

Magnetic Resonance Arthrography of the Labral-Ligamentous Complex of the Shoulder: An Update

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Abstract

Magnetic resonance (MR) arthrography is increasingly replacing conventional MR imaging for many clinical indications in the shoulder. It is particularly useful in providing additional information about structures which form the labral-ligamentous complex, an important stabiliser of the shoulder. These structures are the fibrocartilaginous glenoid labrum, the glenohumeral ligaments, and the long head of the biceps tendon. The MR arthrographic technique is reviewed, together with anatomical considerations, including normal variants, relating to the labral-ligamentous complex. Lesions such as glenoid labral tears, SLAP lesions, glenohumeral ligament tears, loose bodies and paraglenoid cysts can be demonstrated. In summary, MR arthrography is a useful imaging technique that provides detailed information about the labral-ligamentous complex, particularly when surgery is being contemplated.

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Introduction

Shoulder instability is a frequently encountered clinical problem in young active people following injury, particularly in athletes. The labral-ligamentous complex is increasingly recognised as being an important structural component that contributes to shoulder instability.¹⁻³ Magnetic resonance (MR) arthrography is a relatively new imaging technique that has been shown to be superior to radiographs, conventional arthrography, computed tomography (CT), CT arthrography and conventional MR imaging in the evaluation of structural changes affecting the shoulder.⁴⁻⁷ Currently, the major indications for MR arthrography are in assessment of rotator cuff injury and glenohumeral instability. MR arthrography is now regarded as being the best initial imaging investigation for evaluating instability.^{8,9} Unlike CT techniques, MR arthrographic images can be obtained in the axial, coronal and sagittal planes. Its advantages include lack of ionising radiation hazard, and superior soft tissue contrast and resolution. Through instillation of intra-articular contrast material, MR arthrography is much better than conventional MR imaging for depiction of internal joint structures, such as the labrum, various ligaments and loose bodies. Its ability to demonstrate subtle lesions of the labral-ligamentous

complex aids the surgeon in considering treatment options, especially arthroscopic repair.^{8,9} This clinical update reviews the techniques currently used in MR arthrography of the labral-ligamentous complex of the shoulder, relevant anatomical considerations, and clinical applications.

MR Arthrographic Techniques

MR arthrography may be performed indirectly or directly. The indirect method entails intravenous injection of a gadolinium chelate, such as gadopentetate dimeglumine (Gd-DTPA), while the direct method consists of an intra-articular injection of iodinated radiographic contrast agent, Gd-DTPA solution, normal saline or air. Indirect MR arthrography relies on the intravenously-injected Gd-DTPA diffusing from the capillary bed into the interstitial space of the synovium, and then into the joint space not only of the shoulder, but also in every joint in the body.^{10,11} The intravenous technique produces an arthrographic effect, with the signal intensity being dependent on the degree of synovial enhancement. Disadvantages of this technique are: poor synovial enhancement in non-inflamed joints, unpredictable joint distension, and extraneous enhancement of all vascularised structures such as areas of pericapsular or intra-articular inflammation and subchondral oedema.^{10,11}

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In general, large capacity joints, such as the shoulder, are less suited to indirect MR arthrography.

Direct MR arthrography, in which the contrast material is introduced intra-articularly, allows selective examination of the shoulder joint. Unlike the indirect method, there is controlled capsular distension and excellent depiction of the internal structures. Normal saline is not an ideal contrast medium as it has the same signal characteristics as pre-existing joint and subacromial fluid. This MR technique relies on T2-weighted sequences for acquisition of images, leading to a longer data acquisition time, greater risk of motion artifacts, and a reduced signal-to-noise ratio.¹² In direct MR arthrography, T1-weighted imaging sequences improve diagnostic accuracy by delineating intra-articular structures, differentiating partial from small full-thickness rotator cuff tears, and in the detection of articular-sided partial-thickness rotator cuff tears.^{8,9,13} Addition of T2-weighted sequences helps identify extra-articular fluid collections, and shows bone marrow lesions or peri-articular masses.⁸

