Learning objectives

1. To illustrate the normal anatomy including normal variants seen on MR arthrography of the shoulder.
2. To understand the difference between normal variants and pathology.
3. To illustrate the appearance of some of the pathology encountered on this examination.

Background

Use of MR Arthrography to investigate instability of the shoulder is widespread. This is primarily to evaluate the glenoid labrum and glenohumeral ligaments. Normal anatomy or anatomic variations can lead to interpretive errors in those new to the technique or the unwary. Ultrasound is now the technique of choice for evaluating tendon and muscle pathology along with impingement, but these conditions can coexist in patients with impingement and the understanding of the pathological MR findings in these conditions is also important in this group of patients.

Imaging findings OR Procedure details

MR arthrographic technique

Injection

Injection into the shoulder joint is an aseptic procedure usually performed under fluoroscopic guidance. Ultrasound may also be used to guide injection. Many operators prefer a posterior approach as the needle is then in no danger of causing misinterpretation around the anterior labrum where most pathology lies.

Another common site of injection is the rotator interval anteriorly - the site of the anterior port in shoulder arthroscopy (Fig 2). Iodinated contrast media may be used to confirm needle position prior to injection of approximately 10-12mls of dilute gadolinium (although this does dilute the ready prepared gadolinium) .

MR sequences
In our institution all MR arthrograms are imaged on a 1.5T MR scanner with a dedicated shoulder coil to improve resolution. The standard sequences are T1 fat saturated images in axial and coronal oblique planes, PD fat sat coronal oblique and T1 without fat sat sag oblique to assess muscle atrophy.

ABER position is also used to help assess the labrum, particularly in suspected SLAP tears or Bankhart lesions.

**Review of MR arthrographic Anatomy:**

**Rotator Cuff muscles:**

The four rotator cuff muscles are the subscapularis, supraspinatus, infraspinatus, and teres minor. (Fig 1) The subscapularis inserts in the lesser tuberosity and the latter three insert into the greater tuberosity. The tendons actually fan out and interdigitate with each other making particularly supraspinatus and infraspinatus difficult to differentiate from each other.²³

The supraspinatus tendon runs between the undersurface of the acromion and the top of the humeral head primarily filling the subacromial space on a radiograph of the shoulder.

Tendons are normally low signal intensity on all pulse sequences, but can be subject to magic angle artifact (particularly supraspinatus).⁴

The supraspinatus and infraspinatus can be seen well in the coronal oblique plane. (Fig 3,4) The subscapularis tendon and muscle can be shown best on axial images. (Fig 5) On sagittal oblique images, the tendons of the supraspinatus, infraspinatus, teres minor, and most proximal portion of the long head of the biceps, and the multiple tendon slips of the subscapularis all are imaged in cross section, surrounded by their associated muscles. (Fig 6)

Subscapularis tendon blends with the transverse ligament at its insertion. This ligament crosses between the lesser tuberosity and the greater tuberosity and holds the long head of biceps tendon (LHB) in its groove.

The LHB inserts into the superior labrum leading to the so called bicipito-labral complex or biceps anchor. It then runs in the bicipital groove and is cut transversely on axial images seen as a round or oval structure.
A small amount of fluid may be seen normally in the LHB tendon sheath as this communicates with the shoulder joint.

The rotator interval is a triangular space between subscapularis and supraspinatus and LHB tendon passes through this as it enters the joint. This can be a site of tears, but it can be lax as a variant and also post arthroscopy as it is used as the site for anterior ports.

**Coraco-Acromial arch:**

The coraco-acromial arch is formed by the coracoid process the acromion and the intervening coraco-acromial ligament. The underlying structures are the subacromial subdeltoid bursa, supraspinatus tendon/muscle and the LHB tendon.

It is debated whether or not acromial shape primarily causes impingement syndromes, but three types of acromial shape are usually described:

1) Curved - Most common.
2) Flat
3) Flat with a marginal hook - most common shape found in patients with impingement.

Normally, the lateral aspect of the acromion is oriented nearly horizontal or slopes downward posteriorly on sagittal oblique images. Sloping of the acromion in either direction or the normal variant of os acromiale can be seen in patients with impingement.

The coraco-acromial ligament restricts anterior and superior motion of the humeral head and overlying tendons. This can become thickened and/or calcified and contribute to impingement.

Subacromial subdeltoid bursa lies beneath the bony structures and is not usually seen on MR arthrography unless distended with fluid or contains contrast which has passed through a full thickness cuff tear.

**The Labrum:**

The labrum is a fibrocartilaginous tissue that attaches to the rim of the glenoid of the scapula. It deepens the glenoid fossa and is the attachment site for the long head of the
biceps tendon and of the glenohumeral ligaments. Frequently there is a rim of hyaline cartilage between the fibrocartilage and the glenoid which returns slightly higher signal and should not be mistaken for a tear.

The normal labrum is usually triangular in shape on the cross sectional images. (Fig 8,9,10)

There are labral variants which one should be aware of. The location of these is key to correct interpretation. Using the clock face analogy (3 anterior and 9 posterior whichever shoulder is being described) all the normal variants occur between 1-3 o'clock.

