FROZEN SHOULDER: RELIABILITY OF SHOULDER MR ARTHROGRAPHY

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ABSTRACT

PURPOSE: The purpose of this study is to evaluate the MR arthrographic findings in patients with frozen shoulder and to test its reliability using shoulder arthroscopic findings as the gold standard.

MATERIALS AND METHODS: During a period of 13 months, 19 patients clinically diagnosed as frozen shoulder syndrome were evaluated using MR arthrography and results were confirmed by shoulder arthroscopy within 3 months of the MR arthrography. Nineteen other subjects free of frozen shoulder as proved clinically and arthroscopically were used as control subjects matching with the patient group in number, sex, and age, those subjects underwent MR arthrography for other shoulder pathologies within 3 months before surgery. Evaluation criteria of the MR arthrography were; thickness of the coracohumeral ligament (CHL), thickness of the joint capsule, volume of the axillary recess, abnormalities of the CHL, subcoracoid fat triangle, superior glenohumeral ligament, subscapularis tendon, long head of biceps tendon, and subscapularis recess.

RESULTS: Thickened coracohumeral ligament (CHL) was significantly more common in patients with frozen shoulder than in control subjects (12 patients vs 1 control subject) with a threshold value of 4 mm, it has 63% sensitivity and 95% specificity for diagnosing frozen shoulder, while thickened capsule in the rotator cuff interval with a threshold value of 7 mm was having 68% sensitivity and 84% specificity and was more prevalent in patients than control subjects, in contrary to thickened capsule in the axillary recess which was not significant. Small axillary recess volume with a threshold value of 0.53 mL was more common in patients with frozen shoulder, having sensitivity of 84% and specificity of 74%. Complete obliteration of the subcoracoid fat triangle has a specificity of 100% for diagnosing frozen shoulder, yet, not sensitive (42%). Abnormality of the CHL and synovitis-like abnormality at the superior border of the subscapularis tendon and in subscapularis recess were more common in patients than control subjects.

CONCLUSION: MR arthrography is a reliable imaging modality for diagnosing frozen shoulder, with characteristic findings including thickened CHL, thickened capsule at the rotator cuff interval and complete obliteration of the subcoracoid fat triangle.

Introduction

The term frozen shoulder was used in 1934 by Codman. Neviaser in 1945 suggested the term “adhesive capsulitis” describing characteristic synovial changes in the glenohumeral joint in patients with frozen shoulder; he reported that the contracted capsule peeled from the humeral head like “adhesive plaster from skin”. The estimated prevalence of frozen shoulder is 2%-3% in the general population and 5%-6% in patients evaluated by shoulder surgeons.1-3

The term shoulder stiffness is defined as a restriction of the passive range of motion of the shoulder. True adhesive capsulitis, is the type of shoulder stiffness where loss of passive range of motion is related to a connective tissue inflammatory process affecting the capsule of the joint.4

The diagnosis of frozen shoulder is probably less frequent, but recognition of this abnormality has an important effect on therapeutic decisions and may promote invasive therapy, such as manipulation under anesthesia, or arthroscopic capsular release.1
Although physical examination remains the cornerstone for diagnosis, other diagnostic modalities including MRI refines both diagnosis and outcome of treatment.5

Magnetic resonance (MR) imaging is widely used to assess shoulder pain. A large number of publications have described the MR imaging assessment of the rotator cuff, labrum, capsule, and biceps tendon.6-8

Thickening of the joint capsule in the axillary recess has been described as a characteristic sign of frozen shoulder,9 but this characterization has not been confirmed by other investigators.10

Studies based on findings at arthroscopy11,12 and at open surgery13,14 have shown that the main abnormalities in patients with frozen shoulder were inflammation of the region of the rotator cuff interval, synovitis at the anterosuperior glenohumeral joint, and thickening of the coracohumeral ligament (CHL).1

Objectives The purpose of this study is to evaluate the MR arthrographic findings in patients with frozen shoulder and to test its reliability using arthroscopic findings as the gold standard.

