Anatomic Study

Anatomical Basis for Injection around First Dorsal Compartment of the Wrist: A Fresh Cadaveric Study

In Yae Cheong, MD¹, Im Joo Rhyu, MD, PhD^{2,3}, Ki Hoon Kim, MD, PhD¹, Phil Woo Chung, MD¹, Dasom Kim, BA^{2,3}, Byung Kyu Park, MD, PhD¹, and Dong Hwee Kim, MD, PhD^{1,3}

From: ¹Department of Physical Medicine & Rehabilitation, College of Medicine, Korea University, Seoul, Republic of Korea; ²Department of Anatomy, College of Medicine, Korea University, Seoul, Republic of Korea; ³Practical Anatomy Center College of Medicine Korea University Seoul, Republic of Korea

Address Correspondence: Dong Hwee Kim, MD, PhD Department of Physical Medicine & Rehabilitation Korea University Ansan Hospital 516 Gojan-dong, Ansan City, Gyeonggi Province, Korea 425-707 E-mail: mkdh@korea.ac.kr

Disclaimer: In Yae Cheong, MD, and Im Joo Rhyu, MD, PhD contributed equally to this work. Conflict of interest: Each author certifies that he or she, or a member of his or her immediate family, has no commercial association (i.e., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted manuscript.

Manuscript received: 12-19-2015 Revised manuscript received: 02-11-2016 Accepted for publication: 02-11-2016

Free full manuscript: www.painphysicianjournal.com **Background:** It is important to understand the anatomical relationship between the medial and lateral branches of superficial radial nerve (SRN) and the first dorsal compartment to prevent and minimize possible injury to these nerves during various procedures around the tip of radial styloid process (RSP).

Objective: To delineate the anatomical location of the SRN in relation to the extensor pollicis brevis (EPB) and abductor pollicis longus (APL) tendons.

Study Design: Observational study.

Setting: Academic medical center.

Methods: The width of the first dorsal compartment, distance between the EPB tendon and the closest medial branch of the SRN, and distance between the APL tendon and the closest lateral branch of the SRN were measured. The distances were measured at the RSP (the tip of the RSP) and RSP+1 (1 cm proximal to the tip of the RSP) levels.

Results: The median distances between the EPB tendon and the closest medial branch of the SRN at the RSP and RSP+1 were 6.0 mm (range: 1.6 - 11.0 mm) and 3.2 mm (range: -2.0 - 9.4 mm), respectively. The median distances from the APL tendon to the closest lateral branch of the SRN at the RSP and RSP+1 were -2.0 mm (range: -9.0 - 8.4 mm) and 1.0 mm (range: -7.2 - 8.0 mm), respectively. A high percentage of overlap (up to 59%) was observed between the lateral branch of the SRN and the APL tendon.

Limitation: This study is limited by its small sample size.

Conclusion: Due to the anatomical proximity of the branches of the SRN and the first dorsal compartment around the RSP, physicians must be cautious during procedures near this location. It is important to approach from above the EPB, rather than from above the APL, when performing blind procedures, although ultrasound guidance is preferable.

Key words: Superficial radial nerve, abductor pollicis longus, extensor pollicis brevis, cadaver; wrist, first dorsal compartment

