Skeletal Radiology (2019) 48:1269–1274
https://doi.org/10.1007/s00256-018-3105-3

TECHNICAL REPORT

Shoulder manipulation under targeted ultrasound-guided rotator interval block for adhesive capsulitis

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Received: 10 August 2018 / Revised: 8 October 2018 / Accepted: 18 October 2018 / Published online: 16 November 2018
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Abstract

Objective To describe and evaluate the outcome following shoulder manipulation under rotator interval block for the treatment of adhesive capsulitis.

Materials and methods Patients with adhesive capsulitis referred by our local orthopaedic shoulder surgeons consented to targeted ultrasound-guided injection of the glenohumeral joint via the rotator interval. Inclusion criteria included a failure to respond to conservative treatment and the absence of a full-thickness rotator cuff tear. Twelve millilitres of a mixture of local anaesthetic and steroid was injected into the rotator interval using a 21-gauge needle, with a small volume of the same solution instilled into the subacromial bursa. Following injection, under local anaesthetic block, patients were gently manipulated into abduction, external rotation and internal rotation as far as they could comfortably tolerate. Patients were assessed pre-injection with documented pain scores from 0 to 10 on a visual analogue scale (VAS) and the Oxford Shoulder Score (OSS) questionnaire. Initial follow-up comprised a VAS pain score at 1 h, 24 h and 2 weeks. Clinical review by the referring orthopaedic surgeon was performed at 2 months post-injection. Long-term follow-up involved a VAS pain score and the OSS questionnaire at 5 months.

Results Forty patients were suitable for inclusion in the study. Twenty-three were female (57.5%) and 17 were male. The mean age was 52 years (range, 31–73 years). Twelve patients were post-operative. The duration of symptoms ranged from 3 months to 18 months. Mean pre-procedure OSS was recorded as 23.3 (range, 4–36). The mean VAS pain score was 7.7 before the procedure (range, 4 – 10), 3.4 at 1 h (range, 0–8), 2.9 at 24 h (range, 0–8), and 1.8 at 2 weeks (range 1–4). Orthopaedic follow-up at an average of 66 days post-injection was recorded in 18 patients. All patients reported initial improvement of their shoulder pain and return to near full range of movement; however, recurrence of adhesive capsulitis symptoms was recorded in 5 patients. One case of rupture of the long head of the biceps tendon was reported, but the patient remained asymptomatic. Long-term follow-up at 5 months was obtained in 31 patients, with a mean OSS of 42 (range, 21–60) and VAS of 2.3 (range, 0–7).

Conclusion Manipulation under general anaesthesia is a well-recognised treatment for adhesive capsulitis. We report that targeted ultrasound-guided injection of the rotator interval and manipulation of the shoulder under local anaesthetic blockade result in good outcomes in reducing shoulder pain and symptoms of adhesive capsulitis with low recurrence and complication rates.

Keywords Ultrasound · Shoulder · Rotator interval · Adhesive capsulitis · Frozen shoulder · Interventional techniques · Guided injection

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Introduction

Adhesive capsulitis of the shoulder, also known as frozen shoulder, is characterized by a painful, gradual loss of both active and passive glenohumeral motion [1]. Adhesive capsulitis is common and is reported to have a lifetime incidence in 5% of the population [2, 3]. It is often idiopathic, but a number of risk factors have been reported including diabetes mellitus, female gender, hyperlipidaemia, thyroid disease, previous trauma and Caucasian ethnicity [4, 5]. Adhesive capsulitis is usually self-limiting [6], but many patients may

suffer from years of pain and disability if the condition is left untreated [7]. The underlying cause of adhesive capsulitis is poorly understood, but is believed to be a combination of synovial inflammation and capsular fibrosis [8].

The anterior capsule and the rotator interval, a triangular space formed by the boundaries of the supraspinatus, subscapularis, and coracoid in the anteromedial aspect of the shoulder (Fig. 1), have been implicated in the pathogenesis of adhesive capsulitis. Neer et al. [9] suggested that a tightened coracohumeral ligament (CHL) restricts external rotation in patients with adhesive capsulitis. A number of papers have reported improvement of shoulder function following surgical release of the coracohumeral ligament in chronic adhesive capsulitis [10–12]. Although adhesive capsulitis is usually diagnosed clinically, capsular thickening of the axillary recess, obliteration of the subcoracoid fat, shortening of the rotator cuff interval length, distention of the superior subscapularis bursa, and thickening of the coracohumeral ligament have been observed with magnetic resonance imaging (MRI) [13–20]. Thickening of the coracohumeral ligament on ultrasound is also reported to be highly suggestive of adhesive capsulitis [21] and the coracohumeral ligament (CHL) is stiffer in the symptomatic shoulder than in the unaffected shoulder on shear wave elastography [22].