Anatomical considerations:

The shoulder complex has the greatest mobility of all joints of the body. There is little bony congruity between articular surfaces; that is why the joints of the shoulder complex have to rely on adjacent ligaments and muscles to provide stability.15

The glenohumeral ligaments (superior, middle, and inferior) are thickened bands of the anterior joint capsule.

The inferior glenohumeral ligament (IGL) (Fig.1) is the largest and most important of the glenohumeral ligaments consisting of anterior and posterior bands as well as an axillary pouch. Its anterior and posterior bands are attached to and contribute to the formation of the anterior and posterior glenoid labra,16 while the insertion is into the humeral neck at the periphery of the articular margin,17 in one of two configurations either as a collar-like attachment, or as a V-shaped attachment.18 The axillary pouch attaches to the inferior two thirds of the entire circumference of the glenoid by means of the labrum,19 it is located between the anterior and posterior bands, and extends inferior to the body of the glenohumeral joint as a redundancy of thickened capsular tissue best visualized on coronal oblique images of MRI and by arthroscopy.17

The middle glenohumeral ligament (MGL) attaches the glenoid labrum and scapular neck to the anterior aspect of the anatomic neck of the humerus, medial to the lesser tuberosity. This structure can be identified between the subscapularis tendon and the anterior labrum or anterior band of the IGL. The MGL demonstrates the greatest variation in size and thickness. A poorly defined or absent MGL is present in 30% of shoulders studied.17

The superior glenohumeral ligament (SGL) (Fig.1) is the smallest and least understood of the glenohumeral capsular structures. The SGL originates from the upper pole of the glenoid cavity and base of the coracoid process, and is attached to the MGL, to the biceps tendon, and to the labrum. It inserts just superior to the lesser tuberosity in the region of the bicipital groove. A normal foramen or opening exists between the SGL and MGL, allowing communication with the subscapularis bursa.17 The SGL has been reported to be present in 90% to 97% of the shoulders studied.20 The size of the SGL varies, ranging from a thin thread-like thickening of the capsule to a more substantial ligament.20 The SGL is closely related to the extra-articular coracohumeral ligament.

The three glenohumeral ligaments appear of low signal on both T1- and T2-weighted images.

Arthroscopically, the three glenohumeral ligaments can be seen as three zones of distinct capsular thickening.

The rotator cuff interval is bordered superiorly by the anterior margin of the supraspinatus tendon and inferiorly by the superior border of the subscapularis tendon, this triangular area which contains both the coracohumeral (Fig.2) and superior glenohumeral ligaments, has the coracoid process as its medial boundary. This interval is an integral part of the cuff and capsule and can be distinguished only by sharp dissection.21

The coracohumeral ligament (Fig.3) has a broad thin origin along the lateral border of the coracoid, and as the ligament passes laterally, it divides into two main bands, one of them inserts onto the an-
terior edge of supraspinatus tendon and the greater tuberosity. The other band inserts onto the superior border of the subscapularis, the transverse humeral ligament, and the lesser tuberosity. The coracohumeral ligament has extensions that envelope the cuff tendons. The coracohumeral ligament is a well defined structure superficial to the shoulder capsule and not just a thickening of the capsule.21

Materials and Methods

Patients and Control Subjects:

During a period of 21 months; 33 patients with the clinical diagnosis of frozen shoulder underwent MR arthrography. Nineteen patients (twelve women, 7 men) were included in our prospective study based on the following criteria: (1) clinically diagnosed as frozen shoulder; (2) plain radiograph showed no abnormality other than disuse osteopenia; and (3) arthroscopy was done within 3 months of the MR arthrography with arthroscopic confirmation of frozen shoulder in the form of thickened capsule and synovitis in the area of the rotator cuff interval and axillary pouch and treated with arthroscopic release.

Patients’ age ranged from 32 -to- 75 years (mean, 44.8 years), the age range among men was 40 -to- 75 years (mean, 60.2 years) and among women was 32 -to- 61 years (mean, 53.5 years). All patients underwent conservative therapy before the definitive management. MR arthrography was done in all patients to demonstrate additional pathologic conditions that might influence the surgical procedure such as rotator cuff tear or long head of biceps lesion.

