ARTHRITIS & RHEUMATISM
Vol. 62, No. 7, July 2010, pp 1862–1869
DOI 10.1002/art.27448

A Randomized, Double-Blind, Controlled Study of Ultrasound-Guided Corticosteroid Injection Into the Joint of Patients With Inflammatory Arthritis

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Objective. **Most corticosteroid injections into the joint are guided by the clinical examination (CE), but up to 70% are inaccurately placed, which may contribute to an inadequate response. The aim of this study was to investigate whether ultrasound (US) guidance improves the accuracy and clinical outcome of joint injections as compared with CE guidance in patients with inflammatory arthritis.**

Methods. **A total of 184 patients with inflammatory arthritis and an inflamed joint (shoulder, elbow, wrist, knee, or ankle) were randomized to receive either US-guided or CE-guided corticosteroid injections. Visual analog scales (VAS) for assessment of function, pain, and stiffness of the target joint, a modified Health Assessment Questionnaire, and the EuroQol 5-domain questionnaire were obtained at baseline and at 2 weeks and 6 weeks postinjection. The erythrocyte sedimentation rate and C-reactive protein level were measured at baseline and 2 weeks. Contrast injected with the steroid was used to assess the accuracy of the joint injection.**

Results. **One-third of CE-guided injections were inaccurate. US-guided injections performed by a trainee rheumatologist were more accurate than the CE-guided injections performed by more senior rheumatologists (83% versus 66%; $P = 0.010$). There was no significant difference in clinical outcome between the group receiving US-guided injections and the group receiving CE-guided injections. Accurate injections led to greater improvement in joint function, as determined by VAS scores, at 6 weeks, as compared with inaccurate injections (30.6 mm versus 21.2 mm; $P = 0.030$). Clinicians who used US guidance reliably assessed the accuracy of joint injection ($P < 0.001$), whereas those who used CE guidance did not ($P = 0.29$).**

Conclusion. **US guidance significantly improves the accuracy of joint injection, allowing a trainee to rapidly achieve higher accuracy than more experienced rheumatologists. US guidance did not improve the short-term outcome of joint injection.**

Corticosteroid injections into the joint are commonly used in rheumatology practice. Guidelines published by the American College of Rheumatology (ACR) support their role in the treatment of inflammatory arthritis (1), but much of the evidence for their use derives from studies performed in the 1970s in which no controls were used (2,3). Corticosteroid injections into the joint do not always produce clinical or symptomatic improvement in the target joint; the reasons for this are unclear (4).

Most joint injections in rheumatology practice are delivered using the clinical examination (CE) to guide the injection (5), but a number of studies have demonstrated that the accuracy of CE-guided injections is poor (29–63% inaccurate), and this may contribute to the lack of clinical benefit observed in some patients (4,6–10). Only 2 studies have reported the effect of accuracy on the efficacy of attempted intraarticular (IA)

ISRCTN: 75459849.

Drs. Cunnington and Kane's work was supported by the Arthritis Research Campaign (project grant 16169).

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Dr. Platt has received consulting fees, speaking fees, and/or honoraria from Abbott and SonoSite (less than $10,000 each).

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Submitted for publication May 18, 2009; accepted in revised form February 26, 2010.

injection of corticosteroids in patients with inflammatory and noninflammatory arthritis. Eustace et al (7) reported improved outcome for accurate shoulder injections at 2 weeks postinjection, whereas Jones et al (4) did not detect a significant difference between accurate and inaccurate IA injections.

Musculoskeletal ultrasound (US) is being increasingly performed by rheumatologists to improve diagnosis and intervention. US allows the direct visualization of the injection needle within the joint structures in real time to ensure accurate needle placement and has been shown in small series to improve the accuracy of needle placement and joint aspiration as compared with CE guidance (11,12). Further investigation on a larger scale is warranted to confirm that US can improve the accuracy of joint injection and to determine the effect of improved accuracy on the clinical response. The aim of this study was to determine whether US guidance improves the accuracy and clinical outcome of attempted IA injection of corticosteroids as compared with CE guidance in patients with inflammatory arthritis.

