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EXPERT DIAGNOSTIC STUDY

Ultrasound-guided Cubital Tunnel Injection: Description of Technique and Accuracy in a Cadaver Model

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ABSTRACT

Introduction: Ulnar nerve (UN) and cubital tunnel morphology is influenced by elbow positioning, potentially compromising injection accuracy and placing the nerve at risk during cubital tunnel injection.

Materials and methods: Based on previous anatomical studies of the cubital tunnel, a proof of concept injection model was developed. Eighteen above-elbow cadaver specimens were positioned in 45° elbow flexion and in neutral forearm rotation. The ultrasound transducer was oriented in the transverse plane, in-line with the medial epicondyle and olecranon tip, facilitating visualization of the UN and cubital tunnel. A 25-gauge needle oriented parallel to the ulna was inserted percutaneously at the midpoint between olecranon and epicondyle. The needle was advanced under ultrasound guidance to replicate injection and was secured. Open dissection confirmed its location.

Results: 18/18 needle tips were within the cubital tunnel and no needles penetrated the UN.

Discussion: Ultrasound-guided cubital tunnel injection, with the elbow in 45° flexion and with neutral forearm rotation was a safe and reliable technique in this cadaveric model. Future clinical studies may evaluate the efficacy of both diagnostic and therapeutic cubital tunnel injection.

Keywords: Cubital tunnel, Injection, Sonography, Ulnar nerve, Ultrasound.

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INTRODUCTION

The use of corticosteroid injection in the diagnostic and therapeutic strategies for the management of carpal tunnel syndrome has been described extensively. Its use in the management of compressive neuropathy of the ulnar nerve (UN) at the elbow, however, is not uniform and there is a paucity of information regarding its utility in the treatment of the second most common upper extremity nerve compression syndrome. Injection accuracy, particularly influenced by the dynamic morphology of the UN[1] and cubital tunnel[1,2] with elbow positioning, has not been established and may influence outcomes regarding medication delivery and avoidance of iatrogenic nerve injury.

Alterations in the morphology of the UN and cubital tunnel were described by Gelberman et al.[1] Specifically, Gelberman et al[1] found the cross-sectional area of the tunnel and UN to change in shape from a triangle in full extension to an ellipse in full flexion, with the UN encompassing the smallest percentage of the tunnel (44%) at 454 flexion. Additionally, at 45A the pressure in mm Hg of the cubital tunnel is at its lowest and most amendable to retaining an injection. In a separate study using three-dimensional digitization technology, James et al[2] found the height of the cubital tunnel (distance from the floor to Osborne's ligament) was greatest at 45 .

These previous anatomic studies provide initiative for developing a standardized method for ultrasound-guided cubital tunnel injection. The purpose of our cadaveric study was to investigate the safety and reliability of an ultrasound-guided cubital tunnel injection considering previously defined anatomic parameters.

MATERIALS AND METHODS

Institutional Review Board approval was obtained for this study. Eighteen fresh-frozen transhumeral amputation specimens without evidence of previous elbow injury were randomized into one of three injection groups of six specimens each. Attempted ultrasound-guided needle placement within the cubital tunnel, without penetration of the UN, was performed for each group by one of a board-certified hand surgeon, a hand surgery fellow, or orthopaedic surgery resident. The arms were positioned with 45° elbow flexion and neutral forearm rotation. Two palpable superficial anatomic landmarks, the medial epicondyle and olecranon tip, were marked for reference. A musculoskeletal ultrasound transducer (18 MHz transducer, MyLabOne Musculoskeletal, Esoate North America, Indianapolis, IN) was oriented in-line with the medial epicondyle and olecranon tip and the UN was identified for orientation in the inlet of the

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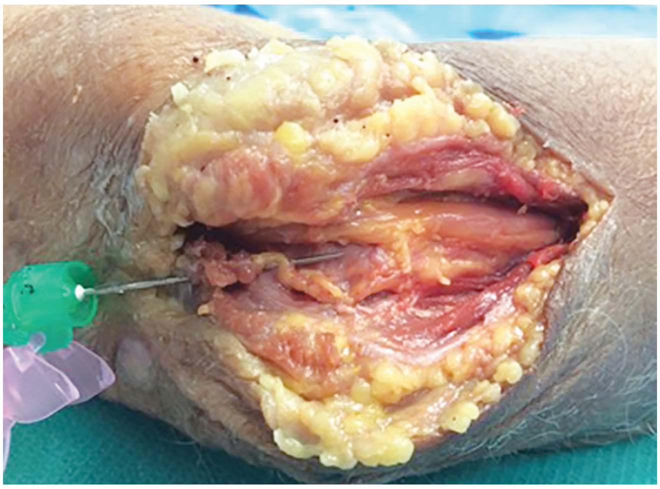

Fig. 1: Successful safe needle placement in the cubital tunnel. (Note the UN's position beneath the medial epicondyle and the needle's proximity to the olecranon tip. The needle is pointed distally)

cubital tunnel. A 25-gauge needle oriented parallel to the ulnar shaft was inserted percutaneously at the midpoint between the olecranon and medial epicondyle. Using ultrasound guidance, the needle was manipulated until it was identified deep to Osborne's ligament and posterior to the UN (Fig. 1). Utmost importance was placed on protecting the UN, to avoid needle penetration of the nerve, and on placing the tip of the needle within the cubital tunnel, replicating a safe position for injection. Final needle placement was confirmed using ultrasound and was secured with clamps and manual stabilization while dissection was performed to confirm the needle's trajectory and the final location of the needle tip (Fig. 2).

