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**David Connell**
**Ravi Padmanabhan**
**Rachelle Buchbinder**

# Adhesive capsulitis: role of MR imaging in differential diagnosis

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D. Connell (✉) · R. Padmanabhan
R. Buchbinder
Department of MRI,
St. Frances Xavier Cabrini Hospital,
183 Wattletree Road, Malvern,
Victoria 3144, Australia
e-mail: dconnell@netspace.net.au
Tel.: +61-3-95081444
Fax: +61-3-95009453

**Abstract** The purpose of this study was to describe and characterize the MR imaging findings in a group of patients who underwent surgery for adhesive capsulitis. Twenty-four MR imaging studies in 24 consecutive patients with clinical evidence of adhesive capsulitis were performed prior to arthroscopic capsulotomy. There were 17 women and 7 men with a mean age of 53.5 years. Images were scrutinised for changes in the synovium particularly in the rotator interval, around the biceps anchor and axillary pouch. Intravenous gadolinium was given routinely. We also examined a control group of 22 patients who underwent the same MR imaging protocol after referral for rotator cuff pathology. Soft tissue density showing variable enhancement after gadolinium administration was visible in the rotator interval in 22 of 24 studies on MR imaging. Seventeen patients showed soft tissue density partially encasing the biceps anchor. Ten patients showed thickening and gadolinium enhancement of the axillary pouch. Three patients from the study cohort had partial tears of the supraspinatus tendon. All the patients subsequently had surgery which confirmed fibrovascular scar tissue in the rotator interval, around the biceps anchor and a variable degree of synovial inflammation of the glenohumeral capsule. Two patients from a control group with suspected rotator cuff pathology showed abnormal intensity in the rotator interval on MR imaging. Magnetic resonance imaging can identify changes in the shoulder joint that correspond to abnormalities seen at surgery. This may be useful for discriminating adhesive capsulitis from other causes of shoulder pain.

**Keywords** Adhesive capsulitis · Frozen shoulder · MR imaging · Arthroscopy

## Introduction

Codman first used the term frozen shoulder to describe a disease of slow onset with pain near the insertion of deltoid, inability to sleep on the affected side, painful and restricted elevation and external rotation, and a normal radiographic appearance [1]. In 1945 Neviaser described pathological changes in the synovium and suggested the term adhesive capsulitis [2]. The disorder remains a common condition of uncertain aetiology often affecting women aged between 40 and 60 years [3].

The diagnosis of adhesive capsulitis can usually be made on clinical findings alone; however, the disorder may mimic other causes of shoulder pain such as rotator cuff disease and impingement [4]. Arthrography has been the advocated imaging test of choice to assess adhesive capsulitis but has been shown to be unreliable in some cases [5, 6]. Arthroscopy has the advantage of directly scrutinising the joint capsule and typically demonstrates pathological change within the subscapularis bursa, rotator interval and axillary pouch [7, 8, 9, 10, 11]. In particular, inflammatory change is commonly

seen in the rotation interval extending towards the biceps anchor.

Magnetic resonance imaging is commonly used to investigate shoulder disorders and remains the obvious modality to non-invasively identify changes in the synovium and capsule typical of adhesive capsulitis, and to exclude other causes of shoulder pain and dysfunction which may mimic this disorder. To our knowledge, no study has correlated the MR imaging findings of adhesive capsulitis with those found at surgery. We performed a study in order to characterize the MR imaging findings in a group of patients with adhesive capsulitis prior to undergoing arthroscopic capsulotomy.

## Materials and methods

From September 1998 to July 2001, 24 shoulder joints in 24 patients with clinical evidence of adhesive capsulitis were referred by several upper limb orthopaedic surgeons and rheumatologists for MR imaging prior to arthroscopic capsulotomy. There were 17 women and 7 men with a mean age of 53.5 years (age range 38–71 years). The right shoulder was affected in 13 cases and the left in 11 which made up the study cohort.