Pain Physician 2016; 19:E893-E900

t is well known that the superficial radial nerve (SRN) lies over the anterior surface of the radius and ulna in the distal third forearm, after piercing through the deep fascia of the brachioradialis and extensor carpi radials longus muscle. As it extends distally, it bifurcates into the lateral and medial branches: the lateral branch extends along the dorsoradial side of the thumb, while the medial branch continues distally and divides into branches that supply the ulnar side of the thumb, dorsum of the hand, and the radial 2.5 - 3.5 fingers (1). Furthermore, as the SRN crosses the lateral surface of the distal radius, it runs adjacent to the first dorsal compartment of the wrist. The first dorsal compartment is composed of the abductor pollicis longus (APL) and extensor pollicis brevis (EPB) tendons, which are enclosed within synovial tendon sheaths and play a role in thumb motion. People performing tasks that require frequent finger motions often experience pain in the dorsal wrist compartment due to synovitis and tendinopathy caused by friction from overuse of the fingers and wrists. Among the 6 dorsal compartments of the wrist, the first dorsal compartment is the most common site for such problems; therefore, procedures involving this area are commonly required. During these procedures, the adjacent SRN may be vulnerable to injury. In addition, treatment of diseases of the first dorsal compartment, such as simple injections for De Quervain's disease, operative incisions for percutaneous placement of external fixation pins in the distal radius, and port insertion for arthroscopic surgery of the wrist (2), may also injure the adjacent SRN. Such injury can cause sensory deficits in the innervating territory; in rare cases, it leads to the formation of painful neuromas (3).

To prevent iatrogenic SRN injury around the wrist, it is crucial to know the anatomical relation between the SRN and the APL and EPB tendons around the radial styloid process (RSP). However, few studies have identified the anatomical proximity of these structures, or suggested a safe approach for performing procedures in this area. Through fresh cadaver dissection, this study aimed to delineate the anatomical relationship between the SRN and tendons of the first dorsal compartment, and suggest a safe approach for interventions or procedures performed around the RSP.

METHODS

Participants

Seventeen wrists from 9 fresh cadavers (6 men, 3 women), with no known history of disease or trauma around the wrist, were dissected. The median age of the cadavers was 70 years, with a range of 58 – 98 years. One limb was excluded due to its poor state of preservation.

Methods

Seventeen arms were dissected to expose the SRN and tendons of the first dorsal compartment. Firstly, the

branching patterns of the SRN were analyzed around the wrist and forearm, and the contribution of the lateral antebrachial cutaneous nerve to the SRN was assessed. Secondly, as schematically shown in Fig. 1, the following anatomical parameters between the branches of the SRN and tendons of the first dorsal compartment were measured: the width of the first dorsal compartment (FC), which includes the APL and EPB tendons; the distance between the APL tendon and the closest lateral branch (LB) of the SRN (APL_LB); and the distance between the EPB tendon and the closest medial branch (MB) of the superficial radial nerve (EPB_MB). All of the parameters were measured using Vernier calipers at 2 levels, viz., the tip of the radial styloid process (RSP) and 1 cm proximal to the tip of the radial styloid process (RSP+1). Each parameter was labeled 1, when measured at the RSP level, and 2, when measured at the RSP+1 level. APL_LB and EPB_MB were recorded in negative values when the branches of the SRN and the tendons of the first dorsal compartment overlapped or crossed over. In other words, if the lateral branch of the SRN was lateral to the APL tendon, APL_LB was recorded as a positive value, whereas if it was located medial to the lateral margin of the APL tendon, it was recorded as negative values. Likewise, EPB_MB was recorded as a positive value if the medial branch of the SRN was medial to the EPB tendon and was recorded as a negative value if this branch was located lateral to the medial margin of the EPB tendon.

Statistical Analysis

The statistical analysis was performed with SPSS version 21.0 (SPSS Inc., Chicago, IL, USA). Data are presented as median and ranges. Comparisons between RSP and RSP+1 levels were examined using Wilcoxon signed rank test.

RESULTS

The branching patterns of the SRN were determined (Table 1). They were classified into 5 types, excluding 2 cases of variations. Among the 17 wrists, 2 wrists from different cadavers demonstrated anatomical variations, where the lateral antebrachial cutaneous nerve of the forearm replaced the lateral branch of the SRN (Fig. 2). In these cases, the SRN had a single branch that supplied only the areas compatible with that of the medial branch found in most of the other cadavers. The 5 branching patterns were 1) single medial and lateral branches at both the RSP and RSP+1 levels (11 wrists; Fig. 3A); 2) single lateral branch and 2 medial