MR imaging findings were prospectively assessed for the diagnosis of frozen shoulder. The diagnostic criteria were defined based upon certain quantitative and qualitative criteria as defined basically on Mengiardi et all as well as other orthopedic literatures related to frozen shoulder.11-14, 22

Quantitative criteria: Measurements were obtained to the nearest one-tenth millimeter and then rounded to the nearest whole millimeter.

(a) the thickest portion of the CHL on sagittal oblique images (Fig.2) of more than 7mm, (c) volume measurements in the axillary recess; width and height were measured on coronal oblique images, while the depth on transverse images. The volume of the axillary recess was calculated in milliliters by using the equation for elliptical volume, \( v = 0.52\text{hwd}, \) where h is height, w is width, and d is depth.

Qualitative criteria: The following qualitative criteria were evaluated and characterized as present or absent (a) abnormalities of the CHL, characterized by signal intensity changes and/or contour irregularity, (b) lesion of the superior glenohumeral ligament, characterized by signal intensity changes and/or contour irregularity, (c) partial (Fig.5) or complete (Fig.6) obliteration of the subcoracoid fat triangle, (d) synovitis-like abnormality at the superior border of the subscapularis tendon (Fig.7), (e) synovitis-like abnormality at the articular surface of the subscapularis tendon (Fig.8), (f) synovitis-like abnormality around the long biceps tendon, (g) synovitis-like abnormality in the subscapularis recess (Fig.9), and (h) leakage of contrast material along the subscapularis muscle. The subcoracoid fat triangle was analyzed in the sagittal oblique plane. The borders of the triangle were defined by (Fig.3); the coracoid process anterosuperiorly, by the CHL superiorly, and by the joint capsule posteroinferiorly. Synovitis-like abnormalities were diagnosed on the basis of evidence of synovial irregularity and/or thickening.

The control group included 19 subjects (matched to 19 patients) who underwent MR arthrography which was done within 3 months before surgery and had shown neither clinical nor arthroscopic signs of frozen shoulder. Other matching criteria were age (the overall range was, 30 -to- 71 years; mean, 44.6 years; while range in men, 30 -to- 64 years; mean, 59.7 years; and range in women, 35 -to- 71 years; mean, 51.1 years), and sex (twelve women, 7 men). The indications for arthroscopy were impingement syndrome (n = 10), instability (n = 4), and rotator cuff tear (n = 5).

MR Arthrography:

The glenohumeral joint was entered with a 22-gauge spinal needle with a posterior approach and fluoroscopic guidance. The spinal needle was con-
nected directly to a syringe filled with contrast material. First, a 4 ml solution composed of 2 ml of nonionic iodinated contrast material (iopromide, Ultravist; 300 mg/ml, Schering, Berlin, Germany) and 2 ml of 1% lidocaine (Abbott Laboratories, North Chicago) was injected to confirm the intraarticular location of the 22-gauge spinal needle. This was followed by an injection of 8–10 ml of a solution composed of 2 ml of gadopentetate dimeglumine (Magnevist; Schering, Berlin, Germany) diluted with 250 ml of normal saline. Radiographs were obtained in all patients after gentle movement of the shoulder, the patients were then sent to the MR suite, where MR arthograms were immediately obtained without further movement of the shoulder. No complications related to injection of the nonionic iodinated contrast material, injection of 2 ml of 1% lidocaine, or injection of the mixture of gadopentetate dimeglumine and saline occurred during MR arthrography.

**MR Imaging Protocol:**

MR imaging was performed by using an 0.23T imager (Panorama, Philips Medical Systems, MR Technologies, Finland) equipped with a dedicated receive-only shoulder coil.

