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Basic Study

Anatomic Location of the First Dorsal Extensor Compartment for Surgical De-Quervain's Tenosynovitis Release: A Cadaveric Study

Thandoni *et al.* First Dorsal Extensor Compartment Surgical Release

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Abstract

BACKGROUND

De-quervain's tenosynovitis is a disorder arising from the compression and irritation of the first dorsal extensor compartment of the wrist. Patients who fail conservative treatment modalities are candidates for surgical release. However, risks with surgery include damage to the superficial radial nerve and an incomplete release due to inadequate dissection. Currently, there is a paucity of literature demonstrating the exact anatomic location of the first dorsal extensor compartment in reference to surface anatomy. Thus, this cadaveric study was performed to determine the exact location of the first extensor compartment and to devise a reliable surgical incision to prevent complications.

AIM

To describe the location of the first dorsal compartment in relation to bony surface landmarks to create replicable surgical incisions.

METHODS

Six cadaveric forearms, including four left and two right forearm specimens were dissected. Dissections were performed by a single fellowship trained upper extremity orthopaedic surgeon. Distance of the first dorsal compartment from landmarks such as Lister's tubercle, the wrist crease, and the radial styloid were calculated. Other variables studied included the presence of the superficial radial nerve overlying the first dorsal compartment, additional compartment sub-sheaths, number of abductor pollicis longus tendon slips, and the presence of a pseudo-retinaculum.

RESULTS

Distance from the radial most aspect of the wrist crease to the extensor retinaculum was 5.14 ± 0.80 mm. The distance from Lister's tubercle to the distal aspect of the extensor retinaculum was 13.37 ± 2.94 mm. Lister's tubercle to the start of the first dorsal

compartment was 18.43 ± 2.01 mm. The radial styloid to the initial aspect of the extensor retinaculum measured 2.98 ± 0.99 mm. The retinaculum length longitudinally on average was 26.82 ± 3.34 mm. Four cadaveric forearms had separate extensor pollicis brevis compartments. The average number of abductor pollicis longus tendon slips was three. A pseudo-retinaculum was present in four cadavers. Two cadavers had a superficial radial nerve that crossed over the first dorsal compartment and retinaculum proximally (7.03mm and 13.36mm).

CONCLUSION

An incision that measures 3mm proximal from the radial styloid, 2cm radial from Lister's tubercle, and 5mm proximal from the radial wrist crease will safely place surgeons at the first dorsal compartment.

Key Words: De-quervain's tenosynovitis; First extensor compartment; Cadaveric study; Superficial radial nerve; Radial styloid; Lister's Tubercle

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Core Tip: Surgical release of the first extensor compartment at the level of the wrist has been well documented with multiple different techniques. Injury to the superficial radial nerve, decompressing the incorrect compartment, tendon injury, and incomplete release of the compartment leads to patient morbidity. We describe the precise anatomic location of the first dorsal compartment in relation to bony surface landmarks to create replicable surgical incisions. We demonstrate the location of the superficial radial nerve and document the variances in the first compartment sub-sheaths. In doing so, we have created a surgical protocol that will ensure a complete first compartment release.

INTRODUCTION

De-quervain's tenosynovitis is a common pathology of the wrist resulting in thickening of the synovial sheath and extensor ²retinaculum containing the first dorsal extensor compartment¹. Subsequent irritation of the first dorsal compartment, containing the abductor pollicis longus (APL) and extensor pollicis brevis (EPB) tendons, leads to radial sided wrist pain and inflammation². Repetitive grasping and twisting motions of the hand and wrist leads to increased inflammation along with decreased functional use of the wrist. Initial non-operative management of de-quervain's tenosynovitis includes the use of over-the-counter anti-inflammatory medications, supportive thumb spica bracing, and corticosteroid injections^{3,4}. Failure of these conservative measures warrants surgical intervention²⁻⁴.

