Successful injection of the acromioclavicular joint with use of ultrasound: anatomy, technique, and follow-up

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Background: Injection into the acromioclavicular (AC) joint is often inaccurate (approximately 50%) even in experienced hands. In light of new anatomic observations, we evaluate accuracy of an innovative ultrasound-guided method and follow the clinical course of successful therapeutic injections.

Method: Relevant anatomy was investigated in 200 three-dimensional computed tomography scans, 100 magnetic resonance images, and 14 cadavers. Baseline measurements of joint depth and width were performed ultrasonically in 100 normal volunteers; 50 symptomatic patients were injected. Uniquely in a clinical ultrasound study, injection success was documented by arthrography. Outcomes after concomitant steroid instillation were observed for 6 months by visual analog scale (VAS) scores and pain provocation test results.

Results: Anatomic studies showed that the widest area for joint penetration was anterior superior. Injection success rate was 96%, overwhelmingly on the first needle pass. Shallow joint depth allowed access with a standard 3-cm needle. Joint width diminished with age but did not reduce injection success. Cadaveric joints admitted 1.2 ± 0.5 mL, but fluid ingress was initially blocked by soft tissues in one third of both cadaveric and clinical cases. Diligent follow-up after steroid injection showed sustained pain relief in the majority with isolated AC disease but significantly less in those with concomitant shoulder disorders.

Conclusion: This high level of clinical injection success, irrefutably substantiated with arthrography, has not been previously demonstrated. The anterior superior aspect of the joint is the preferred place for entry. Initial intra-articular blockage to fluid inflow is common but can be surmounted. Encouraging 6-month results of steroid instillation in isolated AC disease do not apply to patients with coexisting shoulder pathologic processes.

Level of evidence: Level IV, Case Series, Treatment Study.

Keywords: Ultrasound-guided AC joint injection; AC anatomy

The acromioclavicular (AC) joint is commonly involved in pain syndromes around the shoulder either as an isolated source or more commonly with other types of shoulder disease, particularly rotator cuff disease. Local injection into the joint is a well-accepted technique for treatment and differential diagnosis. Symptomatic relief obtained with
a combination of steroid and local anesthetic is usually short-lived\textsuperscript{10} but in some studies has been prolonged.\textsuperscript{9,27} The difficulty with injections, however, is inaccuracy in entering the joint, which, even in experienced hands, has been estimated to succeed in only 40\% to 60\%.\textsuperscript{2,17,18,29} Ultrasound guidance has been proposed as a substitute for or an adjunct to manual palpation and has proved to markedly increase joint ingress in cadaver studies.\textsuperscript{3,17} However, the techniques used in cadavers are not directly applicable to patient practice. Clinical ultrasound studies reporting high degrees of success are unsubstantiated by objective means.\textsuperscript{20} A proven, simple, sterile, ultrasonic method for injection into the joint—indisputably confirmed by arthrography—has heretofore not been available. On the basis of new observations of relevant AC anatomy not previously discussed in the orthopedic literature, together with baseline ultrasonic measurements in normal subjects and additional cadaveric studies, we investigate an innovative technique for AC injection guided by ultrasound. In addition, the clinical course of successful therapeutic injections is closely observed for the first time in a patient population during a 6-month period.

**Materials and methods**

This is a prospective case study series of ultrasound-guided AC injections, preceded by relevant baseline ultrasonic measurements from normal volunteers, additionally informed by anatomic observations culled from computed tomography and magnetic resonance images together with cadaveric specimens.

Ultrasound measurements of the depth at which the AC joint is found under the skin and the greatest width of the joint in a coronal plane were obtained bilaterally from 100 volunteer hospital staff and orthopedic patients without a history of AC injury or other shoulder complaints (total of 200 measurements). The width was measured along a horizontal line defining the superior bone margins of the joint. Joint depth was then measured from 2 mm below this horizontal line upward to the skin surface (Fig. 1). To examine variations due to natural processes of aging, individuals were divided into 3 age groups: 25 to 40 years, 41 to 60 years, and 60 + years. Body mass index was also calculated for each subject. Special attention was taken to include obese (body mass index > 30) individuals, in whom greater joint depth beneath adipose tissue might be anticipated. Volunteers were examined in a sitting posture with arms in neutral position.