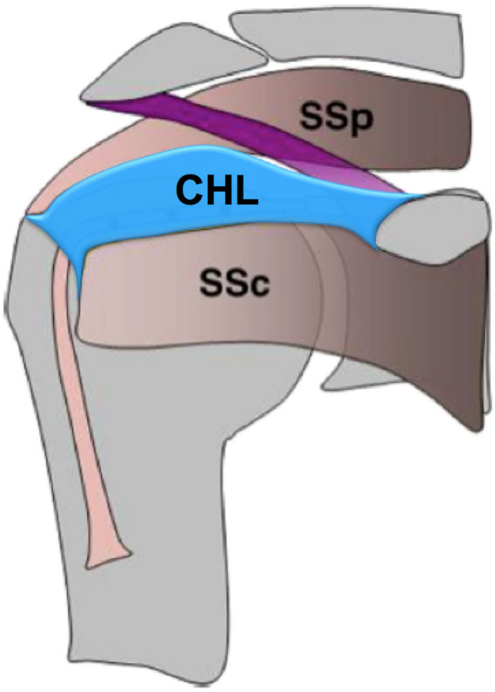

Fig. 1 Diagram of the rotator interval. The rotator interval is the space in the anterior shoulder capsule between the supraspinatus (*SSp*) and subscapularis (*SSc*) tendons. The long head of the biceps tendon passes through the rotator interval, which is in continuity with the glenohumeral joint. The roof of the rotator interval is formed by the coracohumeral ligament (*CHL*), shown in *blue*. The CHL arises outside the glenohumeral joint from the lateral aspect of the base of the coracoid process of the scapula. It broadens to merge with the rotator interval capsule and inserts on both the lesser and greater tuberosities spanning the bicipital groove. The distal fibres of the CHL interdigitate with those of the anterior SSp and SSc tendons

Several treatment options have been advocated, including physical therapy, anti-inflammatory medication, corticosteroid injections targeting the glenohumeral joint, subacromial bursa or rotator interval [23, 24]. Some studies have suggested an improvement following hydrodilatation, usually with steroid in the injectate [25, 26]. In their novel paper, Yoong et al. [23] reported 91% improvement in pain scores and 95% improvement in Oxford Shoulder Score (OSS) at 4 months following targeted hydrodilatation via the rotator interval. In this paper, Yoong et al. suggested that an anterior approach to performing hydrodilatation via the rotator interval may lead to improved clinical outcomes by targeting with the injectate the areas most often implicated in the pathophysiology of adhesive capsulitis, namely the CHL and adjacent capsular structures, in addition to the biceps tendon sheath and the rest of the glenohumeral joint cavity. Various surgical approaches are also described, most commonly manipulation under anaesthesia (MUA) and arthroscopic capsular release [27]. We describe a technique of shoulder manipulation following targeted ultrasound-guided rotator interval block for adhesive capsulitis.

Materials and methods

Technique

A 15-MHz linear array ultrasound transducer (LOGIQ E9, GE or Aplio 500, Canon), sterile ultrasound gel, two 10-ml syringes, one 5-ml syringe, and a 25-mm-long 23-gauge (green) needle were used.

A pre-injection assessment of the patient's range of motion was performed with the patient sitting, followed by a routine ultrasound examination of the shoulder, in particular assessing for pathological conditions in the rotator cuff and rotator interval, CHL thickening, subacromial subdeltoid effusion or impingement on dynamic imaging.

If there was sufficient clinical evidence of adhesive capsulitis, as demonstrated by a global reduction in range of motion, especially external rotation, in the absence of significant rotator cuff pathological conditions, the patient was submitted for an ultrasound-guided rotator interval injection.

The patient sat upright or lay semi-supine. The shoulder was slightly extended and the hand supinated to facilitate visualization of the rotator interval anteriorly. The transducer was placed over the anterior shoulder and a long-axis view of the rotator interval, with the biceps at the centre of the image and supraspinatus and subscapularis to either side (Figs. 2 and 3). In this position the often thickened CHL could be seen draped superiorly over the biceps tendon.