1) Sublabral foramen - Anterosuperior labrum not attached to glenoid (Fig 11,12)

2) Buford complex - Anterosuperior labrum congenitally absent, thick middle glenohumeral ligament. (Fig 13,14)

3) Sublabral recess - Sublabral recess does not extend posterior to the biceps attachment, this is in contrast to a SLAP lesion which does.)²,³,⁴ (Fig 15,16)

**The Joint Capsule:**

Posteriorly the capsule always inserts into the posterior labrum.

Anteriorly three patterns are described:

1) Capsule inserts into the labrum.

2) Capsule inserts 1cm behind the labrum.

3) Inserts more than 2cms behind the labrum.

However, studies of cadavers have shown that capsule attachment is statistically similar between those with both clinically stable and unstable shoulders. Now this has little influence on identifying surgical candidates. Indeed, overdistension of the joint can make the anterior capsule appear to be lax.

The glenohumeral ligaments represent thickenings of the anterior joint capsule. The three ligaments are the superior (SGHL), middle(MGHL), and inferior(IGHL) glenohumeral ligaments. (Fig 16)
The SGHL arises from the superior glenoid tubercle and attaches to the superior aspect of the lesser tuberosity.

The MGHL is the most variable of the ligaments and is absent in up to 30%. It arises most frequently from just inferior to the SGHL and attaches to the medial aspect of the lesser tuberosity.

The IGHL is the main stabilising ligament with an anterior and a posterior band. They arise from the anteroinferior and posteroinferior 2/3 of the glenoid labrum and attach to the surgical neck of humerus.$^{2,3,4}$

**Pathology found in patients complaining of instability.**

**Bony Lesions:**

1) **Hill- Sachs defect** - results following an anterior dislocation and is an acquired osseous abnormality from an impaction fracture on the posterolateral aspect of the humeral head. Best seen on axial MRIs on the two most superior images through the humeral head as a concave defect in the posterolateral aspect of the humeral head. This is pathognomonic of instability.$^{4}$ (Fig 18,19)

2) **Bankart fracture** - results following an anterior dislocation and is a fracture of the anteroinferior glenoid. This fracture can be shown best on axial and sagittal oblique images.$^{4}$ (Fig 18,20-24)

3) **Reverse Hill Sachs** - results from a posterior shoulder dislocation and is an impaction fracture of the anteromedial aspect of the humeral head. This gives rise to the trough sign on a shoulder radiograph.$^{4}$ (Fig 25)

4) **Reverse Bankart fracture** - fracture of posterior aspect of the glenoid.$^{4}$

**Labral lesions:**

The labrum may have partial-thickness or full-thickness tears or avulsed, crushed or frayed.

1) **Bankart lesion:** It is the most common injury following anterior dislocation. It is a detachment of the anteroinferior labrum (with or without labral tears) from the glenoid with a tear of the anterior scapular periosteum. It may or may not be associated with a fracture of the anteroinferior glenoid (Bankart fracture).$^{3,4}$
2) **ALPSA lesion:** Anterior labroligamentous periosteal sleeve avulsion is an avulsion of the anterior labrum from the anteroinferior glenoid with an intact anterior scapular periosteum that has been stripped from the bone (periosteal sleeve), but that remains attached to the labrum.\(^3\),\(^4\) (Fig 26, 27)

3) **SLAP lesion Superior labral anterior and posterior:** occur at the attachment site of the long head of biceps and is a term applied to tears involving the superior labrum that are oriented in an anterior and posterior direction. This gives patients a sensation of instability although the shoulder may appear stable on clinical testing. It can coexist with other abnormalities. (Fig 28)

4) **GLAD lesion Glenolabral articular disruption:** It is a nondisplaced anteroinferior labral tear with an associated chondral injury. (Fig 29)

5) **Labral cysts** can occasionally be seen in association with labral tears. These can cause pain and feeling of instability. When seen in the spinoglenoid notch they can cause compression of the suprascapular nerve and isolated infraspinatus muscle weakness. (Fig 30)

**Muscular tears:**

Muscular tears are not a cause of instability, but can coexist with other pathology. Rotator cuff tears are not uncommon following dislocation, particularly in the older age group:

1) **Complete supraspinatus tear:** It is seen as discontinuity of the tendon fibers and high signal gadolinium filling the gap between disrupted tendon fragments on T1W images. There is usually retraction of the tendon and muscle and there may be muscle belly atrophy.\(^3\),\(^4\) (Fig 31)

2) **Partial supraspinatus tear:** Most common tear. Normally the insertional fibers of the cuff on the greater tuberosity are disrupted from the bone. Undersurface partial tear: fills in with high signal intensity gadolinium solution. Partial-thickness tears: on the upper (bursal) surface of the tendon need to be evaluated similar to regular shoulder MRI without arthrography because gadolinium cannot enter the tear in that location. (Fig 32)

3) **Long Head of biceps pathology:** Contrast normally enters the LHB tendon sheath. LHB is torn in 7% of full thickness rotator cuff tears in this instance the sheath is empty.\(^4\)

Degeneration of the tendon can be seen with swelling and abnormal intermediate signal within the tendon.
In subluxation/dislocation the tendon can be seen to lie medial to the groove. This means that the transverse ligament is disrupted with or without a subscapularis tear. If the LHB tendon is dislocated and lies within the joint, then there must be a subscapularis tear. (Fig 33)

**TAKE HOME MESSAGE**

Labral anomalies are common and can easily be confused with pathology. If the clock face technique is used then interpretation of the perceived abnormality becomes easier.

