The Relationship of the Posterior Interosseous Nerve to the Supinator Muscle in the Dorsal Approach to the Proximal Radius: A Descriptive and Quantitative Anatomic Study of Filipino Cadavers

Leslie M. Reyes,[1] Phillip Anthony B. Kho[2] and Edward H.M. Wang[2]

[1]*Department of Anatomy, College of Medicine, University of the Philippines Manila*
[2]*Department of Orthopedics, College of Medicine and Philippine General Hospital, University of the Philippines Manila*

ABSTRACT

Background and Objective. The posterior interosseous nerve (PIN) is vulnerable to injury in the dorsal approach to the proximal radius. The goal of this study is to describe the quantitative relationship of the PIN to the supinator muscle in the context of anatomic landmarks. Knowledge of superficial landmarks related to the PIN would hopefully minimize iatrogenic injury to the posterior interosseous nerve.

Methods. 12 cadavers (22 forearms) were dissected and analyzed. The length of the supinator muscle was determined. The oblique distances of the PIN entry and exit points to the proximal and distal borders of the supinator muscle as well as their perpendicular distances to the lateral epicondyle-Lister's tubercle (LE-LT) reference line were measured and recorded. The number of PIN branches inside the supinator substance was recorded. Mean and median values were determined and subjected to statistical analysis.

Results. Mean supinator length was 5 centimeters. Ninety-one percent of the cadaveric forearms had PIN branches inside the supinator muscle substance. Twelve of the 22 forearms (55%) had 2 branches. The mean oblique distances of the PIN from the lateral epicondyle to the entry and exit points in the proximal and distal borders of the supinator muscle was 3.52 and 7.31 centimeters, respectively. The mean perpendicular distances of the PIN from LE-LT reference line to the entry and exit points in the proximal and distal borders of the supinator muscle was 1.13 and 1.26 centimeters, respectively. An imaginary danger-zone 4 centimeters wide overlying the LE-LT reference line depicts the possible area where the PIN and its branches may most likely be located.

Conclusion. The dorsal approach to the proximal radius may allow a safe exposure without causing iatrogenic injury to the posterior interosseous nerve through the use of superficial anatomic landmarks and reference lines in combination with mean measurements from our study.

Corresponding author: Leslie M. Reyes, MD, FPOA
Department of Anatomy
2nd Floor, Calderon Hall
College of Medicine
University of the Philippines Manila
547 Pedro Gil St. Ermita, Manila 1000 Philippines
Telephone: +632 5264194
Email: lmreyes2001@yahoo.com

Key Words: Posterior interosseous nerve (PIN), supinator muscle, Lateral epicondyle - Lister's tubercle (LE-LT) reference line, Thompson dorsal approach, proximal radial fracture, safe zones

Introduction

The surgical exposure of the proximal third of the radial shaft can be made using Henry's anterior approach or Thompson's posterior approach.[1,2] The latter is considered one of the workhorse exposures in exposing the proximal radius and elbow joint in the management of fractures, arthritis, or contractures. While other approaches to the proximal radius have been described in literature, the dorsal approach offers the advantage of less soft tissue stripping owing to the smaller amount of soft tissue structures that need to be traversed to gain access to the proximal radius. Patients can therefore expect more rapid return of wrist and hand function. An internal fixation plate applied on the dorsal aspect of the proximal radius is thus less likely to cause mechanical block to pronation than if applied to the volar surface. One of the disadvantages of the dorsal approach include the potential risk of iatrogenic injury to the posterior interosseous nerve (PIN).[3]

The posterior interosseous nerve (PIN) crosses obliquely through the surgical field from proximal and anterior to distal and posterior. There is little data describing the position of the PIN with respect to the proximal part of the radius and the elbow joint from a posterior and lateral approach.

There is a paucity of information in the neurosurgical and orthopaedic literature regarding the surgical anatomy surrounding the posterior interosseous nerve (PIN) and its relation to the supinator muscle. To date, only the study by Tubbs et.al has identified superficial surgical landmarks for identifying the PIN.[4]

Objectives

The goal of this study is to describe the quantitative relationship of the PIN to the supinator muscle and to provide easily recognizable superficial bone landmarks for identification of the PIN in Filipinos by coming up with imaginary danger zones that will guide the surgeon to safely avoid the PIN when incising the supinator in the dorsal approach to the proximal third of the radius. It is the hope of

the authors that with the knowledge gained from this study, iatrogenic injury to the PIN be minimized during surgical procedure utilizing the dorsal or posterior approach to the proximal radius.

