Relationship between the Branching Patterns of the Radial Nerve and Supinator Muscle

Anna Jeon,1 Ye-Gyung Kim,2 Seong-Oh Kwon,3 and Je-Hun Lee4

1Department of Anatomy, College of Medicine, Ewha Womans University, Seoul, Republic of Korea
2Department of Anatomy, College of Medicine, Chung-Ang University, Seoul, Republic of Korea
3Department of Neurosurgery, CHA Gumi Medical Center, CHA University, Pocheon, Republic of Korea
4Korea Institute for Applied Anatomy, College of Sports Science, Korea National Sport University, Seoul, Republic of Korea

Correspondence should be addressed to Seong-Oh Kwon; humil@naver.com and Je-Hun Lee; leejehun@knsu.ac.kr

Received 16 April 2021; Revised 19 July 2021; Accepted 4 October 2021; Published 14 October 2021

Academic Editor: Cem Kopuz

Copyright © 2021 Anna Jeon et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

The posterior interosseous nerve (PIN) innervates the posterior compartment muscles of the forearm and is a continuation of the deep branch of the radial nerve. The anatomic descriptions of PIN vary among different authors. This study investigated the distribution patterns of PIN and its relationships to the supinator muscle. This study investigated which nerves innervate the posterior compartment muscles of the forearm, the radial nerve, and the PIN, using 28 nonembalmed limbs. Also, the points where the muscle attaches to the bone were investigated. The measured variables in this study were measured from the most prominent point of the lateral epicondyle of the humerus (LEH) to the most distal point of the radius styloid process. For each specimen, the distance between the above two points was assumed to be 100%. The measurement variables were the attachment area of the supinator and branching points from the radial nerve. The attachment points of the supinator to the radius and ulna were 47.9% ± 3.6% and 31.5% ± 5.2%, respectively, from the LEH. In 67.9% of the specimens, the brachioradialis and extensor carpi radialis longus (ECRL) were innervated by the radial nerve before superficial nerve branching, and the extensor carpi radialis brevis (ECRB) innervated the deep branch of the radial nerve. In 21.4% of the limbs, the nerve innervating the ECRB branched at the same point as the superficial branch of the radial nerve, whereas it branched from the radial nerve in 7.1% of the limbs. In 3.6% of the limbs, the deep branch of the radial nerve branched to innervate the ECRB. PIN was identified as a large branch without divisions in 10.7% and as a deep branch innervating the extensor digitorum in 14.3% of the limbs. The anatomic findings of this study would aid in the diagnosis of PIN syndromes.

1. Introduction

The posterior interosseous nerve (PIN) innervates the posterior compartment muscles of the forearm and is a continuation of the deep branch of the radial nerve. PIN is termed so for its emergence from between the 2 heads of the supinator muscle. Before the radial nerve passes through the supinator, it is commonly identified as the deep branch of the radial nerve [1, 2]. The muscles in the posterior compartment of the forearm are innervated by the radial nerve; anatomy textbooks provide more detailed information on the origin of specific nerves innervating those muscles.

However, some anatomy textbooks provide slightly differing descriptions of PIN. Gray’s Anatomy [1] describes the brachioradialis (BR) and extensor carpi radialis longus (ECRL) as being innervated by the radial nerve before branching into the superficial and deep branches. The extensor carpi radialis brevis (ECRB) was described to be innervated by the deep branch of the radial nerve before penetrating the supinator muscle. The authors explained that PIN innervated the extensor digiti minimi (EDM), extensor digitorum (ED), and extensor carpi ulnaris. Another textbook [2] described BR and ECRL to be innervated by the radial nerve. The ECRB, ED, EDM, supinator, and ECU were described as being innervated by the deep branch.
branch of the radial nerve. The extensor indicis (EI), abduc-
tor pollicis longus (APL), extensor pollicis longus (EPL), and
extensor pollicis brevis (EPB) were described to be innerv-
ated by PIN. Considering the varying descriptions, ana-
tomic research is required to identify the correct anatomic
structure, which may aid in diagnosis and management of
nerve entrapment syndrome. Of note, anatomic variability
is critical to medical practice and should be considered by
clinicians [3].

