Sonographic Appearance of the Posterior Interosseous Nerve at the Wrist

Jay Smith, MD, Marco Rizzo, MD, Jonathan T. Finnoff, DO, Yusef A. Sayeed, MD, MPH, MEng, Johan Michaud, MD, Carlo Martinoli, MD

Objectives—The purpose of this study was to determine whether sonography can identify the distal posterior interosseous nerve at the wrist.

Methods—On the basis of previous anatomic descriptions, high-resolution musculoskeletal sonography was used in an attempt to identify the distal posterior interosseous nerve in the wrists of 20 unembalmed cadaveric specimens (11 male and 9 female; ages 54–98 years). High-frequency scanning (17–5 MHz) of the fourth dorsal extensor compartment revealed a small (1–3 mm) hypoechoic structure located on the compartment floor, presumed to represent the posterior interosseous nerve. Electronic calipers measured the distance between Lister’s tubercle and this structure, as well as the structure’s radial-ulnar width and volar-dorsal height. The presumed posterior interosseous nerves of 10 specimens were then injected with diluted colored latex using sonographic guidance. Subsequent dissection definitively identified the sonographically visualized and injected structure.

Results—Dissection revealed latex within the posterior interosseous nerve in all 10 injected specimens, thus confirming that the sonographically visualized structure represented the distal posterior interosseous nerve. The nerve was identified sonographically in all 20 examined specimens, was located an average of 4.88 mm (range, 2.10–10.0 mm) ulnar to Lister’s tubercle, and had an average width and height of 2.35 mm (range, 1.20–3.50 mm) and 1.01 mm (range, 0.80–1.40 mm), respectively.

Conclusions—High-resolution sonography can reliably identify the distal posterior interosseous nerve within the fourth dorsal extensor compartment. Clinicians should consider formal evaluation of the posterior interosseous nerve in patients presenting with dorsal wrist pain syndromes. Future investigations should explore the potential role of sonographically guided percutaneous procedures directed at the posterior interosseous nerve.

Key Words—arthritis; denervation; injection; nerve; posterior interosseous nerve; sonography; wrist

Chronic dorsal wrist pain is a disabling clinical problem that may result from a variety of pathoetiologic processes, including arthritis, instability, capsular injury, dorsal wrist ganglia, and neuroma formation.1–7 Regardless of etiology, pain mediation via the terminal branches of the posterior interosseous nerve appears to play an important role in the clinical syndrome of dorsal wrist pain.2,3,8 Consequently, complete or partial wrist denervation has been used as palliative treatment of chronic dorsal wrist pain when curative or reconstructive procedures are not feasible.2,3,6,8 Whereas complete wrist denervation requires multiple
incisions to resect the ulnar, radial, median, and lateral and medial antebrachial cutaneous nerves, partial denervation using a single incision to resect the posterior interosseous nerve with or without the anterior interosseous nerve has produced similar clinical results in some published series.1–3,6,8

Multiple anatomic studies have elucidated the distal anatomy of the posterior interosseous nerve because of its importance as a pain mediator in dorsal wrist pain syndromes and its surgical relevance for wrist denervation procedures.3–6,9 Shortly after exiting the distal supinator, the posterior interosseous nerve typically divides into 6 branches arranged ulnar to radial, which course in the dorsal forearm compartment. The fifth branch runs superficial to the abductor pollicis longus, ultimately bifurcating into radial and ulnar divisions.9 After innervating the extensor pollicis longus and brevis muscles, the radial division of the fifth branch courses distally toward the wrist between the deeply located interosseous membrane and the superficially located extensor pollicis longus.9 This terminal division of the nerve eventually enters the radial side of the fourth wrist dorsal extensor compartment, coursing deep to the extensor digitorum and extensor indicis proprius tendons before arborizing into multiple branches, which innervate the dorsal wrist capsuloligamentous structures (Figure 1).1,3,6,9–11 Although the posterior interosseous nerve is generally 1 to 3 mm in diameter in the fourth dorsal compartment, it may enlarge by several millimeters as part of a distal swelling referred to as “Acrel’s ganglion.”3,10 The etiology and function of Acrel’s ganglion remain indeterminate, but recent histologic studies have shown that it does not contain nerve cell bodies and is therefore not a true ganglion.10