AC joints in 10 cadavers aged 70 to 83 years were injected with saline by the same needle type and syringe to be used in the clinical trial to anticipate the joint volume to be administered during the in vivo study. Four additional joints were removed by excision of the lateral clavicle and acromion, leaving all periarticular soft tissues intact. These joints were injected with contrast material and radiographs obtained. Joints were opened and examined with needles in situ. Histologic evaluation was performed on selected cases.

A total of 200 three-dimensional computed tomography scans (3DCTs), initially obtained for purposes of evaluating humeral head fractures, and an additional 100 magnetic resonance imaging (MRI) studies done for rotator cuff disease were inspected for aspects of AC joint anatomy relevant to this study.

The joint injection arm of this study involved consecutive patients seen in our shoulder clinic who demonstrated AC symptoms with or without other shoulder disease. AC joint pain distribution has been well defined by Gerber et al.\textsuperscript{6} and pain in this distribution was prerequisite for inclusion in this study. However, pain in additional areas of the epaulet did not exclude inclusion because it is well recognized that AC joint disease is most often accompanied by other shoulder maladies.\textsuperscript{3} In cases in which concomitant rotator cuff disease was suspected, MRI studies were performed. Patients included in the study had to additionally test positive on a minimum 4 of 6 commonly accepted AC pain provocation tests. The nature of the proposed study was fully explained to each patient. The first 50 who volunteered were serially enrolled; however, patients with workers’ compensation or other litigious claims were excluded. The most common diagnosis in those with isolated AC findings (15 patients) was degenerative or post-traumatic arthritis. The most common concomitant diagnosis was rotator cuff tear, complete (18) or partial (8). Additional diagnoses were calcific tendinitis (3), idiopathic frozen shoulder (3), malunited 3-part humeral head fracture (2), and superior labral anterior-posterior lesion with paralabral cyst (1). However, even in patients with other shoulder comorbidities, the AC joint symptoms were substantial or predominant at the time of initial examination. Patients were aged 26 to 83 years (average, 53 years); 28 were women. The right side was involved in 34.

**Injection protocol**

1. Patients are examined in the supine position with the arm in neutral. Examination in the sitting position was not possible in our hospital fluoroscopic setup. Serendipitously, we found that the supine position better stabilizes the scapula and is additionally comfortable for the patient.

2. Skin around the AC joint is prepared with chlorhexidine/alcohol. Effective skin antisepsis invariably removes skin markings, no matter the type of marking pen used. For this reason, visible skin markings at the injection site are not required but are shown here by way of illustration (Fig. 2).
3. The head of an ultrasonic 12F linear transducer probe (both GE LOGIQ™ [Jiangsu, China] and Philips HDI 5000 [Bothell, WA, USA] machines were used, depending on availability) is scored at its midpoint and the mark extended up the side of the probe to be easily seen.

4. The end of the probe is covered with transparent sterile dressing (Tegaderm film; 3M, St. Paul, MN, USA), which protects but does not obscure the marked midline. Sterile ultrasound gel (Ultra-Gel Aquarius 101; Medi-Lab, Glendale, CA, USA) is applied in the minimum requisite volume.

5. The anterior superior portion of the AC joint is ultrasonically visualized in the coronal plane. Joint width and depth are measured as in the asymptomatic volunteers. Measurements are made at the defined middle of the ultrasound screen, corresponding to the middle of the transducer probe (Fig. 3). The midline of the probe against the skin is thus coterminous with both the middle of the electronic screen and the widest portion of the AC joint. This defines the point for joint injection.