The planes of imaging for MR arthrography are selected to best demonstrate the structures of interest. MR arthrography images are conventionally obtained with the shoulder in a neutral position. External rotation optimises visualisation of the biceps-labral complex, while abduction-external rotation is the best position for evaluating the inferior glenohumeral ligament and anterior capsular attachment.^{14,15} Additional of exercise during MR arthrography has neither a beneficial or detrimental effect upon image quality.¹⁶ Three-dimensional (3D) MR arthrography producing so-called “virtual MR arthroscopic” images have been described.^{17,18} Currently, diluted Gd-DTPA is the ideal contrast agent for MR arthrography.^{19,20} The amount of Gd-DTPA used is much less than for indirect (intravenous) arthrography.²¹ The optimal concentration of the Gd-DTPA solution for direct MR arthrography has been found to be 2 mmol/L, although higher concentrations have been safely used.^{22,23} Generally, 12 to 20 mL of Gd-DTPA solution is injected into the shoulder joint,^{8,9,24-27} although intra-articular doses as high as 40 mL has been suggested for the evaluation of recurrent anterior dislocation.²⁸

The correct needle position for direct MR arthrography is usually confirmed by the injection of iodinated radiographic contrast agent following needle placement under fluoroscopic guidance^{8,9,21} (Fig. 1). Intra-articular needle placement may, however, be performed under ultrasound guidance,²⁹ using palpation,³⁰ or with MR guidance.^{31,32} Disadvantages of MR arthrography are related mainly to the discomfort caused by needle placement, ionising radiation hazard during fluoroscopy, and risks of adjacent soft tissue damage associated with needle

placement. A recent study has shown that patients have found MR arthrography to be less painful than expected, and are able to accept any resultant discomfort very well.³³ Additional time for planning and performing the procedure is required, as the fluoroscopic suite is usually distant to the MR unit.⁸ A technique for prior fluoroscopic landmarking of the shoulder joint in order to shorten the MR arthrographic examination time has been described.³⁴ MR imaging should be performed within 30 minutes of the intra-articular injection to minimise absorption of the contrast agent and to prevent a loss of capsular distension. The addition of intra-articular epinephrine helps to delay absorption and improve the sharpness of the subsequent MR images.³⁵

To date, a very low incidence of minor complications associated with intra-articular Gd-DTPA injection has been reported. This technique has a good safety record, with fewer reported reactions compared to intravenous use.⁹ One should, however, be aware that none of the available gadolinium products are licensed for intra-articular use in the UK, USA, and also worldwide. At present, approval at local level and informed consent are recommended. In many centres in the USA, local approval is given to radiologists for performing MR arthrography by their respective institutional review boards.⁸ In the clinical situation, its widespread acceptance by radiologists and referring orthopaedic surgeons justifies its continued application.^{8,9}

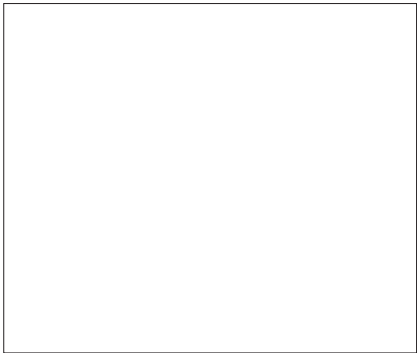
Labral-Ligamentous Complex

Anatomical Considerations

The labral-ligamentous complex consists of the glenoid labrum, and the superior, middle and inferior glenohumeral ligaments. The long head of the biceps tendon, by virtue of its attachment to the superior labrum, should probably be regarded as a component of this complex. The function of this complex is to provide passive stabilisation of the shoulder joint by anchoring the humerus to the glenoid rim. The glenoid labrum is composed of fibrocartilaginous tissue that has a low signal intensity on both T1- and T2-weighted MR images. The labrum deepens the glenoid cavity by its attachment around the glenoid rim (Fig. 2). However, the size and shape of the glenoid labrum can be variable,³⁶⁻³⁸ leading to interpretation problems. For example, a small normal labrum may be difficult to distinguish from a mildly deficient labrum. Sometimes, a recess may be present between the anterior cartilaginous labrum and the bony glenoid, or between the attachments of the middle and inferior glenohumeral ligaments, simulating a labral tear. Hyaline articular cartilage is frequently present between the fibrocartilaginous labrum and the glenoid cortex, predominantly in the superior half of the joint. As the signal intensity of hyaline cartilage is



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Fig. 1. Conventional arthrogram shows placement of the needle into the glenohumeral joint under fluoroscopic guidance. Diluted Gd-DTPA solution is instilled after confirmation of needle position by radiographic contrast injection.