Case	Gender	Age	Side	RSP				RSP+1			
				No of LB	No of MB	APL_LB	EPB_MB	No of LB	No of MB	APL_LB	EPB_MB
1	F	67	L	1	1	8.4	7.8	1	1	8.0	3.8
1	F	67	R	1	1	2.4	6.0	1	1	0.0	0.8
2	F	83	L	1	1	-3.0	5.9	1	1	1.0	3.2
2	F	83	R	1	1	-2.4	5.3	1	1	1.0	3.8
3	F	98	L	1	1	-2.0	4.3	1	1	-1.9	2.0
3	F	98	R	1	1	-2.0	4.3	1	1	-1.9	2.0
4	М	58	L	1	1	-3.0	5.0	1	1	-2.0	0.0
4	М	58	R	1	3	0.0	11.0	1	1	2.4	5.8
5	М	60	L	1	1	-4.0	9.9	1	1	-2.7	5.2
5	М	60	R	1	1	-2.7	7.8	1	1	-1.4	4.6
6	М	69	L	1	1	0.0	10.4	1	1	1.4	9.4
6	М	69	R	1	1	1.3	8.6	1	1	2.8	6.0
7	М	72	R	1*	2	-5.0	7.0	1	1	-3.4	4.0
8	М	79	L	1*	2	-3.0	6.0	1	1	5.2	3.2
8	М	79	R	1	2	2.0	3.0	1	1	6.0	2.0
9	М	70	L	1	3	1.0	1.6	1	2	2.6	-2.0
9	М	70	R	2	2	-9.0	3.0	2	2	-7.2	2.4

Table 1. Number of branches of superficial radial nerves at both levels.

RSP, the tip of the radial styloid process; RSP+1, 1 cm proximal to the tip of the radial styloid process; No of LB, lateral branch number of radial superficial nerve; No of MB, medial branch number of radial superficial nerve; APL_LB, the distance between abductor pollicis longus (APL) tendon and the closest lateral branch; RSP, the tip of the radial styloid process; EPB_MB, the distance between extensor pollicis brevis (EPB) tendon and the closest medial branch. If the lateral branch of the SRN was lateral to the APL tendon, APL_LB was recorded as a positive value, whereas if it was located medial to the lateral margin of APL tendon, it was recorded as negative values. Likewise, EPB_MB was recorded as a positive value if the medial branch of the SRN was medial to the EPB tendon and was recorded as a negative value if this branch was located lateral to the medial margin of EPB tendon. Asterisks indicate that lateral antebrachial cutaneous nerve substitute for lateral branch of superficial radial nerve.

branches that bifurcated between the RSP and RSP+1 positions (Fig. 3B); 3) single lateral branch and 3 medial branches which trifurcated between the RSP and RSP+1 positions (Fig. 3C); 4) single lateral branch and 3 medial branches which first bifurcated proximal to RSP+1 and divided into 3 branches between the RSP and RSP+1 positions (Fig. 3D); and 5) 2 medial and 2 lateral branches which both bifurcated proximal to the RSP+1 position (Fig. 3E).

The median, minimum, and maximum values of the anatomical measurements are shown in Table 2. The median width of the first dorsal compartment was 7.2 mm at the RSP and 7.6 mm at the RSP+1. The median distance between the EPB tendon and the closest SRN medial branch was 6.0 mm at the RSP (range: 1.6 - 11.0 mm) and 3.2 mm at the RSP+1 (range: -2.0 – 9.4 mm). The median distance between the APL tendon and the closest SRN lateral branch was -2.0 mm at the RSP (range: -9.0 – 8.4 mm) and 1.0 mm at the RSP+1 (range: -7.2 – 8.0 mm) position. The EPB tendon and the medial branch only overlapped at the RSP+1 level in 1 of 17 cases. On the other hand, the APL tendon and lateral branch of the SRN overlapped in 10 of 17 cases at the RSP level and in 7 of 17 cases at the RSP+1 level, which amounts to approximately half of the cases.