In addition to the main research question, we were also able to evaluate the magnitude of response to all attempted IA corticosteroid injections. This may enable us to compare the effects of a simple, regularly performed, cheap procedure with those of more complex and expensive interventions, such as a change in disease-modifying antirheumatic drug (DMARD) or biologic therapy, in order to inform our patients and practice. We were interested in exploring the relationship between the confidence in one's ability to perform IA injection and the actual accuracy of the injection to help guide our practice.

PATIENTS AND METHODS

Patients. Patients over the age of 16 years with a diagnosis of inflammatory arthritis were recruited from rheumatology outpatient clinics at 4 hospitals in the northeast of England. Recruitment required evidence of an inflamed joint (satisfying 2 of the following 3 criteria: exacerbation of pain, exacerbation of stiffness, or local findings of synovitis) involving either the shoulder (glenohumeral joint), elbow, wrist, knee, or ankle. Local findings of synovitis were assessed by the referring consultant. Synovitis was defined as the presence of joint swelling or inflammation in combination with the patient's report of pain or the clinical findings of joint tenderness.

Patients were excluded if they required an immediate change in their treatment (nonsteroidal antiinflammatory drugs, DMARDs, or corticosteroids, whether via oral, IA, or intramuscular route), if they had had a change in their treatment within 28 days prior to study entry, if they had a second joint requiring IA injection, or if they had evidence of potential sepsis or allergy to corticosteroids or contrast agent.

Study design. Using stratified randomization, according to the joint that was to be injected, patients underwent either US-guided or CE-guided joint injection. The independent clinical assessor (NM), the radiologic assessor (GH), and the patient receiving the injection were all blinded to the method of guidance.

Injection protocol. Skin disinfection and aseptic technique were used for both the US-guided and the CE-guided

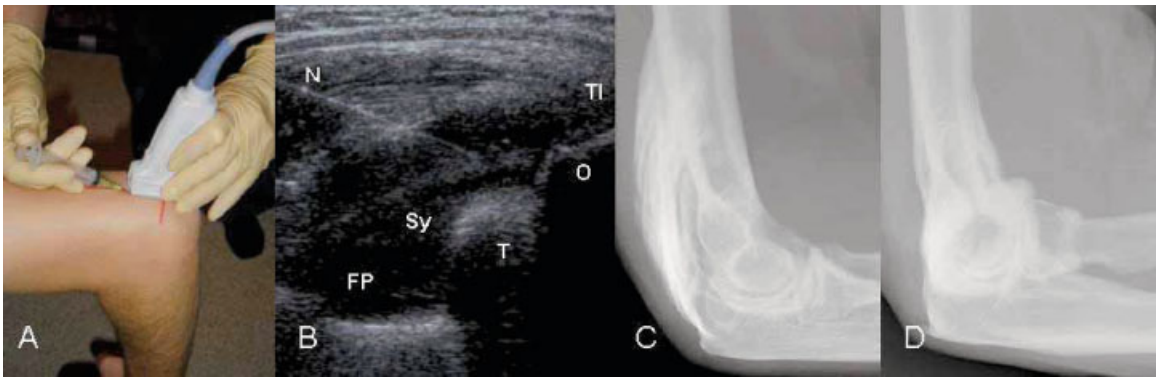

Figure 1. Ultrasound (US)–guided injection of corticosteroids into the elbow, grayscale US image of the injection, and subsequent radiographs of an accurate and an inaccurate elbow injection. **A** and **B,** The US transducer was placed longitudinally on the posterior aspect of the elbow joint (**A**) to produce the image seen in **B**. The needle was then inserted from the proximal aspect to place the needle tip in the joint space, which could be seen on the US monitor (**B**). Following injection of a combination of corticosteroid, lidocaine, and contrast agent (iohexol; see Patients and Methods for details), plain radiographs were obtained to verify the accuracy of needle placement. **C,** Lateral radiograph of the elbow, showing contrast agent outside the joint space in the area of the triceps insertion, representing an inaccurate injection. **D,** Lateral radiograph of the elbow, showing contrast agent in the joint space, representing an accurate injection. **N** = needle with tip in joint space; **TI** = triceps muscle insertion; **O** = olecranon; **Sy** = synovitis; **T** = trochlea; **FP** = olecranon fossa fat pad.