All patients reported an insidious onset of shoulder pain and dysfunction ranging from 15 weeks to 26 months (mean 10.2 months). Eight patients had a history of diabetes and one had autoimmune thyroid disease. The initial diagnosis was made on the basis of history and clinical findings. All patients had undergone medical treatment including anti-inflammatory medication, physiotherapy and hydrodilatation (14 of 24) and were considered refractory cases.

Clinical criteria for the condition included pain and stiffness for greater than fifteen weeks, increasing in nature and most severe at rest with restriction of passive motion greater than 30° in two or more planes of movement. Exclusion criteria included rheumatoid arthritis, previous shoulder surgery, previous trauma or abnormal radiographs.

Twenty-two patients with clinical suspicion of rotator cuff pathology were also referred for MR imaging (12 men, 10 women; mean age 54.5 years). None of these patients were felt clinically to have adhesive capsulitis. There were 14 right shoulders and 10 left shoulders. The mean duration of symptoms was 3.2 months (range 10 days to 13 months) and the interval from consultation to MR scanning was 17.2 days (range 0–45 days). This made up the control group.

Patients were examined with a 1.5-T superconducting unit (Signa Horizon, GE Medical Systems, Milwaukee, Wis.) at two clinical sites. Both MR units had an LX platform; the only difference was in bore length. The patients lay in a supine position with the arm placed in a neutral position by the side. A phased-array surface coil (Shoulder Array, Medrad, Indianola, Pa.) was centred over the glenohumeral joint and strapped in place.

An axial localising image was obtained followed by these sequences:

1. Oblique coronal fast spin-echo (FSE) sequence ($TR/TE_{eff}$= 4000 ms/36 ms) along the axis of the supraspinatus muscle, 512×320 matrix, two signals acquired, 15-cm field of view (FOV), 3-mm slice thickness with no gap and echo train length (ETL) 8–10.
2. Oblique coronal FSE sequence ($TR/TE_{eff}$=3500 ms/45 ms) with a 256×256 matrix (zipped to 512), two signals acquired, 15-cm FOV, 3.5-mm slice thickness and 0.5-mm interslice gap with frequency-selective fat suppression (Chem Sat, GE Medical Systems, Milwaukee, Wis.) and ETL 8–10.
3. Axial and sagittal FSE sequence ($TR/TE_{eff}$=4000 ms/36 ms with a 512×320 matrix, two signals acquired, 15-cm FOV, 3.0-mm slice thickness and no interslice gap, ETL 8–10. A 23-G catheter was inserted into an antecubital vein and a total bolus of 10 ml of gadolinium was injected. The next two sequences were performed without delay.
4. Oblique coronal and axial post-gadolinium T1-weighted fat-suppressed FSE sequence with a 320×256 matrix, two signals acquired, 15 -cm FOV, 3.0-mm slice thickness and ETL 8–10.

The rotator interval was assessed with respect to fibrovascular scar tissue formation. This was believed to be present if there was a discrete focus of homogeneous intermediate signal within the rotator interval, often obliterating the fat surrounding the coracohumeral and superior glenohumeral ligaments and coming in contact with the subscapularis tendon The biceps anchor was also evaluated. This was felt to be abnormal if a focus of abnormal signal obliterated the fat encasing the biceps tendon sheath. Increased signal on the FSE sequences ($TR/TE_{eff}$=3500 ms/45 ms) with fat saturation was evaluated and enhancement, if any, was noted on the post-contrast T1-weighted images. Gadolinium enhancement was assessed as either mild, moderate or marked.

The axillary pouch was assessed with respect to thickening and enhancement. Thickening greater than 4 mm was felt to be significant [12], as was any enhancement. The rotator cuff was assessed using established MR imaging criteria [13]. The MR images were interpreted by two musculoskeletal radiologists by means of consensus. The interpretation represents the original report.