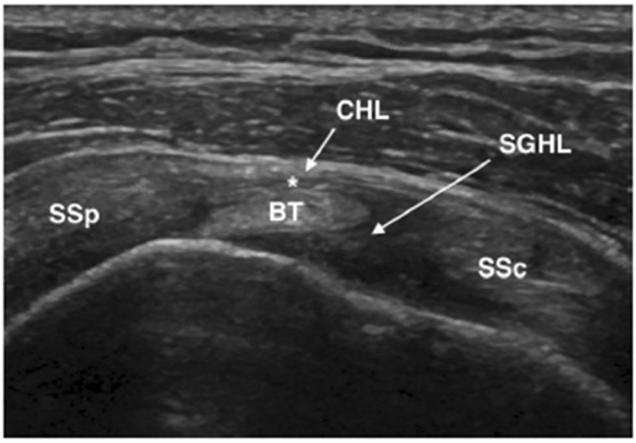

Fig. 2 A transverse ultrasound image of the rotator interval with the long head of the biceps tendon (*BT*) at the centre of the image. The superior glenohumeral ligament (*SSp*) is anterior to the biceps tendon and the CHL forms the roof of the interval superiorly. The SSp lies laterally and the SSc lies medially. The *asterisk* indicates the target point of the needle for targeted rotator interval injection

Routine skin antisepsis and subcutaneous infiltration with 1% lidocaine was performed using a 25-mm 23-gauge needle, which was then advanced just superficial to the CHL with further infiltration of 1% lidocaine. Following this, the needle was advanced deep to the CHL, into the rotator interval, positioned in the biceps tendon sheath between the CHL above and biceps tendon below (Fig. 4) and a 12-ml mixture of 1% lidocaine and 0.5% bupivacaine and 40 mg of triamcinolone was gently instilled. With correct intra-articular needle positioning, the injected fluid should flow freely away from the needle tip. This may be confirmed using Doppler imaging with a rim of flow surrounding the long head of the biceps tendon confirming extension of the injectate into the joint. Following injection, patients were invited to perform active movement of the shoulder. Patients were asked to lift their arm above their head. For internal rotation, patients were asked to place their hand between their shoulder blades and for external rotation patients were asked to keep their elbow tucked in and to repeatedly rotate their supinated hand out as far as they could go in a repetitive circular motion. Patients often noticed an immediate

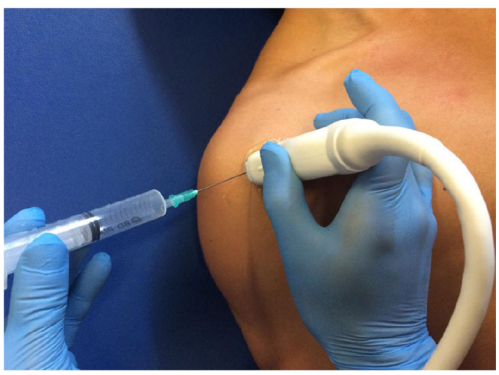

Fig. 3 The approach used to access the rotator interval

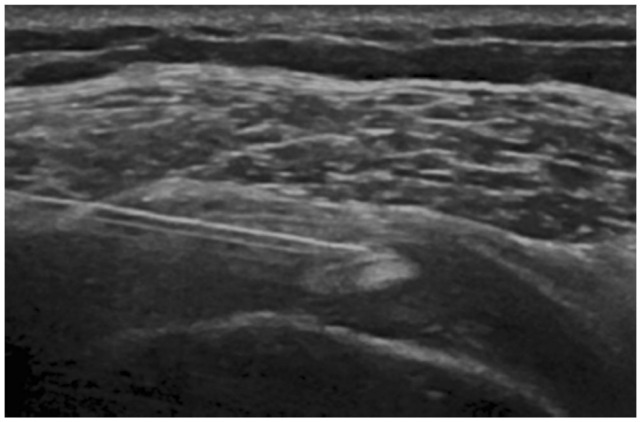

Fig. 4 Transverse ultrasound image of the rotator interval with the biceps tendon at the centre of the image. Using a long-axis needle approach, the needle tip lies between the CHL, as it forms the roof of the rotator interval, and the long head of the biceps tendon sheath below

improvement in their range of movement and were then gently manipulated into a full range of elevation and internal and external rotation under a local anaesthetic block (Fig. 5).

Methods

Institutional review board approval was obtained before commencing this study. The study included patients who were referred from our local shoulder orthopaedic surgeons for consideration for outpatient therapeutic-guided injection over a 1-year period (November 2016 to November 2017).