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Fig. 5. Coronal T1-W MR arthrographic image shows the normal triangular-shaped superior glenoid labrum (arrowheads) from which the long head of the biceps tendon arises.



Fig. 2. Axial T1-W MR arthrographic image shows normal triangular-shaped anterior labrum (arrowhead) and more rounded posterior labrum (arrow) outlined by the injected Gd-DTPA solution.

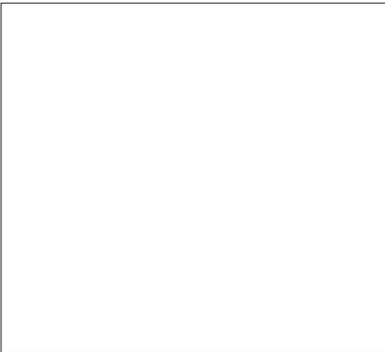


Fig. 6. Axial T1-W MR arthrographic image shows a deficient anterior labrum (black arrowheads) with associated medial stripping of the anterior capsular attachment and a capacious anterior joint space (broad white arrows). The patient presented with recurrent episodes of anterior glenohumeral dislocation.

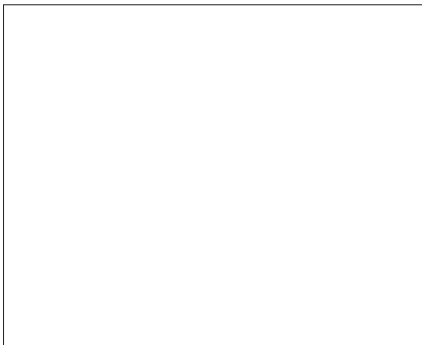


Fig. 3. Axial T1-W MR arthrographic image shows the normal band-like superior glenohumeral ligament (arrowheads) curving from its origin in the anterosuperior labrum towards the humerus.

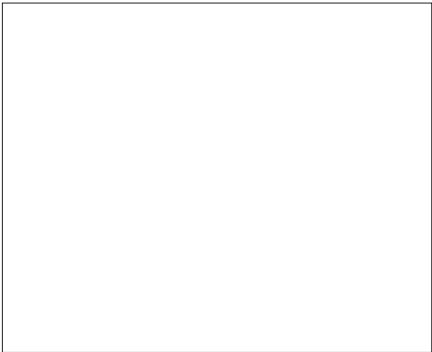


Fig. 7. Coronal T1-W MR arthrographic image shows 2 vertical linear areas of contrast within the superior labrum (white arrows), consistent with the “double Oreo” sign of a SLAP tear.

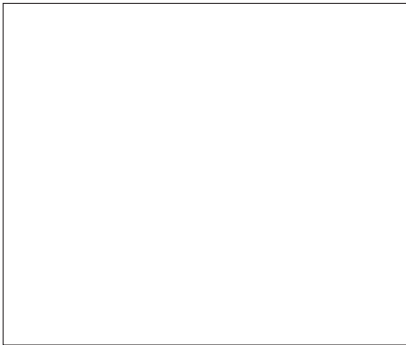


Fig. 4. Axial T1-W MR arthrographic image shows the normal anterior band of the inferior glenohumeral ligament (arrows) curving within the axillary pouch from the anteroinferior glenoid labrum to the humerus. The long head of biceps tendon (arrowheads) is seen within its contrast-filled tendon sheath in the bicipital groove of the humerus.

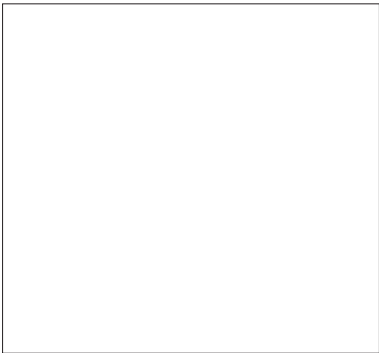


Fig. 8. Axial fat suppressed T1-W MR arthrographic image shows a large loose body (arrowhead) in the axillary pouch. The loose body was difficult to see on the conventional MR image.

higher relative to that of fibrocartilage, this intercartilaginous interface may simulate a labral tear on axial MR images, or a superior labral anterior-posterior (SLAP) lesion on oblique coronal MR images.³⁸⁻⁴² Other normal anatomical variants that may simulate lesions include the superior sublabral recess, sublabral foramen, and the Buford complex.³⁸⁻⁴⁸ The Buford complex is due to absence of the anterosuperior glenoid labrum and a cord-like middle glenohumeral ligament that attaches directly to the superior labrum, anterior to the biceps tendon origin. It can be mistaken for a detached labrum, both arthroscopically and during MR arthrography.^{43,45,46}

