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Research Article

Accuracy of Radiohumeral Joint Injections: A Cadaveric Comparison of Ultrasound and Landmark Guidance in Experienced and Novice Practitioners

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Abstract

Objective: To compare the accuracy of ultrasound-guided versus landmark-guided radiohumeral joint injections and assess the effect of practitioner experience.

Design: Cadaveric comparison using 19 specimens. One experienced sports medicine physician (>20 years' experience) and two fourth-year medical students performed 40 injections (18 expert, 22 novices) evenly split between methods (ultrasound vs landmark-guided). Dissection confirmed injection accuracy (>50% dye within joint).

Results: Expert: 88.9% (ultrasound) vs. 77.8% (landmark); Student 1: 80% vs. 40%; Student 2: 66.7% vs. 50%. No differences achieved statistical significance.

Conclusions: Ultrasound yields consistently high accuracy, particularly beneficial for novice practitioners-consistent with findings in elbow and upper limb injection literature.

Introduction

Accurate radiohumeral joint injection is critical in the management of lateral epicondylitis, osteoarthritis, and inflammatory arthropathies, yet landmark-guided techniques often yield inconsistent results-especially in small joints where accuracy can be under 50% [1, 2]. Ultrasound guidance has repeatedly been shown to enhance injection accuracy across multiple joints, including the glenohumeral (92.5% vs. 72.5%), acromioclavicular (100% vs. 40%), and subacromial space injections (100% vs. 63%) [3, 4]. Systematic reviews confirm the overall superiority of ultrasound for musculoskeletal injections [5, 6] and cadaveric data for elbow injections demonstrate consistently high accuracy rates [7-9].

A recent cadaveric study by Ricci et al. described a proximal-to-distal in-plane ultrasound technique for elbow injection, achieving precise intra-articular placement with excellent needle visualization [8]. Other studies have similarly documented the technical advantages of ultrasound-guided elbow approaches, including improved visualization of the joint space and avoidance of neurovascular structures [10-12]. Given this evidence, we hypothesized that ultrasound guidance would result in higher

accuracy for radiohumeral joint injections, particularly for inexperienced injectors, while experienced providers would maintain high performance regardless of technique.

Methods

Study Design and Setting

Cadaveric study conducted in 2022-2023 at the Geisel School of Medicine (Dartmouth) anatomical donation program.

Ethical Statement

Institutional review board review was waived due to the cadaveric nature, with adherence to ethical guidelines for anatomical research. Patients and the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

Cadavers

Nineteen specimens (mean height 162.6 cm, mean age 90 years, predominantly Caucasian, deaths primarily from natural causes) were used.

Participants

One sports medicine physician (family medicine-trained, sports medicine fellowship, >20 years of practice) and two fourth-year medical students with no prior injection experience.

Injection Protocol

- Expert: 18 injections (9 ultrasound-guided, 9 landmark-guided)
- Student 1: 10 injections (5 each)
- Student 2: 12 injections (6 each)

Ultrasound guidance was performed using a handheld high-frequency linear probe (Butterfly Network Inc., 2022 model) in-plane with a 25-gauge, 1.5-inch needle. Landmark-guided injections used palpation of the lateral epicondyle and radial head. All injections used ~1 mL diluted acrylic paint as injectate. Ultrasound guidance was always performed on the right elbow of each cadaver, and landmark-guided injections were always performed on the left elbow. This fixed assignment was maintained for both the experienced physician and the medical students. Following injection, the joint was dissected to confirm accuracy, defined as >50% of the dye within the radiohumeral joint.

Statistical Analysis

Accuracy rates with 95% confidence intervals were calculated using the Clopper-Pearson method. Fisher's exact test compared proportions within and between injectors and techniques.

Results

Accuracy Rates:

- Expert: 88.9% (ultrasound) vs. 77.8% (landmark), p = 1.000
- Student 1: 80.0% (ultrasound) vs. 40.0% (landmark), p ≈ 0.524
- Student 2: 66.7% (ultrasound) vs. 50.0% (landmark), p = 1.000

No within-injector differences were statistically significant (Table 1, Figure 1). When pooled across all injectors, ultrasound-guided injections were accurate in 16/20 cases (80.0%; 95% CI, 56.34-94.27%), whereas landmark-guided injections were accurate in 12/20 cases (60.0%; 95% CI, 36.05–80.88%; Table 2). Although ultrasound guidance demonstrated a 20% absolute increase in accuracy, this difference did not reach statistical significance (Fisher's exact test, p = 0.301). Overall injections performed by advanced practitioner vs. students combined also approached but did not reach statistical significance (p ≈ 0.165).

Table 1: Radiohumeral Joint Injection Accuracies by Provider and Technique.

