Accuracy of Ultrasound-Guided Versus Palpation-Guided Acromioclavicular Joint Injections: A Cadaveric Study

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Objective: To describe a technique for sonographically guided acromioclavicular joint (ACJ) injections and compare its accuracy to palpation-guided injections in a cadaveric model.

Design: Prospective laboratory investigation.

Setting: Procedural skills laboratory at a tertiary medical center.

Methods: A single experienced operator completed 10 sonographically guided and 10 palpation-guided ACJ injections in unembalmed cadavers. Injection order was randomized and all injections were completed with diluted colored latex. Co-investigators blinded to the injection technique dissected each specimen and graded colored latex location as accurate (in the ACJ), partially accurate (within and outside the ACJ), or inaccurate (no latex in the ACJ).

Main Outcome Measurements: Direct assessment of injected dye within the ACJ via dissection.

Results: All 10 sonographically guided ACJ injections accurately placed latex into the ACJ (100% accuracy), whereas only 4 of 10 (40%) palpation-guided injections accurately placed latex within the ACJ ($P = .0054$).

Conclusions: This cadaveric investigation suggests that sonographic guidance can be used to inject the ACJ with a high degree of accuracy, and should be considered superior to palpation guidance. Clinicians should consider using sonographic guidance to inject the ACJ when diagnostic specificity is paramount or when otherwise clinically indicated.

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INTRODUCTION

Idiopathic or posttraumatic disorders affecting the acromioclavicular joint (ACJ) are well-established causes of shoulder pain [1, 2]. Identification of the ACJ as a primary source of shoulder pain can be challenging. Pain arising from the region of the ACJ may be suggestive of an ACJ disorder, but is rarely diagnostic in isolation [3]. Physical examination maneuvers such as ACJ palpatory tenderness, cross-body arm adduction, and resisted horizontal abduction have been shown to have low sensitivities and poor positive predictive values in confirming the ACJ as a pain generator [4]. Furthermore, degenerative changes in the ACJ are commonly seen on radiographs and magnetic resonance imaging (MRI) in asymptomatic individuals older than 35 years, and therefore lack diagnostic specificity [1, 5, 6]. Consequently, some clinicians have advocated the use of local injections to confirm the ACJ as a pain generator in patients presenting with shoulder pain of uncertain etiology [2, 7-10].

Few studies have evaluated the accuracy of needle placement into the ACJ for diagnostic or therapeutic purposes [10-13]. Using a cadaveric model, Partington and Broome reported that only 66% of 24 palpation-guided ACJ injections performed from a superior approach accurately placed dye into the ACJ [10]. Two investigations on live subjects reported a 40%-50% accuracy rate of palpation-guided ACJ injections and 100% accuracy with fluoroscopically-guided injections [11, 12]. Pichler et al found palpation-guided ACJ injection accuracy to be 57% and fluoroscopically guided ACJ injection accuracy to be 100% using a cadaveric model [13].

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Ultrasound (US) guidance has increasingly been used to accurately place needles into target regions, including intra-articular spaces [14-16]. Although US-guided ACJ injections have been described [17], no prior investigation has prospectively determined the accuracy of US-guided versus palpation-guided ACJ injections. Accurate intra-articular placement of injectate into the ACJ has significant consequences for proper diagnosis of shoulder disorders, selection of appropriate therapeutic interventions, and surgical decision-making for patients undergoing shoulder surgery [18]. Therefore, the primary purpose of this investigation was to prospectively determine the accuracy of US-guided versus palpation-guided ACJ injections performed in a cadaveric model by a single experienced operator. We hypothesized that US-guided ACJ injections would be significantly more accurate than palpation-guided injections in this cadaveric model.

Figure 1. Needle approach for palpation-guided acromioclavicular joint injections.

METHODS

Cadaveric Specimens

Twenty unembalmed cadaveric ACJ specimens, consisting of 10 left ACJ cadaveric specimens and 10 right ACJ cadaveric specimens, were obtained through the Mayo Clinic Department of Anatomy Mayo Foundation Bequest Program. Specimens were brought to room temperature immediately before the study. No specimen demonstrated signs of prior surgery, trauma, or major deformity about the shoulder. The project was approved by the Mayo Clinic Bio-Specimens Subcommittee of the Institutional Review Board.