Following MR imaging, 24 shoulder joints in 24 patients underwent arthroscopic surgery. The interval from the time of MR imaging to surgery ranged from 4 to 28 days (mean 9.2 days). The surgeon had access to the MR imaging reports.

## Results

In the control group the rotator interval was shown to be a space between the glenoid and coracoid process, with the subscapularis tendon lying inferiorly and the biceps tendon sitting above. Its contents include the coracohumeral and superior glenohumeral ligaments, which were seen as distinct structures surrounded by fatty tissue (Fig. 1) best seen on sagittal imaging. The axillary pouch was a continuous band of low signal hanging like a hammock between the humeral head and inferior glenoid labrum. It was best appreciated on the coronal oblique images.

Twenty-four cases of adhesive capsulitis were referred for MR imaging in 24 patients prior to surgery. The results are summarized in Table 1. The MR imaging demonstrated soft tissue abnormality in the rotator interval in 22 of 24 studies. The superior glenohumeral ligament was at least partially encased in 22 cases and the lesion would often extend to and involve the coracohumeral ligament (16 of 22; Fig. 2). The rotator interval lesion was shown to sit in front and often coming in contact with the undersurface of the biceps anchor (17 of 24). The amount of fibrovascular scar tissue was variable (Fig. 3). Of the 24 studies, 10 showed definite thickening of the axillary pouch >4 mm (Fig. 4) [12].

Twenty patients (20 of 24), showed gadolinium enhancement of the rotator interval soft tissue lesion or

**Table 1** MR imaging findings in patients with adhesive capsulitis. *SGH* superior glenohumeral; *GH* glenohumeral

| Patient | Left/ right | Age (years) | Gender | Duration of symptoms | MR imaging findings | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Signal abnormality | | | | Gadolinium enhancement[c] |
| | | | | | SGH ligament[a] | GH ligament[a] | Biceps anchor[a] | Axillary pouch[b] | |
| 1 | Left | 53 | F | 19 months | ++ | ++ | + | | + |
| 2 | Right | 54 | F | 4 months | +++ | ++ | +++ | ++ | ++ |
| 3 | Right | 62 | F | 5 months | ++ | + | ++ | + | ++ |
| 4 | Right | 49 | M | 11 months | +++ | | ++ | | + |
| 5 | Left | 47 | F | 12 months | | | | | |
| 6 | Left | 67 | F | 26 months | + | ++ | | | |
| 7 | Right | 71 | F | 7 months | +++ | + | ++ | | ++ |
| 8 | Left | 38 | M | 4 months | +++ | +++ | +++ | + | + |
| 9 | Right | 54 | M | 15 weeks | ++ | ++ | + | ++ | +++ |
| 10 | Right | 55 | F | 12 months | +++ | | ++ | + | ++ |
| 11 | Left | 62 | F | 10 months | + | | | | |
| 12 | Right | 60 | F | 4 months | ++ | ++ | + | | + |
| 13 | Right | 50 | F | 5 months | ++ | ++ | ++ | | +++ |
| 14 | Left | 48 | M | 5 months | +++ | +++ | +++ | ++ | ++ |
| 15 | Right | 68 | F | 7 months | + | + | | | |
| 16 | Left | 41 | M | 12 months | | | | + | + |
| 17 | Left | 47 | F | 12 months | +++ | | +++ | | +++ |
| 18 | Right | 59 | F | 15 months | +++ | | | | + |
| 19 | Right | 52 | F | 24 months | ++ | + | ++ | + | ++ |
| 20 | Right | 49 | F | 5 months | +++ | ++ | + | + | ++ |
| 21 | Left | 50 | M | 8 months | + | +++ | +++ | | ++ |
| 22 | Left | 40 | M | 8 months | ++ | | | | + |
| 23 | Right | 52 | F | 9 months | +++ | ++ | ++ | + | + |
| 24 | Left | 55 | F | 6 months | +++ | ++ | ++ | | ++ |