The arm position was standardized, with the thumb pointing upward. T1-weighted turbo (fast) spin-echo images (TSE) were obtained in the transverse plane, and in the sagittal oblique plane; repetition time (TR)/echo time (TE), 400/12 msec; section thickness, 5mm; intersection gap, 0.5mm; field of view (FOV), 220mm; matrix, 270x270; echo train length (turbo factor), 2-3. Fat-suppressed T1-weighted spin-echo images (short tau inversion recovery “STIR”) were obtained in the axial and coronal oblique planes; IR TSE, 2510(80)/12; section thickness, 4.5mm; intersection gap, 1.5mm; FOV, 220mm; matrix, 192x216, echo train length, 4. T2-weighted TSE images were obtained in the coronal oblique plane; TR/TE, 4000/110 msec; section thickness, 5mm; intersection gap, 0.5mm, FOV, 220mm; matrix, 192x200; echo train length, 20. Intermediate-weighted TSE images were obtained in the coronal oblique plane; TR/TE, 2000/10 msec; section thickness, 5mm; intersection gap, 0.5mm; FOV, 220; matrix, 192x216; echo train length, 12.

**Analysis of MR images:**

The thickest portion of the CHL is measured on sagittal oblique T1-weighted images perpendicular to CHL surface.

Capsular thickness in rotator cuff interval is measured 1.5 cm anterolateral to base of coracoid process on sagittal oblique T1-weighted images. Thickest portion of capsule perpendicular to surface of humeral head is measured along a radial line drawn to centre of humeral head. Thickest portion of capsule in axillary recess is measured on coronal oblique intermediate-weighted images separately for humeral and glenoid portions.

Maximal height and width of axillary recess are measured on coronal oblique images, and depth is measured on corresponding transverse images.

**Arthroscopic technique:**

General anesthesia is used in all cases. Some cases had additional interscalene block for postoperative pain control (six cases).

For arthroscopic release; Beach chair position is used in all cases due to ease of assessing the improvement in range of motion after each step. Examination under anesthesia was done to every patient to reveal actual passive range of motion after elimination of pain and muscle spasm. No trial of manipulation was done before introduction of the scope to avoid bloody arthroscopic field and to assess the isolated effect of the arthroscopic release. Arthroscopic adhesolysis was started through local intra-articular injection of about 50-100cc normal saline to distend the joint, back flow of the injected fluid from the joint was considered as rough estimate of intra-articular location. The following steps were used for release; (1) synovectomy using motorized shaver. No electrocautery or laser is used in any case to reduce the cost and to standardize the procedure. Synovectomy involved the rotator interval, biceps, and subscapularis. It is continued further anteriorly; after release of the capsule, the coracohumeral ligament was released up to the bony coracoid process which was then cleaned from the soft tissues. In few cases, the coracohumeral ligament was cut with the rotator interval capsule, and was not clearly seen. Reaching the bony coracoid and cleaning it was considered enough proof that the coracohumeral
ligament must have been released, (2) the next step is clearing the axillary pouch using small synovia-
tor and arthroscopic basket very carefully to avoid
axillary nerve injury, at this stage, the humeral head
should have obviously moved away from the gle-

Statistical analysis:
The significance of the qualitative criteria was
statistically calculated using the Chi-square test,
and a P value of less than 0.05 was considered sta-
tistically significant difference.

Results
Quantitative criteria: Table 1

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Sensitivity n/patients</th>
<th>Specificity n/subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of CHL ≥ 4 mm (range, 3.5-6.3 mm)</td>
<td>12/19 (63%)</td>
<td>18/19 (95%)</td>
</tr>
<tr>
<td>Thickness of capsule in the rotator cuff interval ≥ 7 mm (range, 4.2 mm-8.1 mm)</td>
<td>13/19 (68%)</td>
<td>16/19 (84%)</td>
</tr>
<tr>
<td>Axillary recess volume threshold 0.53 mL (range, 0.12 mL-0.98 mL)</td>
<td>16/19 (84%)</td>
<td>14/19 (74%)</td>
</tr>
</tbody>
</table>

Qualitative criteria: Table 2 & 3

Incidence of obliteration of the subcoracoid fat tri-
gle (partial or complete) was significantly higher in
patients with frozen shoulder than in control subjects
(74% vs 37%) with a specificity of 63%, meanwhile,
complete obliteration of the subcoracoid fat triangle
was 100% specific for diagnosing frozen shoulder pa-
tients, yet, not sensitive (42%).