injections. Injections undertaken via US or CE guidance were intended to be injected into the following sites: shoulder (glenohumeral joint), elbow (humeroulnar joint), wrist (radiocarpal, midcarpal, or radioulnar joint; injection directed toward maximal synovitis seen on US), knee, or ankle (tibiotalar joint). Joints were injected with an admixture of 40 mg of triamcinolone acetonide, 1 ml of 1% lidocaine, and the contrast agent iohexol (350 mg/ml preparation; Omnipaque) (Nycomed) using a 21-gauge needle. Iohexol was used in differing volumes depending on the joint (4 ml for the knee injection and 2 ml for the shoulder, elbow, ankle, or wrist injection).

CE-guided injection. For the CE-guided injection, the anatomic approach was the approach the clinician would normally use for each injection.

US-guided injection. The US-guided injection was performed in real time according to standardized-approach techniques (13,14). For the shoulder, elbow, wrist, and knee, a direct visualization approach was used, where the needle was visualized on the US monitor in real time during the injection to ensure accuracy (see Figure 1). For the ankle joint, an indirect visualization approach was used because of the angle of the joint.

Blinding of injection guidance. For patients receiving a CE-guided injection, a "sham ultrasound" was performed. The probe was placed a short distance from the injection site on the patient's joint while the CE-guided injection took place. The clinicians could not view the image on-screen.

Assessment of injection accuracy. The accuracy of the injection was assessed by radiography of the injected joint in 2 standard planes performed immediately after injection to localize the iohexol contrast agent (see Figure 1). Radiographs were scored as either accurate or inaccurate by a single consultant musculoskeletal radiologist (GH) who was blinded to the method of guidance used.

Outcome variables measured. Outcome was measured by an independent blinded assessor (NM) at baseline and at 2 weeks and 6 weeks following injection. The following assessments were performed: patient's assessment of function, pain, and stiffness of the target joint using a 100-mm visual analog scale (VAS) on which only 0 and 100 were marked; modified Health Assessment Questionnaire (HAQ) (15), EuroQol 5-domain (EQ-5D) questionnaire (16,17), and range of motion (ROM) using a standard long-levered goniometer.

The overall efficacy of the injection was reported by the patient at the baseline, 2-week, and 6-week visits and during a followup telephone call at 12 weeks. Patients rated efficacy on a scale of 0–3, where 0 = no improvement, 1 = mild improvement, 2 = moderate improvement, and 3 = complete improvement. Responders were patients who had either moderate or complete improvement (score of 2 or 3) in the study joint at the time of assessment. Nonresponders were patients who had either no improvement or mild improvement (score of 0 or 1) at the time of assessment.

The erythrocyte sedimentation rate (ESR) and the C-reactive protein (CRP) level were measured at baseline and at 2 weeks postinjection.

Following delivery of the injection, clinicians were asked to rate their satisfaction as to whether they thought the injection they had delivered was accurate or not accurate. A 4-point Likert scale was used for this assessment.

Ethical considerations. Ethical approval for this study was given by the Newcastle Local Research Ethics Committee. The study was assigned an International Standard Randomized Controlled Trial Number (ISRCTN 75459849).

Statistical analysis. Statistical analysis was performed using Minitab 14 software. Parametric data were expressed as the mean ± SD and were analyzed using either a 2-sample *t*-test or a paired *t*-test. Nonparametric data were expressed as the median and range and were analyzed using Mann-Whitney U test. A chi-square table was used to analyze associations between the accuracy of the injection and the clinician's satisfaction with the injection performed. A best-fit regression model was used to assess predictors of response to IA injections. *P* values less than 0.05 were considered statistically significant.

