Impact of outpatient clinic ultrasound imaging in the diagnosis and treatment for shoulder impingement: a randomized prospective study

Aamir Saeed · Mumtaz Khan · Siobhan Morrissey · David Kane · Alexander Duncan Fraser

Abstract The use of musculoskeletal ultrasonography (MSUS) in guiding subdeltoid injection has been shown to improve outcome up to 6 weeks in a few small studies. A recent meta-analysis identified the need for further studies with longer-term outcome and larger sample size. This randomized prospective study assessed whether clinic-based MSUS can significantly improve diagnostic accuracy in shoulder pain and whether MSUS-guided shoulder injection results in improved long-term outcomes. One hundred consecutive patients with 125 painful shoulders were recruited. Patients were randomized to receive either sonographic assessment with consequent palpation-guided injection (group 1, \(n = 66\)) or sonographic assessment with a MSUS-guided injection of 40 mg of methylprednisolone acetate (group 2, \(n = 59\)). A blinded rheumatologist (aDF) performed clinical assessments at baseline, 6

Key message “This study has compared MSUS-guided and palpation-guided shoulder injection in chronic shoulder pain and has shown superiority of MSUS-guided injections with better long-term outcome up to 12 weeks”.

Introduction

Shoulder pain causes significant morbidity with an incidence of 11.2–19 cases per 1,000 patients per year [1]. Lifetime shoulder pain prevalence is reported to range between 6.7 and 66.7 % with the commonest cause being rotator cuff tendinopathy including tear. The true prevalence of structural rotator cuff tendinopathy is difficult to assess as patients may be asymptomatic. The overall
prevalence of tears of the rotator cuff on MRI is 34% among symptom-free patients of all age groups—15% full-thickness tears and 19% partial-thickness tears [2, 3]. The mechanism of rotator cuff tendinopathy and subsequent tear is complex. However, rotator cuff impingement beneath the coracoacromial arch with or without associated rupture of the cuff is believed to be a major contributor [4, 5]. Optimal treatment for rotator cuff tendinopathy remains a matter of debate owing largely to the lack of well-designed studies using imaging—such as MRI or ultrasound—for the objective diagnosis of shoulder pain and application of standardized treatment protocols.

Local corticosteroid injections, either intra-articular or into periaricular structures such as bursae, are well established in the treatment for shoulder pain. When carefully performed, injections are well tolerated and have demonstrated benefit for symptomatic subacromial impingement [6]. Poor response to palpation-guided injection has been correlated with suboptimal needle placement with inaccuracy of injections ranging from 13 to 71% [7–9]. High-resolution ultrasonography (US) has in recent years been widely adopted by rheumatologists as a bedside tool valuable in diagnosing shoulder pathology and is readily available, safe and useful for guiding musculoskeletal procedures [10–12]. To date, only 3 small studies with short-term follow-up (6 weeks) have been undertaken to determine whether sonographic-guided local corticosteroid injection is more effective than palpation-guided injection in patients with periaricular shoulder disorders [13–15]. A recent meta-analysis has shown that image-guided (ultrasound) corticosteroid injections potentially offer a significantly greater clinical improvement over blind injections in adults with shoulder pain. This analysis emphasized that results should be interpreted with some caution due to the limited number of studies and small sample sizes available for review [16].

In this large randomized prospective study, we assessed whether outpatient-based US can significantly improve the accuracy of diagnosis of shoulder pain and whether guiding shoulder injection with US offers a long-term (12 weeks) benefit to the patient above that provided by palpation-guided injection.

Materials and methods

This was a randomized single-blinded prospective study of 100 consecutive patients referred to a rheumatology outpatient clinic with shoulder impingement pain. All patients had shoulder pain of at least 3-month duration with minimal or no response to non-steroidal anti-inflammatory drugs (NSAIDs).

Plain radiographs of the shoulder were obtained for all patients to exclude fracture, glenohumeral osteoarthritis, chronic inflammatory arthritis, bone tumours, osteonecrosis and other bone conditions. Patients who had clinical and radiological findings indicating moderate osteoarthritis, referred pain from the neck or internal organs and generalized muscular pain syndrome with bilateral muscular pain in the neck and shoulders, a history of inflammatory arthritis, previous fractures or surgery to the shoulder, or contraindications to local steroid injections were excluded. Patients who had been treated with local corticosteroid injections and/or physiotherapy within 1 month of study initiation were excluded. The study was approved by the hospital ethics committee as per institutional requirement, and informed consent was obtained from each patient prior to study. Age, sex, duration of symptoms, shoulder or shoulders involved, day and nocturnal pain were recorded initially for all patients. A single consultant rheumatologist (ADF)—blinded to the results of ultrasound and to the treatment received by the patient—performed the shoulder evaluations at baseline and at 6 and 12 weeks post-injection. This included active and passive range of shoulder motion, shoulder function tests (SFTs) for impingement (Hawkins–Kennedy test and supraspinatus tendon tenderness), visual analogue scale (VAS) for pain with scores ranging from 0 (no pain) to 10 cm (maximum pain) and physician global assessment (PGA) of disease activity on the scale of 0–10 cm [17] and any adverse outcomes of injections.