Synovitis-like abnormality at the superior border
of the subscapularis tendon and subscapularis recess
were fairly more frequent in patients than in con-
trol subjects; 12 patients (63%) vs 4 control subjects
(21%), and 13 patients (68%) vs 6 control subjects
(32%) respectively.

Abnormalities of the CHL were more prevalent in
patients than control subjects 79% vs 21%.

Rest of the evaluated qualitative criteria showed
non-significant difference between the patients with
frozen shoulder and control subjects.

Arthroscopically:
Difficult entry of the arthroscope was the earliest
sign for diagnosing adhesive capsulitis in our patients,
sometimes necessitating more than one entry attempt.

All patients showed signs of synovitis in the area
of rotator cuff interval (Table 4). Eleven patients had
an intact rotator cuff. Two patients had a full-thickness
tear of both the supraspinatus and infraspinatus ten-
don, and 2 patients had a partial thickness tear of the
supraspinatus tendon. In one patient complete tear of
the long head of biceps (Table 5).

Arthroscopy was done for the control subjects
group with the following findings: five patients had
rotator cuff tear (three patients had partial thickness
tear and 2 patients had full-thickness tear), 4 patients
with anteroinferior instability, 10 patients had shoul-
der impingement syndrome, and 2 patients diagnosed
as superior labrum anterior-posterior lesion (SLAP)
(Table 6).
### Table 2: Significant qualitative criteria

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Sensitivity n/patients</th>
<th>Specificity n/subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abnormality of the CHL</td>
<td>15/19 (79%)</td>
<td>15/19 (79%)</td>
</tr>
<tr>
<td>Obliteration of the subcoracoid fat triangle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Present</td>
<td>14/19 (74%)</td>
<td>12/19 (63%)</td>
</tr>
<tr>
<td>b. Complete</td>
<td>8/19 (42%)</td>
<td>19/19 (100%)</td>
</tr>
<tr>
<td>Synovitis-like abnormality at the superior border of the subscapularis tendon</td>
<td>12/19 (63%)</td>
<td>15/19 (79%)</td>
</tr>
<tr>
<td>Synovitis-like abnormality in the subscapularis recess</td>
<td>13/19 (68%)</td>
<td>13/19 (68%)</td>
</tr>
</tbody>
</table>

### Table 3: Non-significant qualitative criteria

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Patients</th>
<th>Control subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synovitis-like abnormality at the articular surface of the subscapularis tendon</td>
<td>5/19 (26%)</td>
<td>3/19 (16%)</td>
</tr>
<tr>
<td>Leakage of contrast along subscapularis muscle</td>
<td>3/19 (16%)</td>
<td>2/19 (11%)</td>
</tr>
<tr>
<td>Synovitis-like abnormality around long biceps tendon</td>
<td>14/19 (74%)</td>
<td>10/19 (53%)</td>
</tr>
<tr>
<td>Abnormal superior glenohumeral ligament</td>
<td>17/19 (89%)</td>
<td>15/19 (79%)</td>
</tr>
</tbody>
</table>

### Table 4: Arthroscopic findings in patients with frozen shoulder

<table>
<thead>
<tr>
<th>Criterion</th>
<th>MR arthrography n/patients</th>
<th>Arthroscopy n/patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickening and fibrosis of CHL</td>
<td>15/19 (79%)</td>
<td>16/19 (84%)</td>
</tr>
<tr>
<td>Reduction in axillary recess volume</td>
<td>16/19 (84%)</td>
<td>17/19 (89%)</td>
</tr>
<tr>
<td>Synovitis-like abnormality in the rotator cuff interval</td>
<td>14/19 (74%)</td>
<td>19/19 (100%)</td>
</tr>
<tr>
<td>Synovitis-like abnormality at the articular surface of subscapularis muscle</td>
<td>5/19 (26%)</td>
<td>17/19 (89%)</td>
</tr>
<tr>
<td>Synovitis-like abnormality around long biceps tendon</td>
<td>14/19 (74%)</td>
<td>8/19 (42%)</td>
</tr>
</tbody>
</table>