6. Adjacent to the midline mark on the transducer head and in a plane perpendicular to it, a standard 3-cm, 23-gauge needle is introduced through the skin. No skin anesthetic is used. The needle is slanted posterior approximately 30° to pass under the probe to enter the joint at a depth slightly greater than the premeasured perpendicular distance from the skin. In the mind’s eye, the 3-cm needle is easily parsed into thirds and so used to closely approximate the premeasured depth. The height of the joint itself (average, 9.1 mm) gives added protection against overpenetration. Sometimes, but not consistently, the needle itself can be seen ultrasonically, aiding in its correct placement.

7. Approximately 0.3 mL of contrast material (Iomeron 350; Bracco, Milan, Italy) is introduced and visualized with radiography (Fig. 4). If joint entry is successful, a portion of a mixture of 1 mL steroid (Depo-Medrol 40; Pfizer, Brussels, Belgium) and 4 mL local anesthetic (1% Lidocaine; AstraZeneca, London, UK) is injected to the extent that the joint will accommodate it without inordinate pressure. The remainder of the fluid is injected, in equally divided volumes, into the capsular and ligamentous tissues below and then above the joint as the needle is withdrawn.

8. If joint entry is not accomplished and bone is struck, the needle is reinserted. If more than 2 skin penetrations are required, it is deemed a failure of this guided ultrasonic technique. The needle is then repositioned into the joint with use of fluoroscopy, confirmed by contrast, and the therapeutic solution is administered.

Patients were examined for shoulder pain before and at one-quarter hour after injection. Subsequent examinations followed at 2 weeks and then on a monthly basis for 6 months in total with use of an 11-point visual analog scale (VAS) for pain (10 being excruciating pain, 0 no pain at all). Six months was arbitrarily considered sufficient follow-up for a local steroid injection and was longer than in any previous ultrasound injection study. In addition, 6 specific pain provocation tests in use for the
diagnosis and evaluation of AC joint disease were administered at each follow-up examination. These tests were (1) direct palpation over the AC joint; (2) horizontal adduction, internal rotation, and resisted elevation—the Bell–van Riet test\(^2\) (a combination of active adduction\(^1\) and the O’Brien test\(^1\)); (3) forward flexion >140°; (4) resisted internal rotation with the elbow flexed at the side; (5) internal rotation behind the back; and (6) inferior posterior manual translation of the clavicle on the acromion—the Paxinos test.\(^2)\) A positive finding for these tests required that pain be experienced in the classic AC referral area delineated by Gerber et al.,\(^6\) but concomitant pain in other shoulder regions was not debarred.

**Statistical methods**

Statistical analyses were performed with MATLAB software (MathWorks Inc, Natick, MA, USA) and thresholded at a conservative \(P < .01\). For statistical analysis on VAS, we used a 2-way mixed-effects model analysis of variance with repeated measures followed by post hoc Student \(t\) tests Bonferroni corrected for multiple comparisons. Deviation from mean is reported in standard error measurements. The pain provocation measure was defined by summation of the 6 administered tests, in which a positive pain response received a value of 1 and a negative response a value of 0. Statistics on this measure were performed with nonparametric methods. For the clinical follow-up, the area under the curve was calculated for the whole 6-month period for each subject and then taken to a group level analysis by nonparametric Mann-Whitney test.

**Results**

On 3DCTs (Fig. 5, A) and on MRIs (Fig. 5, B), the AC joint was observed to consistently open up anteriorly even in cases with advanced degenerative disease. This finding has not been previously emphasized in the orthopedic literature. This observation led us to pay close attention to the anterior superior joint region during ultrasonic examination and to confirm that this area offers the widest locale for potential needle insertion. It is also the seat of the intra-articular meniscus (Fig. 5, C, D).