The superior glenohumeral ligament (SGHL) arises from the anterosuperior labrum, just anterior to the origin of the long head of the biceps tendon. It extends to the lesser tuberosity where it blends with the coracohumeral ligament. The SGHL is the most consistently identified intra-articular ligament on shoulder MR imaging (Fig. 3). The middle glenohumeral ligament (MGHL) is the most variable in terms of size and attachment site. It arises from the anterosuperior labrum, by itself or in combination with the SGHL. It inserts into the base of the lesser tuberosity, and its appearance may change according to the degree of rotation of the shoulder. The MGHL may be completely absent, or may appear thick and cord-like in the Buford complex. The inferior glenohumeral ligament (IGHL) is the most important of the three ligaments, and is an important stabiliser of the anterior shoulder joint. It consists of a thicker anterior band and a posterior band, with the axillary recess in-between. The anterior and posterior IGHL bands extend from the antero-inferior and postero-inferior aspects of the glenoid labrum respectively, and insert onto the humeral neck. Both the MGHL and IGHL are generally best visualised on axial and sagittal MR arthrographic images (Fig. 4). The long head of the biceps tendon arises from the anterosuperior glenoid rim, courses laterally through the superior part of the joint, and exits through the bicipital groove of the humerus (Fig. 4). The labral-bicipital junction and proximal biceps tendon are best seen on axial and coronal MR arthrographic images (Fig. 5), while the bicipital portion is best seen on the axial images.^{38,39,41-43,47,49}

The performance of conventional MR imaging in the assessment of the labral-ligamentous complex of the shoulder has been inconsistent, particularly when the joint lacks distension due to absent or insufficient joint fluid, and when anatomical variations of the labrum exist. MR arthrography enables separation of the labrum from the glenohumeral ligaments and joint capsule, and hence decreases the possibility of a false positive diagnosis of labral lesions.^{6,39,41,47,49} All parts of the glenoid labrum, the three glenohumeral ligaments and the long head of biceps tendon are optimally depicted on MR arthrographic images.

Lesions

Glenoid labral tears are diagnosed with high sensitivities and specificities on MR arthrography, ranging from 90% to 95%,^{5,6,26,27} in contrast to conventional MR imaging where specificities range from 67% to 86%, and sensitivities range from 44% to 95%.⁵⁰⁻⁵² Tears are depicted as absence or deficiency of the labrum, an irregular frayed appearance, contrast filling of a torn labrum, and opacification of the space between the detached labrum and the glenoid surface^{3,5,6,26,27,53} (Fig. 6). Posterior labral tears and injuries associated with posterior dislocation are also well demonstrated on MR arthrography.⁵⁴ MR arthrograms obtained with the arm in the abduction and external rotation (ABER) position increases the sensitivity of depicting anterior glenoid tears, compared to axial MR arthrograms with the shoulder and arm in a neutral position.^{14,15,55,56} By showing the location and length of the labral abnormalities relative to the origin of the IGHL, MR arthrography is able to differentiate stable from unstable labral lesions.^{3,6} The IGHL is considered abnormal if it is absent, discontinuous, attenuated, or attached to the scapular neck medial to the glenoid rim. Abnormal findings of the inferior labral-ligamentous complex has been found to be 76% sensitive and 98% specific in predicting glenohumeral instability on MR arthrography.²⁷ MR arthrography has also been found to be useful in the demonstration of other abnormal subtypes of the labral-ligamentous complex, such as the Perthes (Bankart lesions with an intact but medially-stripped scapular periosteum), glenolabral articular disruption (GLAD), anterior labroligamentous periosteal sleeve avulsion (ALPSA) and humeral avulsion of the glenohumeral ligament (HAGL) lesions.^{8,9,57-62}