Anatomic studies on the association between PIN and
the supinator muscle exist [4–14]. However, detailed infor-
mation on the precise point of branching out of the radial
nerve to innervate each posterior compartment muscle in
the forearm with the superficial branch is needed. Thus, this
study is aimed at conducting a detailed anatomic study on
the nerve branches emerging from the radial nerve of the
forearm.

2. Materials and Methods

Fourteen embalmed adult cadavers (males, 7; females, 7; age
range 63-95 years) were dissected for this study. All cadavers
used in this study were legally donated to medical school.
This study was conducted in accordance with the Declara-
tion of Helsinki.

Limbs showing evidence of surgery or injury around the
forearm region were excluded. To measure variables associ-
ated with the branching of the radial nerve, the most prom-
inent point of the lateral epicondyle of the humerus (LEH)
and the most distal point of the styloid process of the radius
(SPR) were identified before dissection. A line connecting
the LEH and the SPR was used as the reference line. For each
specimen, the distance between the above two points was
assumed to be 100%. The y coordinate was extended and
measured in the direction of the arm and marked as the
(+) value. Conversely, the same measurement but towards
the forearm was marked as the (–) value (Figure 1). Only
the radial and ulnar attachment points of the supinator mus-
cle were measured directly from the LEH (Figure 2). The ref-
erence point was expressed as the absolute distance along the
reference line using the LEH as the starting point.

For the dissection, only the skin was removed to expose
the hypodermis, and the superficial fascia was then carefully
removed to identify the neurovascular structures on the pos-
terior elbow region. Further careful dissection was per-
formed to identify the nerve branches around the supinator by removing some extensor muscles. After the dis-
section of the nerve branches around the supinator, the
nerve branch points around the muscular and cutaneous
branches of the radial nerve were investigated. The measure-
ment variables were as follows:

(1) The reference line between the LEH and SPR
(2) The attachment points of the supinator to the radius
and ulna from the LEH
The branching points of each posterior forearm muscle from the LEH, and

(4) The transverse distance from the radial nerve to the LEH.

The measurements were conducted with the forearm in the supinated position. A single observer obtained all measurements using a measuring tape and digital callipers (resolution 0.01 mm, CD-20PSX, Mitutoyo, Japan). The data were analysed using SPSS version 23.0 (IBM SPSS Inc., Chicago, IL, USA).

3. Results

The mean distance of the reference line from the LEH to the SPR was $247.3 \pm 15.7$ mm. The distances from the reference line did not differ significantly between males and females or between the right and left sides ($p \geq 0.05$).

The attachment points of the supinator to the radius and ulna were $-118.3 \pm 10.9$ mm (47.9 $\pm$ 3.6%) and $-77.8 \pm 13.6$ mm (31.5 $\pm$ 5.2%), respectively, from the LEH (Table 1 and Figure 2). In all specimens, the BR and ECRL had (+) y coordinate values. The branch points of the radial nerve for BR and ECRL were $20.3 \pm 3.2$% and $13.9 \pm 4.1$%, respectively (Table 2 and Figure 3). With regard to ECRB, in 25.0% of the specimens, the nerve branched superiorly to the reference line, with a mean value of $4.0 \pm 5.2$%. In contrast, in 36.0% of the specimens, the nerve branched inferiorly to the reference line, with an average value of $-13.3 \pm 7.6$%. Furthermore, in 39.0% of the specimens, the nerve branched on the reference line (Table 2 and Figure 3).