RESULTS

Baseline characteristics of the study subjects and adverse events. A total of 184 patients were randomized and received a joint injection. Figure 2 shows a flow chart of patients in the study and treatment changes necessitating study withdrawal. Table 1 details which joints were injected in the study and the baseline characteristics of the study participants, which were similar

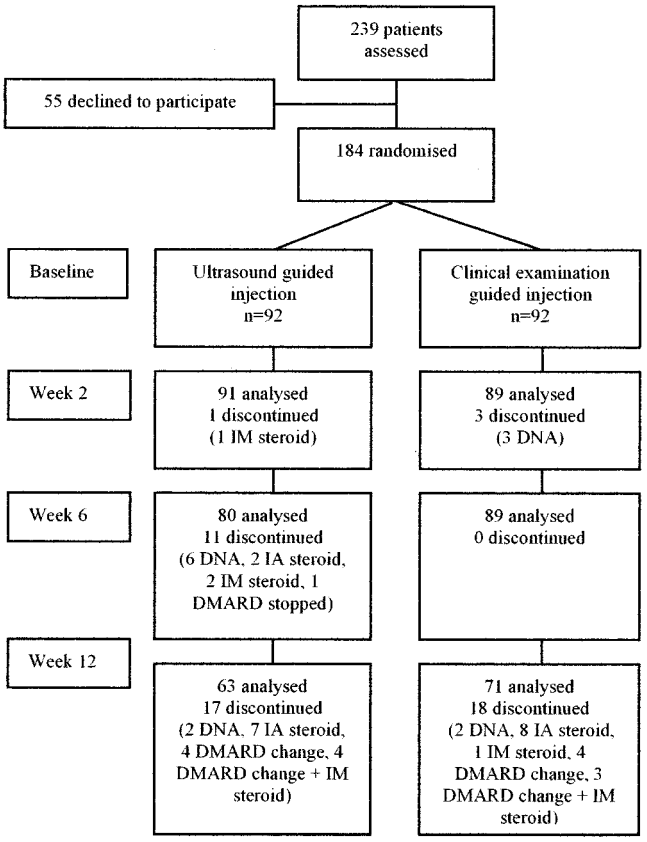

Figure 2. Flow chart showing the distribution of study patients from initial contact to completion of the study. IM = intramuscular; DNA = did not attend; IA = intraarticular; DMARD = disease-modifying antirheumatic drug.

Table 1. Baseline characteristics of the study patients and injected joints, by randomization group*

	Ultrasound-guided injection	Clinical examination–guided injection
Age, mean ± SD years	57.9 ± 14.5	58.4 ± 13.9
% female	69	75
% RF positive	88	90
Diagnosis, % of patients		
Rheumatoid arthritis	71	74
Psoriatic arthritis	11	12
Other	17	15
HAQ score, mean ± SD	1.45 ± 0.74	1.57 ± 0.73
EQ-5D score		
VAS score, mean ± SD	57.3 ± 19.3	54.2 ± 20.6
Index, median (range)	0.59 (−0.24–1.00)	0.59 (−0.24–0.80)
CRP, median (range) mg/liter	13 (0–14)	14 (0–83)
ESR, median (range) mm/hour	30 (2–100)	38 (5–115)
Patient's assessment of target joint, by VAS, mean ± SD mm		
Function	58.8 ± 20.4	57.4 ± 19.8
Pain	65.5 ± 20.6	61.9 ± 20.2
Stiffness	62.2 ± 23.3	63.9 ± 19.3
No. of joints injected		
Shoulder	19	20
Elbow	11	11
Wrist	14	16
Knee	35	33
Ankle	13	12

* RF = rheumatoid factor; HAQ = Health Assessment Questionnaire; EQ-5D = EuroQol 5-domain; VAS = visual analog scale (0–100 mm); CRP = C-reactive protein; ESR = erythrocyte sedimentation rate.

for both randomization groups. There was no increase in side effects as a result of using US guidance for joint injection.

Training of the clinicians who injected the joints. All 92 US-guided injections were performed by a research fellow (JC), who had 9 months of experience as a rheumatology trainee prior to the study. In addition, she completed a basic 8-session musculoskeletal US training course over 3 months, and then had further training in US-guided injection techniques, including injecting 36 joints under US guidance prior to the study.

Of the 92 CE-guided injections, 58 (63%) were performed by 9 rheumatology consultants (median rheumatology experience 15.0 years [range 9–33 years]), and 34 (37%) were performed by 9 rheumatology trainees (median rheumatology experience 3.0 years [range 1–8 years]).