DISCUSSION

In this cadaver study, the anatomical proximity between the SRN and the tendons of the first dorsal compartment of the wrist was confirmed. As seen in Table 2, the lateral branch of the SRN and the APL tendon were located within 8.4 mm (maximum value) of each other, and showed a high percentage of overlap. This implies that there is a strong possibility of a SRN injury occurring during procedures approaching within 8.4 mm of the APL tendon. Additionally, the medial branch of the SRN was located within 11.0 mm (maximum value) medial to the EPB tendon, with only one case of overlap. Thus, it is safer to avoid procedures and incisions within a maximum of 8.4 mm lateral to the APL tendon and 11.0 mm medial to the EPB tendon at the RSP and RSP+1 levels.

However, in the case of corticosteroid injections for de Quervain's disease within the first dorsal compartment at the RSP (4,5), a different approach is required. It is recommended that the EPB tendon, which has a low percentage of overlap with the nerve based on our study, be palpated before injection. The injection should be administered immediately above or immediately medial to the EPB during blind procedures, or preferably while using ultrasound for guidance. When



Fig. 2. Lateral antebrachial cutaneous nerve (blue arrowheads) substitutes for the lateral branch of superficial radial nerve (yellow arrowheads).



making incisions around this area, a skin-only incision followed by a blunt dissection is recommended in order to prevent nerve injury (6).

Although several cadaver studies have investigated the anatomical course of the SRN to date (3,6-8), all these studies were conducted using embalmed cadavers fixed with formalin. In contrast, fresh cadavers preserved in a freezer without any chemical fixation or intervention were dissected in this study. This is therefore the first fresh cadaver study investigating the anatomical course of the SRN in relation to the first dorsal compartment. Moreover, in contrast to previous studies on SRN neuropathy, this study reports the anatomical relationship between the SRN and the first dorsal compartment of the wrist in terms of exact distance, while also describing the branching patterns of the SRN. Although Ali and his colleagues (9) reported a safe zone to avoid SRN injury with Kirschner wire fixation for distal radius fracture with a cadaveric study, this study provides precise guidelines to approach procedures or operations conducted around the RSP of the wrist, with a view to avoiding nerve injury.

		APL_LB		EPB_MB			
	RSP	RSP+1	P-value	RSP	RSP+1	P-value	
Median value	-2.0	1.0	0.002	6.0	3.2	0.000	
Minimal value	-9.0	-7.2		1.6	-2.0		
Maximal value	8.4	8.0		11.0	9.4		

Table 2. Relative location between branches of the superficial radial nerve and tendons in the first dorsal compartment according to levels.

EPB_MB, the distance between the extensor pollicis brevis (EPB) tendon and the closest medial branch; APL_LB, the distance between the abductor pollicis longus (APL) tendon and the closest lateral branch; RSP, the tip of the radial styloid process; RSP+1, 1 cm proximal to the tip of the radial styloid process.

If the lateral branch of the SRN was lateral to the APL tendon, APL_LB was recorded as a positive value, whereas if it was located medial to the lateral margin of the APL tendon, it was recorded as negative values. Likewise, EPB_MB was recorded as a positive value if the medial branch of the SRN was medial to the EPB tendon and was recorded as a negative value if this branch was located lateral to the medial margin of EPB tendon.

