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# Labrocapsular Ligamentous Complex of the Shoulder: Normal Anatomy, Anatomic Variation, and Pitfalls of MR Imaging and MR Arthrography<sup>1</sup>

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Magnetic resonance (MR) imaging is a useful modality for evaluating the labrocapsular ligamentous complex (LCLC) of the shoulder. MR arthrography is an important and occasionally indispensable supplementary modality for accurate differentiation between normal and deranged glenohumeral joints. Because of the joint distention that occurs during MR arthrography, it is especially helpful in detecting subtle capsular derangement, as occurs in patients with atraumatic instability. Also, some of the pitfalls associated with MR imaging of the LCLC are less likely to occur with MR arthrography. Radiologists should look for several key abnormalities when evaluating MR images of the shoulder: an anterior or posterior Bankart lesion; a Hill-Sachs defect; a tear of the rotator cuff, glenoid labrum, or superior labrum-biceps tendon attachment; and loose bodies. Knowledge of normal anatomy, normal variations, and pitfalls in image interpretation related to evaluation of the LCLC will help the radiologist accurately detect debilitating derangements associated with glenohumeral instability.

**Abbreviations:** FSE = fast spin echo, LCLC = labrocapsular ligamentous complex, MPGR = multiplanar gradient recalled, SE = spin echo, SLAP = superior labrum, anterior and posterior

**Index terms:** Shoulder, abnormalities, 414.42 • Shoulder, anatomy, 414.13, 414.92 • Shoulder, arthrography, 414.12149 • Shoulder, injuries, 414.481 • Shoulder, MR, 414.1214

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## ■ INTRODUCTION

Shoulder instability is a debilitating condition that primarily affects young, active people. Magnetic resonance (MR) imaging has emerged as an important modality for imaging the labro-capsular ligamentous complex (LCLC) of the shoulder. Knowledge of the normal anatomy of this region, anatomic variations, and imaging pitfalls will help prevent errors in diagnosis of LCLC lesions.

Glenohumeral instability has multiple causes that can be divided into two major categories: traumatic and atraumatic (1). In the former, an acute, traumatic anterior dislocation is the initial event. These patients often develop recurrent unidirectional instability. Cases of atraumatic instability may have various underlying causes, but all share several common features (1,2): The instability is not associated with a single major event but may be congenital or due to repetitive microtrauma. It is often multidirectional and may be bilateral. The symptoms may be vague pain or perceived weakness rather than a sensation of instability.

Identifying and separating these groups has important implications in management of patients with glenohumeral instability. A Bankart-type repair is usually preferred for treatment of traumatic, unidirectional instability (1). The initial treatment modality for atraumatic instability is physical therapy and rehabilitation. If surgery is required, an inferior capsular shift to treat multidirectional instability or subacromial decompression to relieve secondary rotator cuff impingement is usually indicated.

Preoperative imaging is not always required for evaluation of instability, but certain patients may benefit from MR imaging evaluation. These include patients with multidirectional instability, symptoms of concomitant rotator cuff disease (secondary impingement), or an equivocal history or physical examination results. Elite athletes who engage in strenuous overhead overuse activities such as swimming, throwing, or gymnastics often present a particular diagnostic challenge. Although they may have no history of dislocation, physical examination may elicit evidence of both glenohumeral instability and supraspinous tendon impingement. The radiologist should look for several key abnormalities when evaluating the MR images. The abnormalities of greatest interest to the referring physician include an anterior or posterior Bankart lesion, Hill-Sachs defect, rotator cuff tear, glenoid labral tear, superior labrum-

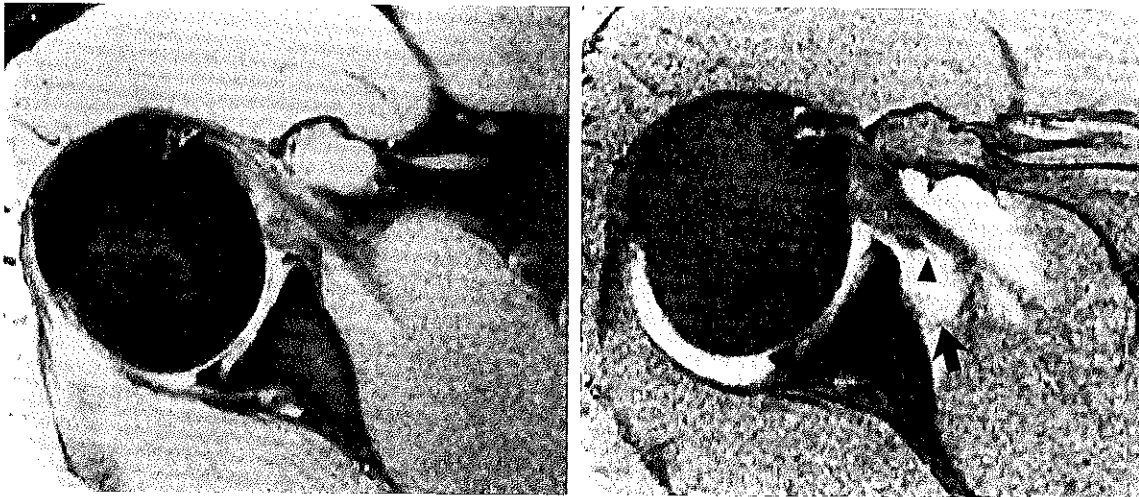
biceps tendon attachment tear (superior labrum, anterior and posterior [SLAP] lesion), and loose bodies. A full discussion of imaging of the abnormalities of glenohumeral instability is beyond the scope of this article, but a brief introduction is included.