The reported size and location of the distal posterior interosseous nerve at the wrist suggest that this structure should be amenable to sonographic evaluation using modern high-resolution ultrasound equipment.12–14 Because of recent technological advancements, high-resolution sonography has emerged on the forefront of nerve imaging, capable of resolving nerves at the millimetric and submillimetric levels.12–15 However, to our knowledge, the sonographic appearance of the posterior interosseous nerve at the wrist has not been previously reported. During sonographic examination of patients presenting with dorsal wrist pain syndromes, we have observed a small (1–3 mm) noncompressible ovoid structure located on or within the radial floor of the fourth dorsal extensor compartment. We hypothesized that this structure represented the distal posterior interosseous nerve. The primary purpose of this investigation was to validate our observations and document the ability of sonography to image the distal posterior interosseous nerve at the wrist. The clinical implications of distal posterior interosseous nerve imaging are 2-fold. First, when appropriate, the posterior interosseous nerve could be included in the sonographic evaluation of patients presenting with dorsal wrist pain syndromes, including dorsal wrist ganglia.7 Second,
percutaneous procedures targeting the nerve would become feasible, including diagnostic injections or therapeutic ablative procedures. In the latter case, sonographically guided percutaneous ablation of the nerve could be used in selected patients as an alternative to open surgical partial wrist denervation.1–3

Materials and Methods

General Design
This investigation was approved by the Mayo Clinic’s Biospecimens Subcommittee of the Institutional Review Board. Twenty fresh-frozen cadaveric specimens free of obvious surgery, trauma, or deformity in the distal forearm and wrist regions were obtained through the Department of Anatomy’s Mayo Foundation Bequest Program and thawed at room temperature immediately before investigation. The primary author (J.S.) scanned the fourth dorsal wrist extensor compartment regions in 20 unembalmed cadaveric specimens to locate a structure thought to represent the distal posterior interosseous nerve. On the basis of anatomic descriptions and our prior experience, the nerve was anticipated to appear sonographically as a small (1–3 mm in diameter) noncompressible hypoechoic ovoid structure coursing along the radial aspect of the fourth extensor compartment and located just superficial to or within the underlying connective tissue (Figure 1).3,10 Scans were completed from the distal forearm to the radiocarpal articulation. When the presumed posterior interosseous nerve was identified, electronic calipers were used to record its width (radial-ulnar), height (volar-dorsal), and location relative to Lister’s tubercle (Figure 2). All scans were completed in the Mayo Clinic Procedure Skills Laboratory using an iU22 ultrasound machine with a 17–5 MHz linear array transducer (Philips Healthcare, Bothell, WA). At the time of the investigation, the primary author had more than 7 years of experience performing diagnostic and interventional musculoskeletal sonography.

In 10 of the cadaveric specimens, the primary author also completed a sonographically guided injection into the presumed posterior interosseous nerve using diluted yellow latex.1 The cadaveric hand was placed in a prone position, and the fourth dorsal extensor compartment tendons were visualized using an anatomic transverse view, short axis to the tendons. Injections were completed with a 25-gauge, 38-mm stainless steel needle using an in-plane (long-axis) approach. The needle was advanced under real-time sonographic guidance from either ulnar to radial or radial to ulnar, based on the view providing the best acoustic window. In 9 of 10 cases, the ulnar-to-radial direction provided a more direct route to the presumed nerve because Lister’s tubercle often prevents an unobstructed path from the radial side. When advancing the needle from the ulnar side, the needle may be passed either superficial or deep to the extensor digiti minimi tendon within the fifth dorsal extensor compartment, depending on the sonographic view providing the best visualization. In each case, the needle was passed under direct sonographic guidance into the presumed posterior interosseous nerve. Once this structure was penetrated, a total of 0.5 to 1.0 mL of diluted yellow latex was injected into the structure (Figure 3). Injected specimens were then

Figure 2. A, The box over the dorsum of the wrist indicates the transducer position to obtain a transverse view of the fourth dorsal extensor compartment (live model). B, Transverse sonogram of the fourth dorsal extensor compartment (4th EXT CPT TR) showing a hypoechoic ovoid structure located on the compartment floor (horizontal and vertical arrows). The structure was located 4.0 mm ulnar to Lister’s tubercle (L) and measured 1.3 mm radial-ulnar and 1.0 mm volar-dorsal. This structure was thought to represent the distal posterior interosseous nerve and was subsequently targeted for intraneural injection. EDC indicates extensor digitorum communis tendons; RAD, radial; ULN, ulnar; and 3, extensor pollicis longus (third dorsal wrist compartment). Top is superficial; bottom, deep; right, ulnar; and left, radial.

Smith et al—Sonographic Appearance of the Posterior Interosseous Nerve
frozen to allow the latex to solidify and were thawed 1 week later for dissection. A fellowship-trained hand-surgeon (M.R.) with 7 years of experience completed dissections in the 10 injected cadaveric specimens, identifying the posterior interosseous nerve just proximal to the distal radioulnar joint and then tracing it distally into the fourth dorsal extensor compartment. Once the extensor compartment was entered, the surgeon transected the nerve to document the presence or absence of latex within the nerve. The surgeon’s findings were recorded as a “hit” (latex within the nerve) or “miss” (latex not within the nerve).