Injector	Method	Accurate	Total	Accuracy (%)	95% CI Lower	95% CI Upper
Experienced	Ultrasound	8	9	88.89	51.75	99.72
Experienced	Landmark	7	9	77.78	39.99	97.19
Medical Student 1	Ultrasound	4	5	80.00	28.36	99.49
Medical Student 1	Landmark	2	5	40.00	5.27	85.34
Medical Student 2	Ultrasound	4	6	66.67	22.28	95.67
Medical Student 2	Landmark	3	6	50.00	11.81	88.19

Table 2: Pooled Radiohumeral Joint Injection Accuracies by Technique.

Method	Accurate	Total	Accuracy (%)	95% CI Lower	95% CI Upper
Landmark	12	20	60	36.05	80.88
Ultrasound	16	20	80	56.34	94.27

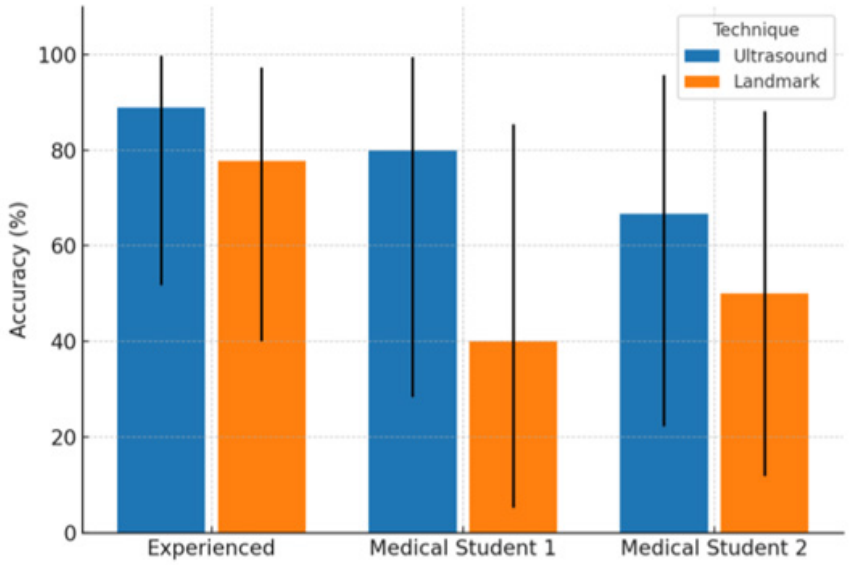

Figure 1: Accuracy of Radiohumeral Joint Injections by Technique and Experience Level.

Discussion

While our small sample size limited statistical power, the observed trends are consistent with prior work showing that ultrasound improves injection accuracy, especially for novice practitioners [3, 5, 8, 9, 13, 14]. For elbow injections, cadaveric and clinical studies have reported ultrasound-guided accuracy rates from 91% to 100% compared to 37.5% to 100% for landmark techniques [7-9]. The proximal-to-distal approach described by Ricci et al. provides an example of an ultrasound-specific technique that could be readily taught to trainees [8]. Several studies have demonstrated that even in small target joints like the radiohumeral, ultrasound provides reliable needle placement and helps avoid structures like the radial nerve. These studies have emphasized ultrasound's role in improving success rates and confidence in small-joint injections for learners [10-12, 15, 16].

The observed trends also suggest that ultrasound can reduce variability for novices, whereas experienced practitioners maintain high accuracy regardless of technique. These findings align with studies in the glenohumeral [3], acromioclavicular [1, 2], and sacroiliac joints [5], as well as procedural training literature [4, 11, 12]. Limitations of this study include the small sample size, cadaveric-only design, absence of procedural timing data, and lack of randomization. The absence of procedural timing data means we cannot comment on whether one technique was faster to perform, required more setup, or presented greater technical difficulty. Procedural time is an important practical outcome, as ultrasound guidance can sometimes require additional preparation and scanning-particularly for novice operators-which may influence workflow in clinical settings.

The lack of randomization in this study specifically refers to the fact that ultrasound guidance was always performed on the right elbow, and landmark guidance was always performed on the left elbow for each cadaver. This fixed side-to-technique pairing introduces the possibility of systematic bias if anatomical differences between sides, injector handedness, or cadaver positioning made one side easier to access than the other. It also prevented alternating or randomizing the sequence of injections, meaning that potential learning effects (improvement with repetition) or fatigue could have influenced results.

Conclusion

Ultrasound guidance consistently enhances accuracy in radiohumeral joint injections, particularly for novice injectors. Experienced practitioners achieve high accuracy across both methods. The findings support integrating ultrasound-based training into musculoskeletal procedural education.

Acknowledgement

None.

Conflict of Interest

No conflict of interest.

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