Accuracy of joint injections. All injections were reported as either definitely accurate or inaccurate, based on independent assessment of plain radiographs. The US-guided injections were significantly more accurate than the CE-guided injections, with 76 of the 92 US-guided injections being accurate (83%), compared with 61 of the 92 accurate CE-guided injections (66%) ($P = 0.01$). This study was not powered to detect a difference in accuracy within individual joints, but there was a trend toward increased accuracy with US-guided injections for all joints, particularly the shoulder, elbow, and ankle (Table 2).

Outcome of joint injection, comparing US-guided versus CE-guided injections. There was no statistically significant difference between US-guided and CE-guided injections for any of the major outcome variables measured at 2 weeks or 6 weeks. The 2 separate component parts of the EQ-5D (the VAS scores and the index) did reach statistical significance. The main results are presented in Table 3.

Outcome of joint injection, comparing accurate versus inaccurate injections. There was a statistically significantly greater improvement in the VAS score for function in the accurate injection group (n = 137) as compared with the inaccurate injection group (n = 47) as assessed by the patients at 6 weeks (30.6 mm versus 21.2 mm; $P = 0.030$). In addition, there was a trend toward improvement in the VAS score for function at 2 weeks and in the VAS score for pain at 2 weeks and 6 weeks for the accurate injection group as compared with inaccurate injection group. The results are shown in Table 3.

Outcome of corticosteroid injection in a single inflamed joint. Corticosteroid injections into inflamed joints, regardless of the method of guidance or the accuracy of the injection, resulted in significant symptomatic and clinical benefits. There was a significant improvement in the VAS scores for function, pain, and stiffness as assessed by the patient at 2 weeks and 6 weeks (Figure 3).

A change in the HAQ score of >0.22 has been shown by Redelmeier et al (18) to be clinically relevant.

Table 2. Rates of accurate injections with ultrasound or clinical examination guidance*

Joint injected	No. of joints accurately injected: Ultrasound guided	No. of joints accurately injected: Clinical examination guided	*P*
All joints	76/92 (83)	61/92 (66)	0.010
Shoulder	12/19 (63)	8/20 (40)	0.137
Elbow	10/11 (91)	7/11 (64)	0.100
Wrist	11/14 (79)	12/16 (75)	0.817
Knee	32/35 (91)	27/33 (82)	0.242
Ankle	11/13 (85)	7/12 (58)	0.131

* Values are the number of joints accurately injected/total number injected (%).

Table 3. Changes in outcome measures, by injection guidance and by accuracy, from baseline to 2 weeks and 6 weeks*

	Guidance for injection			Accuracy of injection		
	Ultrasound	Clinical examination	*P*	Accurate (n = 137)	Inaccurate (n = 47)	*P*
Change in VAS scores for patient's assessment of target joint, mean ± SD mm						
Baseline to 2 weeks						
Loss of function	−29.2 ± 23.4	−33.4 ± 21.4	0.211	−32.7 ± 22.1	−27.1 ± 23.2	0.159
Pain	−40.3 ± 23.2	−36.8 ± 24.3	0.324	−40.2 ± 22.0	−34.0 ± 28.0	0.176
Stiffness	−33.1 ± 29.4	−38.5 ± 24.4	0.182	−36.0 ± 26.3	−35.0 ± 29.5	0.849
Baseline to 6 weeks						
Loss of function	−29.9 ± 25.6	−27.4 ± 27.7	0.668	−30.6 ± 27.7	−21.2 ± 22.3	0.030†
Pain	−38.2 ± 26.8	−34.9 ± 27.1	0.436	−38.5 ± 25.3	−30.4 ± 30.8	0.132
Stiffness	−30.9 ± 28.4	−35.9 ± 27.1	0.247	−33.4 ± 27.8	−33.8 ± 28.0	0.934
Change in HAQ scores, median (range)						
Baseline to 2 weeks	−0.25 (−1.3–0.5)	−0.25 (−1.1–0.8)	0.336	–	–	
Baseline to 6 weeks	−0.13 (−1.6–0.6)	−0.13 (−0.9–0.5)	0.466	–	–	
Change in EQ-5D scores						
VAS score, mean ± SD						
Baseline to 2 weeks	8.8 ± 15.7	13.9 ± 17.5	0.039†	–	–	
Baseline to 6 weeks	7.7 ± 21.4	7.3 ± 21.7	0.897	–	–	
Index, median (range)						
Baseline to 2 weeks	0.07 (−0.53–0.80)	0.04 (−0.64–0.91)	0.279	–	–	
Baseline to 6 weeks	0.09 (−0.71–0.74)	0.00 (−0.80–0.91)	0.035†	–	–	
Change in CRP from baseline to 2 weeks median (range) mg/liter	−4 (−83–62)	−6 (−67–75)	0.470	–	–	
Change in ESR from baseline to 2 weeks median (range) mm/hour	−4 (−52–44)	−6 (−67–44)	0.360	–	–	

