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TECHNICAL REPORT

Targeted ultrasound-guided hydrodilatation via the rotator interval for adhesive capsulitis

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Abstract
Objective To describe and evaluate ultrasound-guided hydrodilatation via the rotator interval for the treatment of adhesive capsulitis.
Materials and methods Patients referred to our department with adhesive capsulitis were consented for hydrodilatation. Inclusion criteria included a failure to respond to conservative treatment and the absence of full thickness rotator cuff tear. Twenty-one milliliters of a mixture of local anesthetic and steroid was injected into the rotator interval using a 21-gauge needle. Patients were followed up at 2 weeks and 4 months, with documented pain scores from 0 to 10 on a visual analogue scale and the Oxford Shoulder Questionnaire.
Results Twenty-two patients were suitable for inclusion in the study. Nineteen were female (86 %) and three were male. The mean age was 55 years (range, 32–71 years). The duration of symptoms ranged from 4 weeks to 20 months. At 4 months, 19/22 (86 %) of patients described either complete (7/22) or good (12/22) improvement in their symptoms. The mean pain score was 8.4 prior to the procedure, 3.1 at 48 h and 1.9 at 4 months, and 20/22 (91 %) had a lower pain score after 4 months. There was a statistically significant ($p<0.05$) improvement in the Oxford shoulder score, from a mean of 13.6 pre-procedure to 36.5 at 4 months.
Conclusions The rotator interval and anterior joint capsule are strongly implicated in the symptomatology of adhesive capsulitis. The novel use of targeted ultrasound-guided hydrodilatation via the rotator interval gives good results in reducing shoulder pain and symptoms in adhesive capsulitis.

Keywords Ultrasound · Shoulder · Interventional techniques · Adhesive capsulitis

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Introduction

Adhesive capsulitis, or frozen shoulder, is a common condition resulting in pain and global restriction of motion at the glenohumeral joint. There is inflammation, thickening, and contracture of the joint capsule [1]. It is often idiopathic, but there is an association with diabetes [2] and previous trauma [3]. There is a peak incidence between 40 and 60 years of age, with females more often affected [4–6]. It is primarily a clinical diagnosis, with night pain and significant loss of external rotation characteristic findings [7]. The typical natural history is of gradual resolution of symptoms over a 1 to 3-year period, which may or may not be complete [8]. The anterior capsule and rotator interval are primarily involved in adhesive capsulitis [9].

The rotator interval is a triangular space formed by the boundaries of the supraspinatus, subscapularis, and coracoid, in the anteromedial aspect of the shoulder (Fig. 1). It contains the intra-articular long head of biceps tendon, coracohumeral (CHL), and superior glenohumeral ligaments (SGHL) [10]. The rotator interval is believed to contribute to stability of the long head of biceps tendon and glenohumeral joint [11, 12].

The long head of the biceps tendon passes through the interval towards its insertion on the superior glenoid [13]. In the interval, the biceps tendon sheath is outside the joint capsule but continuous with the glenohumeral joint (i.e., extrasynovial and intra-articular). The floor of the interval is the SGHL and anterior joint capsule. The roof is formed by the CHL, a broad structure arising from the lateral aspect of the

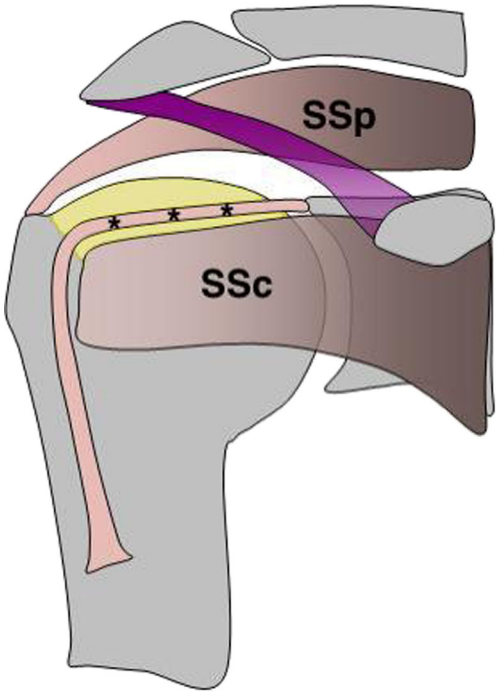

Fig. 1 Diagram of the right rotator interval. The rotator interval (highlighted in *yellow*) is the space in the anterior shoulder capsule between the supraspinatus (SSp) and subscapularis (SSc) tendons. The long head of the biceps tendon (*asterisks*) passes through this space. The coracohumeral ligament, which forms the roof of the interval, is not shown