Surgical release of the first extensor compartment is the standard of care following failure of conservative treatment modalities. Various surgical techniques have been described in the literature to ensure a complete release of the compartment. Prior studies have compared the efficacy of transverse *vs* longitudinal incisions to achieve a safe release of the compartment, with both techniques having their own risks and benefit profiles⁵⁻⁸. Novel techniques including ultrasound guided and percutaneous release of the first dorsal compartment have also been studied to ensure efficacy and safety^{9,10}. However, surgical intervention does pose risk, mainly to the superficial radial nerve which courses in close proximity to the surgical incision. The literature has closely documented the course and associated branches of the superficial radial nerve, which can arise 1.5 to 2 centimeters (cm) proximal to Lister's tubercle and 5-8 cm from the radial styloid, placing great emphasis on meticulous care to avoid iatrogenic nerve injury during release of the tendon sheath¹¹⁻¹⁵.

Interestingly, multiple anatomic variants and sub-sheaths within the compartment itself can hinder a complete surgical release and resolution of clinical symptoms. Cadaveric studies have documented varying numbers of tendons and tendon slips of the APL in

the first dorsal compartment¹⁶⁻¹⁸. Differing numbers of subsheaths and septi between tendons were found once the compartment was exposed, requiring further dissection to ensure a complete release of all constricting factors on the tendon sheath¹⁸⁻²⁰.

However, there is currently a paucity of literature that accurately demonstrates the exact anatomic location of the first dorsal compartment at the level of the wrist^{21,22}. The inability to accurately replicate a reliable surgical incision into the first compartment places the superficial radial nerve at risk and may lead to inadequate releases based on sub-sheath variability. Therefore, the inability to create reproducible incisions intra-operatively can lead to unnecessary dissection into other extensor compartments, damage to surrounding neurovascular structures, increased operative time, and wound complications.

³ The aim of this study is to determine the precise anatomic location of the first dorsal compartment in relation to bony surface landmarks in order to create reliable and replicable surgical incisions. Secondary aims of this project are to document the location of the superficial radial nerve and to document the variances in the first compartment sub-sheaths. In doing so, our aim is to create a surgical protocol that will ensure a complete first compartment release without injury to the surrounding neurovascular structures when treating de-Quervain's tenosynovitis.

MATERIALS AND METHODS

Six cadaveric forearms were obtained to perform this study including four left and two right forearm specimens. All specimens included the entire forearm and hand from the proximal ulna to the fingertips. In total, four cadavers were male and two were female. All cadaver specimens were obtained from different individuals. Cadaver specifications included age ranges from thirty to sixty years of age. The two right forearm specimens were from a sixty-year-old male and a thirty-seven-year-old female specimen. Of the four left forearm specimens, three were from male cadavers while one forearm was

from a female cadaver. The age ranges for the left forearm cadavers included a fifty-five-year-old male, fifty-eight-year-old male, thirty-three-year-old male, and a thirty-two-year-old female.

Inclusion criteria for our study included cadaver models within age ranges of 30-60 with no prior trauma history or surgical intervention to the wrist and hand region that would otherwise confound results from a soft tissue standpoint. Exclusion criteria included cadavers with prior history of wrist or hand surgical intervention. Cadavers with a history of surgical history including retained hardware, prior fractures, history of skin grafting, or soft tissue or bony trauma were excluded. All specimens included the entire forearm and hand from the proximal ulna to the fingertips. Any specimens with evidence of prior amputations related to trauma or vascular disease were excluded. Fresh frozen cadaveric forearms were thawed only once at which time all surgical dissections were undertaken (Image 1). The cadaveric forearms were purchased using institutional research funding.

Surgical technique:

All cadaveric dissections and data measurements were performed by a single fellowship trained hand and upper extremity orthopaedic attending surgeon under loupe magnification. Dissection was performed in one sitting with all cadaveric arms having undergone the same timeframe of thawing. A longitudinal incision was used for all specimens centered dorsally over the radial styloid and extended proximally to ensure full exposure of all structures. Dissection was performed using a #15 scalpel to incise skin and dermis. Metzenbaum scissors were subsequently used to dissect subcutaneous tissues in order to identify structures such as the superficial radial nerve, the first dorsal compartment, and all associated sub-sheaths. The entire first dorsal

compartment, extensor retinaculum, and available branches of the superficial radial nerve were identified and marked. After appropriate exposure was achieved, the pre-determined variables were measured using caliper instruments (Images 2-5).