+ mild; ++ moderate; +++ marked abnormal signal intensity
[a] Abnormal focus of soft tissue signal with obliteration of fat encasing the SGH/CH ligaments and biceps anchor
[b] Thickening of axillary pouch
[c] Gadolinium enhancement of the contents of the rotator interval, biceps tendon sheath and axillary pouch

**Fig. 1** A 23-year-old male football player with suspected right rotator cuff pathology. Sagittal MR image (TR/TE=4000 ms/36 ms) shows a normal rotator interval. Note the *thin dark band* of the coracohumeral ligament (*black arrow*) coming to sit above the biceps tendon (*short white arrow*), beneath the supraspinatus. The superior glenohumeral ligament (*long white arrow*) and subscapularis are shown

axillary pouch to a variable degree (Fig. 5). Two patients showed low signal intensity with no enhancement. One patient demonstrated subluxation of the biceps tendon into the rotator interval which was encased in scar tissue and showed mild enhancement. Two patients showed no abnormality in the rotator interval. One of these patients had thickening of the axillary pouch while one had a partial tear of the rotator cuff. All 10 patients with thickening of the axillary pouch enhanced with gadolinium.

Twenty-four patients went to surgery and the presence of fibrovascular scar in the rotator interval or subscapularis bursa was confirmed in all cases. All patients showed variable but global abnormality of the synovium and capsule including the biceps anchor and axillary pouch. The severity of inflammation ranged from red synovium with adhesions (stage 2) to mature capsular adhesions (stage 4). There were no patients with a vascular inflammatory synovitis (stage 1). No pathological specimens were sent for histological analysis.

Three patients from the study cohort (3 of 24) were shown to have rotator cuff tears on MR imaging. Two tears were felt to be partial tears of supraspinatus and one a torn subscapularis tendon. One patient was felt to have a normal rotator interval and axillary pouch, one

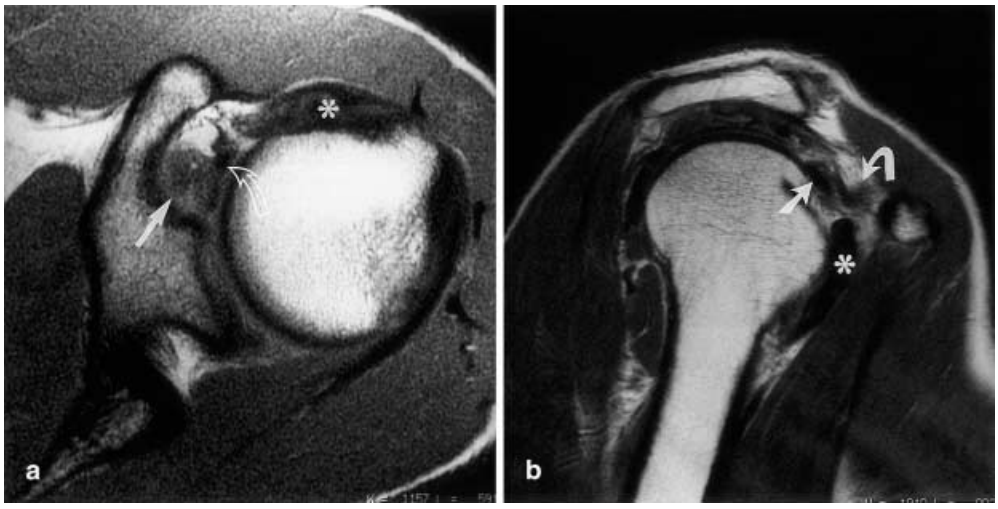


**Fig. 2a, b** A 49-year-old woman with clinical evidence of right adhesive capsulitis. **a** Axial MR image (TR/TE= 4000 ms/36 ms) shows soft tissue intensity in the concavity of the coracoid process (*white arrow*) which extends towards the superior glenohumeral ligament (*open arrow*). Subscapularis is shown (*asterisk*). **b** Sagittal MR image (TR/TE= 4000 ms/36 ms) shows poorly defined soft tissue intensity encasing the coracohumeral ligament (*curved arrow*) and filling the rotator interval. Biceps tendon (*short arrow*) and subscapularis (*asterisk*) are shown