All US assessments were performed with Acuson Sequoia™ 512 ultrasound systems by Siemens, CA, USA, using 8L–5R MHz linear phased-array transducer according to a standardized scanning method [18, 19]. All US assessments were undertaken by a single experienced musculoskeletal sonographer (AS). In all patients, both shoulders were scanned to compare US findings in asymptomatic and symptomatic shoulders. Impingement syndrome was evaluated while performing ultrasound examination by dynamic movements of the arm from neutral position to 90° abduction in order to detect encroachment of the acrocmion on the supraspinatus tendon and subacromial subdeltoid bursa (SA-SD). All pathological findings were recorded including rotator cuff disease (tendinosis, partial- or full-thickness tendon tear, SA-SD bursitis), AC joint synovitis and biceps tendon pathology.

A computer-generated randomization scheme with permitted block sizes of 2 and 4 was implemented. After the baseline registration, each participant was allocated a study number. Patients were then randomized to receive either a palpation-guided subacromial injection of 40 mg methylprednisolone acetate with 4 ml of lidocaine hydrochloride (Group 1, 50 patients) or a musculoskeletal ultrasonography (MSUS)-guided injection of 40 mg of methylprednisolone acetate with 4 ml of lidocaine hydrochloride (Group
Table 1 Baseline demographics and ultrasound findings in symptomatic shoulders

<table>
<thead>
<tr>
<th></th>
<th>MSUS-guided</th>
<th>Palpation-guided</th>
<th>p</th>
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<tbody>
<tr>
<td>Total no. of shoulders</td>
<td>50</td>
<td>50</td>
<td>NS</td>
</tr>
<tr>
<td>Symptomatic shoulders</td>
<td>59</td>
<td>66</td>
<td></td>
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<tr>
<td>Duration of symptoms, weeks, mean, SD</td>
<td>19.64 ± 1.84</td>
<td>20.02 ± 1.52</td>
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<tr>
<td>Clinical findings</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>R</td>
<td>33</td>
<td>39</td>
<td>NS</td>
</tr>
<tr>
<td>L</td>
<td>26</td>
<td>27</td>
<td></td>
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<tr>
<td>VAS pain score mean (0–10 cm)</td>
<td>6.34 ± 1.74</td>
<td>6.39 ± 1.83</td>
<td></td>
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<tr>
<td>PGA score, mean (0–10 cm)</td>
<td>5.5 ± 2.07</td>
<td>5.48 ± 1.94</td>
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<tr>
<td>Ultrasound findings</td>
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<td></td>
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<tr>
<td>Biceps pathology (tendonopathy/tear)</td>
<td>10 (17)</td>
<td>6 (9)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>RC impingement</td>
<td>15 (25)</td>
<td>14 (21)</td>
<td>NS</td>
</tr>
<tr>
<td>RC partial-thickness tear</td>
<td>14 (24)</td>
<td>17 (26)</td>
<td>NS</td>
</tr>
<tr>
<td>RC full-thickness tear</td>
<td>13 (22)</td>
<td>13 (20)</td>
<td>NS</td>
</tr>
<tr>
<td>SA-SD bursitis</td>
<td>9 (15)</td>
<td>8 (12)</td>
<td>NS</td>
</tr>
<tr>
<td>ACJ pathology</td>
<td>7 (12)</td>
<td>8 (12)</td>
<td>NS</td>
</tr>
</tbody>
</table>

NS not significant, RC rotator cuff, SA-SD subacromial-subdeltoid, ACJ acromioclavicular joint

Fig. 1 Demographics

2, 50 patients) directed to the main ultrasound pathology or SA-SD bursa. Prior to injection, all patients underwent a sonographic examination of their shoulders (Table 1; Fig. 1). Post-injection steroid placement was recorded in the MSUS-guided group of patients only.

