PICTORIAL REVIEW

MRI of the rotator interval of the shoulder

J.C. Leea, S. Guya, D. Connella, A. Saifuddina,c,*, S. Lambertb,c

Departments of aRadiology and bOrthopaedics, The Royal National Orthopaedic Hospital NHS Trust, Stanmore, Middlesex, UK, and cThe Institute of Orthopaedics and Musculoskeletal Sciences, University College London, UK

Received 4 July 2006; received in revised form 7 November 2006; accepted 22 November 2006

The rotator interval of the shoulder joint is located between the distal edges of the supraspinatus and subscapularis tendons and contains the insertions of the coracohumeral and superior glenohumeral ligaments. These structures form a complex pulley system that stabilizes the long head of the biceps tendon as it enters the bicipital groove of the humeral head. The rotator interval is the site of a variety of pathological processes including biceps tendon lesions, adhesive capsulitis and anterosuperior internal impingement. This article describes the anatomy, function and pathology of the rotator interval using magnetic resonance imaging (MRI).

© 2007 The Royal College of Radiologists. Published by Elsevier Ltd. All rights reserved.

Introduction

The rotator interval of the shoulder refers to the interspace between the supraspinatus and subscapularis tendons through which courses the long head of biceps tendon. Separate terms have been applied to the musculotendinous separation around the coracoid process (anterior rotator interval) and to the separation of the supraspinatus and infraspinatus muscles and their corresponding tendons around the scapular spine (posterior rotator interval).1 In this paper, the term rotator interval refers to the anterior rotator interval. This article reviews the relevant anatomy, clinical and radiological features of disorders of the rotator interval.

The normal rotator interval

Anatomy

The rotator interval subtends a medially based triangular space bordered superiorly by the leading edge of the supraspinatus tendon, inferiorly by the superior aspect of the subscapularis tendon, medially by the base of the coracoid process and laterally by the long head of biceps tendon and its sulcus (Fig. 1).

Cadaveric and arthroscopic studies have described the macroscopic constituents of the rotator interval.2–4 The medial rotator interval contains the long head of biceps tendon as it inserts into the superior glenoid labrum. As the biceps tendon passes laterally through the rotator interval, it is covered superficially by fibres of the coracohumeral ligament whilst a condensation of the superior glenohumeral ligament and the joint capsule lie deep to it (Fig. 2). The superior glenohumeral ligament, which arises from the supraglenoid tubercle adjacent to the long head of biceps tendon, inserts into the lesser tuberosity, forming the anterior covering band of the long head of biceps tendon in its sulcus (Fig. 2). The coracohumeral ligament arises from the proximal third of the dorsolateral aspect of the coracoid process and passes through the rotator interval in union with the superior glenohumeral ligament (Figs. 1 and 2). The coracohumeral ligament fibres then fan out laterally to insert into the greater tuberosity and bicipital sheath, as well as fusing with the anterior fibres of supraspinatus and superior fibres of subscapularis tendon insertions.5
The transverse humeral ligament is a broad band that passes between the lesser and greater tuberosities converting the intertuberculous groove into a canal. The combination of the coracohumeral, superior glenohumeral and transverse humeral ligaments, and the subscapularis tendon insertion, is referred to as the biceps “reflective pulley” or “sling”. The principal function of the biceps pulley is to prevent medial subluxation of the biceps tendon out of the intertuberculous groove during active movement and to increase biomechanical efficiency during biceps contraction.

**Magnetic resonance imaging (MRI) of the rotator interval**

Standard imaging planes for MRI of the shoulder include coronal oblique, sagittal oblique and axial sequences. The oblique sagittal plane, taken parallel to the glenoid fossa and orthogonal to the long axis of the rotator interval and cuff, is the single most valuable sequence to evaluate the interval and its contents. A combination of proton density and T2-weighted (T2W) spin-echo or turbo spin-echo, high-resolution (<3 mm) sequences using a high image matrix is recommended.