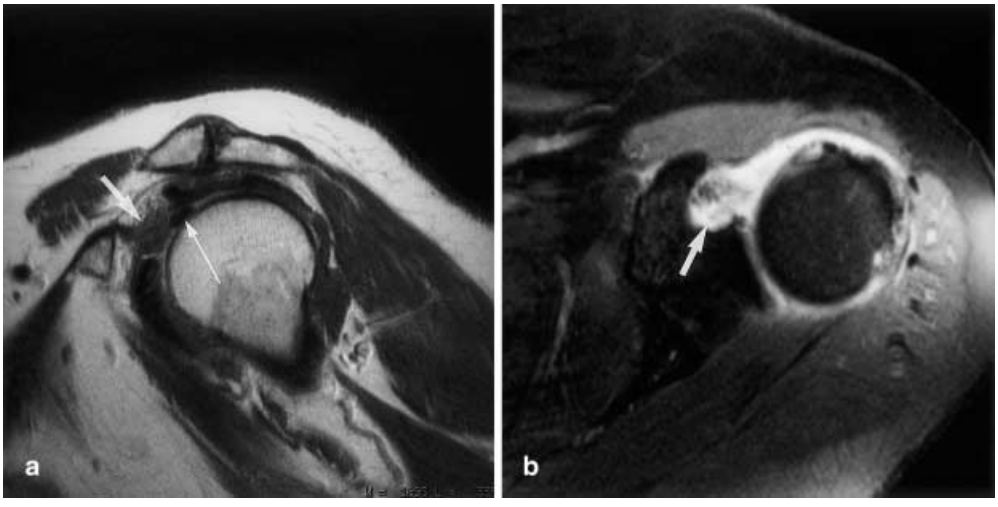


**Fig. 3a, b** A 50-year-old woman with a 4-month history of loss of left shoulder movement. **a** Sagittal MR image (TR/TE=4000 ms/36 ms) shows a lesion (*thick arrow*) obliterating the fat of the rotator interval and extending towards biceps (*thin arrow*). The lesion sits above biceps. **b** Axial post-gadolinium MR image (TR/TE=600 ms/12 ms) shows vivid enhancement of the rotator interval lesion (*arrow*) with diffuse enhancement of the capsule