Statistics
Descriptive statistics were used to report the frequency with which sonography could identify the structure hypothesized to be the posterior interosseous nerve among the 20 cadaveric specimens. The means and ranges for the nerve’s width, height, and distance from Lister’s tubercle were calculated. For the 10 injected cadaveric specimens, the frequency of hits (latex within the nerve) and misses (latex not within the nerve) was recorded.

Results
A total of 20 (11 male and 9 female) unembalmed cadaveric wrist specimens were included in this investigation. The average age of the donor population was 69.9 years (range, 54–98 years), and the average body mass index was 22.5 kg/m² (range, 17.0–35.5 kg/m²). A structure presumed to be the posterior interosseous nerve based on its location and size was sonographically identified in all 20 cadaveric wrist specimens and appeared as a noncompressible hypoechoic ovoid structure located on or within the floor of the fourth dorsal extensor compartment. Considering all 20 wrist specimens, the posterior interosseous nerve was located an average of 4.88 mm (range, 2.10–10.0 mm) ulnar to Lister’s tubercle with an average radial-ulnar width of 2.35 mm (range, 1.20–3.50 mm) and volar-dorsal height of 1.01 mm (range, 0.80–1.40 mm).

Subsequent dissection revealed intraneural latex in all 10 injected cadaveric wrist specimens, confirming that the sonographically visualized and injected structure in fact represented the distal posterior interosseous nerve in the fourth dorsal extensor compartment (Figure 4).

Discussion
To our knowledge, a formal investigation documenting the ability of high-resolution sonography to image the distal posterior interosseous nerve within the fourth dorsal extensor compartment has not been previously reported. In all 20 unembalmed cadaveric wrist specimens, we identified a structure presumed to be the posterior interosseous nerve based on prior anatomic descriptions. Sonographically guided latex injection and dissection among 10 of the specimens subsequently confirmed that this structure was in fact the posterior interosseous nerve.

Documenting the ability to sonographically visualize the distal posterior interosseous nerve at the level of the wrist has important clinical implications. Diagnostically, clinicians may consider formal assessment of the posterior interosseous nerve in patients presenting with dorsal wrist
pain syndromes. Similar to other body regions, sonography may reveal focal caliber changes due to compression or neuroma formation, as well as identify impinging structures such as osteophytes and dorsal wrist ganglia. Future clinical experience with distal posterior interosseous nerve sonography will further define the role of diagnostic sonography in this region. Therapeutically, sonographic guidance provides the opportunity to precisely place needles or other instruments within or in close proximity to the distal posterior interosseous nerve. Theoretically, sonographically guided percutaneous distal posterior interosseous nerve denervation could be attempted by transecting the nerve or ablating it using chemical (eg, phenol) or electrical (eg, radio frequency) means. Percutaneous posterior interosseous nerve ablation may thus provide a nonsurgical treatment option for patients with chronic dorsal wrist pain syndromes. Future investigations should explore the feasibility, efficacy, and safety of sonographically guided percutaneous procedures directed at the posterior interosseous nerve in appropriately selected patient groups.

Further comment is warranted regarding the location and size of the distal posterior interosseous nerve in the fourth dorsal extensor compartment, as reported in this investigation. Although we located the nerve in all 20 unembalmed cadaveric specimens, its location and size were variable. The nerve was located an average of 4.88 mm ulnar to Lister’s tubercle, but its location ranged from 2.10 to 10.0 mm among the 20 specimens. Excluding 2 specimens in which the nerve was located 8 and 10 mm ulnar to Lister’s tubercle, 18 of 20 nerves were located within 6 mm of Lister’s tubercle. The radial-ulnar nerve width averaged 2.35 mm (range, 1.20–3.50 mm), and the volar-dorsal height averaged 1.01 mm (range, 0.80–1.40 mm). Not surprisingly, although quantitatively small, these average values are clearly within the resolution capabilities of modern ultrasound equipment. The variable size and location of the posterior interosseous nerve in the fourth dorsal extensor compartment suggest that the nerve may be more or less conspicuous in certain individuals, which may be a function of body habitus, hand dominance, interindividual variability, or the location at which the measurements are completed. Because the primary purpose of this investigation was to document the ability to sonographically image the posterior interosseous nerve in the dorsal wrist region, our methods preclude further comment with respect to the effect of body habitus, hand dominance, and interindividual variability on nerve conspicuity. During this investigation, all measurements were completed at the level of Lister’s tubercle to maintain consistency between specimens. However, we have observed that the conspicuity of the posterior interosseous nerve may be improved by moving the transducer either proximally or distally. The reason for the altered conspicuity was not formally explored as part of this investigation but is most likely multifactorial. It should be noted that we did not observe a focal posterior interosseous nerve swelling, the so-called Acrel’s ganglion, in any of our sonographic images or dissected specimens. Clinically, we recommend locating the nerve using a short axis-view within the fourth extensor compartment and then scanning proximally and distally to image the nerve in its full extent, as well as its relationship to adjacent structures (Figures 2 and 3).