## ■ MR IMAGING AND MR ARTHROGRAPHY

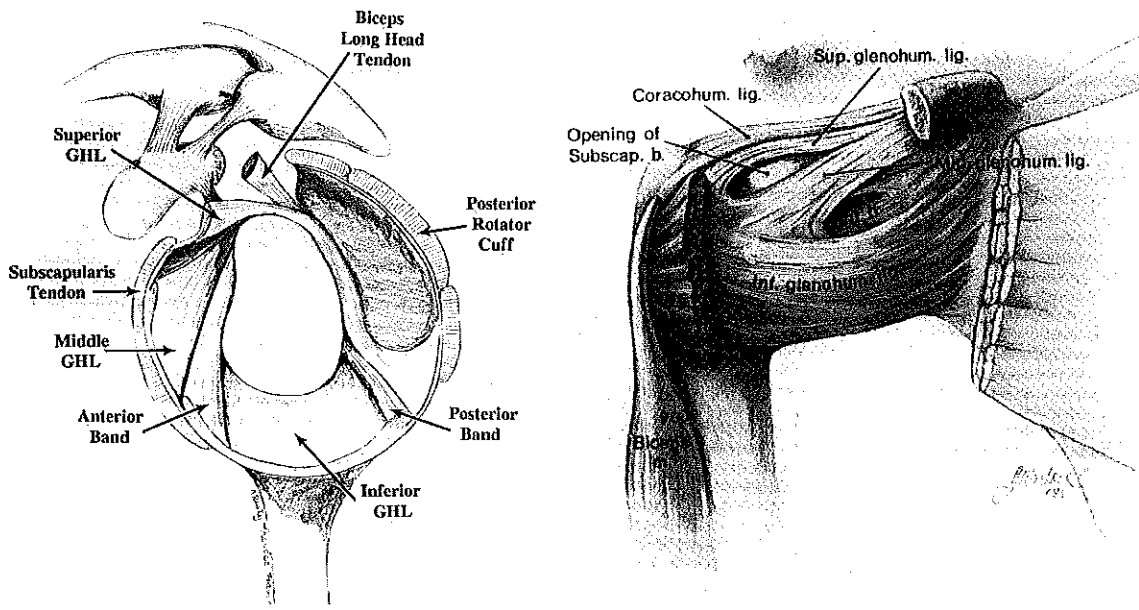
MR arthrography should be considered a complementary procedure to shoulder MR imaging. We reserve MR arthrography for cases in which surgery is being considered for clinically significant glenohumeral instability and identification of additional abnormalities may alter the treatment plan. We find MR arthrography especially useful in patients with atraumatic instability. Without adequate distention of the joint capsule, the subtle Bankart lesions and capsular abnormalities that are often present in these patients may not be evident. In these cases, the information derived from MR arthrography is superior to that derived from MR imaging without joint distention (Fig 1).

Arthrography should be performed immediately before the MR imaging portion of the examination. Either gadolinium or saline may be used for intraarticular contrast enhancement, although the U.S. Food and Drug Administration has not yet approved gadolinium for this purpose (3). In our experience, saline-enhanced MR arthrography and gadolinium-enhanced MR arthrography are both effective. Saline-enhanced MR arthrography does not require institutional review board approval or informed consent from the patient for use of an investigational drug. MR arthrography is performed by using fluoroscopic guidance. Intraarticular positioning of the needle is confirmed with a small amount of iodinated contrast material. Fifteen to 40 mL of contrast material are then injected. Patients undergoing MR arthrography may have capacious joint cavities, and large amounts of contrast material are often required for adequate distention.

We use the same imaging protocol for routine MR imaging and MR arthrography with saline contrast material. Our standard imaging protocol includes coronal oblique, axial, and sagittal oblique T2-weighted images and an axial gradient-echo sequence. The axial sequences are most valuable for evaluating Bankart lesions and most labral injuries. Coronal oblique and sagittal oblique images best depict the rotator cuff and supraspinous muscle outlet. Coronal oblique and axial images are used to evaluate the attachment of the tendon of the long head of the biceps muscle and the superior labrum.



**Figure 1.** (a) On an axial multiplanar gradient-recalled (MPGR) image (500/10 [repetition time msec/echo time msec], 30° flip angle) obtained before injection of contrast material, labral attenuation and irregularity of the glenoid capsular attachment are suggested. (b) On an axial MPGR image (500/10, 30° flip angle) obtained after injection of contrast material, stripping of the anterior capsule (arrow) and an incompetent middle glenohumeral ligament (arrowhead) are clearly demonstrated.



**Figure 2.** Drawings of the LCLC from the lateral (a) and anterior (b) perspectives. (Figure 2b reprinted, with permission, from reference 5.) In a, *GHL* = glenohumeral ligament; in b, *lig.* = ligament, *b.* = band, *m.* = muscle, *Sup.* = superior, *Mid.* = middle, *Inf.* = inferior, *Subscap.* = subscapular, *Coracohum.* = coracohumeral, *glenohum.* = glenohumeral.

**ANATOMY OF THE LCLC**

The anterior LCLC is composed of the anterior labrum and glenoid fossa, anterior capsule, anterior glenohumeral ligaments, and subscapular musculotendinous unit (4,5). The posterior LCLC is composed of the posterior labrum and glenoid fossa, the posterior capsule and poste-

rior portion of the inferior glenohumeral ligament, and the posterior rotator cuff muscles and tendons (Fig 2). Injury to any of these structures may contribute to glenohumeral instability.

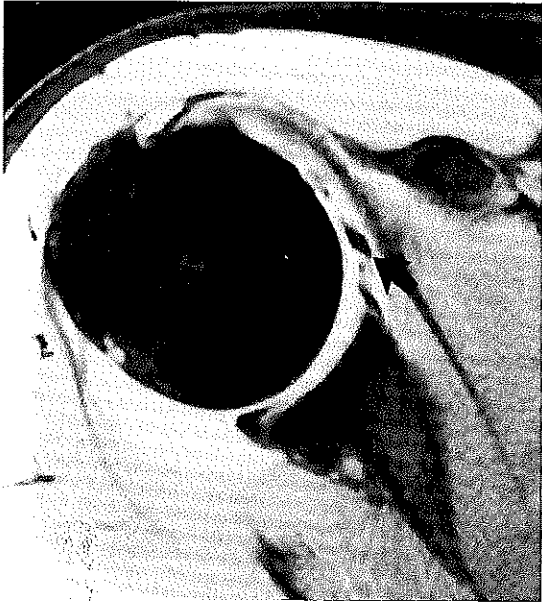


**Figure 3.** Axial (1,800/70) (a), coronal oblique (1,800/70) (b, c), and sagittal oblique (500/15) (d) spin-echo (SE) images show the superior glenohumeral ligament (solid arrow in a and b) and coracohumeral ligament (arrowhead in c and d). The tendon of the long head of the biceps muscle (open arrow in b) is also shown.

