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ARTICLE

Anatomic surface landmarks to guide injection for posterior interosseous nerve block

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ABSTRACT

Proper injection of the posterior interosseous nerve (PIN) is important for both the therapeutic and diagnostic management of wrist pain. However, no anatomical study exists describing the site of injection based on individual wrist width. We sought to develop a reproducible anthropometric ratio utilizing external wrist surface anatomy to predict a safe and accurate injection site for the PIN. Fresh frozen cadaver forearms were dissected at the University of Louisville tissue lab. Several anthropometric measurements were obtained in order to develop a reproducible ratio to calculate location of injection. A total of 16 cadaver forearms of equal male to female ratio were obtained. On average, the male forearm had a greater mean wrist circumference obtained at the level of Lister's tubercle compared to female forearms, 17.1 cm vs. 13.5 cm. An injection given ulnar to proximal edge of Lister's tubercle at a length of one-fourth the distance between Lister's tubercle and radial aspect of ulnar styloid resulted in 100% accurate perineural injection without intraneural injection. An anthropometric ratio of one-fourth the distance from Lister's tubercle to the ulnar styloid was able to predict accurate injection sites for the distal PIN in cadaveric specimens of varying anatomical proportions.

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Introduction

Chronic wrist pain is a debilitating and common ailment with a multifaceted etiology [1]. Several treatment options have been developed including partial to total arthrodesis, proximal row carpectomy, and wrist denervation. The latter treatment was first described by Wilhelm et al. in 1959 and required several incisions for complete denervation leading to relief of pain in nearly 80% of patients [2,3]. More recently, partial denervation of the PIN alone has shown to be similarly effective at alleviating pain with a single dorsal incision [4].

The PIN provides antebrachial extensor innervation and is the main contributor to the innervation of the dorsal wrist capsule [5,6]. Anatomically, the PIN originates from the bifurcation of the radial nerve and passes through the Arcade of Frohse to emerge dorsally at the distal edge of the supinator muscle [5]. Distally it continues within the 4th extensor compartment with a variable course and branching pattern differing even amongst opposite forearms of the same cadaver [7]. A fifth branch divides into a radial and ulnar branch at 12.8 ± 2.2 cm proximal to Lister's tubercle where the radial branch supplies extensor pollicis longus (EPL) and extensor pollicis brevis (EPB) before passing deep to the interosseous membrane and an ulnar branch that supplies extensor indicis (EI) and EPL before giving off a terminal articular branch approximately 5–10 cm in length to the dorsal aspect of the wrist capsule [5,6].

Vital to establishing the potential usefulness of denervation is a diagnostic injection of local anesthetic. It is paramount the injection be accurate to provide adequate blockade of the PIN, or a false negative result may preclude patients from a beneficial procedure, as Wilhelm originally listed non-remediation of pain with injection as a contraindication to denervation [3]. Grutter et al. described a technique delivering a large amount of methylene blue to the PIN with 100% accuracy with injecting 1 cm ulnar to the proximal aspect of Lister's tubercle [6]. Given patients come in varying shapes and sizes, the goal of this study is to standardize the use of Lister's tubercle to locate the PIN based on individual anthropometry to ensure accuracy and safety with injecting local anesthetic.

Methods

The study was performed at the Acland Fresh Tissue Lab at the University of Louisville, Louisville, KY. A total of 16 fresh frozen cadaver forearms were obtained. None of the specimens had a history of wrist surgery, and there were no visible external scars. Various external anatomic measurements of the wrists were performed using palpable external land marks on the dorsum of the wrist (i.e. ulnar styloid and Lister's tubercle). Wrist circumference was obtained at the level of Lister's tubercle.

In specimens one and two, injections were performed using a modified version of Seldinger's technique, using an 18-gauge needle, 1 cm ulnar to the proximal aspect of Lister's tubercle to the depth of the dorsal interosseous membrane as described by Grutter et al. [6]. A guide wire dipped in gentian violet dye was inserted through the needle 10 times to mark the site of injection.