Table 1: Attachment region of the supinator.

| Side   | Mean ± SD (mm) | Mean ± SD (%) |
|--------|----------------|---------------|
| Radius | $-118.3 \pm 10.9$ | $47.9 \pm 3.6$ |
| Ulna   | $-77.8 \pm 13.6$ | $31.5 \pm 5.2$ |

Table 2: Nerve branching point from the radial nerve to muscle innervation.

| Muscles   | Mean ± SD (mm) | Mean ± SD (%) |
|-----------|----------------|---------------|
| BR        | $49.9 \pm 6.9$ | $20.3 \pm 3.2$ |
| ECRL      | $33.8 \pm 9.0$ | $13.9 \pm 4.1$ |
| (superiorly to the RL) | $10.9 \pm 14.5$ | $4.1 \pm 5.2$ |
| ECRB      | (inferiorly to the RL) | $-13.3 \pm 7.6$ | $-5.3 \pm 3.1$ |

RL: reference line.
We identified the branching points of the radial nerve after determining which muscle it innervated. In 67.9% of specimens, the BR and ECRL were innervated by the radial nerve before superficial nerve branching, and the ECRB was innervated by the deep branch of the radial nerve (Figure 3). In 21.4% of all specimens, the nerve innervating the ECRB branched out of the same point as the superficial branch of the radial nerve (Figure 4). In 7.1% of the specimens, the nerve branched out from the radial nerve (Figure 5). In 1 specimen (3.6%), the deep branch of the radial nerve branched to innervate the ECRL (Figure 6).

In most cases (67.9%), after the radial nerve penetrated the supinator, it segregated into 2 large branches (superficial and deep branch) in the supinator and innervated the posterior compartment muscles of the forearm. Thus, the superficial branch innervated the superficial muscles such as the ED and EDM, and the deep branch innervated deep muscles such as the EI, APL, EPB, and EPL (Figure 7). However, some varying nerve branching patterns were also observed. One large branch was found to innervate all muscles without nerve division in 10.7% of the specimens. In 14.3% of the specimens, the deep branch innervated the ED (Figures 8 and 9). We observed some communicating nerve branches between the superficial and deep branches (7.1%) (Figure 10).

4. Discussion

A study using cadaver dissection [5] reported that the ECRB was innervated by the radial nerve, superficial radial nerve, and PIN in 45.0%, 29.0%, and 26.0% of the specimens, respectively. Our study focused on identifying the level at which the radial nerve branched to innervate the ECRB. There were many specimens (75.0%) where the nerve branch emerged below the x coordinate line. However, on further examination, the nerve originated from the deep branch, the superficial radial nerve, and the radial nerve in 53.3%, 26.7%, and 20.0% of the specimens, respectively. A previous study [5] reported that the nerve innervating the ECRB branched from the superficial radial nerve. However, no branches from the superficial radial nerve were observed in this study. The radial nerves were also named differently in this study compared to the previous studies.

The distribution of branches at a certain point on the radial nerve is important information for surgery. A previous study [5] reported a distance of $1.0 \pm 0.3$ cm from the biceps tendon; however, in our study, the distance was measured from the LEH in the supinated position, and the average distance was $2.2 \pm 0.3$ cm. These results were helpful in clinical applications such as distal biceps repair drilling [4] or nerve transfer surgery [15]. Another anatomic study that attempted to identify a safe zone for arthroscopic surgery of the anterior elbow showed that forearm pronation widens...
the safe zone [16]. A study assessed the position of the radial nerve using a posterior approach [17]. This study also assessed the association between the position of the radial nerve and the surrounding structures. Although we did not study the change in the position of the radial nerve according to pronation or supination of the forearm, changes in nerves according to the movement or the location of nerves through various approaches need to be studied.