coracoid, passing over the anterior shoulder, and inserting into the greater and lesser tuberosities of the humerus [14], merging with the anterior joint capsule. Contracture and thickening of the CHL is a frequent finding in adhesive capsulitis [15].

Many treatments have been described for adhesive capsulitis, including hydrodilatation. This involves the distension of the glenohumeral joint with fluid, which may reduce pain and increase motion by stretching and/or rupturing the joint capsule [16]. The concurrent injection of intra-articular steroid may reduce the underlying inflammation within the joint. Hydrodilatation is typically performed using fluoroscopic [17] or ultrasound guidance [18] using anterior and posterior approaches, respectively. Although a variety of injections into and around the shoulder joint are commonly performed using radiological guidance [19, 20], ultrasound-guided hydrodilatation via the rotator interval has not been previously described. In this article, we describe this novel approach in adhesive capsulitis. This has the intuitive advantages of targeting the anterior joint capsule in the vicinity of the CHL as well as co-existing biceps tenosynovitis.

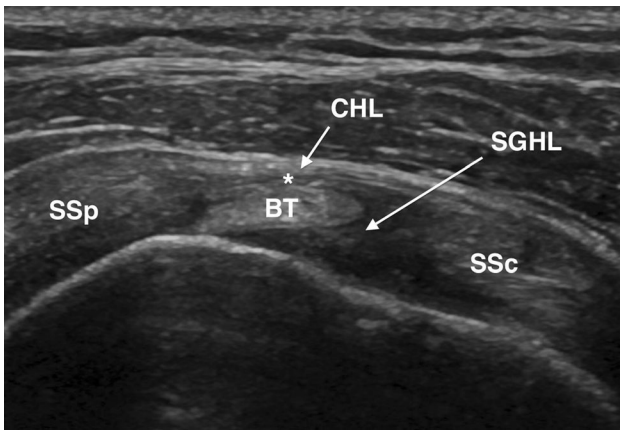

Fig. 2 A transverse long-axis ultrasound image of the normal rotator interval with the biceps tendon (BT) at the center of the image. The SGHL lies anterior to the biceps tendon and the CHL lies superiorly, forming the roof of the interval. Supraspinatus muscle (SSp) lies laterally and subscapularis muscle (SSc) lies medially. The asterisk indicates the target point of the needle in our technique

Materials and methods

Technique

A 15-MHz linear array ultrasound transducer (LOGIQ E9, GE Healthcare, UK), sterile ultrasound gel, two 10 ml syringes, one 1-ml syringe, and a 50 mm long 21-gauge (green) needle were used.

An assessment of the patient's range of motion is performed with the patient sitting, followed by a routine ultrasound examination of the shoulder, in particular assessing for pathology in the rotator cuff, rotator interval (Figs. 2 and 3), and subacromial bursa.

If there was sufficient evidence of adhesive capsulitis as demonstrated by a global reduction in range of motion, especially external rotation, in the absence of significant rotator cuff pathology, the patient was consented for an ultrasound-guided hydrodilatation.

The patient lies supine or semi-supine with the affected shoulder closest to the radiologist. The shoulder is slightly extended and the elbow flexed to facilitate visualization of the rotator interval anteriorly. The transducer is placed over the