Methods

This descriptive anatomic study included 12 available cadavers from the Anatomy Laboratory of the Department of Anatomy of the University of the Philippines College of Medicine. The cadavers were the traditionally formalin-embalmed ones dissected by the medical students and were chosen for their better exposure and less decomposition. All the subjects were adults with no specific data as to age and cause of death.

The cadaveric forearms were positioned as close to 90 degrees of elbow flexion and full pronation when possible (Figure 1). With the skin already removed, dissection was done between the extensor digitorum communis and the extensor carpi radialis brevis. The origins of these muscles were detached in order to completely expose the supinator muscle underneath. Visualization of the proximal and distal borders of the supinator was ensured so as to identify the PIN entry and exit points into and from the supinator muscle substance.

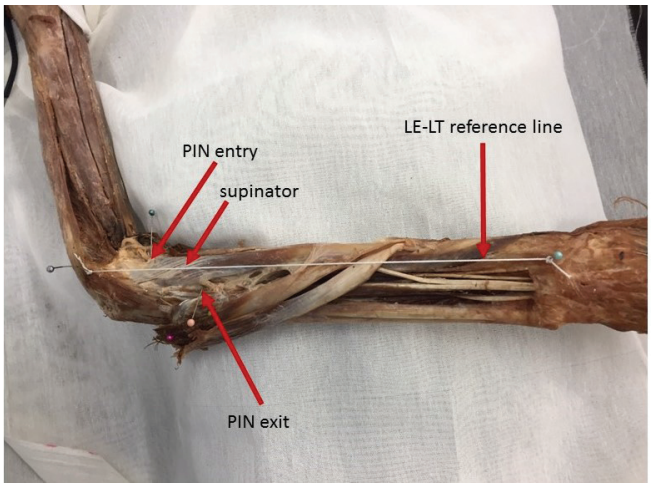

Figure 1. Lateral Epicondyle – Lister's Tubercle (LE-LT) Reference Line.

The supinator muscle longest length was measured and recorded from the most proximal border to the most distal border. A straight reference line was setup from the lateral epicondyle of the distal humerus to the Lister's tubercle in the distal radius (LE-LT reference line) (Figures 1 and 3). Oblique straight-line measurements were taken from the lateral epicondyle to the PIN entry and exit points in the proximal and distal borders of the supinator muscle. From these entry and exit points, perpendicular distances to the LE-LT reference line were measured and recorded (Figures 1, 2 and 4).

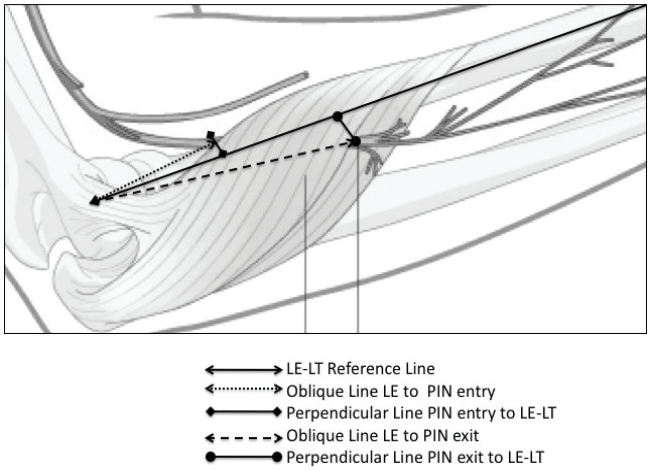

Figure 2. Diagram of PIN measurements.

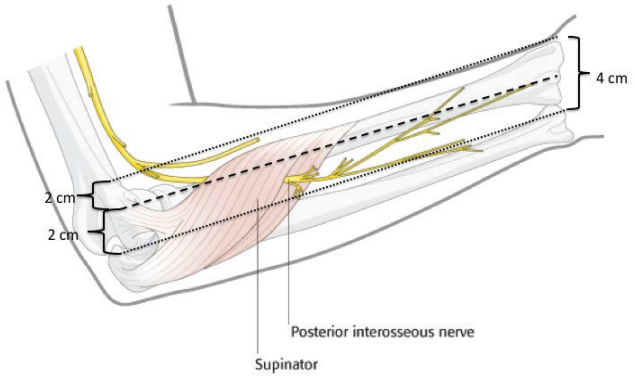

Figure 3. Danger-Zone area.