The superior, middle, and inferior glenohumeral ligaments are focal thickenings of the anterior joint capsule that form a "Z," with the middle glenohumeral ligament as the oblique band (Fig 2b) (5). The superior glenohumeral ligament extends from the superior glenoid fossa—just anterior to the origin of the tendon of the long head of the biceps muscle—to the lesser tuberosity, where it blends with the coracohumeral ligament (Fig 3a, 3b). The coracohumeral ligament originates from the lateral margin of the coracoid process and blends with the transverse humeral ligament as it crosses the upper aspect of the bicipital groove (Fig 3c,

3d). The coracohumeral ligament and superior glenohumeral ligament are minor contributors to the stability of the abducted glenohumeral joint (1). The superior glenohumeral ligament may have a more important role in the stability of the adducted shoulder (6).

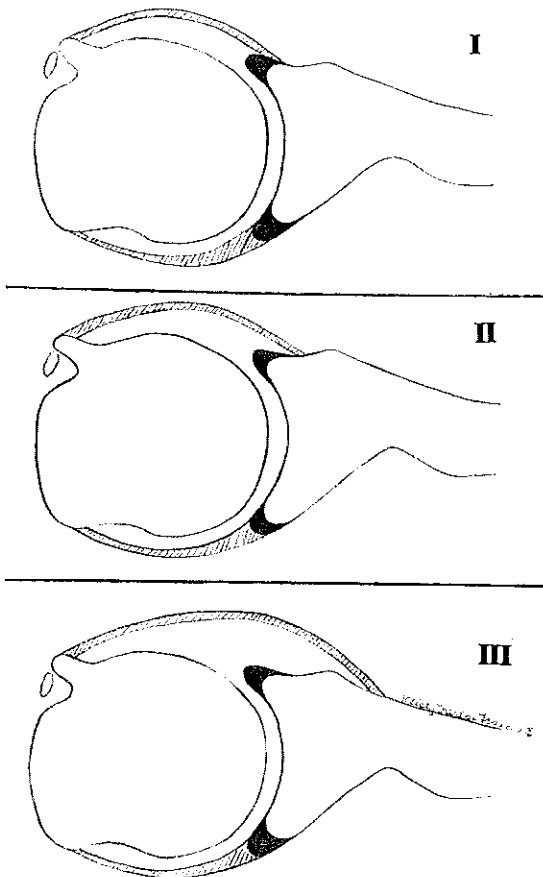
The middle glenohumeral ligament is the most variable glenohumeral ligament in both size and constancy (5). It may originate from the labrum or neck of the glenoid fossa, and it courses deep to the subscapular tendon to blend and insert with the posterior aspect of this tendon at the base of the lesser tuberosity (Fig 4). The middle glenohumeral ligament may be attenuated or absent in up to 30% of shoulders (1). It is an important secondary stabilizer of the glenohumeral joint, particularly when



**Figure 4.** Axial MPGR image (400/10, 30° flip angle) shows the middle glenohumeral ligament (arrow) between the anterior labrum and subscapular tendon.



**Figure 6.** Axial fast SE (FSE) image (3,000/90) shows the anterior labral attachment site of the normal inferior glenohumeral ligament (arrow).

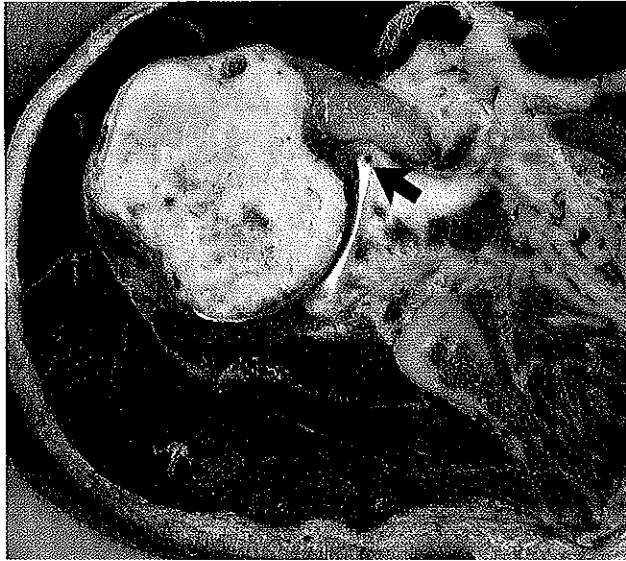


**Figure 5.** Drawings of the normal variations of the anterior capsular attachment. *I* = type I, *II* = type II, *III* = type III.

the humerus is at 45° of abduction and externally rotated. The middle glenohumeral ligament is frequently injured during anterior glenohumeral dislocations.

The variable origins of the middle glenohumeral ligament and anterior capsule have been classified into three types (Fig 5) (1,7). In our opinion, it is only when the joint is distended that these different types can be differentiated. The type I capsule is the most common (75% of cases). It may either attach at the labral tip or blend with the labrum near the base. The type II capsule attaches to the glenoid fossa within a short distance of the labral base. The type III capsule attaches more medially along the scapular neck and may predispose to instability (7). We believe that a large anterior pouch (congenital or acquired) or an anterior capsular tear that has healed may appear identical to a type III capsule.