In the 100-person asymptomatic volunteer group, ultrasonically measured distance from the skin to the superior aspect of the joint did not significantly depend on laterality and was on average 1.2 cm (Fig. 6, A). Thus joint depth beneath the skin was always within reach of a standard 3-cm needle, even in obese individuals (1.4 cm), in whom depth measurements were significantly greater than in normal-weight persons (\(P = .01\)). Joint width measured on average 0.4 cm. This dimension showed the anticipated narrowing with age (Fig. 6, B; \(r = -0.52; P < .001\)). Because of joint narrowing, needle access is potentially more challenging with increasing age; but by our midline injection technique, success was not affected by this parameter.

Our cadaver studies showed that the AC joint would accept on average 1.2 ± 0.5 mL of fluid through a 23-gauge needle before sufficient pressure built up to push back the
plunger of the 5-mL plastic syringe. This was similar to our subsequent in vivo observations, although we did not measure exact intra-articular volumes in the clinical cases. In 5 of the 14 cadaver specimens (37%), push-back with no fluid inflow was noted from the onset. In these cases, on opening of the joint with the needle in situ, it was seen that the needle tip was obstructed by soft tissues (Fig. 7, A, B) that proved, on gross and histologic examination, to be residual degenerative meniscus. This percentage of inflow impairment was grossly similar to the 33% of our clinical cases in which the needle was seen on fluoroscopy to be in the joint but where the injection of fluid was initially blocked.

In the clinical arm of the study, we successfully documented joint entry in 48 of 50 patients (96%). Entry was gained on the first needle pass in 42 (84%) and required a second pass in 8 patients, principally during the beginning learning curve of the study. Fluoroscopically assisted guidance, constituting failure of our ultrasonic technique, was required in 2 cases of endomorphic individuals, in whom it was difficult to stabilize the skin under the ultrasound probe.

When initial strong resistance to fluid inflow was encountered, suggestive of soft tissue or meniscal block, our strategy was to penetrate the needle below the joint until, with additional pressure, the lumen was cleared and free flow achieved. The disencumbered needle was then withdrawn into a slightly different joint area and the therapeutic dose successfully administered per the protocol. These cases were not considered failures of the technique.

In the supine position, only 2 patients complained of pain during the injection process. No subsequent infections were seen.

Clinical follow-up

Two patients with concomitant rotator cuff tears were lost to follow-up, leaving a total of 48 persons observed for 6 months. We observed that initial quarter-hour follow-up demonstrated complete or nearly complete relief of symptoms as indicated by VAS ratings and the clinical AC provocation test findings in all but 2 patients. Subsequently, in the 15 patients who had isolated AC disease, VAS scores indicated a significant improvement at final 6-month follow-up over preinjection values by an average of 5.5 ± 1.4 (Fig. 8, A; \( P < 10^{-5} \)). Regression to preinjection pain level was observed in only 1 patient (3 months after injection), whereas 8 of the 15 remained essentially pain free (VAS score ≤2) for the entire 6 months. Pain levels, measured as the sum of the 6 specific AC pain provocation tests, also significantly improved during the 6-month period in the isolated AC group (Fig. 8, B; \( P < 10^{-5} \)). Direct palpation and the Bell–van Riet test were the 2 tests most likely to show regression of results to painful preinjection status. VAS pain relief ratings at 3 months were strongly predictive of persistent relief at 6 months (Pearson linear correlation: \( r = 0.91, P < 10^{-5} \); correlation between 2 and 6 months: \( r = 0.68, P < 10^{-5} \)), indicating that a reliable long-term recovery can be predicted at this stage.

Comparable salutary results for the 18 patients with concomitant full-thickness rotator cuff tears were less marked and less prolonged (Fig. 8, A, B), as indicated by a significant interaction in a repeated-measures analysis of variance with group (AC only/AC with full rotator cuff tear) and improvement (initial pain/final pain) as factors for VAS scores (\( P < 10^{-5} \)). Moreover, we found a significant difference between the groups throughout the 6-month period for both VAS scores and pain provocation test results as indicated by area under the curve calculations (both \( P < 10^{-5} \)). No differences were found for initial pain ratings between the 2 groups (\( P > .1 \)). In the combined AC/rotator cuff tear group, 69% of patients regressed to their original preinjection pain ratings within an average of
6 ± 0.3 weeks ($P < .001$ in direct comparison with AC group, Fisher exact nonparametric test), with only 3 of these 18 patients pain free (VAS score $\leq 2$) at 6 months.