Equipment

US guidance was performed using a Merlin 1101 portable US system (B-K Medical Systems, Wilmington, MA) and a 6-12 MHz linear array transducer with a 38-mm footprint. During the US-guided needle placement, the transducer was covered with a sterile US cover to simulate clinical conditions (Civco, Kalona, IA).

Injection Procedures

The primary investigator (J.S.) injected each ACJ of 10 unembalmed cadavers (10 left ACJ, 10 right ACJ; 20 ACJ total) using either a palpation-guided or an US-guided technique. Balanced randomization with respect to the left and right ACJ cadaveric specimens was applied to both order of injection and to the guidance method used. At the time of the investigation, the primary investigator had 4 years' experience performing US-guided ACJ injections and more than 10 years' experience performing palpation-guided ACJ injections. All injections were completed in the Mayo Clinic Procedural Skills Laboratory.

A 25-gauge, 1.5-inch needle with 1 mL of 50% diluted colored latex solution (Ward's Natural Science, Rochester, NY) was used for all injections. Palpation-guided injections were performed with the specimen in the supine position. The medial acromion and lateral clavicle were palpated and the needle advanced in a lateral-to-medial direction. The needle passed between the bony margins of the acromion and clavicle, penetrating the ACJ capsule and superior ligaments (Figure 1) [19]. As necessary, a single needle repositioning was allowed to simulate clinical conditions. When the operator was satisfied with placement, 1 mL of diluted latex was injected into the ACJ.

Although several US-guided needle approaches to the ACJ are possible, a lateral-to-medial approach was used for consistency. The transducer was placed in an anatomic coronal plane, positioned across the ACJ. As necessary, additional US gel was placed under the lateral (acromial) side of the transducer to provide ample standoff and facilitate needle advancement under the transducer. After optimizing ACJ sonographic visualization, the needle was advanced in a lateral-to-medial direction, parallel to the long axis of the transducer. The needle was sonographically visualized to penetrate the ACJ capsule and ligaments, and was subsequently advanced between the bony margins of the acromion and clavicle (Figures 2A, 2B). After intra-articular positioning with sonographic visualization, 1 mL of diluted latex was injected into the ACJ. For illustrative purposes, a representative oblique coronal image of the ACJ on T2-weighted MRI is shown in Figure 3.

Assessment

At a minimum of 24 hours post-injection, a study co-author (W.P.), blinded to injection technique, dissected each specimen and assessed the accuracy of each injection. Injections were graded as accurate (in the ACJ), partially accurate

