hill-Sachs or "trough" deformity (fracture of the anteroinferior humeral head, Fig. 14). The patient with multidirectional instability may demonstrate a constellation of findings of both anterior and posterior instability (52).

CLASSIFICATION OF GLENOHUMERAL INSTABILITY

The unstable shoulder usually subluxes or dislocates in an anteroinferior direction. There are, however, individuals with "multidirectional instability," which includes subluxation or dislocation in the anterior, posterior, and inferior directions. In these patients, therapy directed at only the more common anterior component of their pathology may result in continued symptomatology due to persistent inferior or posterior instability (29, 44, 49). Isolated posterior instability is relatively uncommon and is classically associated with seizure activity due to epilepsy or electroconvulsive therapy.

Instability has been divided into two broad types—anatomic and functional. In anatomic instabil-



FIG. 16. SLAP lesion. Axial image, SE 1,500/15. The abnormal signal at the base of the superior labrum (arrow) represents detachment of the labrum from the underlying glenoid.

FIG. 17. Bankart lesion with and without joint fluid. Axial images. A: SE 1,500/80. Images were acquired within 24 hours of anterior dislocation, and the joint is distended with fluid from the acute injury. The labrum (arrow) is detached from the glenoid. B: SE 1,500/80. Three weeks later, the joint fluid has been resorbed. The anterior labrum is truncated, but the Bankart lesion is more difficult to appreciate.



ity, the patient has recurrent subluxation or dislocation and clinical signs of instability can usually be elicited. With functional instability, the glenohumeral joint is clinically stable but the patient reports clicking, pain, or intermittent locking, and a subjective feeling that the joint is unstable (24, 49, 53).

Although recurrent glenohumeral instability may be referable to a prior traumatic dislocation, there are many patients with instability who cannot recall a specific inciting event. These patients may present with vague complaints including arm numbness, nonspecific pain, or decreased range of motion, and often present a diagnostic challenge (37, 54, 55). The cause of nontraumatic instability has long been debated. While bony configuration such as variations in the depth and radius of curvature of the glenoid fossa and the version angle of the bony glenoid may contribute to instability, it is generally believed that nontraumatic instability results from a deficiency in the soft-tissue support of the glenohumeral joint. Structures implicated include a type 3 capsular insertion and con-

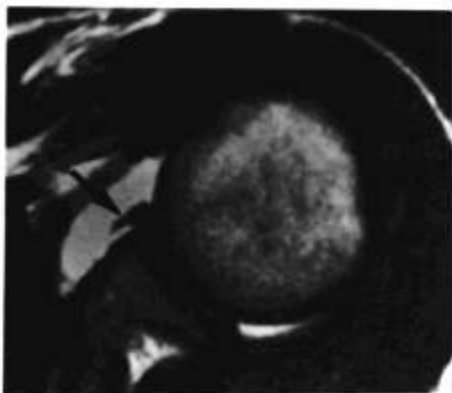


FIG. 18. Saline MR arthrogram. Axial image, CSFSE 3,000/95. The anterior labrum (arrow) is lifted off the glenoid. This Bankart lesion would have been difficult if not impossible to detect without joint distention.

genitally small or absent glenohumeral ligaments. Individuals with congenital or idiopathic capsular and ligamentous laxity may also experience glenohumeral instability (15, 31, 32, 44, 54, 56).

Atraumatic anterior shoulder instability is commonly seen in athletes, particularly those whose sport involves repetitive throwing and excessive overhead activities such as baseball pitchers, tennis players, football quarterbacks, and swimmers (2, 15, 31, 32, 57, 58). This type of motion alters the tissues of the shoulder joint in order to allow for an increased range of external rotation. This is usually achieved by increasing the laxity of the anterior supporting structures.

By assigning a patient with recurrent instability according to the presence or absence of a history of trauma and the direction of instability, one can often predict the associated pathology and determine the necessity for and type of surgical intervention (59). TUBS refers to *T*raumatic *U*nidirectional (anterior) instability. A *B*ankart lesion is usually present, and *S*urgery (a Bankart repair) is often necessary. AMBRI refers to the patient with *A*traumatic dislocation that is often *M*ultidirectional and *B*ilateral. *R*ehabilitation (rotator cuff strengthening) should be the initial treatment attempted. If this fails, surgery should address the *I*nferior capsule (an inferior capsular shift). While this classification system is very useful for patients at the two extremes of pathology, there is a large population of individuals who do not fit into these two categories and require additional evaluation prior to intervention.