All MSUS-guided and palpation-guided injections were performed by the same experienced physician (AS). For palpation-guided injection, a standard technique was performed using a 21G needle via a lateral approach to inject the subacromial-subdeltoid (SA-SD) bursa [13]. For
Table 2  SFTs, patient VAS and PGA scores at 0, 6 and 12 weeks

<table>
<thead>
<tr>
<th>Category</th>
<th>Week 0</th>
<th>Week 6</th>
<th>p</th>
<th>Week 12</th>
<th>p</th>
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</thead>
<tbody>
<tr>
<td>SFTs scores</td>
<td></td>
<td></td>
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<tr>
<td>MSUS-guided (44 joints)</td>
<td>1.81</td>
<td>0.43</td>
<td>Delta BL, p &lt; 0.01</td>
<td>0.54</td>
<td>Delta BL, p &lt; 0.05</td>
</tr>
<tr>
<td>Palpation-guided (46 joints)</td>
<td>1.5</td>
<td>0.60</td>
<td></td>
<td>0.65</td>
<td></td>
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<tr>
<td>VAS scores</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MSUS-guided group (mean ± SD)</td>
<td>6.34 ± 1.74</td>
<td>1.68 ± 1.67</td>
<td>&lt;0.05</td>
<td>2.18 ± 2.66</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Palpation-guided group (mean ± SD)</td>
<td>6.39 ± 1.83</td>
<td>2.67 ± 2.04</td>
<td>&lt;0.05</td>
<td>3.26 ± 2.97</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>PGA scores</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MSUS-guided group (mean ± SD)</td>
<td>5.5 ± 2.07</td>
<td>1.48 ± 1.49</td>
<td>&lt;0.05</td>
<td>2.00 ± 2.68</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Palpation-guided group (mean ± SD)</td>
<td>5.48 ± 1.94</td>
<td>2.17 ± 1.92</td>
<td>&lt;0.05</td>
<td>2.98 ± 2.86</td>
<td>&lt;0.05</td>
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</table>

SFTs shoulder function tests (1 positive test = 1 score)

MSUS-guided injection, a two-handed technique was used with the transducer held in one hand and the syringe with 21G needle in the other hand. The needle was directed in real time by US from the skin to the target (e.g. subdeltoid bursa, acromio-clavicular joint or biceps pathology). In those shoulders where ultrasound demonstrated more than one pathologies, the pathology most consistent with clinical examination was injected.

When there was effusion in both the SA-SD bursa and the biceps tendon sheath, injection was directed into the SA-SD bursa. For confirmed rotator cuff pathology and in patients with clinical impingement but normal shoulder, ultrasound SA-SD bursa injection was performed. When ultrasound confirmed the principal pathology as acromio-clavicular joint inflammation or biceps tendon inflammation, MSUS-guided injection of the principal pathological structure was performed. No patient received physical therapy during the follow-up period. However, all patients with the loss of shoulder range of movement were given post-injection instructions in pendulum exercises and slow shoulder abduction. No restriction was placed on the patient’s ability to work or to use their shoulder as tolerated, or on NSAID intake.

Statistical Analysis: Mann–Whitney U test was used for statistical analysis. p < 0.05 was considered significant. All hypothesis tests were two-tailed with a significance level of 5 %. We calculated point estimates with associated 95 % confidence intervals for mean differences in improvement between groups. An analysis of covariance model was employed with adjustment for baseline differences [20].

**Results**

One hundred patients (65 female, 35 male, mean age 57.7 years, range 21–85 years) with 125 symptomatic shoulders were enrolled in the study. The mean duration of symptoms was 18 weeks (range 14–22 weeks). All patients had a clinical diagnosis of shoulder impingement by a consultant rheumatologist (ADF) (Table 1) [21]. Fifty patients (59 symptomatic shoulders) were randomized to the MSUS-guided injection group, and 50 patients (66 symptomatic shoulders) were randomized to the palpation-guided injection group. Flow diagram shows follow-up and reasons for exclusion of patients during the study period (Fig. 1). Eighty patients (90 shoulders) completed 12-week follow-up. There were no significant differences between the MSUS-guided and palpation-guided shoulder injection groups for age, sex, mean duration of symptoms, shoulder involved and baseline ultrasound findings (Table 1).

Small but significant differences were observed at the beginning of the study for SFTs (Hawkins–Kennedy test and supraspinatus tendon tenderness) as the MSUS-guided injection group had relatively worse shoulders compared to the palpation-guided injection group (Table 2). SFT improved significantly from baseline in both groups at 6 and 12 weeks. However, significantly greater improvements were noted at both time points in the MSUS-guided injection group (Delta BL, p < 0.01 and p < 0.05), respectively (Table 2; Fig. 2).

Patient VAS score showed 73.5 and 65.6 % improvements at 6 and 12 weeks in the MSUS-guided group, significantly greater than the improvements seen in the blinded group (59 and 49 %), respectively (Table 2; Fig. 3). Similarly, significant improvements were seen in the PGA score 73.3 and 67.5 % at 6 and 12 weeks, respectively, in the MSUS-guided group. These were significantly higher than those in the palpation-guided group at the same time points (p < 0.05) (Table 2; Fig. 4).