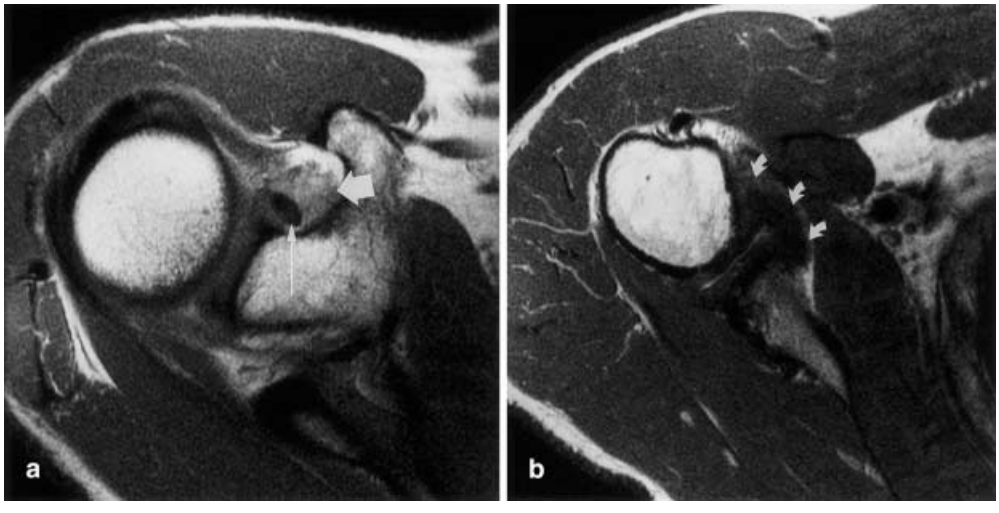


**Fig. 4a, b** A 54-year-old man with a 15-week history of insidious right shoulder pain. **a** Axial MR image (TR/TE= 4000 ms/36 ms) shows soft tissue (*short white arrow*) partially encasing a band-like middle glenohumeral ligament (*long white arrow*) within the rotator interval. **b** Axial MR image (TR/TE= 4000 ms/36 ms) further inferiorly shows marked thickening of the anterior band of the inferior glenohumeral ligament (*arrows*)