* VAS = visual analog scale (0–100 mm); HAQ = Health Assessment Questionnaire; EQ-5D = EuroQol 5-domain; CRP = C-reactive protein; ESR = erythrocyte sedimentation rate.
† Statistically significant difference.

There was a clinically relevant reduction in the HAQ score for all joints at 2 weeks. There were significant improvements in the mobility ($P = 0.03$), pain/discomfort ($P < 0.01$), and anxiety/depression ($P = 0.03$) domains of the EQ-5D at 2 weeks and in the pain/discomfort domain at 6 weeks, as well as a signifi-

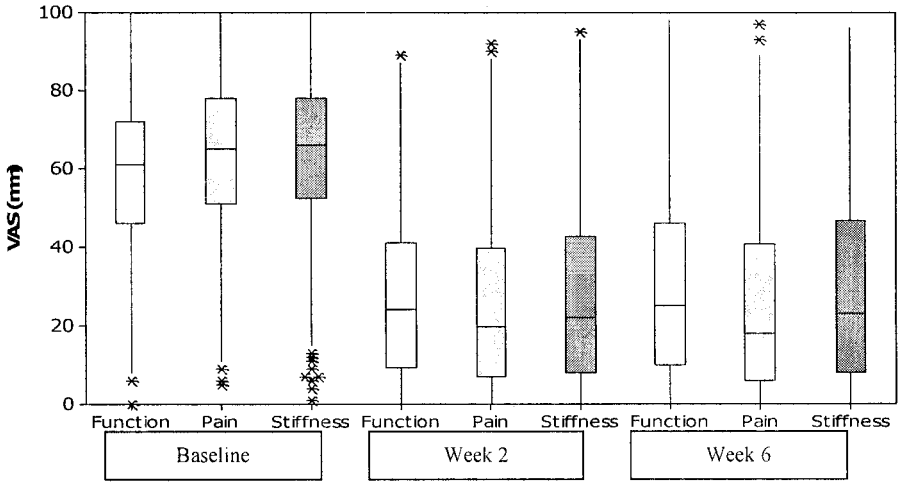

Figure 3. Patient's assessment of pain, function, and stiffness in the injected joint. A 100-mm visual analog scale (VAS) was used to record each patient's assessment of the injected joint at baseline and at 2 weeks and 6 weeks postinjection. Data are shown as box plots. Each box represents the 25th to 75th percentiles. Lines inside the boxes represent the median. Lines outside the boxes represent the 10th and the 90th percentiles. Asterisks indicate outliers.

cant improvement in the EQ-5D VAS score and index at 2 weeks and 6 weeks. The median reduction in the CRP level was 5 mg/liter (range –83–75) ($P < 0.01$) and median reduction in the ESR was 6 mm/hour (range –67–44) ($P < 0.01$), at 2 weeks. There was a significant improvement in the ROM in all joints at both 2 weeks and 6 weeks, except for external rotation of the shoulder, where the improvement did not reach statistical significance. There were high numbers of patients who reported a moderate or a good response to the injection at each time point, and this high response rate was sustained at 12 weeks (81% at 2 weeks, 77% at 6 weeks, and 69% at 12 weeks) in those reporting a response.