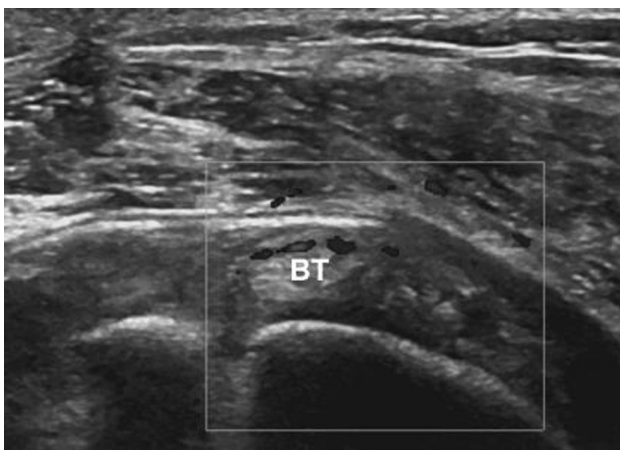

Fig. 3 Transverse ultrasound image of the rotator interval in a patient complaining of pain and restricted range of movement. There is soft tissue thickening and hypervascularity in the interval, suggestive of adhesive capsulitis. *BT* biceps tendon

anterior shoulder and a long-axis view of the rotator interval, with the biceps at the center of image and supraspinatus and subscapularis to either side, is obtained. The CHL is seen draped superiorly over the biceps tendon (Fig. 2).

Routine skin antisepsis and subcutaneous infiltration with 1 % lidocaine is performed. A 21-gauge needle is introduced into the rotator interval using an oblique path within the imaging plane of the transducer, from lateral to medial (Fig. 4). The needle tip is imaged in real-time throughout its passage from superficial to deep and is positioned in the biceps tendon sheath between the CHL above and biceps tendon below (Fig. 5).

In the presence of adhesive capsulitis, some resistance and often significant pain on initial injection of fluid is expected and the patient is warned about this. A 50:50 mixture of 20 ml of a mixture of 1 % lidocaine and 0.5 % bupivacaine is slowly injected using 10 ml syringes and a connecting tube. Any air bubbles within the injectate are removed to prevent any obscuration of the ultrasound images. With correct intra-articular needle positioning, the injected fluid should flow freely away from the needle tip, although in the author's experience some extra-articular spillage around the interval and into the subcoracoid and subacromial bursae is expected. No distinction was made between cases where possible capsular rupture occurred during the procedure (a sudden reduction in the resistance to injection) and those where it did not. Forty milligrams of triamcinolone is injected just before the needle is removed. Both passive and active gentle manipulation of the glenohumeral joint is performed post-procedure.

Methods

Institutional ethical committee approval was obtained prior to commencing the study.

The study included patients who were referred for ultrasound of the shoulder and consideration for outpatient therapeutic-guided injection over a 1-year period (March 2013 to March 2014).

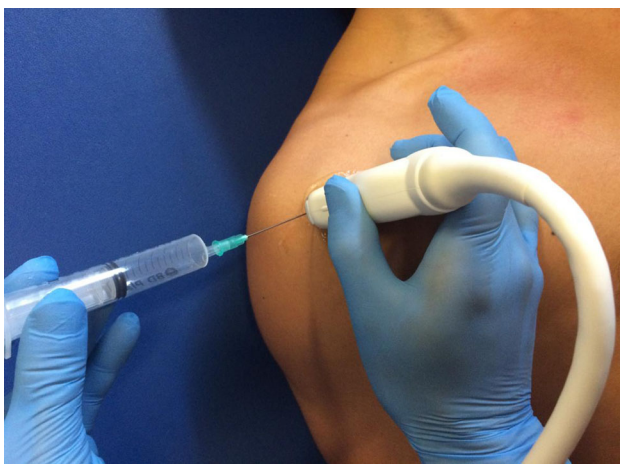

Fig. 4 The approach used to access the right rotator interval

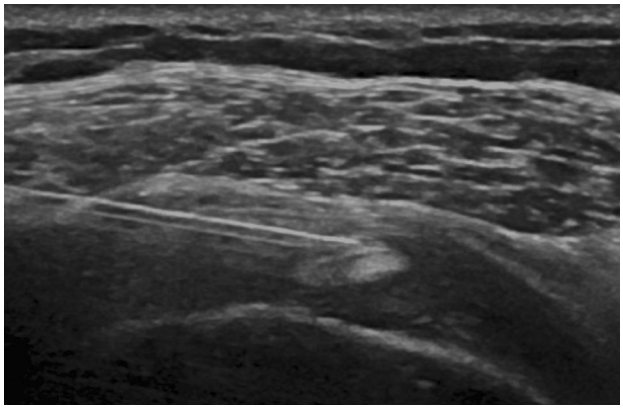

Fig. 5 Transverse ultrasound image of the rotator interval with the biceps tendon at the center of the image. The needle tip lies between the CHL above and biceps tendon sheath below