Even when wrist surgeons and procedure administrators are careful in their procedures or operations around the distal radius, SRN injury may inadvertently occur. During surgery for de Quervain's disease, the SRN may be injured in 27% of patients (10). Open or arthroscopic harvesting of the radial artery for coronary artery bypass grafting, insertion of Kirschner wires for wrist fractures, and intravenous injection for adjacent cephalic vein can lead to SRN injury (11-13). Damage to the SRN may occur in the main trunk or its branches, and in the medial and lateral branches. The location of pain and abnormal sensation, such as hypoesthesia or paresthesia, can be different according to lesion site of the SRN. Damage to the main trunk of the SRN is expressed on the dorsal side of hand, thumb, and index finger; damage to medial branch of the SRN is expressed on the dorsomedial aspect of the thumb and the dorsum of the index finger and hand; damage to the lateral branch of the SRN is expressed on the dorsolateral side of the thumb and hand (14). Tinel's sign is positive at the site of the nerve injury. Superficial radial neuropathy symptoms may be confused with symptoms of de Quervain's tenosynovitis. The latter produces pain and signs of inflammation around the distal radial forearm and wrist. However, in case of superficial radial neuropathy, true sensory symptoms, including numbness or paresthesia, are developed. Occasionally, patients with de Quervain's tenosynovitis may develop superficial radial neuropathy probably due to bystander inflammation involving the SRN (15). Complex regional pain syndrome (CRPS) can develop after injury or irritation of the SRN in patients who are treated with external fixators or who have radial incisions for distal radius fracture. In patients with CRPS after distal radius fracture, the common presentations are a warm, swollen hand, allodynia, stiffness, and pain that is refractory to narcotics (16). If patients with distal radius fracture have CRPS symptoms, coexistent superficial radial neuropathy should be evaluated and neurolysis of the SRN could be needed.

This study used data obtained from the dissection of fresh cadavers to clarify the anatomical relationship between tendons of the first dorsal compartment and the SRN. The results were reported in exact distances, in order to suggest a safe approach for procedures performed around this location and to prevent SRN injury. The results suggested that it is best to avoid procedures and incisions within a maximum of 8.4 mm lateral and 11.0 mm medial to the tendons of the first dorsal compartment at the RSP and RSP+1 levels. The results also showed a particularly high percentage of overlap between the lateral branch of the SRN and the APL tendon: the lateral branch of the SRN often crosses over the APL tendon as it runs distally through the wrist. It is therefore safe to palpate the tendon and approach the EPB tendon from above when performing blind procedures, especially during blind injections for de Quervain's disease. The anatomical structure of this region should be considered and high-resolution ultrasound should be used as optional assistance by surgeons performing wrist surgeries or any procedure around this area, in order to minimize the chance of SRN injury and patients' discomfort.

Nonetheless, there were some limitations to our study. Firstly, as summarized in Table 1, variations in the branching patterns of the SRN are not rare. Several studies have reported a high percentage of variation in SRN branching patterns (8,17-19). Six of the 17 wrists assessed here showed alternative branching patterns, including lateral antebrachial cutaneous nerve variations. Therefore, although this study attempted to identify an approach that would minimize nerve injury by analyzing the average distance between the nerve and tendons, some risks will remain due to anatomical variations. Secondly, the anatomical space between the SRN and the tendons of the first dorsal compartment of the wrist is too small to eliminate all chances of injury during blind procedures. This was indicated by the results of the cadaver dissection that confirmed the anatomical proximity of the SRN and the tendons. This study suggested a safe approach and an exact avoidance zone, solely based on data from cadaver dissection without considering how feasible it would be. Thirdly, with regard to injections into the tendons, although palpating the EPB tendon and injecting immediately above the tendon may reduce the risk of SRN injury, the confined nature of the area of interest makes it difficult to perform this procedure blindly. Ultrasound-guided

injection is recommended in order to prevent injury, although this also requires skill from an expert who is able to detect the thin and small SRN on ultrasound (20).

Conclusion

In conclusion, the SRN in its course to the distal fingers ran very near or across the tendons of the first dorsal compartment. The percentage of overlap was particularly high between the lateral branch of the SRN and the APL tendon. Taking this anatomical proximity into account, it is important to palpate the tendons of the FC in advance when performing blind procedures around the RSP. After palpating the tendons, approach from above the EPB, rather than from above the APL or using ultrasound for guidance is recommended to minimize nerve injury.