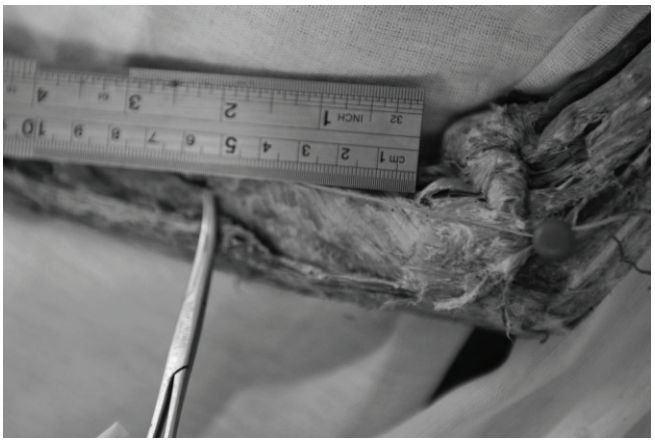

Figure 4. Measurements of PIN entry and exit points.

The mean and median values of the lengths of the supinator muscle, number of PIN branches, and oblique/perpendicular distances of the PIN from the lateral epicondyle and LE-LT reference line were then calculated using STATA software. Analysis between groups was analyzed for significance using a paired T-test with a confidence level of 95 percent.

Table 1. Frequency distribution of the no. of PIN branches inside supinator

No. of PIN Branches inside Supinator	*Frequency*	*Percent*	*Sex*		*Total*
			Female	Male	
0	2	9.09	1 (9%)	1 (9.09%)	2 (9.09%)
1	8	36.3	5 (45.45%)	3 (27.2%)	8 (36.3%)
2	12	54.5	5 (45.45%)	7 (63.6%)	12 (54.5%)
Total	22	100	11	11	22

Table 2. Mean and median values of PIN branches according to sex

	Mean	*Median*	*Standard Deviation*	*P-value*	*Range*
Female	1.36	1	0.67	0.197	0-2
Male	1.5	2	0.70		0-2

Table 3. Oblique distance (cm) of PIN from lateral epicondyle to supinator entry

	Mean	*Median*	*Standard Deviation*	*P-value*	*Range*
Male	3.62	3.5	0.34	0.66	3.3-4.3
Female	3.43	3.45	0.21		3-3.8
Combined	3.52	3.5	0.29		3-4.3

Table 4. Perpendicular distance (cm) of PIN from lateral epicondyle to supinator entry

	Mean	*Median*	*Standard Deviation*	*P-value*	*Range*
Male	1.22	1.3	0.43	0.36	0.5-2
Female	1.06	0.9	0.46		0.5-2
Combined	1.13	1.1	0.44		0.5-2

Table 5. Oblique distance (cm) of PIN from lateral epicondyle to supinator exit

	Mean	*Median*	*Standard Deviation*	*P-value*	*Range*
Male	7.78	7.4	0.91	0.98	6.8-9.2
Female	6.89	6.5	0.89		6-8.6
Combined	7.31	7	0.99		6-9.2

Table 6. Perpendicular distance (cm) of PIN from lateral epicondyle to supinator exit

	Mean	*Median*	*Standard Deviation*	*P-value*	*Range*
Male	1.22	1.2	0.34	0.21	0.6-1.8
Female	1.3	1.2	0.43		0.7-2
Combined	1.26	1.2	0.38		0.6-2

Results

A total of 12 cadavers were used for the analysis, (6 male and 6 female). Two of the 12 cadavers had only a unilateral forearm feasible for dissection giving 11 left and 11 right forearms available for analysis.

The length of the supinator muscle, measured from the most proximal to the most distal border of the supinator muscle gave a mean and median length of 5.04 and 5 centimeters, respectively, with a range of 3.3 - 7.0 cm and a standard deviation of 1.04 cm.

The number of PIN branches inside the supinator muscle substance was recorded. Mean and median values were noted to be 1.42 and 2, respectively, with a range of 0-2 branches.