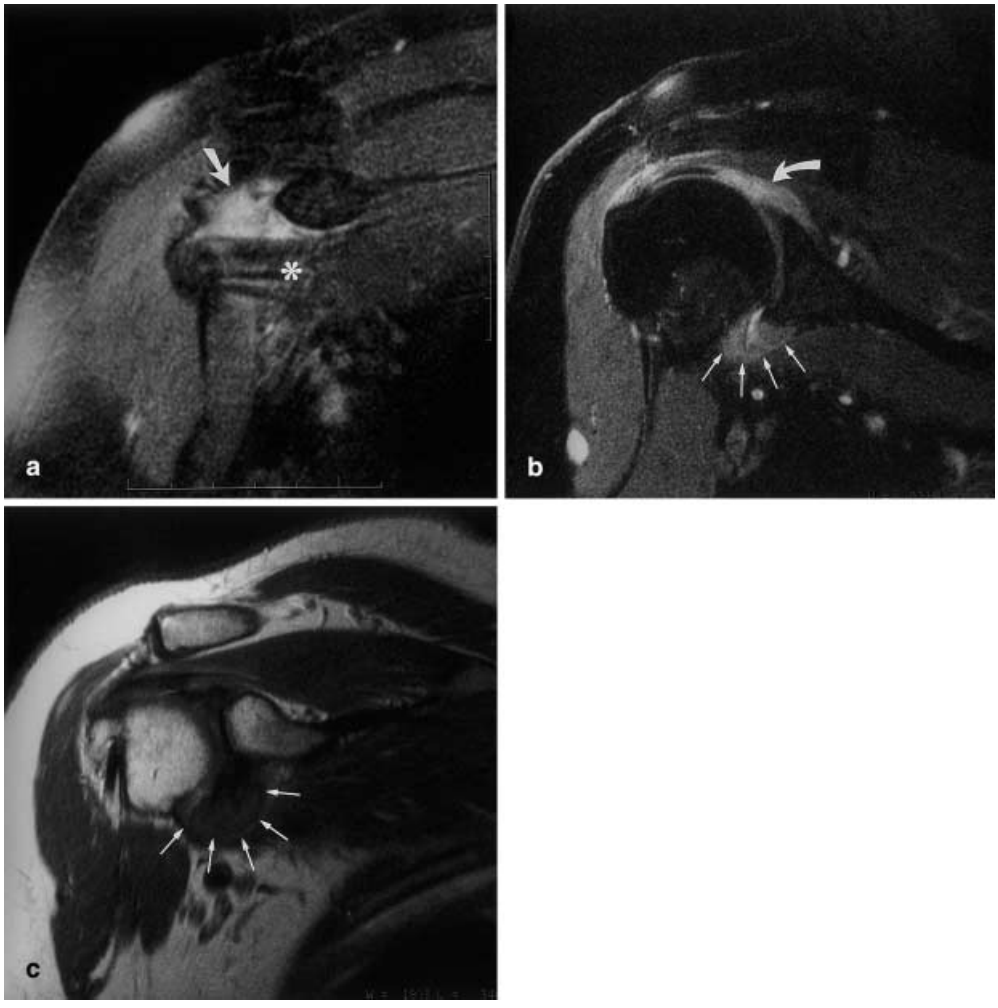


**Fig. 5a–c** A 54-year-old woman diabetic with 4-month history of left shoulder pain and stiffness. **a** Coronal oblique MR image (TR/TE=600 ms/12 ms) following gadolinium shows enhancement of the rotator interval lesion (*arrow*) which sits above the subscapularis tendon (*asterisk*). **b** Coronal oblique MR image (TR/TE=3500 ms/45 ms) with fat suppression taken posteriorly shows mild enhancement of the thickened axillary pouch (*straight arrows*). Note enhancement of the thickened capsule lying above the superior labrum (*curved arrow*) at the biceps anchor. **c** Coronal oblique MR image (TR/TE=4500 ms/36 ms) shows considerable thickening and contraction of the axillary pouch (*arrows*)

had subluxation of biceps into the rotator interval which was encased in mildly enhancing scar tissue and one had soft tissue density in the rotator interval which was mildly enhancing.

Fifteen patients (15 of 22) from the control group had lesions of the supraspinatus tendon identified with MR imaging. There were 8 full-thickness tears, 5 partial tears and 2 patients showed features of severe intrasubstance degeneration and surface fraying. Five patients also had tears of the infraspinatus tendon and 2 patients had partial tears of subscapularis. There was a minimal amount of mildly enhancing soft tissue seen in the rotator interval in 2 of 22 patients from the control group. The joint capsule showed global low-grade enhancement in all studies. All 22 patients from this control group underwent rotator cuff surgery, where 18 tears were identified. The surgery did not include comprehensive assessment of the glenohumeral joint or rotator interval.

## Discussion

The pathophysiology of adhesive capsulitis is uncertain. Researchers have suggested both an inflammatory and fibrotic process [2, 7, 14]. In the early stage, a hypervascular synovial hyperplasia is present consisting principally of synovial cells with only occasional T cells and no B cells. New deposition of collagen results in gradual fibrosis of the subsynovium and capsule [15]. The contents of the rotator interval include the coracohumeral and superior glenohumeral ligaments, both of which are encased in capsulosynovial membrane and thus are subject to the same pathological process as the rest of the glenohumeral joint.

The surgical findings of adhesive capsulitis are consistent and easily recognisable in patients with the disease. Bunker arthroscopied 35 patients with clinical evidence of adhesive capsulitis and in 31 patients demonstrated highly vascular villous fronding of the synovium arising from the subscapularis bursa which spread to a

variable extent across the rotator interval [7]. The remaining 4 patients had dense scarring in this region.

Watson et al. described the inflammatory changes in patients who were treated with arthroscopic capsulotomy [8]. The severity of inflammation reflected the various phases encountered in frozen shoulder [16, 17], including a vascular inflammatory synovitis (stage I), and red synovium and early adhesions (stage 2), pink synovium and pronounced adhesions (stage 3) and mature capsular adhesion (stage 4). There was a predisposition for the entrance of the subscapularis bursa, the rotator interval, the biceps tendon, the subscapularis tendon and the inferior capsule recess synovium. The authors noted that a very swollen and often red biceps tendon was a frequent finding. Numerous other arthroscopic studies have also showed inflammation in the rotator interval [9, 10, 11].

It is not surprising that MR imaging findings correspond to changes that are readily identified by arthroscopy. Several researchers have previously investigated the MR imaging findings in adhesive capsulitis. Carrillon et al. have described gadolinium enhancement of the joint capsule and synovial membrane in all 25 patients and in the axillary recess in 22 of the 25 patients with clinical evidence of adhesive capsulitis [18]. Emig et al. have previously reported thickening of the axillary pouch as a reliable sign of adhesive capsulitis [12], whereas Tamai and Yamato demonstrated gadolinium enhancement of this structure [19]. More recently, Manton et al. reported that capsular/synovial thickness was an inconclusive MR arthrographic sign for distinguishing adhesive capsulitis from normal shoulders, although the study was limited to nine patients [20].