A study using medical images [18] reported that the PIN syndrome is often caused by the radial nerve trunk at the upper arm level rather than the supinator. Furthermore, a study highlighted the importance of neuroimaging methods for better diagnosis of fascicular torsion of the PIN [19]. The results of this study, along with those of the previous studies, provide the anatomic data needed for accurate diagnosis. In this study, we segregated the radial nerve into subdivisions based on the location of the nerve branch. The radial nerve continued to be identified till the emergence of the superficial cutaneous branch; it was identified as the deep branch of the radial nerve between the branching point of the superficial cutaneous nerve and the entry point into the supinator. Finally, the radial nerve was identified as PIN after passing the supinator. In entrapment syndrome, the supinator muscle is often not the cause. Our results should contribute to the knowledge on palpation of the supinator for diagnosis. Our study identified each nerve branching point from the

---

**Figure 7:** A photograph showing the posterior interosseous nerve branch (PIN). BR: brachioradialis; ECRL: extensor carpi radialis longus; ECRB: extensor carpi radialis brevis; asterisk: supinator; ED: extensor digitorum; white arrow: superficial branch of the PIN; black arrow: deep branch of the PIN; asterisk: supinator.

**Figure 8:** A photograph showing the common trunk of the posterior interosseous nerve. BR: brachioradialis; ECRL: extensor carpi radialis longus; ECRB: extensor carpi radialis brevis; asterisk: supinator; ED: extensor digitorum; ECU: extensor carpi ulnaris; asterisk: supinator.

**Figure 9:** A photograph showing the deep branch (arrow) of the posterior interosseous nerve innervating the extensor digitorum (ED). BR: brachioradialis; ECRL: extensor carpi radialis longus; ECRB: extensor carpi radialis brevis; ECU: extensor carpi ulnaris; superficial br. of RN: superficial branch of the radial nerve; asterisk: supinator.
in 25% of the specimens; we believe these results will aid in muscle evaluation in supinator-related syndromes. Finally, our results indicate that treating supinator-related syndromes 48.0% and 32.0% from the LEH towards the radius and the ulna, respectively, using conservative treatment methods may help in better treatment (Figure 2).

Data Availability

The data of this study used to support the finding of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

The authors sincerely thank the donors for donating their bodies to anatomic research. Results from such research can potentially increase mankind’s overall knowledge that can consequentially improve patient care. Therefore, these donors and their families deserve our highest gratitude. This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korean government (MSIT) (No. 2019R1C1C1008845).

References

[1] H. Gray, *Gray’s Anatomy: the Anatomical Basis of Clinical Practice*, Churchill Livingstone, 2005.
[2] K. L. Moore, A. M. R. Agur, and A. F. Dalley, *Essential Clinical Anatomy*, Lippincott Williams & Wilkins, 2007.
[3] A. Żytkowski, R. S. Tubbs, J. Iwanaga, E. Clarke, M. Polgúj, and G. Wysiadecki, “Anatomical normality and variability: historical perspective and methodological considerations,” *Translational Research in Anatomy*, vol. 23, p. 100105, 2021.
[4] D. Becker, F. A. Lopez-Marambio, N. Hammer, and D. Kieser, “How to avoid posterior interosseous nerve injury during single-incision distal biceps repair drilling,” *Clinical Orthopaedics and Related Research*, vol. 477, no. 2, pp. 424–431, 2019.
[5] S. J. Thomas, D. E. Yakin, B. R. Parry, and J. D. Lubahn, “The anatomical relationship between the posterior interosseous nerve and the supinator muscle,” *The Journal of Hand Surgery*, vol. 25, no. 5, pp. 936–941, 2000.
[6] R. S. Tubbs, M. Mortazavi, W. Farrington et al., “Relationships between the posterior interosseous nerve and the supinator muscle: application to peripheral nerve compression syndromes and nerve transfer procedures,” *Journal of neurological surgery. Part A, Central European neurosurgery*, vol. 74, no. 5, pp. 290–293, 2013.
[7] M. Benes, D. Kachlik, V. Kunc, and V. Kunc, “The arcade of Frohse: a systematic review and meta-analysis,” *Surgical and Radiologic Anatomy*, vol. 43, no. 5, pp. 703–711, 2021.
[8] K. Zwart, T. A. P. Roeling, W. F. Leeuwen, and A. H. Schuurman, “An anatomical study to the branching pattern of the posterior interosseous nerve on the dorsal side of the hand,” *Clinical Anatomy*, vol. 33, no. 5, pp. 678–682, 2020.
[9] I. Y. Gilan, V. B. Gilan, and A. H. Öztürk, “Evaluation of the supinator muscle and deep branch of the radial nerve: impact on nerve compression,” *Surgical and Radiologic Anatomy*, vol. 42, no. 8, pp. 927–933, 2020.
BioMed Research International