Inclusion criteria were a marked restriction in range of motion in the affected shoulder, in particular external rotation, failure to respond to conservative (e.g., physiotherapy, oral analgesia) or blind steroid injections and the absence of full-thickness rotator cuff tear or significant glenohumeral joint osteoarthrosis. Suitable patients received an ultrasound-guided hydrodilatation procedure as described above.

Following the procedure, patients were given a form to complete and return after 2 weeks regarding their symptoms as a visual analogue scale from 0 (no pain) to 10 (worst imaginable pain) at various times: before the injection, immediately after, during the first 24 h, during the second 24 h and after 2 weeks. These "pain scores" were documented. A telephone survey was performed at 4 months. Patients were given four options regarding their current symptoms, whether there was complete resolution of symptoms, good improvement, some improvement or no improvement in their symptoms, and asked to select one. Patients were also asked to complete the Oxford Shoulder Questionnaire [21] for the period prior to the hydrodilatation and again at 4 months. This is a validated 12-item questionnaire for measuring patient perception of shoulder problems, with a possible range of scores from 0 (severe shoulder symptoms) to 48 (no shoulder symptoms). The Wilcoxon test was used to establish whether there was a significant difference ($p<0.05$) between pre and post-hydrodilatation scores.

Data regarding demographics, duration of symptoms, relevant history, co-morbidities, and other treatments for their shoulder were recorded. The ultrasound findings in the shoulder at the time of hydrodilatation were also documented.

Results

A total of 22 patients were suitable for inclusion in this study. The mean age was 55 years (range, 32–71 years). Nineteen patients were female (86 %) and three were male. In three

patients, there was a history of diabetes and in another two a clear history of previous precipitating trauma. The duration of shoulder symptoms at the time of procedure ranged from 4 weeks to 20 months. Eleven patients were referred by the orthopedic department, ten by their primary care physician, and one by a rheumatologist. Five patients had preceding non-guided steroid injections, without significant improvement. Supraspinatus tendinopathy was noted on ultrasound in four (18 %) patients but no patients had full thickness rotator cuff tears, bursitis, glenohumeral joint effusion, or significant AC joint arthropathy.

Rotator interval hydrodilatation was well tolerated in all patients with no immediate complications. All 22 patients had reduced pain scores immediately post-procedure, and 20/22 (91 %) had reduced pain scores at 4-month follow-up compared to before the procedure. Mean pain score was 8.4 prior to the procedure, 3.3 immediately after, 3.4 at 24 h, 3.1 at 48 h, 2.1 at 2 weeks, and 1.9 at 4 months.

At 4-month telephone follow-up, there was complete resolution of symptoms in seven (32 %), good improvement in 12 (54 %), some improvement in two (9 %), and no improvement in one (6 %) (Table 1). There was an improvement in the Oxford shoulder scores in 21/22 patients (95 %). Mean Oxford score was 13.6 prior to the procedure (range, 2–35) and 36.5 at 4-month follow-up (range, 13–48). This was statistically significant ($p<0.05$). No patient had further shoulder intervention, other than physiotherapy, during the 4-month period before telephone follow-up.

Discussion

Adhesive capsulitis remains an enigmatic condition. A large number of treatment options are available for adhesive capsulitis. These include physiotherapy, steroid therapy (both oral and intra-articular), hydrodilatation with radiological guidance, manipulation under anesthesia and surgical capsular release [9]. There is a copious amount in the literature regarding the pathogenesis, diagnosis, and treatment options in this common condition and there remains significant uncertainty regarding its management. In particular, as the natural history is of gradual recovery, it is very challenging to accurately assess the results of any intervention [22]. Nevertheless, reducing pain, increasing mobility, and increasing the speed of recovery are desirable outcomes.