### Table 5: Associated lesions in patients with frozen shoulder

<table>
<thead>
<tr>
<th>Lesion</th>
<th>No. of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-thickness tear of both supraspinatus &amp; infraspinatus muscles</td>
<td>2</td>
</tr>
<tr>
<td>Partial thickness supraspinatus tear</td>
<td>2</td>
</tr>
<tr>
<td>Torn long head of biceps</td>
<td>1</td>
</tr>
</tbody>
</table>

### Table 6: Lesions in control subjects

<table>
<thead>
<tr>
<th>Lesion</th>
<th>No. of control subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-thickness tear of both supraspinatus &amp; infraspinatus muscles</td>
<td>2</td>
</tr>
<tr>
<td>Partial thickness supraspinatus tear</td>
<td>3</td>
</tr>
<tr>
<td>Instability</td>
<td>4</td>
</tr>
<tr>
<td>Impingement syndrome</td>
<td>10</td>
</tr>
<tr>
<td>Superior labrum anterior-posterior lesion (SLAP)</td>
<td>2</td>
</tr>
</tbody>
</table>
Fig. 1 Coronal oblique MR arthrography T1-weighted fat-suppressed (STIR) image showing the long head of biceps tendon (block short white arrow), the IGL (block long white arrow) and the SGL (thin long white arrow) in a control subject having instability of the shoulder joint.

Fig. 2 Schematic representation of sagittal oblique section showing, coracoid process (C), humeral head (H), CHL (black arrow heads), and capsule (long black arrow) in rotator cuff interval (Quoted with modification from Mengiardi et al).

Fig. 3 Sagittal oblique T1-weighted MR arthrography image showing the subcoracoid fat triangle with its boundaries; CHL, coracoid process, and joint capsule.

Fig. 4 Sagittal oblique T1-weighted MR arthrography image showing thickened CHL.

Fig. 5 Sagittal oblique T1-weighted MR arthrography image showing partial obliteration of the subcoracoid fat triangle.

Fig. 6 Sagittal oblique T1-weighted MR arthrography image showing complete obliteration of the subcoracoid fat triangle.
Fig. 8 Coronal oblique T1-weighted MR arthrography image showing synovitis-like abnormality with blurred borders and intermediate signal intensity at superior border of subscapularis muscle tendon

Fig. 9 Sagittal oblique T1-weighted MR arthrography image showing synovitis-like abnormality of the subscapularis recess

Discussion

Clinical symptoms of frozen shoulder include slow onset of pain, inability to sleep on the affected arm, and restriction of both active and passive movement. Patients are commonly 40-70 years old and predominantly female.\textsuperscript{1, 23}

Frozen shoulder may be idiopathic (Primary frozen shoulder), preceded by trauma either surgical or non-surgical (Secondary frozen shoulder), or associated with diabetes mellitus or conditions such as Dupuytren disease or with cardiac surgery (bipolar stiffness).\textsuperscript{11, 24, 25} Nowadays, the term adhesive capsulitis is used only for the primarily stiff shoulder. It is believed that adhesive capsulitis is not present if there is no true loss of passive range of motion by actual capsular restraints.\textsuperscript{4}

Physical examination is the cornerstone for diagnosis of adhesive capsulitis of the shoulder.\textsuperscript{5}

Different arthroscopic studies suggest that the central focus of changes is in the contracted coracohumeral ligament and rotator interval, the surrounding tissues of this lesion, the subacromial tissues, and synovial membrane become inflamed, and the portion of the tendon of the long head of the biceps beneath the lesion becomes stenotic.\textsuperscript{1}

Arthroscopy has been shown to be of diagnostic value in cases with adhesive capsulitis. Arthroscopy can clearly rule out other significant intra-articular pathology, conditions such as SLAP lesions, rotator cuff tears, labral tears, glenohumeral arthritis, and subacromial bursitis can be clearly visualized by arthroscopy.\textsuperscript{12, 14} Neer et al\textsuperscript{13} suggested that a tightened CHL restricts external rotation in patients with frozen shoulder.