References

- Park BK, Bun HR, Hwang M, Hong J, Kim DH. Medial and lateral branches of the superficial radial nerve: Cadaver and nerve conduction studies. *Clin Neurophysiol* 2010; 121:228-232.
- Kilic A, Kale A, Usta A, Bilgili F, Kabukcuoglu Y, Sokucu S. Anatomic course of the superficial branch of the radial nerve in the wrist and its location in relation to wrist arthroscopy portals: A cadaveric study. Arthroscopy 2009; 25:1261-1264.
- Lindau RH, Wax MK. Abnormal anatomy of the superficial branch of the radial nerve. *Head Neck* 2013; 35:E262-E263.
- Jeyapalan K, Choudhary S. Ultrasoundguided injection of triamcinolone and bupivacaine in the management of De Quervain's disease. *Skeletal Radiol* 2009; 38:1099-1103.
- Richie CA, 3rd, Briner WW, Jr. Corticosteroid injection for treatment of de Quervain's tenosynovitis: A pooled quantitative literature evaluation. J Am Board Fam Pract 2003; 16:102-106.
- Samarakoon LB, Lakmal KC, Thillainathan S, Bataduwaarachchi VR, Anthony DJ, Jayasekara RW. Anatomical relations of the superficial sensory branches of the radial nerve: A cadaveric study with clinical implications. *Patient Saf Surg*

2011; 5:28.

7.

- Gurses IA, Coskun O, Gayretli O, Kale A, Ozturk A. The relationship of the superficial radial nerve and its branch to the thumb to the first extensor compartment. J Hand Surg 2014; 39:480-483.
- Sulaiman S, Soames R, Lamb C. The sensory distribution in the dorsum of the hand: Anatomical study with clinical implications. Surg Radiol Anat 2015; 37:779-785
- Ali AM, El-Alfy B, Attia H. Is there a safe zone to avoid superficial radial nerve injury with Kirschner wire fixation in the treatment of distal radius? A cadaveric study. Journal of Clinical Orthopaedics and Trauma 2014; 5:240-244.
- Mellor SJ, Ferris BD. Complications of a simple procedure: de Quervain's disease revisited. Int] Clin Pract 2000; 54:76-77.
- Kim G, Jeong Y, Cho Y, Lee J, Cho J. Endoscopic radial artery harvesting may be the procedure of choice for coronary artery bypass grafting. *Circ J* 2007; 71:1511-1515.
- Singh S, Trikha P, Twyman R. Superficial radial nerve damage due to Kirschner wiring of the radius. *Injury* 2005; 36:330-332.

- Sheu JJ, Yuan RY. Superficial radial neuropathy caused by intravenous injection. *Acta Neurol Belg* 1999; 99:138-139.
- Cho NS, Kim KH, Park BK, Kim DH. Superficial radial sensory neuropathy: Medial and lateral branch injury. *Muscle Nerve* 2015; [Epub ahead of print].
- Lanzetta M, Foucher G, Association of Wartenberg's syndrome and De Quervain's desease: A series of 26 cases. *Plast Reconstr Surg* 1995; 96:408-412.
- Li Z, Smith BP, Tuohy C, Smith TL, Andrew Koman L. Complex regional pain syndrome after hand surgery. *Hand Clin* 2010; 26:281-289.
- 17. Davidovich ER, Caetano MR, Nascimento OJ. Total lesion of the radial nerve in the arm with preservation of the superficial radial nerve sensory action potential. Arg Neuropsiguiatr 2013; 71:67-68.
- Davidovich ER, Nascimento OJ. Superficial radial nerve-lateral antebrachial cutaneous nerve anatomic variation. Brain Behav 2014; 4:70-74.
- Poublon AR, Walbeehm ET, Duraku LS, Eilers PH, Kerver AL, Kleinrensink GJ, Coert JH. The anatomical relationship of the superficial radial nerve and the lateral antebrachial cutaneous nerve: A

possible factor in persistent neuropathic pain. J Plast Recon Aesth Surg 2015; 68:237-242. 20. Visser LH. High-resolution sonography of the superficial radial nerve with

two case reports. *Muscle Nerve* 2009; 39:392-395.