Inclusion criteria were a clinical diagnosis of adhesive capsulitis characterised by a restriction in range of motion in the affected shoulder, in particular external rotation, failure to respond to conservative management (e.g. physiotherapy, oral analgesia) or blind steroid injections, and the absence of a full-thickness rotator cuff tear or significant glenohumeral joint osteoarthrosis based on orthopaedic examination and plain film examination. Additional exclusion criteria included glenohumeral joint osteoarthritis, rotator cuff tears, long head of the biceps tendon tears or tendinosis identified on pre-procedure ultrasound. Suitable patients received manipulation under anterior interval local anaesthetic block procedure as described above. Our patients were routinely referred for a course of physiotherapy following their procedure.

Patients were assessed pre-injection with documented pain scores from 0 to 10 on a visual analogue scale (VAS) and the OSS questionnaire, 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) [28]. Initial follow-up comprised a VAS pain score at 1 h, 24 h and 2 weeks. Clinical review by the referring orthopaedic surgeon was performed at 2 months post-injection. Long-term follow-up involved a VAS pain score and the OSS questionnaire at 5 months. The Wilcoxon test was used

Fig. 5 Shoulder manipulation technique. The patient is asked to demonstrate their range of motion before the injection is performed and following the procedure gently helped into elevation, external rotation and internal rotation using a gentle stretching motion

to establish whether there was a significant difference ($p < 0.05$) between pre- and post-procedure 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 the procedure were also documented.

Results

Forty patients were suitable for inclusion in the study. Twenty-three were female (57.5%) and 17 were male. The mean age was 52 years (range, 31–73 years). Twelve patients were post-operative and 6 had a history of diabetes. The duration of shoulder symptoms at the time of injection ranged from 3 months to 18 months. None of the patients had full-thickness rotator cuff tears, glenohumeral joint effusion, or significant clinical features of AC joint arthropathy.

The procedure was generally well tolerated by most patients. However, in the authors' experience, a clear explanation of the procedure is necessary to reassure patients who often anticipate significant pain during manipulation of the shoulder and inviting patients to perform active shoulder movement following local anaesthetic block is often helpful in demonstrating the extent of anaesthesia.

Complete VAS pain diaries were recorded in 31 patients. Twenty-nine of the 31 had reduced pain scores immediately following the procedure and at 24 h, with 2 patients reporting no change. All patients reported reduced pain scores at 2 weeks and all 31 patients reported reduced pain scores at the 5-month follow-up with a mean reduction of 5 points on the VAS score (range 2–10 points).

The mean VAS pain score was 7.7 before the procedure (range, 4–10), 3.4 at 1 h (range, 0–8), 2.9 at 24 h (range, 0–8), 1.8 at 2 weeks (range 1–4) and 2.3 (range, 0–7) at 5 months. There was a significant difference between the pre-injection pain score and score at 1 h ($p \leq 0.05$), at 24 h ($p \leq 0.05$) at 2 weeks ($p \leq 0.05$) and at 5 months ($p \leq 0.05$; Table 1).

Mean pre-procedure OSS was recorded as 23.3 (range, 4–36) with a mean OSS of 42 (range, 21–57) at 5 months ($p \leq 0.05$; Table 2). All patients reported improvement in OSS at 5 months in comparison with their pre-procedure score, with improvement ranging from 1 to 41 points.

Orthopaedic follow-up at an average of 66 days post-injection was recorded in 18 patients. All patients reported initial improvement of their shoulder pain and return to near full range of movement, in many cases after several months of profoundly limited shoulder function. However, recurrence of mild adhesive

Table 1 Visual analogue scale pain score ($N = 31$)

	Score (range)	p
Pre-procedure	7.7 (0–8)	
1 h	3.4 (0–8)	≤ 0.05
24 h	2.9 (0–8)	≤ 0.05
2 weeks	1.8 (0–4)	≤ 0.05
5 months	2.3 (0–7)	≤ 0.05

Table 2 Oxford Shoulder Score ($N = 31$)

	Score (range)	p
Pre-procedure	23.3 (4–36)	
5 months	41.8 (21–60)	≤ 0.05

capsulitis symptoms, specifically limitation at the extreme of external rotation, was reported in 5 patients. One case of rupture of the long head of the biceps tendon was reported in a patient 6 weeks following the procedure; however, the patient remained asymptomatic without a significant loss of power.