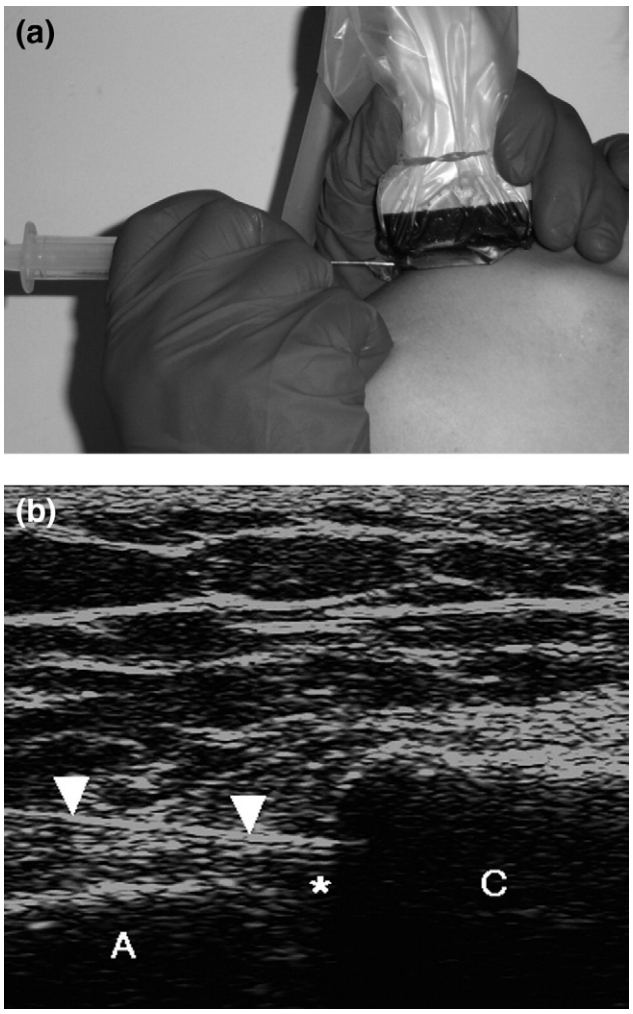

Figure 2. **(A)** Needle approach and US transducer position for US-guided acromioclavicular joint (ACJ) injections. **(B)** US image of the ACJ (asterisk) and needle (arrowheads) in long-axis (in-plane) view. Left = lateral, top = superficial, A = acromion, C = clavicle. (Merlin 1101 US system, B-K Medical Systems, Wilmington, MA).

(within and outside the ACJ), or inaccurate (no latex in the ACJ).

Statistical Analysis

The primary variable of interest was the accuracy of injectate placement achieved with US guidance versus palpation guidance. Statistical analysis was performed by the investigators with assistance of the Mayo Clinic Center for Patient-Oriented Research and the Mayo Clinic Sports Medicine Center research staff. Comparisons of dye location between US-guided and palpation-guided groups were assessed for significance using a 2-tailed Fischer exact test, with significance set at $P < .05$.

RESULTS

The left and right ACJ of each of 10 unembalmed cadavers (20 total ACJ cadaveric specimens) were used for this investigation. There were 8 female and 2 male cadaveric specimens used. Demographic data in mean ± standard deviation for the cadaveric specimens included age 75.8 ± 12.6 years, height 163.6 ± 8.6 cm, weight 58.7 ± 16.1 kg, and body mass index (BMI) 22.1 ± 7.2 kg/m^2.

All 10 US-guided ACJ injections were accurate (100% accurate). Four of the 10 palpation-guided ACJ injections were accurate (40% accuracy), whereas the remaining 6 were inaccurate. Of the 6 inaccurate palpation-guided injections, 4 were on a left ACJ, and 2 were on a right ACJ. No injections in either group were graded as partially accurate. The US-guided ACJ injections were significantly more likely than the palpation-guided injections to reach the ACJ ($P = .0054$).

DISCUSSION

Identifying the ACJ as a pain generator in patients presenting with shoulder pain can be a challenging clinical task [3, 4]. Pain patterns, physical examination maneuvers, and imaging findings alone lack the sensitivity and specificity to accurately identify an ACJ pain generator in many patients [4, 20]. Nonetheless, confirming the presence of a symptomatic ACJ disorder is crucial to appropriately guide nonsurgical or surgical treatment. Some clinicians have recommended diagnostic ACJ injections to assist in the clinical decision-making process [2, 7-10]. However, prior studies report the accuracy of palpation-guided ACJ injections to be only 40%-66% [10-13].

The current investigation represents the first published data reporting the accuracy of US-guided ACJ injections. Our results indicate 100% accuracy of US-guided ACJ injection, which is statistically superior to the 40% accuracy obtained with palpation-guided ACJ injection ($P = .0054$). Of note, the 40% accuracy for palpation-guided injection in the current study is commensurate with previously published data [10-13].

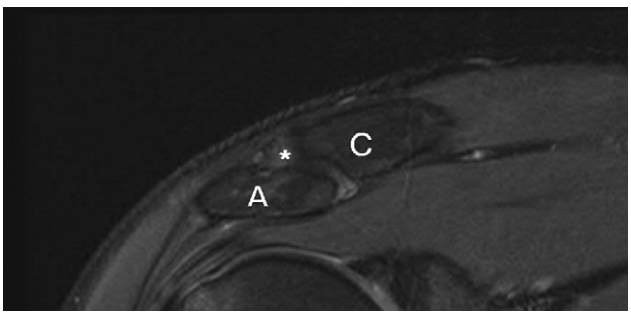

Figure 3. Representative oblique coronal image of the ACJ (asterisk) on T2-weighted MRI. Left = lateral, top = superficial, A = acromion, C = clavicle.