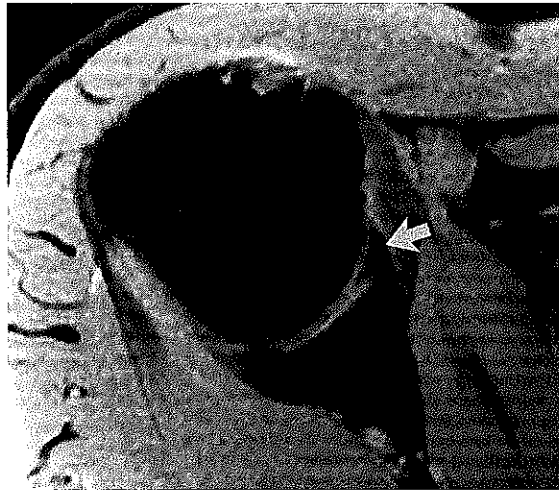
The inferior glenohumeral ligament is the primary shoulder stabilizer beyond 60° of abduction (5). It is considered the most important single component of the LCLC for maintaining glenohumeral stability. The inferior glenohumeral ligament originates from the entire inferior glenoid labrum and inserts along the inferior anatomic humeral neck. It is inseparable from the labrum and adjacent glenoid fossa (Fig 6). The inferior glenohumeral ligament is composed of focal anterior and posterior bands and forms an inferior recess (the axillary pouch) (Fig 2a).



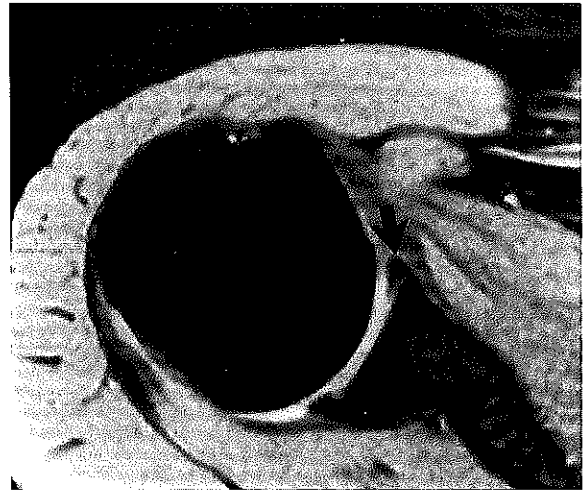
7a.



7b.



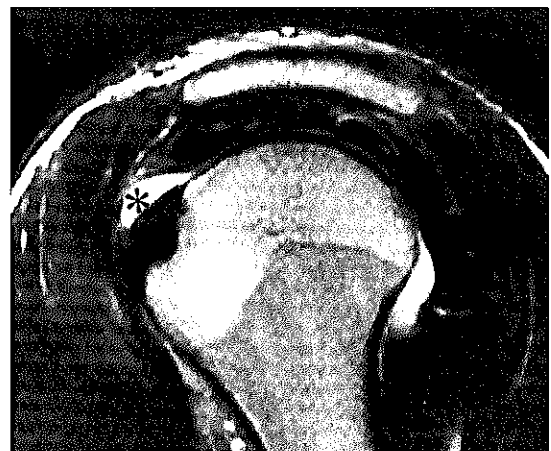
8a.



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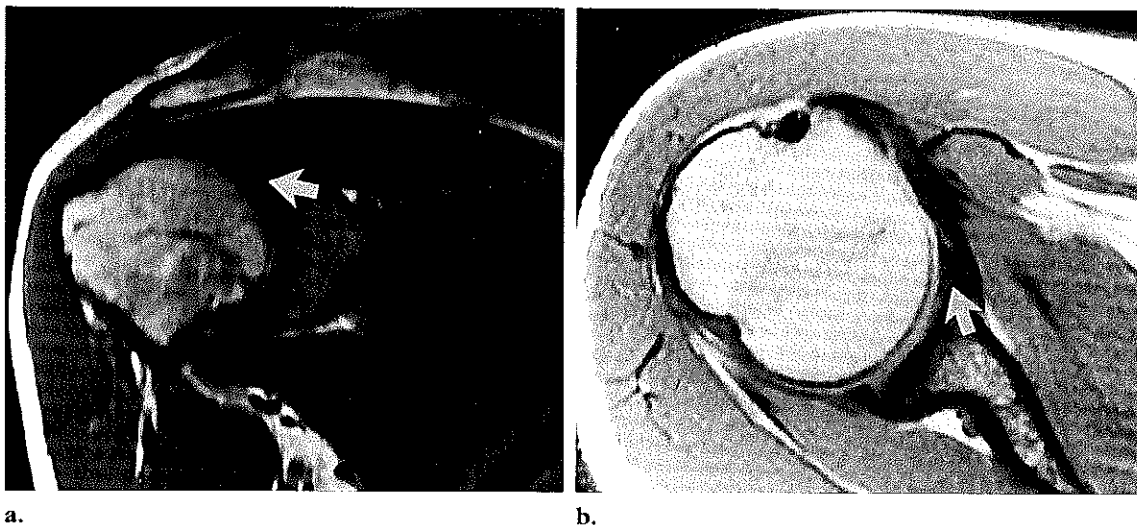
**Figures 7, 8.** (7) Cadaveric sections in the axial (a) and coronal (b) planes show hyaline cartilage (arrow) undercutting the labrum and completely covering the articular surface of the glenoid fossa. (8) Axial MPGR images (550/10, 30° flip angle) show two of the shapes of the fibrous labrum (arrow) in cross section: triangular (a) and round (b).

The glenoid fossa is covered with hyaline cartilage (Fig 7) and is shallow in relation to the humeral head. The fibrous labrum deepens and enlarges the glenoid fossa (7). The labrum may have a variable appearance on cross-sectional images, being triangular, rounded, crescentic, thinned, or absent (Fig 8) (8-14). We have not found notching or cleavages to be common variations. A thinned or absent labrum may reflect aging or osteoarthritis or may be associated with recurrent subluxation or dislocation (8,13).