We noted the PIN to course between the superficial and deep layers of the supinator muscle substance in all 12 cadaveric dissections.

Table 1 shows the frequency distribution of the number of PIN branches. The incidence of PIN branching inside the supinator muscle is 91 percent. The presence of 2 branches inside the supinator muscle substance was noted in 12 of the 22 forearms (54.5%). Only 2 forearms (9.09%) showed no branching of the PIN within the supinator.

Male cadavers had a slightly higher mean and median number of branches (1.5 and 2) as compared to their female counterparts but this was not found to be significant based on T-test analysis (Table 2).

Table 3 shows the oblique distance in centimeters of the posterior interosseous nerve from the lateral epicondyle to the point of entry at the proximal border of the supinator muscle. The mean oblique distance was noted to be 3.52 centimeters. No significant difference on the results between groups was noted (T-test analysis of means).

Table 4 shows the perpendicular distance (cm) of the PIN from its entry point at the proximal border of the supinator muscle to the LE-LT reference line. The mean perpendicular distance was noted to be 1.13 cm. No significant difference in the results between groups was noted (T-test analysis of means).

Table 5 shows the oblique distance in centimeters of the PIN from the lateral epicondyle to the point of exit at the distal border of the supinator muscle. The mean oblique distance was noted to be 7.31 cm. No significant difference in the results between groups was noted (T-test analysis of means).

Table 6 shows the perpendicular distance (cm) of the PIN from its exit point at the distal border of the supinator muscle to the LE-LT reference line. The mean perpendicular distance was noted to be 1.26 cm. No significant difference on the results between groups was noted (T-test analysis of means).

Discussion

In the distal lateral arm, the radial nerve pierces the lateral intermuscular septum passing from the posterior to the anterior compartment of the arm. Here the nerve divides into two terminal branches: the cutaneous superficial radial nerve, which supplies the skin of the radial dorsal aspect of the hand and distal forearm, and the primarily motor PIN. Close to its origin, the PIN is crossed by lateral branches of the recurrent radial artery and vein, the so-called leash of Henry. The PIN descends, passing over the anterior aspect of the radiohumeral joint, and travels deep with respect to the superficial lamina of the supinator muscle, the most proximal edge of which is known as the arcade of Frohse. The PIN then travels to the posterior aspect of the forearm, around the lateral side of the radius exiting between the fibers of the supinator muscle, and is prolonged distally to the middle of the forearm. After traveling through the supinator muscle, the PIN divides and typically produces six branches to the extensor carpi ulnaris, extensor digiti minimi, extensor digitorum communis, extensor pollicis brevis and longus, abductor pollicis longus, and extensor indicis muscles. In some cases, the PIN also produces branches to both radial extensors of the wrist before it enters the supinator muscle.

The supinator muscle and the relationship of the PIN to its substance has been described in a few studies. Ebraheim et al[5] determined the length of the supinator muscle to be 4 centimeters. Tubbs et al[4] measured the distance of the PIN entry and exit to and from the supinator from the lateral epicondyle and determined this to be 6 and 12 centimeters, respectively. Witt et al[6] measured the oblique line from the lateral epicondyle to the supinator exit to be 8.2 centimeters. Cross et al[7] used the radiocarpal joint as a reference point to measure the PIN to the supinator entry and found no difference in length between the anterior and posterior approaches. Diliberti et al[8] used the radiocarpal joint to the radial styloid as reference line to quantify safe zones. Thomas et al[9] examined the anatomical relationship between the posterior interosseous nerve and the supinator muscle. He noted 2 distinct layers as noted by diverging muscles fibers that extended across the radiocapitellar joint to their origins on the lateral epicondyle of the humerus. These 2 layers were present in all of our cadaveric dissections. 91 percent of our dissections (20 out of the 22 forearms) had the posterior interosseous nerve branching within the substance of the supinator muscle. Tubbs et al[4] reported in 1 of their 34 cadaveric upper extremities wherein the right PIN was split into two equal components before it entered the fibers of the supinator muscle. Seradge[10] and colleagues have reported a similar case in which the PIN split, with one half of its fibers exiting inferior to the distal edge of the supinator muscle and the other one half piercing through the supinator muscle.