Treatment options include physical and supportive therapy, intraarticular corticosteroid injection, closed mobilization with anaesthesia, and capsulotomy (whether open surgical or arthroscopic release).\textsuperscript{5, 26}

The precise pathogenesis of frozen shoulder is not known. Histologic and immunocytochemical investigations have demonstrated active fibroblastic proliferation accompanied by transformation of fibroblasts to myofibroblasts.\textsuperscript{11}

MR arthograms with gadolinium-based contrast material are being used increasingly to detect shoulder abnormalities, and they appear to be more accurate than standard MR imaging for assessing the rotator cuff. Fat-suppressed sequences further improve the diagnostic performance of MR arthrography.\textsuperscript{25, 27-29}

In this study thickening of the CHL of 4 mm or more was having 95% specificity for diagnosing frozen shoulder and this result was supported by Emig et al\textsuperscript{9} study and Mengiardi et al\textsuperscript{1} (95%).
while in Manton et al\textsuperscript{10} this result was not supported probably due to less number of patients (nine patients) and the standard of diagnosis was conventional arthrography and not surgical confirmation (except in one patient), meanwhile, abnormalities of the CHL in general were having less sensitivity and specificity (79\% for each), however, significant difference was found between number of patients and control subjects with abnormalities of the CHL unlike in Mengiardi et al\textsuperscript{1} where no significant difference was found.

In our patient group, thickening of the capsule in the rotator cuff interval was significant (84\% specificity) matching with the results of Mengiardi et al\textsuperscript{1} (86\% specificity), as well as Carrillon et al\textsuperscript{30} who reported enhancement of the joint capsule in the rotator cuff interval after the intravenous injection of gadopentetate dimeglumine. Emig et al\textsuperscript{9} used standard MR imaging of the shoulder to measure the thickness of the capsule in the axillary recess and found significant thickening in patients with frozen shoulder, while in our work as well as in Mengiardi et al\textsuperscript{1}, no significant thickening was detected.

Volume reduction of the axillary recess was more prevalent in our patients than control subjects (16 patients vs 5 control subjects), this finding was supported by Mengiardi et al\textsuperscript{1}. The volume reduction of the axillary recess is thought to be due to adhesions,\textsuperscript{1} meanwhile, a number of arthroscopic investigators\textsuperscript{14, 22} failed to reveal such adhesions in the axillary recess. On the other hand, Uitvlugt et al\textsuperscript{12} stated that; the capsule tissue is noticeably more difficult to penetrate in frozen shoulder patients than in shoulders with other pathological conditions. Thus, the finding of small axillary recess volume in patients with frozen shoulder represents a true abnormality as proved by arthroscopy; stated Mengiardi et al\textsuperscript{1}, this evidence was supported in this work where 89\% of our patients showed actual reduction in the volume of the axillary recess during arthroscopy.

Specificity of 100\% was achieved by complete obliteration of the subcoracoid fat triangle (subcoracoid triangle sign), however, sensitivity was low (42\%), and this was confirmed as well in Mengiardi et al\textsuperscript{1}, while both partial and complete obliteration of the subcoracoid fat triangle was more sensitive than specific (74\% and 63\% respectively).

In our patient group all MR arthrographic findings have been correlated with arthroscopic results to assess the diagnostic sensitivity of MR arthrography regarding each individual criterion in contrast to arthrographic findings to refine the arthroscopic procedure to attack the most affected structure(s) in order to reduce operative time and post-operative haemarthrosis. To our knowledge no such a comparison has been made by other investigators. MR arthrography has proved to be over sensitive for biceps tendon synovitis (74\% vs 42\%) as compared to arthroscopy. On the other hand, there was no significant difference between findings of MR arthrography and arthroscopy as regard thickening of the CHL (79\% vs 84\%), and reduction in axillary recess volume (84\% vs 89\%). MR arthrography has proved to be less sensitive for synovitis-like abnormality at the rotator cuff interval and articular surface of subscapularis muscle (74\% vs 100\%, and 26\% vs 89\% respectively).

In conclusion, MR arthrography is a reliable imaging modality for diagnosing frozen shoulder, with characteristic findings including thickened CHL, thickened capsule at the rotator cuff interval and complete obliteration of the subcoracoid fat triangle.

References