Remember - 12 o'clock is superior and 3 o'clock is always anterior.

As a general rule:

Isolated 1 - 3 o'clock labral anomalies are normal variants.

SLAP lesions can extend into the 1-3 o'clock position (or even further), but always extend into the 9-12 o'clock position.

Bankhart and other anteroinferior lesions occur between 3 and 6 o'clock.

Reverse bankhart lesions occur 6 - 9 o'clock. (Fig 34)

**Images for this section:**
**Fig. 1:** Anatomy of Shoulder (Sagittal). SSc-Subscapularis, B-Biceps, SST-Supraspinatus, IST-Infraspinatus, T-Teres minor, SAB-Subacromial bursa. [2]

**Fig. 2:** Site of injection of the joint (Red cross)
Fig. 3: Coronal image showing the infraspinatus muscle (arrow)
Fig. 4: Coronal image showing the supraspinatus muscle (arrow)
Fig. 5: Axial image showing the subscapularis (red arrow) and biceps tendon in the bicipital groove (yellow arrow).
Fig. 6: Sagittal image. Subscapularis (Red dot), Suprspinatus (Blue dot), Infraspinatus and Teres minor (Purple dot). Glenoid (Yellow dot). Coracoid (Green dot) and Acromion (Orange dot).
Fig. 7: Anterior hook of the acromion (red arrow).
Fig. 8: Drawing showing the normal axial appearance of the glenoid.
Fig. 9: Normal glenoid labrum
Fig. 10: Normal appearance of the anterior labrum and the middle glenohumeral liagament(outlined in red)
Fig. 11: Sublabral foramen. Grey arrow.
Fig. 12: Axial image of Sublabral foramen (black arrow), Middle Glenohumeral ligament (red arrow), Subscapularis tendon (yellow arrow)
**Fig. 13:** Buford complex. The Antero-superior labrum is absent (red arrow), the middle glenohumeral ligament(yellow arrow) is seen to be thickened.
**Fig. 14**: Buford complex. Anterior-superior labrum is absent (arrow.)
Fig. 15: Sub labral recess (arrow).
Fig. 16: Sublabral recess (arrow), this does not extend posterior to the biceps attachment
**Fig. 17:** Diagram showing the glenohumeral ligaments. Yellow - Superior, Red - Middle and Green - Inferior glenohumeral ligament. Coracohumeral ligament - Orange.
Fig. 18: Coronal image. Red arrow shows the Hill Sachs lesion, associated Bankart lesion (yellow arrow).
Fig. 19: Hill Sachs lesion (red arrow)
Fig. 20: Labral Bankart. Tear of the labrum (red arrow), no bony avulsion.
Fig. 21: Bony Bankart. Labral tear (red arrow) along with bony injury (blue arrow).
Fig. 22: Axial slice showing the labral Bankart lesion (arrow).
Fig. 23: Bony bankart (arrow)
**Fig. 24:** Axial CT of the same patient. Bony defect(arrow).
**Fig. 25:** Reverse Hill Sach's (yellow arrow) showing the defect in the anterio-inferior margin of the humeral head.
Fig. 26: Drawing of an ALPSA lesion (green arrow). Note the intact periostem (red arrow).
Fig. 27: ALPSA, Axial image. Red Arrow showing an intact periosteum.
**Fig. 28:** SLAP lesion. The tear (red arrow) was seen to extend beyond the level of the biceps tendon (blue arrow) posteriorly.
**Fig. 29:** GLAD lesion. Nondisplaced anteroinferior labral tear with an associated chondral injury (arrow)
Fig. 30: Labral cyst (red arrow).
**Fig. 31:** Full thickness tear of the supraspinatus (red arrow) with contrast in the subacromial space. Retracted end of the tendon (yellow arrow).
**Fig. 32:** Increased signal intensity in the region of supraspinatus near its insertion (arrow) compatible with partial tear.
Fig. 33: The tendon of the long head of biceps is subluxed. Note the position of the tendon (arrow), medial to the bicipital groove.
**Fig. 34:** 1-3 o'clock labral anomalies are normal variants (Red curved arrows), 9-12 o'clock labral tears SLAP (green curved arrow), Reverse bankhart lesions occur 6-9 o'clock (orange arrow), Bankhart and other anteroinferior lesions occur between 3-6 o'clock (purple arrow).
Conclusion

To achieve accurate image interpretation, the Radiologist must be familiar with the appearances of normal anatomy and the typical imaging findings of pathology on MR arthrographic examination of the shoulder.

Personal Information

References