There were 8 patients with coexisting partial-thickness rotator cuff tears. Although this group was too small for reliable statistical tests to be performed, clinically they occupied a middle ground between patients with isolated AC joint disease and those with concomitant full-thickness tears. Of these 8 patients, 3 experienced pain remission (VAS score $\leq 2$) at final 6-month follow-up with reversion to preinjection levels of pain in the others at an average of 8 weeks. Results in the 9 patients with miscellaneous diagnoses were mixed: one with frozen shoulder, one with calcific tendinitis, and the patient with a superior labral anterior-posterior lesion/paralabral cyst remained essentially pain free (VAS score $\leq 2$) at 6 months; the others reverted to preinjection status at an average of 4 weeks.

**Discussion**

Our results demonstrate a significant increase in the proficiency of AC injection with positive clinical implication in selected patients. We emphasize that radiography with the administration of contrast material was used here to irrefutably document successful joint entry—for the first time in a clinical AC ultrasound study—but is not required by the method itself. Our contrast studies, demonstrating success in 96%, give confidence to the use of this technique without radiographic confirmation, thus eliminating the additional incumbent cost and radiation burden.

All previous ultrasonic methods suggested to aid AC injection have significant drawbacks. The techniques in cadaver studies either employ an inordinately thick needle required for reliable out-of-plane needle visualization or use the type of in-plane techniques for scalene blocks and biopsies, which are technically difficult and painful to reproduce in vivo. Some clinical work has been done, notably the pioneering studies of Sabeti-Aschraf et al., but these authors do not provide irrefutable verification of the needle in the joint, and furthermore their technique raises concerns about sterility. These concerns were implicitly acknowledged by the authors, who themselves suggest the type of sterile precautions we have taken in our study.

![Figure 7](https://example.com/f7.png)

**Figure 7** (A, B) Examples of cadaveric specimens in which initial fluid ingress was blocked by degenerative meniscal tissues, histologically confirmed. C. clavicle; A, acromion; M, meniscal tissue.

![Figure 8](https://example.com/f8.png)

**Figure 8** Results of (A) VAS and (B) pain provocation tests during a 6-month period in the 2 most numerous diagnostic categories: (1) isolated AC joint disease and (2) symptomatic AC with concomitant full-thickness rotator cuff tear (AC + RC). The x-axis was exponentially transformed to represent time after injection. The pain provocation measure was defined by summation of the 6 administered tests.
Our 3DCT and MRI anatomic observations, not previously emphasized in the literature to the best of our knowledge, call attention to the consistent widening of the AC joint anteriorly, predisposing to successful needle entry in this area with or without the use of ultrasound. Anatomically, this region is seat to the thickest portion of the articular meniscus, which usually but not always degenerates and involves with advancing age. Not uncommonly, however, it appeared in our cadaver studies that residual meniscus can block fluid delivery from the tip of a thin needle. In such cases, a firm endpoint or spring-back of the syringe plunger is felt even before a minimal amount of fluid can be introduced. This circumstance arose as well in a similar one third of our clinical patients. Thus, although the anterior superior region of the joint is the widest and sometimes only area into which needle entry can be made, residual meniscus may be substantial in this region. Clinicians should anticipate situations in which needle tip blockage by soft tissues may occur and have a strategy to deal with it.