In our study the most common findings were changes in the rotator interval. Soft tissue signal intensity in the rotator interval was visible on the non-contrast images in all cases. This would commonly encase the superior glenohumeral ligament and also includes the coracohumeral ligament. Soft tissue signal intensity would also extend to the biceps tendon anchor. Increased signal was commonly observed on the FSE sequences ($TR/TE_{eff}$= 3500 ms/45 ms) with fat saturation, although any abnormality was more obvious on the post-gadolinium images. Gadolinium enhancement served to enhance the conspicuity of the lesion but was probably not essential for routine diagnosis. The amount of enhancement varied considerably, most likely reflecting the varying degree of vascularity and quantity of established scar tissue according to the disease stage.

The axillary pouch is often a contracted structure hanging between the humerus and glenoid, and thickening of this is exacerbated in adhesive capsulitis. Without joint distension, we found it difficult to rely upon thickening alone as a reliable sign of adhesive capsulitis. The coronal oblique images were most useful for assessing the axillary pouch. Gadolinium administration used in combination with fat-suppression techniques made this thickening more obvious.

Certain technical aspects of the study should be considered. A dedicated surface coil increases the signal-to-noise ratio and a high matrix (512×320) enhances patial resolution thereby increasing conspicuity of any lesion. Care must be taken not to misinterpret partial voluming from the top of the subscapularis muscle as a rotator interval lesion when viewing the images in the axial plane. Confirmation of the lesion in two planes helps to avoid misdiagnosis. The sagittal images were felt to be the most useful for assessing the rotator interval, followed by the axial images.

Limitations of this study include a small case series. There are no tests of observer performance as agreement was reached by consensus and was unequivocal in all cases. It is also noteworthy that normal shoulders also show a degree of capsular enhancement, although this study has not discriminated this enhancement from that in patients with adhesive capsulitis. Our exclusion criteria included trauma. Many adults often have sustained injuries to the shoulder girdle at some time (recalled or not). Trauma can result in thickening and scarring of the glenohumeral capsule and ligaments, and therefore it may be difficult to discriminate between trauma and adhesive capsulitis using MR imaging; however, it is likely that the amount of capsular and ligamentous thickening and degree of enhancement associated with adhesive capsulitis are more florid than due to trauma.

Our referring clinicians seemed to have little trouble in differentiating between adhesive capsulitis and rotator cuff disease on the basis of clinical grounds. Our referral group was confined to a group of upper limb surgeons with a special interest in adhesive capsulitis, and for the patients to enter the study they had to fulfil strong clinical criteria. In less experienced hands and patients whose symptoms and signs are not so well defined, MR imaging could contribute to an accurate diagnosis; however, formal studies that assess the diagnostic value of the presence of these signs are needed; these will require an independent and blinded comparison to a gold standard diagnosis (e.g. surgery) and evaluation of a patient sample that includes an appropriate spectrum of disease as well as different but commonly confused disorders. In addition, evidence of the inter- and intra-rater reliability of the MR imaging assessment will be needed.

Treatment options for adhesive capsulitis include physical therapy, intra-articular corticosteroid injection and closed manipulations [16]. Shoulder hydrodilatation has been shown to be an effective way of treating adhesive capsulitis [21, 22], although it is controversial whether distension offers any benefit to corticosteroid injection alone [23]. Anterior capsulotomy may be used in refractory cases [24, 25].

## Conclusion

The presence of enhancing fibrovascular scar tissue in the rotator interval, soft tissue thickening around the biceps anchor and thickening of the axillary pouch on MR imaging are signs suggestive of adhesive capsulitis. It remains to be seen whether these signs can be used to differentiate patients with adhesive capsulitis from those with other causes of shoulder pain. Further studies are needed.

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