10. V. Jiménez-Díaz, P. Aragonés, L. García-Lamas et al., “The anconeus muscle revisited: double innervation pattern and its clinical implications,” Surgical and Radiologic Anatomy, vol. 43, no. 10, pp. 1595–1601, 2021.

11. T. Bonczar, J. A. Walocha, M. Bonczar, E. Mizia, and J. Filipowska, “Assessing the innervation of the dorsal wrist capsule using modified Sihler’s staining,” Folia Morphologica, vol. 80, no. 1, pp. 81–86, 2021.

12. T. Bonczar, J. A. Walocha, M. Bonczar et al., “The terminal branch of the posterior interosseous nerve: an anatomic and histologic study,” Folia Morphologica, vol. 80, no. 1, pp. 76–80, 2021.

13. E. B. Caetano, L. A. Vieira, J. J. Sabongi Neto, M. B. F. Caetano, C. P. Picin, and L. C. N. D. Silva Júnior, “Anatomical study of the motor branches of the radial nerve in the forearm,” Revista Brasileira de Ortopedia, vol. 55, no. 6, pp. 764–770, 2020.

14. E. B. Caetano, L. A. Vieira, J. J. Sabongi Neto, M. B. F. Caetano, R. G. Sabongi, and Y. D. C. Nakamichi, “Anatomical study of radial tunnel and its clinical implications in compressive syndromes,” Revista Brasileira de Ortopedia, vol. 55, no. 1, pp. 27–32, 2020.

15. Z. Dong, Y. D. Gu, C. G. Zhang, and L. Zhang, “Clinical use of supinator motor branch transfer to the posterior interosseous nerve in C7-T1 brachial plexus palsies,” Journal of Neurosurgery, vol. 113, no. 1, pp. 113–117, 2010.

16. K. M. Chin, M. N. Gilotra, S. Horton, and S. A. Hasan, “Identifying the safe zone in arthroscopic anterior elbow capsulectomy: a cadaveric study,” Orthopedics, vol. 43, no. 5, pp. e399–e403, 2020.

17. A. Patra, P. Chaudhary, V. Malhotra, and K. Arora, “Identification of most consistent and reliable anatomical landmark to locate and protect radial nerve during posterior approach to humerus: a cadaveric study,” Anatomy & Cell Biology, vol. 53, no. 2, pp. 132–136, 2020.

18. P. Bäumer, H. Kele, A. Xia et al., “Posterior interosseous neuropathy: supinator syndrome vs fascicular radial neuropathy,” Neurology, vol. 87, no. 18, pp. 1884–1891, 2016.

19. J. Kollmer, P. Preisser, M. Bendszus, and H. Kele, “Fascicular torsions of the anterior and posterior interosseous nerve in 4 cases: neuroimaging methods to improve diagnosis,” Journal of Neurosurgery, vol. 132, no. 6, pp. 1925–1929, 2019.

20. T. Ceri, A. Podda, J. Behr, E. Brumpt, M. Alllet, and S. Aubry, “Posterior interosseous nerve of the elbow at the arcade of Frohse: ultrasound appearance in asymptomatic subjects,” Diagnostic and Interventional Imaging, vol. 100, no. 9, pp. 521–525, 2019.

21. A. A. Naik, A. Bawa, A. Arya, and A. Gulihar, “Nerve Entrapment around Elbow,” Journal of Clinical Orthopaedics and Trauma, vol. 19, pp. 209–215, 2021.