**Figure 9.** Sagittal oblique FSE image (2,000/85) shows joint fluid in the rotator cuff interval (\*).





**Figure 10.** Coronal oblique (1,800/15) (a) and axial (1,500/15) (b) SE images show articular cartilage (arrow) undercutting the labrum. This appearance may mimic that of a labral tear.



**Figure 11.** Axial SE image (2,200/15) shows normal flattening of the humeral head near the junction with the shaft (arrow), a finding that simulates a Hill-Sachs deformity.

A number of normal recesses may be identified when the joint is filled with fluid. These include the subscapular recess, anterior and posterior pouches, axillary recess, and rotator cuff interval (Fig 9).

#### ■ IMAGING PITFALLS AND NORMAL VARIATIONS

A number of pitfalls in MR image interpretation and potentially confusing anatomic variations have been described, which may mimic the le-

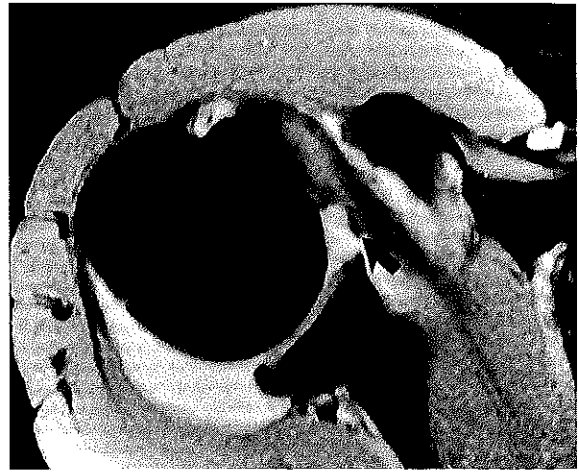
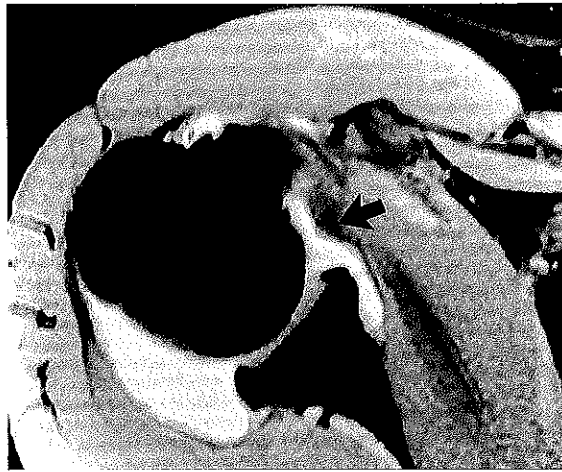
sions of glenohumeral instability (2,4,7-14). We have found that some of these pitfalls are less likely to occur with MR arthrography. We present some of our more challenging cases that illustrate potential shortcomings of MR imaging and MR arthrography.

The articular cartilage of the glenoid fossa undercuts the labrum and may be confused with a labral tear (Fig 10). A normal labral attachment can usually be identified at the periphery of the glenoid fossa. True labral tears will extend to the outer labral surface and are often seen on more than one image.

A normal flattening of the posterior humeral head occurs at its junction with the humeral shaft, and this appearance may simulate a Hill-Sachs deformity (15). This "pseudo-Hill-Sachs lesion" (Fig 11) occurs in the same general posterolateral position as a true Hill-Sachs lesion, but its location is more inferior. A true Hill-Sachs lesion is seen at or above the level of the tip of the coracoid process.

The middle glenohumeral ligament courses immediately adjacent to the anterior labrum and has similar signal intensity characteristics. As a consequence, the middle glenohumeral ligament may appear to represent a portion of the labrum, and a small amount of synovial fluid between these two structures may simulate a





a.  
**Figure 12.** Contiguous axial MPGR images (500/10, 30° flip angle) from inferior (a) to superior (c) show the middle glenohumeral ligament (arrow) simulating a labral tear as it passes near the anterior labrum.

labral tear (Fig 12) (2). In the nondistended joint, the middle glenohumeral ligament can usually be identified by observing its oblique course on consecutive images. When the joint capsule is distended, the middle glenohumeral ligament is usually displaced away from the labrum.

Multiple synovial folds in the axillary pouch and elsewhere in the shoulder joint may resemble loose bodies (Fig 13). Their multiplicity and uniformly small size provide clues to their true identity. Loose bodies are usually larger, may be visible on radiographs, and may be identified by means of enhanced magnetic susceptibility on gradient-echo images.

During MR arthrography, injected fluid may lift the central portion of the superior labrum from the underlying articular cartilage, simulating a superior labral detachment (Fig 14). If this is the case, a normal labral attachment should be

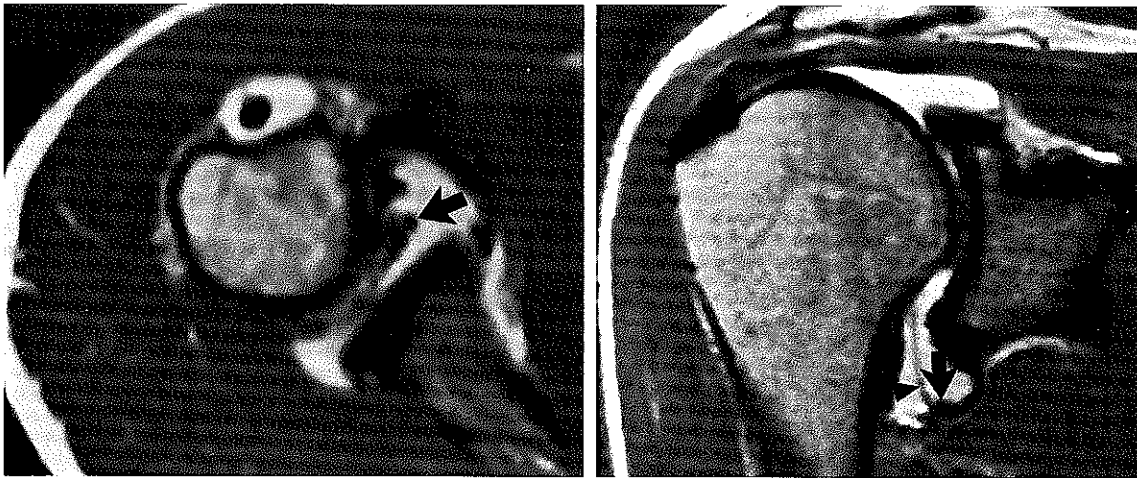
b.