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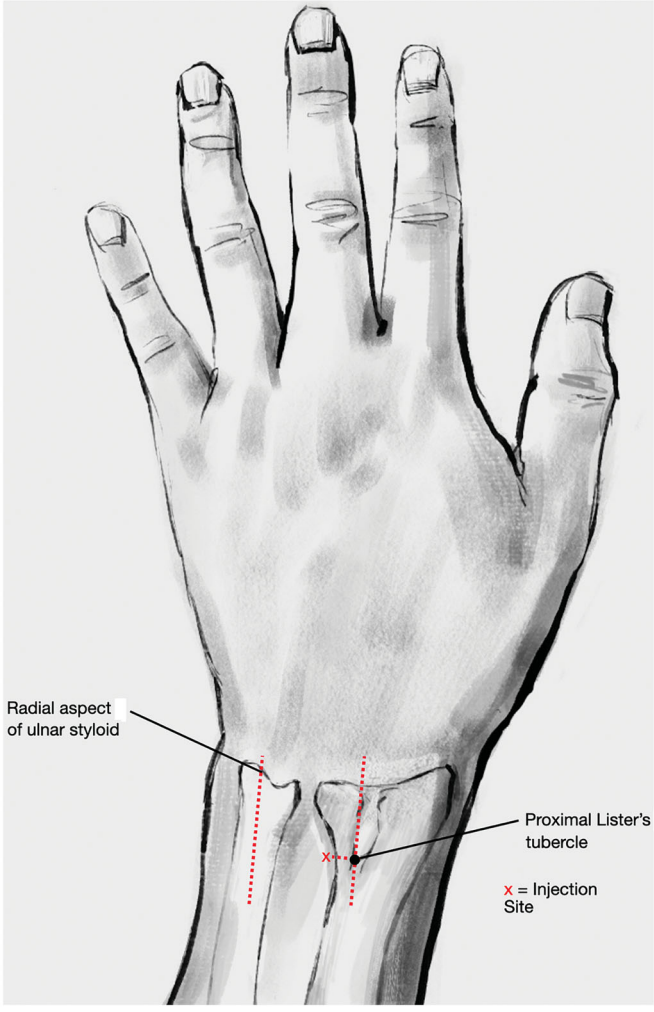

Figure 1. Depiction of wrist. Measurement obtained between radial aspect of ulnar styloid and Lister's tubercle; Injection site: 1/4 the above measurement, ulnar to the proximal aspect of Lister's tubercle.

A dorsal wrist incision was performed and the PIN nerve was isolated. Blunt dissection was performed to isolate the PIN proximally, and its course was tracked along the dorsal interosseous membrane. The location of the injected dye was identified distally and a photograph *in situ* of that location was obtained.

Upon examining the injection sites for specimens 1 and 2, specimen 1 appeared to have an adequate location of injection, however in specimen 2 the dye appeared to go intra-neural. Utilizing both the known location of the nerve and the measured distance between the external landmarks, Lister's tubercle and ulnar styloid, we calculated a simple ratio that would allow for adequate perineural injection while minimizing risk of iatrogenic nerve injury. A ratio of 1/4 the distance from Lister's tubercle to the radial aspect of the ulnar styloid would result in adequate perineural staining for both specimens without risking intraneural injection. This ratio was then utilized to select the site of injection for the following 14 cadavers where the injection protocol and subsequent dissections were carried out exactly as described above, injecting ulnar to proximal aspect of Lister's tubercle at the new calculated distance. In Figure 1, the illustration depicts the plane of Lister's tubercle and the radial aspect of the ulnar styloid using red dotted lines, between which the measurement is obtained. The 'x' marks the calculated 1/4 distance for the site of injection. A reproducible method for identifying the ulnar styloid is to first palpate the more prominent ulnar head and carefully slide the examiner's finger in an ulnar direction. The examiner should feel a depression or groove between the ulnar head and styloid, after which the styloid can be palpated in the ulnar most aspect of the wrist.

Results

A total of 16 forearms were obtained of equal gender assortment. 9 (56%) were left-sided and 7 (44%) were right-sided forearms. The majority (94%) of forearms were from Caucasian patients and on average male wrists had a greater mean circumference as compared to female wrists, 17.1 cm vs. 13.5 cm, respectively. Adequate location for injection for specimens 1 and 2 was found to be ulnar to Lister's tubercle using 1/4 distance from Lister's tubercle to the radial aspect of the ulnar styloid. Utilizing this measured ratio, the site of injection was calculated for specimens 3-16, and it was found that injection in all subsequent specimens resulted in 100% accuracy of perineural staining without risking intraneural injection (Table 1). Figures 2 and 3 demonstrate location of injection as seen in specimen 6.

Measurement and analysis post injection determined that in cadavers 5, 6, 9 and 14, a potential injection at 1 cm ulnar to the proximal edge of Lister's tubercle would have been further ulnar from the PIN, while in specimens 7 and 8, the injection would have been further radial. In cadavers 2 and 10, using a 1 cm measurement would have resulted in intraneural injection.

Discussion

Chronic wrist pain is a multifactorial disease with far reaching clinical implications and various etiologies including degenerative joint disease, prior trauma, inflammatory conditions, and tendinopathy [1]. While several treatment options have been developed for this debilitating condition, one useful option is partial wrist denervation by resection of the sensory PIN supplying the dorsal capsule of the wrist. Anesthetic blockade is performed prior to denervation, where injection accuracy is vital in establishing predictive benefits of denervation [3]. This study sought to standardize injection location to individual patient anthropometry by utilizing surface anatomy on fresh frozen cadaveric forearms.