The capsular component of the normal rotator interval passes from the anterior edge of the supraspinatus tendon to the superior edge of the subscapularis tendon and should be thin, smooth and of uniform low signal intensity on the sagittal oblique sequence (Fig. 3). The capsule may be very thin and

---

**Figure 1** Line drawing of the rotator interval in sagittal section. A, acromion process; C, coracoid process; H, humeral head; LHBT, long head of biceps tendon; CHL, coracohumeral ligament; SGHL, superior glenohumeral ligament; sst, supraspinatus tendon; sc, subscapularis tendon.

**Figure 2** Diagrammatic representation of the biceps reflective pulley system. CHL, coracohumeral ligament; SGHL, superior glenohumeral ligament; C, coracoid process; LHBT, long head of biceps tendon; H, humeral head; GT, greater tuberosity; LT, lesser tuberosity.

**Figure 3** Sagittal oblique PD-weighted fast spin-echo MRI image demonstrating the normal rotator interval capsule as a thin, hypointense band (arrows) extending from the anterior margin of supraspinatus to the superior margin of subscapularis. The long head of biceps tendon (long arrow) is identified between the rotator interval capsule and the humeral head.
difficult to discern, and the presence of high signal intensity fluid and/or synovitis will outline the structure more clearly. The coracohumeral ligament is identified as a single or double hypointense band extending from the posterior aspect of the coracoid process into the rotator interval (Fig. 4).

The biceps tendon can be identified between the rotator interval capsule and the humeral head (Fig. 3). In the sagittal oblique plane, the medial edge of the long head of biceps tendon lies immediately deep to the coracohumeral ligament. The transverse humeral ligament, which forms the lateral boundary of the rotator interval, is optimally demonstrated on axial images as a thin hypointense line bridging the bicipital groove (Fig. 5).

The superior glenohumeral ligament may be difficult to define on conventional shoulder MRI, being optimally imaged on axial MR arthrography (MRA; Fig. 6). In fact, some authors believe that all of the structures of the rotator interval are optimally imaged using direct MRA. Chung et al. performed a cadaveric study comparing standard MRI and MRA on the same shoulder. The authors found that only the extra-articular portion of the long head of biceps tendon was seen in all cases on standard MRI whilst on direct MRA, the intra-articular course of the long head of biceps tendon could also be reliably identified (Fig. 7). In the study of Chung et al., the superior glenohumeral ligament was not identified at all on standard MRI sequences and the coracohumeral ligament was seen in only 60% of the specimens, whereas both ligaments were seen in all cases on MRA. Chung et al. also recommended a dedicated sequence perpendicular to the coracohumeral ligament/superior glenohumeral ligament complex to fully evaluate these structures and the long head of biceps tendon. In our experience, this extra sequence frequently adds little to the diagnosis. Isolated rupture of the rotator interval capsule may be missed on axial and coronal oblique planes and should be assessed on the sagittal oblique acquisition.

Function and clinical lesions of the rotator interval

The rotator interval is a defined anatomical space but its constituent parts play several important roles in the shoulder. Instability of the long head of biceps tendon and the glenohumeral joint, as well as synovial changes in adhesive capsulitis, are all recognized pathological processes that involve the rotator interval.

Long head of biceps tendon abnormalities

Pulley lesions

The biceps pulley is formed by the intimate arrangement between the coracohumeral, superior glenohumeral and transverse humeral ligaments plus the subscapularis tendon, as mentioned above (Fig. 2). These structures act together to form the medial wall of the superior biceps pulley preventing medial subluxation of the long head of biceps tendon. It is important to note that biceps instability may be due to avulsion of the superior glenohumeral ligament/coracohumeral ligament complex, as well as the more widely recognized tear of the subscapularis tendon.