RESULTS

Open dissection confirmed ultrasound imaging observation that 18/18 needles were positioned successfully within the cubital tunnel deep to Osborne's ligament, superficial to the medial collateral ligament and posterior to the UN. The UN was not penetrated during needle placement in any specimen.

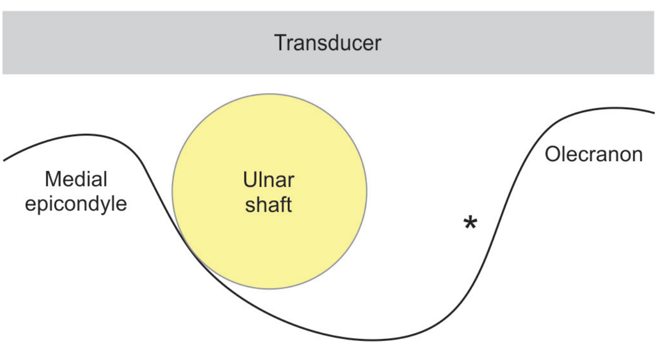

Fig. 2: Representation of transducer placement and ultrasonography image of a needle (*) in the olecranon floor of the cubital tunnel and the UN safely adjacent to the medial epicondyle

DISCUSSION

Cubital tunnel syndrome is symptomatic UN dysfunction at the level of the elbow resulting from a combination of compression, traction, and friction.[3] With a standardized incidence of 21 in 100,000 person-years,[4] it is the second most common site of peripheral nerve compression after carpal tunnel syndrome.[5] Four commonly prescribed nonsurgical treatment options include[3] maintaining a resting elbow position of 45 to 50 flexion, nighttime splinting, avoiding direct pressure to the medial elbow on resting surfaces, and discontinuing triceps strengthening exercises. Local steroid injection into the cubital tunnel is a fifth option that surgeons may use in a diagnostic and/or therapeutic manner prior to surgical decompression. Only five studies[6-10] have examined the clinical outcomes of cubital tunnel injection, and currently no clear consensus exists on efficacy or technique.

Three studies[6-8] report improved clinical results after corticosteroid injection; however, there is great variance in techniques. In terms of patient position, Rampen et al[6] followed seven patients after a supine, 90 , no comment on rotation steroid injection and noted improvement in four patients at 6 weeks. Alblas et al[7] injected nine elbows supine, 90 , no comment on rotation and found five patients improved at 3 months. Pechan and Kredba,[8] in a limited study with minimal technique described, found improved conduction velocities after injection but minimal clinical improvement.

On the contrary, two studies[9,10] found no improvement with injection. van Veen et al[9] in a well-designed randomized, double-blinded, placebo-controlled trial with 55 total patients did not demonstrate a positive effect when patients received an ultrasound-guided corticosteroid injection compared with placebo. In terms of intervention technique, van Veen injected subcutaneously at maximum UN thickness with no reference to patient position. Hong et al[10] injected 12 patients without ultrasound into the "cubital tunnel" with no description of position, then splinted 7 of the 12 patients and found no difference at 1- and 6-month follow-up.

Perhaps there are such mixed results because no studies have truly confirmed with imaging they are injecting deeper than subcutaneous. The only two clinical studies that have used ultrasound[6,9] placed the injections subcutaneously. While it can be argued that this small distance may be irrelevant, it stands to reason that the closer the anti-inflammatory injection can be to the nerve, the more surface area is exposed to the medication.

Of note, one other ultrasound-guided cadaveric technique article is published.[11] Kim et al[11] described a hydrodissection technique that involved positioning the patient prone with the arm in full extension and full supination. The needle was then used to elevate and mobilize the UN off the medial epicondyle. Red dye was then injected into the floor of the cubital tunnel to confirm accuracy. This was performed in 12 elbows. While they reported no injuries to the UN, it is our opinion that intentionally mobilizing the nerve with a sharp instrument should be avoided since the tunnel can easily be accessed from the medial aspect of the olecranon.

This study's aim is to standardize cubital tunnel injection so that it is as reliable and repeatable as possible. The width of the UN varies by 50%[1] depending upon elbow flexion, so for patient safety arm positioning cannot be overstated. The need for a reliable technique is based upon the fact that there is no consistency between the five clinical trials[6-10] involving injections of the UN at the elbow.

Three variables are never standardized: Position of the arm, depth of the injection, and use of ultrasonography. We described the previous technique based upon a review of the anatomic literature, previous injection techniques, and practicality of the clinical setting. Specifically, we based arm positioning considering that at 454 elbow flexion the height of the tunnel is maximized,[2] pressure is lowest, and the UN occupies the least amount of area in the cubital tunnel.[1] The "safe zone" is along the olecranon tip, and as such the needle in this technique was first advanced slowly until just before the needle contacted the olecranon, at which time the needle was consistently visualized on the ultrasound screen. This is advantageous because it allows safe placement of the needle posterior to the nerve while hugging the olecranon, as well as creating a larger surface area for the corticosteroid to bathe the nerve. There have been no studies examining the effect of pronation and supination on the cubital tunnel and nerve, so intuitively we decided to use neutral rotation as it is comfortable for the patient and would allow easy positioning in the clinic. This arm position was safe in all 18 cadaveric injections and reproducible at varying levels of user experience (orthopaedic surgery resident, hand fellow, and attending).

The previously discussed anatomical studies[1,2] described alterations in UN and cubital tunnel morphology with changes in elbow position. Yet, there is no consistency in the literature regarding arm position. Our series of injections suggest that supine, 45t flexion, neutral rotation, and direct ultrasound visualization is reliable and may minimize nerve injury. More prospective, randomized clinical trials with improved injection technique involving standardized arm positioning and direct visualization of the cubital tunnel and UN via ultrasonography are needed to evaluate efficacy and long-term results.

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