Variables of Interest:

Various data points were obtained to maximize a reproducible surgical site incision over the first dorsal compartment. The length of the distal phalanx of the thumb and the distance from the thumb distal interphalangeal joint to the tip of the digit were two topographical data points that were collected. Creating an incision centered over the first dorsal compartment based on those two measurements was analyzed to determine the proximity of those values to the extensor retinaculum. The overall length of the extensor retinaculum was obtained and served as a key measurement that allowed comparison measurements from other landmarks (Figure 2). Other landmarks of interest included Lister's tubercle, the wrist crease, and the radial styloid. Obtaining distances from each of these landmarks to the extensor retinaculum were obtained to determine which data points reliably placed our incision over the first dorsal compartment (Figures 3-5). Important other parameters that were documented included the presence or absence of the superficial radial nerve overlying the first dorsal compartment, additional compartment sub-sheaths, number of APL tendon slips, and the presence of a pseudoretinaculum (IFigure 6). All measurements were obtained using the same methodology in each cadaveric forearm.

Statistical Analysis:

Cadaveric measurement data were analyzed using descriptive statistics. The mean, standard deviation and standard error values were calculated manually using standard equations. Confidence intervals were then computed manually using standard formulas prior to the creation of the data figures and tables. Statistical review of the study was performed by a biomedical statistical team at our home institution.

RESULTS

Data points from all six cadavers were analyzed to determine the overall distribution of each variable of interest (Figure 1). Data gathered remained in proximity within each variable analyzed as no significant outliers were seen after histogram analysis (Figure 1). All measurements from the six cadavers were also averaged prior to comparison amongst the other data points. The average length of the thumb distal phalanx was $30.11 \pm 3.39\text{mm}$ while the average length of the distal phalanx crease to the tip of the digit was $30.70 \pm 3.74\text{mm}$. The average length of the extensor retinaculum from its proximal to its distal length was $26.82 \pm 3.34\text{mm}$. Therefore, the length from the thumb interphalangeal joint to the thumb tip gives a reasonable estimate of about 3mm and can be used as a measurement to determine the overall length of the extensor retinaculum. The distance from the radial most aspect of the wrist crease to the retinaculum was $5.14 \pm 0.80\text{mm}$. The distance from Lister's tubercle to the proximal aspect of the retinaculum measured $13.37 \pm 2.94\text{mm}$ while distance from Lister's tubercle to the start of the first dorsal compartment was $18.43 \pm 2.01\text{mm}$. The length from the radial styloid to the initial aspect of the extensor retinaculum measured $2.98 \pm 0.99\text{mm}$ (Table 1).

Only two cadavers had a superficial radial nerve that crossed over the first dorsal compartment. In two cadaver specimens, the superficial radial nerve was initially encountered at 7.03mm and 13.36mm proximal to the most proximal aspect of the extensor retinaculum. In both of those dissections, the superficial radial nerve was seen continuing its course directly dorsal over the extensor retinaculum and radial to the radial styloid. The superficial radial nerve was not encountered even with thorough dissection in the remaining four cadavers. Four out of six cadaveric forearms had a separate EPB compartments and sub-sheaths. The average number of APL tendon slips was three. A pseudo-retinaculum was also present in four out of six cadavers. A

pseudo-retinaculum was not appreciated in cadavers that did not have a separate EPB sub-sheath (Table 1).

DISCUSSION

De-quervain's tenosynovitis warrants surgical intervention in patients who continue to suffer from significant wrist pain and decreased function after failing conservative modalities including physical therapy, anti-inflammatory medications, and corticosteroid injections. Surgical release of the first extensor compartment at the level of the wrist has been well documented with multiple different techniques implementing either longitudinal or transverse incisions. Risk of iatrogenic injury to the superficial radial nerve, decompressing the incorrect compartment, tendon injury, and incomplete release of the compartment can lead to significant patient morbidity. Currently, there has not been a documented reproducible incision that reliably places surgeons in the first dorsal compartment that ensures a safe and complete surgery.