SLAP lesions refer to tears occurring at the site of attachment of the superior labrum to the long head of biceps tendon.⁶³ They are typically found in young adult athletes who use repetitive overhead arm motions or are injured after a fall on an outstretched hand. SLAP lesions are centred on the superior labrum at or near the attachment of the biceps tendon. Four types of SLAP lesions have been described, and this classification is still widely accepted at the present time.⁶³ The original classification has however been modified and refined.⁶⁴⁻⁶⁶ Assessment of SLAP lesions using conventional MR imaging has produced inconsistent results.⁶⁷⁻⁶⁹ MR arthrography is a reliable technique for evaluation of SLAP lesions, and shows the superior labral tear, irregularity of the long head of biceps tendon insertion, displacement of the superior labrum, and a fragment of the labrum inferiorly between the glenoid fossa and the humeral head.^{3,14,48,70,71} Distinguishing physiological recesses such as a sublabral recess from a type II SLAP lesion may be difficult on conventional MR images but is improved using MR arthrography.⁷² MR finding of a laterally-curved and posterior high-signal area in the superior labrum has been

found to be a reliable sign of a SLAP lesion.⁷³ The “double Oreo” sign, consisting of two high-signal intensity lines in the superior labrum when present, is considered to be highly specific for a SLAP tear^{40,73} (Fig. 7). Addition of arm traction in external rotation provides increased detection of SLAP lesions compared to MR studies obtained without arm traction.⁷⁴ Bicipital tendon rupture and dislocation associated with SLAP lesions may also be detected on MR arthrography.

Intra-articular loose bodies are not uncommonly found following shoulder injury. Loose bodies may be composed of bone, cartilage, fibrous tissue, fibrin, fat or blood.⁸ MR arthrography has been shown to be effective in detecting loose bodies in the shoulder^{6,53} (Fig. 8). Cysts around the labrum are associated with labral tears. The cyst location often indicates the position of the tear. Extension of the cyst into the spinoglenoid or suprascapular notch may occur, leading to nerve compression and muscle atrophy. T2-weighted sequences are helpful for the detection and diagnosis of paraglenoid labral cysts.^{75,76}

Conclusion

MR arthrography demonstrates anatomical structures and lesions of the labral-ligamentous complex that may not be visible on conventional MR imaging of the shoulder. Its advantages include arthrographic joint distension and delineation of the intra-articular structures, combined with the superior spatial resolution of MR imaging. Currently, MR arthrography is most valuable in the evaluation of lesions of the glenoid labrum, glenohumeral ligaments, long head of biceps tendon, and the detection of loose bodies. In general, MR arthrography is most useful where surgery is contemplated, and where conventional MR imaging is equivocal or undiagnostic.

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QUESTIONS

1. In performing MR arthrography of the shoulder:
 - a) Using the indirect (intravenous) technique provides superior joint distension compared to the direct technique.
 - b) The glenohumeral ligaments are better visualised than on conventional MR imaging.
 - c) Exercising the joint during arthrography is required to ensure a significant improvement in image quality.
 - d) Fluoroscopic guidance is seldom used for needle placement.
2. Regarding the labral-ligamentous complex of the shoulder:
 - a) The supraspinatus tendon is an important component.
 - b) The middle glenohumeral ligament may have a variable appearance.
 - c) The inferior glenohumeral ligament has a stabilizing function.
 - d) The sublabral recess of the superior glenoid labrum results from repetitive trauma.
3. In tears of the glenoid labrum:
 - a) An absent labrum is not a recognized MR arthrographic sign.
 - b) The relationship between the labrum and the inferior glenohumeral ligament is an important one.
 - c) There is an association between paraglenoid labral cysts and tears.
 - d) Posterior labral tears are commoner than anterior ones.
4. Regarding SLAP lesions of the shoulder
 - a) Mechanism of injury may be due to repetitive overhead arm motion.
 - b) The long head of the biceps tendon is not affected.
 - c) Compared to conventional MR imaging, MR arthrography helps to better differentiate a SLAP tear from a sublabral recess.
 - d) The “double Oreo” sign is found in MR imaging of SLAP lesions.

ANSWER SHEET

Continuing Professional Development:
Clinical Update on MR Arthrography

Question 1		Question 2		Question 3		Question 4	
a) True ☐	False ☐	a) True ☐	False ☐	a) True ☐	False ☐	a) True ☐	False ☐
b) True ☐	False ☐	b) True ☐	False ☐	b) True ☐	False ☐	b) True ☐	False ☐
c) True ☐	False ☐	c) True ☐	False ☐	c) True ☐	False ☐	c) True ☐	False ☐
d) True ☐	False ☐	d) True ☐	False ☐	d) True ☐	False ☐	d) True ☐	False ☐

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