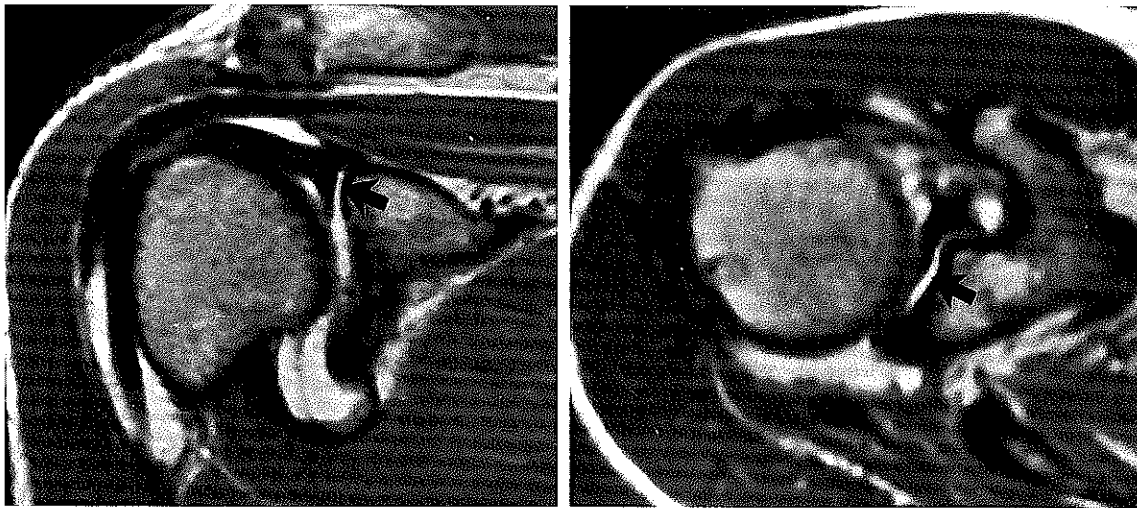
c.

present peripherally, and a normal tendon of the long head of the biceps muscle should be seen on adjacent images.

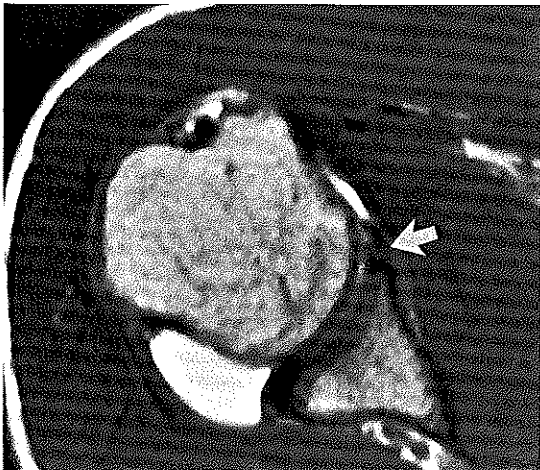
The inferior glenohumeral ligament attaches directly on the labrum. Occasionally, an unexplained focus of increased signal intensity may be seen near this attachment (Fig 15). This focus may represent partial volume averaging. Joint fluid within this interval would indicate a Bankart lesion. A tear with fibrosis and scarring might have an appearance similar to that in Figure 15, and evaluation of adjacent images is required to exclude a tear.



a. b.  
**Figure 13.** Axial (500/25) (a) and coronal oblique (2,000/30) (b) gadolinium-enhanced SE images show synovial folds (arrow) in the axillary recess, simulating loose bodies. The inferior glenohumeral ligament (arrowhead in b) is also seen.



a. b.  
**Figure 14.** Coronal oblique (2,000/30) (a) and axial (500/25) (b) gadolinium-enhanced SE images show joint fluid (arrow) interposed between the labrum and articular cartilage, a normal finding that may be confused with a superior labral detachment.



**Figure 15.** Gadolinium-enhanced axial SE image (350/25) shows increased signal intensity (arrow) near the inferior glenohumeral ligament attachment; fluid does not enter this interval. This appearance simulates that of a tear with fibrosis and scarring.



17.



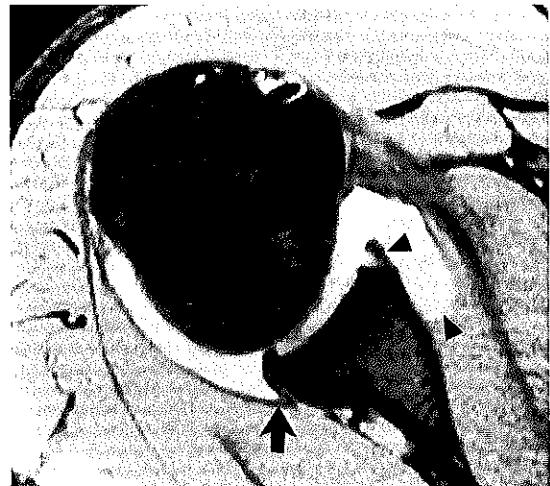
18.

**Figures 17, 18.** (17) Axial FSE image (2,500/84) of a competitive swimmer who experienced shoulder pain shows an enlarged anterior pouch (arrow). It was not clear whether this abnormality was a component of instability or was vital to the patient's high-level performance. No secondary signs of instability were identified. (18) Axial FSE image (3,000/90) of a 21-year-old competitive swimmer, who presented with pain and instability but no history of dislocation, shows a surgically proved spacious anterior capsule (arrow) with a type I attachment.