Disorders of the biceps tendon are optimally imaged using a combination of axial and sagittal T2W sequences. Biceps tendon subluxation is

![Figure 4](image_url)

**Figure 4** (a) Sagittal oblique T2W fast spin-echo sequence demonstrating the normal coracohumeral ligament as a thin, hypointense band (arrowhead) extending from the posterior aspect of the coracoid process to the rotator interval. The ligament is surrounded by fat. (b) Axial T2*W gradient echo. (c) Coronal PD-weighted fast spin-echo sequences demonstrating the normal coracohumeral ligament (arrows).
diagnosed when the tendon is seen to lie on the medial ridge of the bicipital sulcus (Fig. 8) whilst a dislocated tendon may lie within the subscapularis tendon (Fig. 9) or come to lie anterior to the subscapularis tendon. Lesions of the reflection pulley of the biceps tendon have also been described with MRA and features include irregularity of the superior margin of the subscapularis tendon, extra-articular contrast collection and biceps tendon subluxation.

In one arthroscopic study of ‘‘hidden’’ rotator interval lesions in patients with supraspinatus tendon tears, there was a 27% incidence of subscapularis tears and 47% of these were associated with involvement of the superior glenohumeral ligament and medial fibres of the coracohumeral ligament. Ten percent of supraspinatus tendon tears were associated with involvement of the lateral fibres of the coracohumeral ligament. Therefore, retraction of the subscapularis must infer at least a partial tear of the coracohumeral ligament.

Figure 5  Axial T2*W gradient echo MRI image demonstrating the transverse humeral ligament (long arrow) bridging the bicipital groove and covering the long head of biceps tendon (short arrows). Note also the subscapularis tendon (arrowhead).

Figure 6  Axial T1W fat-suppressed direct MR arthrogram demonstrating the superior glenohumeral ligament (arrow).

Figure 7  Coronal oblique T1W fat-suppressed direct MR arthrogram demonstrating the entire length of the intra-articular portion of the long head of biceps tendon (arrowheads).

Figure 8  Axial PD-weighted fast spin-echo MRI image demonstrating a partial articular side tear of the subscapularis tendon with subluxation of the long head of biceps tendon (arrow), which is lying on the medial ridge of the proximal aspect of the bicipital groove.
Biceps tendinopathy and tendon tears
Degenerative changes within the biceps tendon are commonly associated with rotator cuff tears. Biceps tendinopathy is diagnosed when there is increased intra-tendinous signal intensity within a swollen long head of biceps tendon (Fig. 10), and is commonly associated with synovitis and adhesions within the tenosynovial sheath. Partial or complete tears of the long head of biceps tendon are associated with tears of the subscapularis and supraspinatus tendons and are identified on conventional MRI with a reported accuracy of 79%. Partial tears are diagnosed when there is either a longitudinal region of increased intra-tendinous signal intensity reaching the edge of a non-expanded tendon, or when there is an abrupt change in diameter of the long head of biceps tendon on serial axial images. The lack of biceps tendon swelling may distinguish partial tears from tendinopathy, but occasionally, it may not be possible to separate the two conditions on MRI. A complete tear of the long head of biceps tendon will manifest as an empty biceps tendon sheath.

Anterosuperior internal impingement
Anterosuperior internal impingement is a recently described condition in which there is shoulder pain provoked by anterior elevation and internal rotation of the glenohumeral joint, with no symptoms or signs of instability. Depending upon the degree of elevation of the arm, impingement occurs between the long head of biceps tendon and pulley region with the superior most aspect of the labrum, or between the tendinous insertion of the subscapularis and the anterior glenoid labrum and rim. Partial subscapularis tendon tears are the commonest MR arthrographic finding, whilst at arthroscopy an articular surface partial tear of subscapularis, usually associated with a pulley lesion, is the commonest finding. This is optimally demonstrated in the abduction external rotation (ABER) position (Fig. 11).