Association between clinician satisfaction that injection accuracy had been achieved and confirmation of injection accuracy on plain radiography. There was a strong association between the clinician's satisfaction that injection accuracy had been achieved and the radiographically verified accuracy of the injection for the US-guided injection ($P < 0.001$). There was no association between the clinician's satisfaction that injection accuracy had been achieved and the radiographically verified accuracy of the injection for the CE-guided injection ($P = 0.29$).

Predictors of response to injection. The whole study group was analyzed using a best-fit regression model to see if any predictors of a good response to joint injection could be isolated. The model examined the patient's age, sex, diagnosis, disease duration, study joint injected, symptom duration, presence of synovitis, baseline total HAQ score, baseline ROM of the joint, baseline ESR and CRP levels, injection accuracy, and joint damage at baseline as assessed by the Larsen score. No significant predictors of a response were found.

DISCUSSION

Corticosteroid joint injections have been used in the treatment of patients with inflammatory arthritis since the 1950s (2), but they do not always result in clinical or symptomatic improvement. Jones et al (4) demonstrated that joint injections produced a reduction in clinical inflammation in just 45 of 83 inflamed joints (54%) in patients with both inflammatory and noninflammatory arthritis. They hypothesized that one reason for a lack of response could be inaccuracy of the injection and found that the injections were accurate in only 56 of 108 intended IA injections (52%). There was a trend toward a greater reduction in clinical features of inflammation for the accurate injections as compared with the inaccurate injections, but the difference did not achieve statistical significance. Eustace et al (7) examined corticosteroid injection in patients with inflammatory and noninflammatory conditions who had shoulder pain. A total of 14 of 38 injections (37%) were accurate (4 of 14 subacromial injections [29%] and 10 of 24 glenohumeral injection [42%]). There was a significant improvement in stiffness, function, abduction, and flexion in the accurately injected joints as compared with the inaccurately injected joints at 2 weeks.

These 2 studies highlight the fact that the accuracy of CE-guided injections is poor and suggest that improving injection accuracy may improve clinical outcome. However, the significant limitations of these studies limit the conclusions drawn. Jones and colleagues' study had 2 major limitations. First, although they were able to report the findings of all but 1 of their radiographs, they had to classify 21 of 108 radiographs as "uncertain" due to the lack of contrast. Second, they used clinical examination to assess inflammation in the joint, but this has been shown to be insensitive compared with other methods of assessing joint inflammation (19–23). Eustace and colleagues' study was limited by the small number of injections in their study and a very short followup period (2 weeks). Both studies combined patients with inflammatory and noninflammatory arthritis, 2 distinct conditions that may respond differently to an IA injection of corticosteroids.

Various methods can be used to improve the accuracy of IA injections, including fluoroscopy, computed tomography, and magnetic resonance imaging (MRI) (24,25). However, US is the most practical because it is quick, safe, acceptable to patients, uses no radiation, can be performed in the clinic, and demonstrates needle movement in real time to guide positioning. US guidance has been shown in small series to be more accurate than CE guidance for needle placement and fluid aspiration of joints and soft tissue (11,12). The question whether US guidance improves the accuracy of IA injection and whether improved accuracy correlates with improved patient outcome needs further investigation, and when doing this, the methodologic limitations of previous studies need to be addressed. The present study had a closely defined population, in greater numbers, and with accurate reporting of injection accuracy as compared with previous studies. It was a double-blind study and had clearly defined outcome measures to answer the research question.

This study found that joint injections guided by US were significantly more accurate than CE-guided injections. A junior rheumatology trainee with basic musculoskeletal US skills achieved a significantly higher

accuracy rate using US to guide needle placement than did senior trainees and consultants using CE to guide needle placement. However, the study did not find any meaningful differences between US-guided and CE-guided injections for any of the clinical outcomes measured.

Limitations of our study, which may have reduced its power to detect a difference in clinical outcome between the 2 study groups, included the following. First, there was a less than expected difference between accuracy rates for US-guided and CE-guided injections. Second, clinical parameters of inflammation were used as criteria for study enrollment, but these are less accurate than imaging parameters (19–23,26) and may have resulted in the inclusion of patients whose joint was not significantly inflamed. A study reported in 2005 showed that IA injections in which diagnostic US was used to confirm and localize pathologic areas prior to injection were more efficacious than IA injections delivered on the basis of the clinical examination alone (27). Therefore, in future studies, the use of imaging modalities such as US or MRI might be considered in order to confirm inflammation in study participants, thus improving the homogeneity of the sample. Last, we used a uniform dose of 40 mg of triamcinolone acetonide for injection into all joints to standardize the intervention. This may be considered a large dose of corticosteroid for the elbow and wrist joints, increasing the likelihood of a systemic effect and thereby reducing our ability to detect a difference between groups.