Posterior capsular abnormalities are not uncommon in patients with either traumatic or atraumatic instability (1). Normally, the posterior capsule inserts directly into the apex of the posterior labrum. Figure 16 illustrates a posterior capsule that appears to insert at the labral base. The patient had recently experienced an acute traumatic dislocation. We are not certain whether the findings in this case reflect our inability to resolve the capsular insertion or represent a pathologic condition. Similar posterior capsular attachments have been noted in several cases evaluated with MR arthrography, and we suspect that this may be a normal finding in a distended joint.

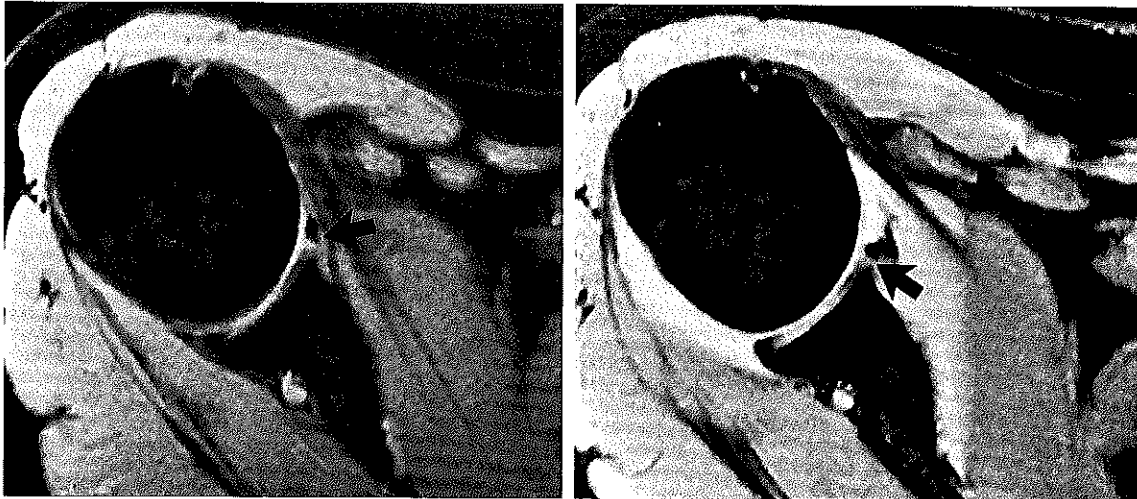
A prominent anterior or posterior pouch may be seen as a normal variation in an asymptomatic individual. These enlarged pouches may also represent the primary capsular abnormality in a patient with atraumatic instability (Figs 17, 18). Supportive secondary signs of instability such as a Hill-Sachs-equivalent lesion or Bankart lesion may help identify the latter group of patients.

Figure 18 is an image from the MR arthrographic examination of the shoulder of a 21-year-old competitive swimmer. She presented with impingement-type shoulder pain and anterior instability but had no history of dislocation. The capsule appeared to attach medially along the neck of the glenoid fossa, suggesting either

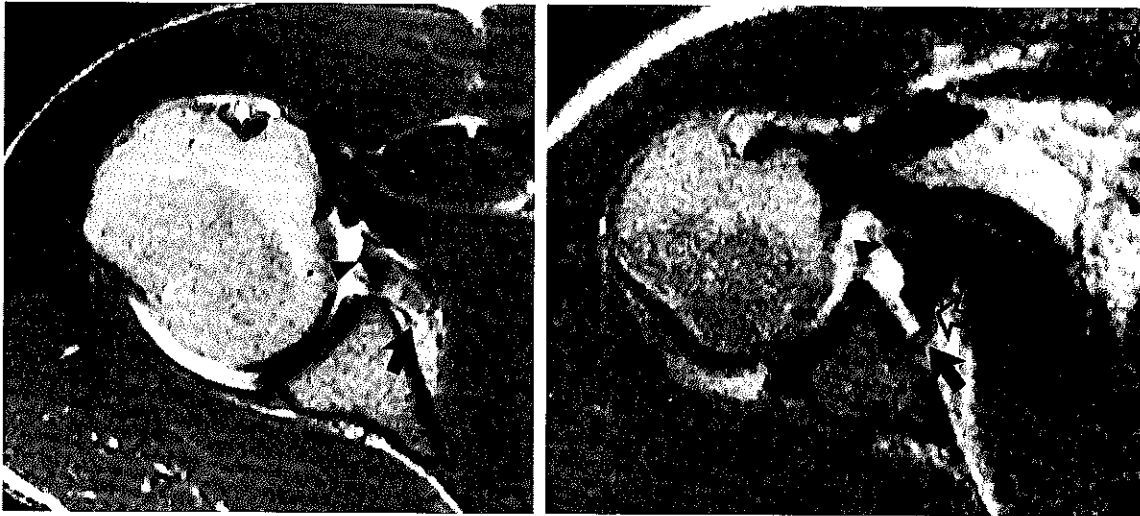


**Figure 16.** On an axial MPGR image (400/10, 30° flip angle), the posterior capsule appears to attach to the glenoid fossa (arrow) rather than the labrum; this may be a normal finding in a distended joint. A Bankart lesion is noted anteriorly (arrowheads).

chronic anterior capsular stripping or a type III capsular insertion, either of which might contribute to instability. At arthroscopy, the capsule appeared to attach normally on the anterior labrum (type I attachment), and the anterior pouch was markedly capacious. Since this patient relied on excessive laxity of the glenohumeral joint for athletic proficiency, she was treated with subacromial decompression and rehabilitation rather than capsular plication. Commonly, the redundancy of the anterior cap-



a. **Figure 19.** Precontrast (a) and postcontrast (b) axial MPGR images (400/10, 30° flip angle) show an apparently torn anterior labrum (arrow). No labral tear was identified at arthroscopy.



a. **Figure 20.** Axial SE images (1,500/70) show the characteristic features of Bankart lesions (a) and Bankart fractures (b): stripping of the anteroinferior capsule (solid arrow) and avulsion of the anterior labrum (arrowhead). In the lesion shown in b, a portion of the glenoid fossa (open arrow) is displaced with the labrum.