We initially hypothesized that in addition to the intra-articular area of the joint, the richly innervated superior and inferior capsuloligamentous structures also contribute to pain production. Thus our clinical protocol deliberately included concomitant infiltration of steroid and anesthetic into the closely adjacent periarticular structures above and below the joint. By way of contrast, the only other arthrographically controlled clinical AC injection study (done with fluoroscopy, not ultrasound) was designed specifically to restrict injection to the AC joint alone by use of a small fluid volume. In this study, pain relief was infrequent and incomplete. After one-quarter hour, only a 38% decrease in pain was observed in the VAS results (follow-up longer than 15 minutes was not done in this study). Our comparable VAS results at one-quarter hour showed 98% of patients with similar or higher levels of relief, suggesting the added value of injecting both the joint itself and the periarticular tissues. Indeed, infiltration of the periarticular structures alone is doubtless the basis for the contention by some that it is not necessary to inject the joint itself to obtain the salutary effect of pain relief. However, for ethical reasons, we have not endeavored to test this hypothesis by deliberately missing the joint in a controlled placebo trial.

In our work, it appears that complete filling of a small joint with therapeutic solution, together with infiltration of all closely surrounding capsuloligamentous structures, provides longer term pain relief than the more temporary relief usually obtained by the incomplete filling of a large joint without ligamentous infiltration, which occurs in injections of the knee, shoulder, and ankle.

It is well recognized that the AC joint may be sloped in the coronal plane rather than perpendicular. However, any inherent slope in this plane does not affect successful entry of a needle into the most superior aspect of the joint. In addition, as measured by others, the joint capsule is elevated on average 4 mm above the superior cortex of the bones, giving an extra margin of safety to superior joint entry. It also appears that the slant of our ultrasound probe that yielded the widest superior joint space also mimicked the anatomic slope sufficiently to allow the needle to pass completely through the joint. In no case did we encounter bone once the joint had been successfully penetrated from above by our technique.

Although it is not specifically addressed in this work, it appears that the learning curve for similar ultrasound injection techniques is not great and can be mastered by those without shoulder experience.

The present study regarding accuracy of injection is well powered in relation to the poor results historically obtained with unguided techniques. However, more power from greater numbers is preferable in evaluating the efficacy of the steroid therapeutic arm of our study. Furthermore, we did not run an untreated control group. Unfortunately, neither is there any detailed study of the natural history of AC joint disease available in the literature to offer a historical control. Accepting these caveats, our 6-month observations are of interest because no other arthrographically documented study of successful steroid injections with comparable patient numbers and prolonged close follow-up has been previously published. Our clinical results in cases of isolated AC joint pain were encouraging. Substantial relief was maintained in the majority of this group during the entire 6-month period. However, in patients with concomitant shoulder disorders, constituting the majority of our subjects, pain relief was notably less. In this group, we did not investigate the possibility of greater and more prolonged relief from a separate contemporaneous subacromial injection.

Another limitation of this study is noteworthy from a practical point of view. We used 2 persons to perform the injection protocol, one to manipulate and hold steady the ultrasound probe and the second to be concerned with matters of sterility and the actual introduction of the needle and therapeutic solutions. It is conceivable that the entire procedure could be accomplished by a solo practitioner, but we have not tested this hypothesis. We have noted, however, in preliminary work preceding this study, that it was insufficient, in our hands, to simply mark or indent the skin over the ultrasonically demonstrated joint with an externally placed needle, paper clip, or similar device. High levels of accuracy and sterility require that the sterile transducer probe remain in place during the injection to stabilize the skin and to give direction to the needle.

Heuristically, one might consider that the simple step-wise ultrasound method used here could further serve as a paradigm for successful injection into other small superfi- cial joints, such as the sternoclavicular joint or the joints of the hand and the foot.

Conclusion

The AC joint has been successfully injected in 96% of patients by an ultrasound-guided method, a considerable
Improvement over historical precedents. Results are substantiated by arthrography for the first time in a clinical ultrasound study. Anatomic observations indicate that the anterior superior aspect of the joint offers the widest area for needle entry, with or without the use of ultrasound. Initial intra-articular blockage to fluid inflow, ostensibly from residual meniscal tissue, may occur in one third of cases and can be overcome. Encouraging 6-month clinical results after steroid instillation in cases of isolated AC disease do not usually apply to patients with coexisting shoulder disease.

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References