Table 1 Patients were asked to evaluate the change in their shoulder symptoms at 4-month telephone follow-up

Improvement in symptoms	Number of patients	Percentage
Complete resolution	7/22	32 %
Good improvement	12/22	54 %
Some improvement	2/22	9 %
No improvement	1/22	5 %

The distension of a contracted and thickened shoulder capsule is intuitively appealing as a treatment for adhesive capsulitis. This was first performed using fluoroscopic guidance [23] and subsequently ultrasound. Ultrasound avoids the use of ionizing radiation and iodinated contrast media, with the further advantage of facilitating an assessment of the rotator cuff and subacromial bursa pre-procedure.

A posterior ultrasound-guided approach to the glenohumeral joint is often used approach to hydrodilatation [18]. However, the orthopedic literature indicates that the predominant pathology in adhesive capsulitis is around the anterior joint capsule and rotator interval [24–26]. A contracted and thickened CHL is an important factor in adhesive capsulitis [27]. This is supported by the most common radiological findings, such as thickening and hypervascularity of the rotator interval on USS [28], thickening of the CHL and soft tissues in the rotator interval, and obliteration of the subcoracoid fat on MRI [29]. We therefore postulate that a targeted rotator interval approach to hydrodilatation may be more efficacious, particularly in the presence of a contracted, irregular capsule. Biceps tenosynovitis frequently co-exists with adhesive capsulitis [30] and our approach enables this to be directly addressed as well. In addition, there is usually better visualization of the rotator interval than the posterior glenohumeral joint recess in patients with a larger body habitus. The patient can also be more easily reassured and their levels of pain monitored using an anterior approach. Leakage of fluid into the adjacent subacromial bursa and rotator interval soft tissues may treat concomitant bursitis as well as capsulitis. An anterior rotator interval approach is often used in fluoroscopic hydrodilatation, but the relation of the needle tip to the biceps tendon and pulley ligaments is not directly visualized. Our initial results suggest that a good medium-term response in terms of reduced pain and improved function is obtained in patients with adhesive capsulitis who have a targeted ultrasound-guided hydrodilatation via the rotator interval. The relative contributions of steroid and volume of fluid are difficult to ascertain.

Although not directly comparable, a recent study of 23 patients who had three consecutive ultrasound-guided hydrodilatation procedures using a posterior approach found that 18/23 (78 %) had “excellent” or “good” results after 6 weeks [31]. This is relatively similar to our results of complete or significant improvement in 19/22 (86 %), with a longer follow-up time of 4 months in our study.

However, caution should be applied when carrying out this procedure. The needle is placed carefully placed between the CHL and biceps tendon and movements during the procedure should be kept to a minimum to avoid trauma to the biceps pulley and supraspinatus muscle. It is hoped that with the smooth passage of a single directly visualized needle, trauma to the adjacent soft tissue can be minimized. A lateral to

medial passage avoids the SGHL, which lies anterior to the biceps tendon in the interval (Fig. 5).

There are a number of limitations to our study. Shoulder pain is complex and multifactorial, and the relative contributions of co-existing subacromial impingement, rotator cuff tendinopathy, glenohumeral and acromioclavicular joint osteoarthritis, as well as pathology outside the shoulder is difficult to quantify. As the natural history of adhesive capsulitis is of gradual resolution [8], it is not possible to know whether a patient would have improved similarly with no intervention. In addition, patients frequently have more than one mode of treatment during the course of their symptoms, which makes it challenging to prove a clear treatment benefit from hydrodilatation. This lack of standardization in treatment, as well as diagnosis at different stages in the disease process and the possible co-existence with other shoulder pathologies, is a challenge common to many studies regarding treatment in adhesive capsulitis [22]. In addition, our study has small numbers, procedures performed by different ultrasound operators, only a medium-term follow-up, as well as a lack of objective range of motion data and correlation with arthroscopic findings.

In conclusion, we have described a novel radiological intervention for adhesive capsulitis, ultrasound-guided rotator interval hydrodilatation. This enables simultaneous targeting of the areas most often implicated in its pathophysiology, namely the CHL and adjacent capsular structures, as well as the biceps tendon sheath and the rest of the glenohumeral joint cavity. Our initial results are promising both in terms of a medium-term improvement in function and reduction in pain.

Conflict of interest The authors report no conflicts of interest associated with this study.

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