SLAP lesions
Tears of the biceps pulley complex may be associated with injuries to the superior glenoid labrum (Fig. 12). In the presence of rotator interval lesions, the superior labrum must be carefully assessed on the coronal oblique sequences and should be smooth and of uniform low signal intensity on all sequences. High signal intensity within the labrum raises the possibility of a SLAP lesion, which is associated with tears of the bicipital anchor and therefore, the rotator interval.

Glenohumeral stability
Cadaveric and arthroscopic studies have found that the structures of the rotator interval are important stabilizers of the glenohumeral joint. Superior—inferior stabilization of the glenohumeral joint in the neutral or internally rotated position relies on maintenance of the intra-articular pressure conferred by an intact rotator interval capsule. A missed rotator interval capsular defect may be responsible for recurrent anteroinferior and multidirectional instability, particularly inferior translation in the adducted and internally rotated position.
arm. Sectioning of the rotator interval capsule in cadaveric shoulder joints was found to increase ranges of flexion, extension, adduction and external rotation. Conversely, imbrication of the capsule reduced the ranges of all these movements. If a rotator interval defect is not closed in a patient with instability, along with the normal capsulolabral tear, then there may be recurrent postoperative symptoms. Detecting and closing a rotator interval defect arthroscopically may be difficult as the rotator interval is regularly used as the anterior portal in shoulder arthroscopy, reducing the chance of discovering lesions of this area.

Type I and II rotator interval lesions
Nobuhara and Ikeda first described the term "rotator interval lesion" as a cause of painful shoulder syndrome characterized by inferior instability in the rotator interval. The authors defined two sub-types: type I, a contracted state, is characterized by a superficial post-inflammatory contraction of the coracohumeral ligament and subacromial bursa following an injury to the rotator interval. It is possible, with the acceptance that the rotator interval is predominantly responsible for superior—inferior stability, that the type I lesion described by these authors is in fact part of the emerging syndrome of sub-coracoid impingement (Fig. 13). The type II lesion occurs in a younger patient group, and is characterized by instability with inflammatory change within the deeper tissues of the rotator interval.

Figure 11  T2W fast spin-echo direct MR arthrogram in the abduction external rotation (ABER) position showing impingement (curved arrow) between the insertion of subscapularis (straight arrow) and the anterosuperior aspect of the glenoid labrum (arrowhead).

Figure 12  Coronal oblique fat-suppressed T1W fast spin-echo direct MR arthrogram image demonstrating a detached tear of the superior glenoid labrum (arrow) extending into the long head of biceps tendon (arrowhead).

Figure 13  Axial T2W GE image obtained in internal rotation showing marked reduction in the space between the lesser tuberosity (long arrow) and the tip of the coracoid process (short arrow) with hyperintensity of the intervening subscapularis tendon.
Adhesive capsulitis

Primary myofibroblastic transformation is thought to initiate contracture of the coracohumeral ligament component of the rotator interval tissue in the early stages of idiopathic frozen shoulder (adhesive capsulitis). As the rotator interval shortens in the mediolateral and craniocaudal directions the relative gliding of the anterior margin of the supraspinatus tendon and the cranial margin of the subscapularis tendon is restricted and external rotation range is diminished. In attempted external rotation the humeral head is then obligatorily displaced downward and backward. In attempted sagittal plane flexion the humeral head is displaced inferiorly: the thickened interval tissue can obstruct further elevation by occupying the subcoracoid space.

Mengiardi et al. described a coracohumeral ligament thickness greater than 4 mm on sagittal oblique MR arthrographic images as a specific sign of adhesive capsulitis. MRI may also show thickening of the rotator interval capsule and exuberant synovitis surrounding the coracohumeral ligament, which may enhance after intravenous gadolinium injection (Fig. 14).

Conclusion

The rotator interval is a complex anatomical region, which can give rise to a variety of clinical symptoms and signs. The imaging features of rotator interval lesions are also variable and the most subtle rotator interval lesions, consisting of small tears of the deep surface of the subscapularis tendon or leading edge of the supraspinatus tendon may easily be overlooked on conventional MRI unless particular attention is given to this region.

References