Discussion

Adhesive capsulitis remains a poorly understood condition. There are a large number of treatment options available, including physiotherapy, targeted steroid injections, and hydrodilatation under radiological guidance, manipulation under anaesthesia and surgical capsular release [29].

A contracted and thickened CHL has been implicated in a number of recent studies as an important factor in adhesive capsulitis [9]. This is consistent with the characteristic radiological findings, such as thickening and hypervascularity of the rotator interval on ultrasound [30], thickening of the CHL and soft tissues in the rotator interval and obliteration of the subcoracoid fat on MRI [14], and increased stiffness on elastography [22]. Targeted treatments, such as steroid injection of the rotator interval [23, 24] and arthroscopic coracohumeral ligament release in patients with adhesive capsulitis [26], have been reported to yield good results.

This article builds on the work of Yoong et al. [23], which first described targeted injection of the rotator interval for adhesive capsulitis. This study, with a larger patient cohort, longer OSS and pain diary follow-up, and orthopaedic clinic assessment, demonstrates that targeted ultrasound-guided injection of the rotator interval and gentle manipulation of the shoulder under local anaesthetic blockade results in excellent outcomes in reducing shoulder pain and symptoms in patients with adhesive capsulitis, with low recurrence and complication rates. We report that more patients showed improvement in their pain scores at 5 months and greater mean improvement in OSS in comparison with Yoong et al.

The authors speculate that manipulation under local anaesthetic block of the rotator interval, especially the coracohumeral ligament, allows for stretching of the thickened CHL. This achieves a similar effect to MUA and may result in a similar outcome to targeted arthroscopic release of the CHL. However, this technique has the advantage of not requiring a general anaesthetic or surgery. Indeed, the procedure can be completed using only a single 25-mm 23-gauge needle. Controlled manipulation of the shoulder with the patient conscious may also help to reduce the risk of serious complications of MUA, typically associated with high-force external rotation. Humeral fracture, glenohumeral dislocation, brachial plexus traction injury [31, 32], intra-articular damage to the cartilage, labral detachments, SLAP lesions, glenoid rim fractures, or rotator cuff tears have been described after MUA [33]. In the authors' experience, our procedure is very well tolerated by awake patients and the improvements in symptoms and motion reported by patients immediately afterwards may also reinforce the patient's commitment to the rehabilitation process, which may in turn contribute to an improved long-term outcome.

There are a number of limitations to our study. As the normal natural history of adhesive capsulitis is of gradual resolution [3], it is not possible to know whether a patient would have achieved a similarly improved long-term outcome without intervention. There may be some lack of standardization in physiotherapy, various physiotherapists were involved and patient compliance with their exercises was not formally measured. In addition, our study has moderate numbers, a medium-term follow-up, limited objective range of motion data based on surgical examination findings and an absence of correlation with arthroscopic findings. Although one case of rupture of the long head of the biceps tendon was reported in our patient cohort, our study is too small to demonstrate a causal relationship or determine the overall risk of tendon injury following rotator interval injection. The patient remained asymptomatic and did not require surgical intervention for their long head of the biceps tendon injury. No control group was included in our article. Further studies to examine the effects of hydrodilatation and rotator interval injection, with and without manipulation or immediate physiotherapy, are required to determine the optimal non-operative treatment of adhesive capsulitis.

In conclusion, we have described a novel combination of ultrasound-guided rotator interval injection and manipulation under local anaesthetic block for the treatment of adhesive capsulitis. Targeted infiltration of a solution of steroid and anaesthetic into the rotator interval and around the coracohumeral ligament, areas most often implicated in its pathophysiology, allows for gentle manipulation of the glenohumeral joint under local anaesthetic block, immediately improving range of motion. This constitutes a simple and short procedure that is very well tolerated by an awake patient, conferring a number of advantages over other possible therapies, as follows:

1. Targeted injection of a solution of local anaesthetic and steroid to the rotator interval
2. Pre- and post-procedure range of movement assessment may be performed with a conscious patient
3. Manipulation allows for release of the rotator interval, with the CHL likely to be the most important structure
4. Post-procedure, patients are encouraged to maintain their range of movement as best they can and to undergo a program of physiotherapy
5. No requirement for radiation, general anaesthetic or surgery

Our initial results are promising for reducing patient pain, improving shoulder function, and avoiding more invasive procedures.

Compliance with ethical standards

Conflicts of interest The authors declare that they have no conflicts of interest.

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