**Figure 4.** A, Dissection of the specimen in Figures 2B and 3. The skin overlying the dorsal distal forearm and fourth extensor compartment has been incised, and the digital extensor tendons ulnarily (asterisk) retracted. The posterior interosseous nerve (arrowheads) is visualized coursing proximal to distal (left to right) and is infiltrated with yellow latex. Left is proximal; right, distal; top, ulnar; and bottom, radial. B, Same specimen and orientation as in A after transection and reflection of the proximal and distal ends of the posterior interosseous nerve. The cut ends of the nerve clearly show intraneural latex, thus confirming that the structure injected using sonographic guidance in fact represents the posterior interosseous nerve. Asterisk indicates reflected extensor tendons.
Several study limitations warrant discussion. First, we recognize the potential limitations imposed by our cadaveric model. The primary purpose of this investigation was to document the ability to sonographically image the distal posterior interosseous nerve as documented by latex injection and dissection. Our methods therefore mandated a cadaveric model. Consequently, we were unable to sonographically visualize the posterior interosseous vessels, which course adjacent to the posterior interosseous nerve in this region. In addition, it is possible that the size and conspicuity of the nerve may be different in vivo, although our clinical experience does not reflect this possibility. Second, although we documented the presence of the distal posterior interosseous nerve in all 20 cadaveric specimens, the frequency with which clinicians can successfully image the nerve in this region remains unknown. For the purposes of this investigation, a very high-frequency 17–5 MHz transducer was used by an experienced examiner to provide submillimetric resolution for the superficially located posterior interosseous nerve.14,15,17 It is unknown whether all 20 nerves would have been successfully visualized with a lower-frequency transducer. In addition, on the basis of our results and previous anatomic dissections, one can expect substantial variability in the location and size of the posterior interosseous nerve between different individuals, in some cases potentially precluding adequate visualization despite the use of high-frequency transducers.3,6,9–11,13 Future investigations may formally examine the ability to image the distal posterior interosseous nerve in vivo using transducers of different frequencies. Third, although the prospect of sonographically guided percutaneous posterior interosseous nerve injections and denervative procedures is intriguing, we recognize that such procedures may be controversial. With respect to injections, prior research has shown acceptable accuracy using palpatory landmarks to complete diagnostic posterior interosseous nerve injections in candidates for wrist denervation.1 Despite the apparent success of palpation-guided injections, sonographic guidance may be indicated in the following circumstances: (1) failed nonguided injection, (2) need to optimize the diagnostic specificity by limiting the injectate volume, and (3) patient factors such as distorted anatomy, poorly defined palpatory landmarks, large body habitus, or bleeding risk (due to the accompanying posterior interosseous artery).18,19 It should be noted that, to our knowledge, sonographically guided posterior interosseous nerve injection techniques have not been described previously. The technique used in this investigation was developed primarily for the purposes of injecting the cadaveric wrist. Although we think that this technique may be most appropriate for clinical applications, identification of the optimal technique (eg, in plane versus out of plane) will require future experience in clinical populations. We also appreciate the current controversy regarding the extent of wrist denervation necessary to provide adequate pain relief in patients with chronic dorsal wrist pain. Whereas some authors propose complete surgical denervation including the ulnar, radial, median, and lateral and medial antebrachial cutaneous nerves, partial denervation focusing on the posterior interosseous nerve, with or without the anterior interosseous nerve, has produced similar clinical results in some published series.1–3,6,8 It is important to recognize that the extent of denervation necessary to provide adequate pain relief may vary between patients, and most clinicians agree that the posterior interosseous nerve is the primary pain mediator in most dorsal wrist pain syndromes.2,3,8 Therefore, exploration of a sonographically guided percutaneous posterior interosseous nerve ablative procedure appears warranted. In appropriately selected patients, sonographically guided percutaneous nerve ablation may provide a viable nonsurgical management option for chronic wrist pain. Whether sonographic guidance can facilitate simultaneous anterior interosseous nerve ablation is unknown and is a topic of future investigation.

In conclusion, this investigation documents the ability to sonographically image the distal posterior interosseous nerve within the fourth dorsal extensor compartment. Clinicians should consider including assessment of this nerve in patients presenting with dorsal wrist pain syndromes. Furthermore, sonographic guidance can be used to perform diagnostic posterior interosseous nerve injections and provides the opportunity to develop percutaneous posterior interosseous nerve ablative techniques to assist in the management of chronic dorsal wrist pain.

References


J Ultrasound Med 2011; 30:1233–1239


8. Dellon AL. Commentary: desensitizing the posterior interosseous nerve alters wrist proprioceptive reflexes—it is ok to lose your nerve. *J Hand Surg Am* 2010; 35:1067–1069.