The precise reason for the relatively poor accuracy of palpation-guided ACJ injections in the current and previous studies is unknown. The ACJ is superficial and presumably easily palpated. However, variability in ACJ orientation, patient body habitus, and presence and degree of degenerative changes may contribute to the inaccuracy of palpation guidance. Although the current study design attempted to control for patient factors by completing one US-guided and one palpation-guided injection in each specimen, we did not specifically assess ACJ orientation or grade the extent of ACJ degenerative changes. It is unlikely that body habitus negatively influenced the palpation-guided results given the low average BMI of our specimens (22.1 ± 7.2 kg/m^2). The influence of these factors on the accuracy of palpation-guided ACJ injections warrants further investigation.

We did not compare US to other image-guided techniques for ACJ injection. Previous studies have reported a high degree of accuracy with fluoroscopically guided ACJ injections, commensurate with the US-guided results of the current investigation [11-13]. Both Bain and colleagues and Bisbinas and colleagues found 100% accuracy of fluoroscopically guided ACJ injection in live patients [11,12]. Pichler and colleagues also found 100% accuracy of ACJ injection using a cadaveric model [13]. Whether US is superior to fluoroscopy for image-guided ACJ injections warrants further study. However, US provides distinct advantages over fluoroscopy, including portability and the absence of ionizing radiation exposure for both the patient and the operator.

The current study focuses on injection accuracy in the context of diagnostic decision-making for nonsurgical and surgical management [2, 7-10]. Recently published data suggest that, at short-term follow-up, US-guided ACJ corticosteroid injections are no more clinically efficacious than palpation-guided injections [17]. However, it is noteworthy that injection accuracy was not assessed in this small study and it is well-known that corticosteroids may have regional effects [21]. Therefore, it is not clear within the study design whether the relative accuracy of US-guided versus palpation-guided injections differed. Furthermore, the lack of differential efficacy between US-guided and palpation-guided corticosteroid injections cannot necessarily be extrapolated to diagnostic local anesthetic injections or other potential therapeutic agents (eg, viscosupplements).

Several limitations of the present study are noteworthy. First, the injections in the present study were performed on unembalmed cadavers. Therefore, clinicians may choose to exercise caution when extrapolating the current results to clinical populations because of possible differences between live and cadaveric tissue characteristics.

Second, our sample size was relatively small, with only 20 total injections performed. Although sufficient to achieve statistical significance, whether similar results would be realized in a larger, more heterogeneous clinical population warrants further study.

Third, a single operator performed all injections in the current study. It is uncertain to what degree differences in experience with US-guided and palpation-guided ACJ injections would affect their respective accuracies. Pichler and colleagues reported the relative accuracies of less experienced and more experienced operators with palpation-guided ACJ injections to be 55% and 58%, respectively [13]. However, the relative accuracies of fluoroscopically guided ACJ injections between different levels of clinician injection experience were not reported in that investigation.

Fourth, our cadaveric specimens had relatively low BMI (22.1 ± 7.2 kg/m^2). The applicability of the data in the present study to patients with larger body habitus is uncertain.

Fifth, the cadaveric specimens in the present study were free from major deformity or prior trauma. It is not known if the presence of these challenges would significantly change the accuracy data we obtained, although it is plausible that US guidance would offer additional benefit in accurately injecting the ACJ of these patients.

Sixth, the present study was limited to the lateral-to-medial approach to ACJ injection. A variation of the lateral-to-medial approach to palpation-guided ACJ injection has been previously described [19]. The lateral-to-medial approach was used in the present study to maintain consistency. Although a directly superior-to-inferior palpation-guided approach to ACJ injection is possible [12], this approach is not easily performed with sonographic guidance because of transducer positioning. The relative accuracies of different approaches to ACJ injection warrant further study.

Several other sonographically guided approaches are possible. These include 1) anterior-to-posterior, needle visualized parallel to long axis of the transducer; 2) anterior-to-posterior, needle visualized parallel to the short axis of the transducer; and 3) posterior-to-anterior, needle visualized parallel to short axis of transducer. The primary investigator has successfully used all of the above approaches in clinical practice, with the choice of approach being dictated by individual patient factors such as body habitus, ACJ alignment, and the presence of deformity.

CONCLUSION

ACJ injections with US guidance in the present study were significantly more accurate than palpation-guided injections. This cadaveric investigation suggests that sonographic guidance can be used to inject the ACJ with a high degree of accuracy and should be considered superior to palpation guidance. Clinicians should consider using sonographic guidance to inject the ACJ when diagnostic specificity is paramount or when otherwise clinically indicated.

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