Wilhelmi *et al* demonstrated ¹ that the distance from the palmar digital crease to the proximal interphalangeal crease (mean, 2.42 ± 0.03 cm) correlated to the distance of the proximal edge of the A1 pulley from the digital palmar crease (mean, 2.45 ± 0.03 cm)²³. They determined that surface landmark ratios can be a reliable and reproducible tool that can lead to successful A1 pulley release without complication in trigger finger surgery²³. Hazani *et al* performed a bony landmark cadaveric study that mapped out and demonstrated that the radial styloid is 0.32 ± 0.57 cm from the distal edge of the extensor retinaculum²¹.

Our study demonstrated that the radial styloid was similarly only 2.98 ± 0.99 mm from the distal aspect of the retinaculum. Notably, we also noted that Lister's tubercle is only 13.37 ± 2.94 mm from the proximal aspect of the retinaculum and 18.43 ± 2.01 mm from the first compartment itself. The most radial aspect of the wrist crease is only about 5mm distal to the retinaculum as well. The length from the thumb interphalangeal joint

to the thumb tip provides an estimate of about 3mm for the entire distance from the radial styloid to the end of the retinaculum. Thus, any incision extending 3cm distal to the radial styloid will place the surgeon at end of the retinaculum, establishing a complete release. Ultimately, placing an incision 3mm from the radial styloid, 2cm from Lister's tubercle, and 5mm from the radial wrist crease can be used to safely place the incision at the level of the first dorsal compartment.

Matzon *et al* demonstrated the common presence of multiple APL slips in 78% of patients and found that 55% of patients had two subsheaths while 8% had three subsheaths²⁴. Kulthanan *et al* re-affirmed those results and demonstrated in contrast that the EPB had a single tendon in 98% of cases²⁵. Their study demonstrated that the APL had multiple slips in 89% of cases ($p < 0.001$)²⁵. Our cadaver forearms had a mean of 3 separate APL slips, with multiple slips being present in each case. EPB sub-sheaths were present in 67% of our cadaveric cases. Therefore, we recommend a thorough evaluation intra-operatively to document and subsequently release all noted APL slips and to also release all EPB sub-sheaths as they will be present in the majority of cases. Being cognizant of this anatomic variant intra-operatively will allow for a full surgical release that can be accomplished during each case.

Importantly, Abrams *et al* found that the superficial radial nerve branches 5.1 cm proximal to the radial styloid¹². They also found that the superficial radial nerve can branch 0.4 cm from the center of the first dorsal compartment and 1.6cm from Lister's tubercle¹². Gurses *et al* found that the lateral dorsal digital branch to the thumb, off of the superficial radial nerve, coursed directly over the first dorsal compartment in 8 out of 20 cadavers¹¹. In our study, we found the superficial radial nerve present in close proximity in only 2 out of the 6 cadavers (7.03mm and 13.36mm proximal to the retinaculum). The other four dissections did not demonstrate a clear superficial radial nerve nearby our surgical site. However, if the superficial bony landmark

measurements stated above are followed, we anticipate that the superficial radial nerve will not be encountered as unnecessary dissection will not be undertaken.

The main limitation of our study includes the small sample size. We were only able to perform six cadaveric dissections which limits the overall data points available for comparison to other studies and diminishes the overall generatability to the general population. Ultimately, a higher sample size of cadaveric forearms could be dissected in the future to obtain a larger data set.

CONCLUSION

Superficial landmarks are a reliable way to create a reproducible incision over the first dorsal compartment in order to obtain a complete release and protect the superficial radial nerve. Creating an incision that measures 3mm proximal from the radial styloid, 2cm proximal from Lister's tubercle, and 5mm radial from the radial wrist crease will safely place surgeons at the level of the first dorsal compartment. Extending the incision 3cm proximal to the radial styloid will fully encompass the extensor retinaculum and allow for a complete release. The APL tendon does reliably have multiple slips and the EPB does contain multiple sub-sheaths in the majority of cases, which are important anatomic variants to be cognizant of intra-operatively.

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