Hoppenfeld[11] describes the line connecting the lateral epicondyle of the humerus and the Lister's tubercle as a guide in making the incision for the posterior approach to the radius. We decided to use this superficial landmark and correlate it with the surgical anatomy of the PIN in relation to the supinator muscle. We believe that if the course of the posterior interossseous nerve could be mapped out with the use of superficial landmarks and reference lines prior to skin incision, the surgeon could better anticipate the location of the PIN. Thus, unnecessary dissections, unnecessary straying out of plane, and most importantly, iatrogenic injury to the posterior interosseous nerve, could be avoided. Our results show that the distance of the PIN entry and exit points to the proximal and distal borders of the supinator muscle were 1.13 centimeters (range=0.6-2) radial and 1.26 centimeters (range=0.5-2) ulnar to the LE-LT, respectively. Based from these results, it could be deduced that a "danger-zone" about 4 centimeters wide exists and is centered over the LE-LT reference line (Figure 2). It is in this "danger-zone" that the posterior interosseous nerve is consistently present in our subjects and is most vulnerable to iatrogenic injury if dissection or retraction should venture into this area. With the forearm in pronation, the PIN traverses the supinator in an oblique direction. It must be kept in mind that, in the proximal part of the supinator, the PIN is nearer the radial side of the proximal radius (perpendicular line entry to LE-LT) whereas in the distal part it is nearer the ulnar side (perpendicular line exit to LE-LT) (Figure 1).

Conclusion

The PIN enters the substance of the supinator between its superficial and deep layers where it sends off branches. In the PIN's entry point in the arcade of Froshe, a danger zone of 2 cm radial to the LE-LT reference line is present, and towards the exit point in the distal part of the supinator, a danger zone of 2 cm ulnar to the LE-LT reference line is similarly present. Knowledge of the dimensions of the danger-zone and awareness of the mean of the oblique and perpendicular distances to the PIN entry and exit points in relation to the supinator muscle (3.52 and 7.31) centimeters allow a more accurate picture of the PIN location by a process of triangulation.

Statement of Authorship
All authors have approved the final version submitted.

Author Disclosure
All the authors declared no conflicts of interest.

Funding Source
This paper was funded by personal funds.

References

1. Henry AK. Extensile exposure, 2nd ed. Edinburgh: Churchhill Livingston; 1973. p. 19.
2. Thompson JE. Anatomical methods of approach in operations on the long bones of the extremities. Ann Surg. 1918; 68(3):309-29.
3. Mekhail AO, Ebraheim NA, Jackson WT, Yeasting RA. Vulnerability of the posterior interosseous nerve during proximal radius exposures. Clin Orthop Relat Res. 1995; (315):199-208.
4. Tubbs RS, Salter EG, Wellons JC 3rd, Blount JP, Oakes WJ. Superficial surgical landmarks for identifying the posterior interosseous nerve. J Neurosurg. 2006; 104(5):796-9.
5. Ebraheim NA, Jin F, Pulisetti D, Yeasting RA. Quantitative anatomical study of the posterior interosseous nerve. Am J Orthop. 2000; 29(9):702-4.
6. Witt JD, Kamineni S. The posterior interosseous nerve and the posterolateral approach to the proximal radius. J. Bone Joint Surg (Br). 1998; 80(2):240-2.
7. Cross JD, White JA, Johnson AE, Blair JA, Hsu JR. Comparison of dorsal and volar approaches to the proximal radius. Orthopedics. 2011; 34(2):93.
8. Diliberti T, Botte MJ, Abrams RA. Anatomical considerations regarding the posterior interosseous nerve during posterolateral approaches to the proximal part of the radius. J Bone Joint Surg Am. 2000; 82(6):809-13.
9. Thomas SJ, Yakin DE, Parry BR, Lubahn JD. The anatomical relationship between the posterior interosseous nerve and the supinator muscle. J Hand Surg Am. 2000; 25(5):936-41.
10. Seradge H, Tian W, Baer C, Seradge A. The posterior interosseous nerve anatomical variation and surgical consideration – a case report of cadaver study. Hand Surg. 1999; 4(1):91-4.
11. Hoppenfeld S, deBoer P. Surgical exposures in orthopaedics: the anatomic approach, 3rd ed. Philadelphia; 2003. 160-162.