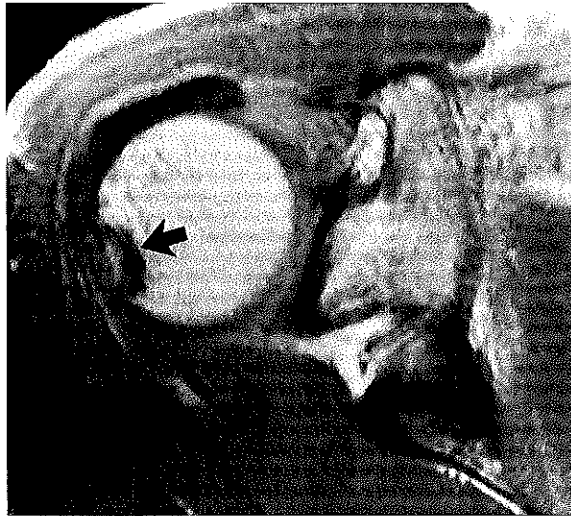
sule may obscure the true capsular attachment in a nondistended joint. Occasionally, the attachment site of a capacious anterior capsule may remain obscured despite adequate joint distention.

The base of the anterior labrum appears separated from the rim of the glenoid fossa on the pre- and postcontrast images shown in Figure 19. At arthroscopy, the labral attachment was not detached, and no capsular abnormalities suggesting a Bankart lesion were identified. This case shows that MR imaging and MR arthrography may not always enable one to differ-

entiate articular cartilage or a labral foramen from a detached labrum, unless there is adequate displacement of the labrum from the rim of the glenoid fossa (16).

#### ■ CLINICAL QUESTIONS AND CRITICAL LESIONS

The Bankart lesion is the cardinal lesion of traumatic anterior dislocation (1,17). It consists of detachment of the capsule, inferior glenohu-

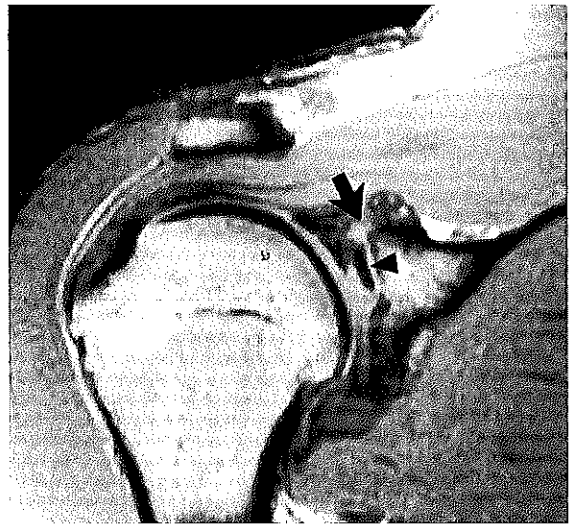


21.

**Figures 21–23.** (21) Axial SE image (1,700/15) shows a Hill-Sachs lesion (arrow) that resulted from a traumatic anterior dislocation. The defect of the posterolateral humeral head is at the level of the coracoid process. (22) Axial FSE image (2,500/90) shows fluid beneath the posterior labrum (arrow), consistent with a labral tear or avulsion. This abnormality is an important indicator of the full extent of the posterior capsular derangement in this patient with multidirectional instability. (23) Coronal oblique SE image (1,800/15) of a competitive gymnast shows an advanced SLAP lesion. Partial avulsion of the origin of the tendon of the long head of the biceps muscle (arrow) is accompanied by a bucket-handle tear of the superior labrum (arrowhead), which is displaced into the joint.



22.



23.

meral ligament, and labrum from the anterior glenoid fossa and stripping of the periosteum from the anterior scapula (Fig 20). Although classically associated with traumatic instability, the Bankart lesion may also be found in patients with atraumatic instability. Additional structural abnormalities of instability may include a redundant inferior capsule, stretching of the joint capsule, and avulsion of the subscapular tendon. The rim of the glenoid fossa may be fractured in traumatic dislocation, the so-called bony Bankart lesion or Bankart fracture (Fig 20b) (18).

The Hill-Sachs lesion, an impacted fracture of the posterosuperior humeral head, is strong evidence of a previous dislocation (Fig 21) (15). Hill-Sachs defects larger than 50% of the articular surface of the humeral head may alter the surgical treatment plan. In our experience, patients with atraumatic instability and no history of frank dislocation often have marrow edema

or subchondral sclerosis in a location that suggests a Hill-Sachs-equivalent lesion.

Bankart (17) considered the labral avulsion, tear, or attenuation that accompanies glenohumeral dislocation to be of secondary importance. It is now thought that assessment of the integrity of the labrum is one of the most important steps in determining the integrity of the capsular ligaments (Fig 22) (1). Labral tears may also be a source of pain; this is referred to as functional instability (1). Such tears are often surgically repaired along with the capsule and ligaments. Injuries of the superior labrum and the tendinous origin of the long head of the biceps muscle are known as SLAP lesions (Fig 23). SLAP lesions are thought to occur after an acute compression or traction injury (19–21). In some instances, labral tears and SLAP lesions are important contributors to or causes of gle-

nohumeral instability. We believe, however, that most labral tears and SLAP lesions are caused by or represent sequelae of glenohumeral instability and, as such, are important imaging signs of derangement of the more important capsular structures.

## ■ CONCLUSION

MR imaging and MR arthrography are useful in evaluating the LCLC of the shoulder. MR arthrography is especially helpful in detecting subtle capsular derangement. Knowledge of normal anatomy, normal variations, and pitfalls in image interpretation related to evaluation of the LCLC will help the radiologist accurately detect debilitating derangements associated with glenohumeral instability.

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