Comparison of accurate injections versus inaccurate injections, regardless of the method of guidance, showed that accurate injections produced a significantly greater improvement in function of the injected joint at 6 weeks, a trend toward improved function at 2 weeks, and improvement in pain at 2 weeks and 6 weeks. The relatively small number of inaccurate injections reduced the power of this analysis, and these observations should be confirmed in a larger cohort.

US-guided accuracy rates in this study were lower than those in published studies (11,12,28), where the procedures were performed by musculoskeletal US experts. Accuracy in those studies was assessed by the clinician, using real-time US observation, or was assessed by the clinician's ability to aspirate the joint, neither of which definitively prove IA placement of the needle when the corticosteroid is injected. In the present study, we used contrast injection followed by plain radiography of the joint in 2 planes to assess accuracy, which was both an independent method and the most objective method of assessing accuracy in clinical practice.

The US clinician's assessment of accuracy was not always synonymous with true accuracy, either in this or previous studies, but there was a significant correlation between the two. In contrast, accuracy assessed by the clinician during CE-guided injections did not predict true accuracy. This suggests that injections under US guidance may be preferable in situations where clinicians need to have confidence in their accuracy, such as for radioactive synovectomy. Guidelines produced for rheumatologists who wish to train in musculoskeletal US have suggested that US-guided intervention should be introduced only as an advanced skill (29). The present study shows that this need not be the case and that accuracy of IA injection can be significantly improved with basic musculoskeletal US skills.

Accurate injection of corticosteroids may improve clinical outcome, but it could also reduce the systemic effects of the corticosteroids. It is known that a single IA corticosteroid injection reduces serum cortisol levels (30) and has transient effects on bone formation (31). One study compared the systemic effects of polyarticular IA corticosteroid injections with intramuscular corticosteroid injections and found that not only did the group that received IA injections have improved efficacy and sustained response at 2 weeks and 4 weeks, but they also had lower blood pressure at each time point studied up to 24 weeks as compared with the group that received intramuscular injections (32).

The overall benefits of joint injections in inflammatory arthritis have been demonstrated in this study. Significant improvements in the patient's assessment of stiffness, pain, and function of the injected joint at 2 weeks and 6 weeks, as evidenced by the VAS scores, and improvements in the HAQ score and the EQ-5D VAS score and index indicate that corticosteroid injection can positively affect overall health status. Our analysis did not identify any predictors of a good response to corticosteroid injection, indicating that all such patients should be considered for a corticosteroid injection of an inflamed joint.

In conclusion, corticosteroid injection in the joints of patients with inflammatory arthritis results in significant alleviation of symptoms and improvement in functional status that is sustained in the medium term in a high proportion of patients. US-guided injections are significantly more accurate than CE-guided injections, but this study did not demonstrate an associated benefit in terms of clinical outcome. However, the lower than expected difference in accuracy between the 2 groups

reduced the power to detect this. US guidance may therefore be considered under the following condition: for joints that are frequently injected inaccurately (such as the shoulder, elbow, and ankle); when less-soluble preparations are injected to reduce the likelihood of tissue necrosis and damage to surrounding tissues; if the anatomy is distorted by the disease process or by obesity; for failure of CE-guided injection; and to reduce the systemic side effects of corticosteroids.

AUTHOR CONTRIBUTIONS

All authors were involved in drafting the article or revising it critically for important intellectual content, and all authors approved the final version to be published. Dr. Cunnington had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study conception and design. Cunnington, Marshall, Isaacs, Platt, Kane.

Acquisition of data. Cunnington, Marshall, Hide, Bracewell, Platt, Kane.

Analysis and interpretation of data. Cunnington, Isaacs, Platt, Kane.

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