When the 2 non-SA-SD bursa injections (biceps injection = 1 and ACJ injection = 1) were excluded from the MSUS-guided group, MSUS-guided SA-SD injection remained significantly more effective than palpation-guided SA-SD injection (VAS score (p < 0.01 and p < 0.05) and PGA score (p < 0.05 and p < 0.01) at all 6- and 12-week time points).
Twenty patients, 11 (20 shoulders) from the palpation-guided group and 9 (15 shoulders) from the MSUS-guided group, were excluded from the study after 6 weeks. These patients showed little or no clinical improvement after the first shoulder injection and required either a repeat shoulder injection or further imaging and surgical opinion based on their symptoms. These shoulders demonstrated a significantly higher percentage of full-thickness supraspinatus tears on ultrasound examination compared to the shoulders that completed 12 weeks of follow-up. On ultrasound examination, 5 shoulders with chronic pain not classical for shoulder impingement on clinical examination showed AC joint inflammation (1 shoulder), partial subscapularis tear (1 shoulder), 1 shoulder was normal, and 2 had partial supraspinatus tear. Apart from mild shoulder pain in a small number of cases within a few hours of shoulder injection, no serious adverse event was observed.

Discussion

High-resolution US has proven to be accurate and reliable in diagnosing a wide range of shoulder disorders when compared to magnetic resonance imaging, arthroscopy and surgical findings [22–26]. MSUS imaging does help in diagnosing and guiding accurate injection placement in complex cases, where clinical examination and standardized techniques are limited [10, 12, 24]. Three studies of 41 and 40 and 67 patients, respectively, have shown benefits of MSUS-guided SA-SD injections compared to palpation-guided SA-SD injections for up to 6 weeks [13–15]. A recent meta-analysis identified the need for further studies with longer-term outcome and larger sample size [16].

This is the largest cohort studied to date comparing 100 patients and 125 painful shoulders and was aimed to assess pain and functional improvements as primary outcome measures. However, injection placement was observed only in MSUS-guided group as per study protocol. Patients were advised to take NSAIDs or mild analgesics to counter the expected pain post-shoulder injection. All patients were advised to perform routine gentle shoulder exercises as tolerated. Significant objective improvements in SPTs (Hawkins–Kennedy and supraspinatus tendon tenderness) were
observed in the MSUS-guided injection group compared to the palpation-guided injection group. Similar improvements were also observed in the patient VAS and physician GA scores. A trend towards a decline in improvements in primary outcome measures from 6 to 12 weeks in both groups was noted (Table 2). There remained a significantly greater improvement in the MSUS-guided injection group at week 12 where the local anti-inflammatory effects of steroid would have resolved.

These findings suggest that MSUS aids better injection placement resulting in an improved clinical outcome in patients with chronic shoulder pain. These findings are also consistent with Eustace and Naredo et al. [8, 13]. While the MSUS-guided group had significantly worse shoulders at baseline, MSUS-guided injection demonstrated greater improvements in pain and function which possibly were related to better injection placements. In a subanalysis, we compared MSUS-guided injections (42 shoulders) to palpation-guided injections (46 shoulders) of SA-SD bursa only (exclusion of 2 shoulders that had AC joint and biceps tendon injections). Significant improvements were still observed in VAS and PGA scores at 6 and 12 weeks.

Palpation-guided injection, although inferior to guided injection, still resulted in highly significant improvements in all parameters measured. Despite this improvement in the palpation-guided injection group was not compared to a placebo group, it must be considered that palpation-guided injection remains an entirely appropriate intervention, which is easier and cheaper to undertake than guided injection in most clinical settings. VAS pain score ranged between 6 and 8 cm for 20 patients, 11 (20 shoulders) from the palpation-guided group and 9 (15 shoulders) from the guided group who were excluded at 6 weeks either due to repeat injection or due to surgical referral. A higher percentage of full-thickness supraspinatus tears were demonstrated in non-responders in both groups, suggesting that ultrasound-confirmed tendon tear is a poor prognostic marker when planning corticosteroid injection.

Although a figure lower than that quoted in previous studies, it is still significant and may well explain in part the failure of some patients to respond to palpation-guided injection in the absence of imaging confirmation of the clinical diagnosis. Results of this large cohort confirm the benefits shown in previous small studies [13–15] in the short term but has also shown significantly better long-term outcome in MSUS-guided injection group (12 weeks).

Based on the results obtained from this study, we conclude that MSUS-guided shoulder injection is superior to palpation-guided injection in managing shoulder pain. When available, US assessment and MSUS-guided injection should be considered in the management of shoulder impingement and particularly in shoulder pain refractory to blind injections.

This study has some limitations that joint injection placements were not specifically observed in both groups although this was not aimed as the primary outcome measure. This study did not record the amount of NSAIDs/mild analgesics taken to counter post-injection pain neither type of physical activity performed by the patients in each group post-shoulder injection.

References