ASSOCIATION WITH IMPINGEMENT SYNDROME

Glenohumeral instability and impingement syndrome may occur concurrently, especially in the athletic population (Fig. 15) (25, 28, 29, 44, 60–62).

These patients often present with a confusing clinical history and physical examination, showing components of both instability and impingement (15, 56). Because instability is actually the underlying disorder, the impingement component has been termed "secondary" impingement syndrome. It is important to recognize these individuals with secondary impingement in order to ensure that therapy and surgical intervention address the appropriate lesion.

Several theories have been proposed to explain this complex of instability and impingement syndrome. Some authors feel that in the patient with multidirectional instability, subluxation may occur superiorly in addition to the usual anterior, inferior, and posterior directions. This would result in compression of the supraspinatus tendon between the coracoacromial arch and the humeral head and cause a symptom complex identical to that of primary outlet impingement. Other theories stress the importance of the rotator cuff in shoulder stability. The rotator cuff muscles serve to help stabilize the shoulder, but in addition, they also act to decelerate the shoulder (37). If the rotator cuff muscles are stretched and have a diminished ability to supply compressive forces to the joint during deceleration, static restraints will fail, resulting in excessive translation of the glenohumeral joint (22, 61-63).

THE SLAP LESION

Isolated labral tears may be found in the anterosuperior portion of the labrum at the attachment of the tendon of the long head of the biceps (Fig. 16). The term "SLAP lesion" has been applied to these tears, a reflection of the location (*Superior Labrum*) and direction of propagation of the tear (*Anterior and Posterior*) (64). SLAP lesions are felt to be secondary to stress placed on the labrum by the attachment of the long head of the biceps tendon either during repetitive throwing movements (27, 31, 40, 62) or a single traction injury (64). The SLAP lesion may also result from a compressive force such as a fall onto an outstretched arm (64) where the labrum and biceps tendon are pinched between the humeral head and the glenoid.

Patients with a SLAP lesion usually complain of pain that is often exacerbated by overhead or throwing activity, painful "catching" or a popping sensation, and a sensation of instability although the joint appears stable with physical examination (62, 64). Although the SLAP lesion does not result from instabil-

ity, the glenohumeral joint may subsequently become unstable if the lesion propagates around the joint.

MR ARTHROGRAPHY

Prior to MRI, computed arthrotomography (the CT arthrogram) was extensively used to evaluate labral and capsular pathology associated with glenohumeral instability. While CT arthrography has been shown to be accurate (28, 29, 52, 65-70) and many centers continue to use this modality, MRI with or without arthrography is now also being used for this purpose. Studies have shown a high positive correlation between CT arthrography and MRI (1, 26, 70), and the choice of which modality to use should be dictated by the experience of the individual responsible for image acquisition and interpretation.

In the setting of an acute dislocation, intra-articular fluid and blood will usually cause sufficient joint distention for easy identification of labral pathology and Bankart lesions. After the fluid has resolved, however, the avulsed labrum may rest adjacent to the underlying glenoid, and edema or hemorrhage in the subscapularis musculotendinous unit may not be evident (Fig. 17). In this setting, MR arthrography may enhance the diagnostic information available from a scan by separating the soft-tissue structures (Fig. 18). Both saline and gadolinium (Gd) have been used for MR arthrography. Most individuals feel that saline is sufficient and does not carry the possibility of side effects that may be associated with intra-articular injection of Gd.

CONCLUSION

In summary, MRI is an effective means to evaluate the unstable glenohumeral joint. If imaging can be accomplished in the immediate period following dislocation, Bankart lesions are readily identified and surgical intervention can be planned. If the patient has never experienced a frank dislocation or if the dislocation is more remote, saline injection into the joint may assist in the diagnosis. Because of the association of instability and impingement syndrome, MR imaging of the painful shoulder should always include imaging in both the axial and coronal oblique planes.

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