The accuracy of injection is critical in not only establishing patient candidacy for denervation, but also for the prevention of iatrogenic complications. Grutter et al. in 2004 sought to standardize injection location by utilizing patient surface anatomy; their work determined an injection of 0.5 ml of dye 1 cm ulnar to the proximal edge of Lister's tubercle resulted in 100% wide staining of the PIN [6]. Our study expands upon that principle but also considers varying patient anthropometry. Utilizing a Seldinger technique with a more precise injection of dye, we found in specimen 2 an injection 1 cm ulnar to the proximal edge of Lister's tubercle resulted in intraneural injection. Intraneural injection can result in mechanical nerve damage and a myriad of pathological gross and histological alteration that can surmount in the occurrence of acute or chronic pain if the injectate is intrafasciular [8]. Patients should be alerted of the warning signs of potential intraneural placement of the needle, such as sharp pain or paresthesia prior to injection and instructed to alert the physician to halt the procedure immediately should they occur. The risk of this iatrogenic cause can be mitigated with a higher accuracy of injection and the utmost caution in technique [9]. Furthermore, it is possible to preclude patients from a potentially therapeutic procedure in denervation by failing to accurately block the PIN yielding a false negative result, as Wilhelm described a lack of response to

Table 1. Demographic and wrist measurement.

Cadaver	Gender	Laterality	Wrist circumference (cm)	Radial aspect of ulnar styloid to Lister's tubercle (cm)	Calculated site of injection (cm)
1	M	R	17.7	2.6	1*
2	F	R	12.5	2.0	1*
3	F	L	12.9	2.6	0.65
4	M	R	16.8	3.3	0.8
5	M	L	18.2	3.8	0.9
6	F	L	13.6	3.5	0.8
7	M	L	19	4.6	1.1
8	M	L	17.2	4.2	1.1
9	F	L	15	3.5	0.85
10	M	R	15	3.5	0.85
11	M	R	16.5	4.0	1.0
12	F	L	13.2	4.0	1.0
13	M	R	16.5	4.2	1.0
14	F	L	14.0	3.0	0.75
15	F	L	13.0	4.0	1.0
16	F	R	14.0	4.0	1.0

*Specimen 1 and 2 were injected at 1 cm in order to obtain the ratio.

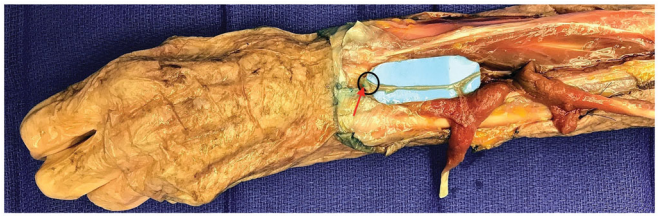

Figure 2. Specimen 6: Location of injected dye; black circle: peri-neural location; red arrow: area of injection within perineural fat.

Figure 3. Specimen 6: Terminal portion of PIN focusing on area of injection; black circle: peri-neural location; red arrow: area of injection within perineural fat.

the injection of local anesthetic as a contraindication to dennervation [3,6].

Interestingly, the results of the diagnostic blockade as reported by Weinstein in a 2002 study of both PIN and AIN resection did not correlate with post-operative pain severity and frequency or DASH scores [10]. This was postulated elsewhere in literature to be a result of percutaneous injection inaccuracy that may result in either missing the targeted nerve or excessive injection blocking several branches unaffected by the subsequent denervation in another study [11]. This theory is also supported elsewhere in the literature by Wilhelm et al., where injections of low amounts of lidocaine 1% are recommended to prevent the false positive results [3]. This supports that being able to accurately inject the PIN, as described by our method, is not only important for the prevention of neural injury, but also paramount for the predictive nature of the diagnostic injection necessitating the need for reliable and reproducible means to locate an adequate injection site.

The authors acknowledge several limitations to this study. First and foremost, the demographics of our specimens did not include those with substantial wrist pathology, where common arthritic and degenerative conditions may result in edematous conditions of the joint potentially obfuscating our choice landmark [1]. Similarly, partial denervation is also performed as an adjunct to other surgical treatments for wrist pain such as arthrodesis; none of our cadavers had prior wrist surgery such that it cannot be stated these ratios apply to such a subset of patients [12]. With only 16 total specimens of varying sizes, the full spectrum of potential anthropometry was not completely evaluated. Although, this study did include cadaver forearms of disparate races, gender, and laterality which may be more representative of the population. As stated above, a more accurate injection can both prevent injury and improve diagnostic accuracy, however it is important to recognize that inaccurate measurements may lead to an erroneous injection in any setting. Therefore, as in any procedure, the individual performing the injection must first have a thorough understanding of the anatomy, and be willing to double check measurements and/or ask for assistance. This is most true if the calculated values are outside the range stated in this study (0.65 – 1.1 cm), for wrist circumferences ranging from 12.5 cm to 19 cm.

In conclusion, we have determined a ratio of 1/4 the distance from the proximal edge of Lister's tubercle to the radial aspect of the ulnar styloid is useful for approximating the location of the PIN for accurate and safe injections. Further study of cadaveric specimens ranging in extremes of wrist size may further our data's applicability to a wider array of anthropometry. Translational studies are also necessary to determine whether our developed ratio has clinical implications, in particular mitigating nerve damage *via* intraneural injection and bolstering the sensitivity and specificity of diagnostic PIN block prior to denervation.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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