Entrapment of the Posterior Interosseous Nerve at the Arcade of Frohse With Sonographic, Magnetic Resonance Imaging, and Intraoperative Confirmation

Vikram Kinni, MD, Joseph Craig, MD, Marnix van Holsbeeck, MD, Donald Ditmars, MD

Entrapment of the radial nerve, specifically the deep branch of the radial nerve (DBRN) in the arcade of Frohse, was first described in 1963. Prolonged entrapment may lead to a constellation of symptoms described in posterior interosseous nerve (PIN) paralysis. Reported attempts at diagnosis using imaging have mostly involved magnetic resonance imaging (MRI), with a limited number of studies characterizing the utility of sonography. Confirmation of entrapment via MRI, sonography, and gross specimens obtained intraoperatively during surgical decompression is presented.

Case Report

A 53-year-old right-handed woman had a 2-year history of left hand numbness. The patient reported 3 to 4 months of left hand weakness with an inability to fully extend her fingers. Her medical history was notable for previous carpal tunnel surgery and arthritis in the elbows and knees.

A general physical examination was unremarkable with the exception of left upper extremity symptoms. Her left finger strength was scored as 3/5 extension and 5/5 flexion. Motor losses were most prominent with abduction and extension of the left thumb and index finger. Her right finger strength was normal. Sensory examination findings were normal, with normal light touch, pinprick, and vibration responses. No numbness, tingling, or pain was reported by the patient on the physical examination. Electromyographic studies reported evidence of severe left radial mononeuropathy at the spiral groove with ongoing denervation of unclear origin. Sonography and MRI were performed to localize the cause of the denervation.
Sonography showed kinking of the radial nerve as it entered the supinator muscle at the arcade of Frohse (Figure 1). Proximal to this area of kinking/compression, the caliber of the radial nerve was 2 to 3 times its normal size compared with the opposite arm. Distal to this area of narrowing, the radial nerve was slightly enlarged, although to a lesser extent. Sonography of the left elbow also showed a 1-cm-thick synovial proliferation, consistent with a pannus circumferentially within the elbow joint and extending into the annular recess and olecranon fossa (Figure 2).

Magnetic resonance imaging of the left elbow showed extensive heterogeneous low/isointense T1 and high T2 signal material intra-articularly, consistent with a pannus (Figure 3, top). The posterior interosseous branch of the radial nerve showed relative thickening as well as an abnormally increased signal deep to the superficial head of the supinator and the extensor carpi radialis brevis within the arcade of Frohse (Figure 3, center and bottom). There was no evidence of an abnormal signal within the supinator muscle to suggest acute denervation edema and no fatty change in the supinator to suggest chronic atrophy.

Surgical decompression of the entrapped nerve was recommended. Intraoperatively, the supinator muscle and the arcade of Frohse were identified. On transection of the arcade of Frohse, the radial nerve was identified posteriorly with a fibrous constricting band along with a vascular network causing an indentation in the nerve (Figure 4). This band was transected, and the vessel was electrocauterized (Figure 4, bottom). The nerve was then characterized as free both grossly and by palpation. Three weeks after release of the posterior interosseous motor branch of the left radial nerve at the arcade of Frohse, there was no pain and an excellent range of motion. Improved extensor pollicis longus muscle motion was evident.

**Discussion**

This report describes the identification of entrapment of the radial nerve at the arcade of Frohse by branches of the recurrent radial artery via MRI, sonography, and intraoperatively. In the proximal forearm, the radial nerve splits into a sensory branch known as the superficial branch of the radial nerve and a predominantly motor branch known as the DBRN. The DBRN passes between the superficial and deep heads of the supinator muscle in the proximal forearm and becomes known as the PIN on entering the posterior compartment of the arm. The PIN then serves to provide motor innervation to the extensor digitorum communis, extensor carpi ulnaris, extensor digiti quinti, abductor pollicis longus, extensor pollicis longus, and extensor pollicis brevis, followed by the extensor indicis proprius muscles. In our patient, the more distally innervated muscles in the nerve branching pattern had the highest loss of function. This was evidenced by the gross deficits in function of the abductor pollicis longus, extensor pollicis longus, and extensor indicis proprius.

Along the course of the DBRN/PIN, the nerve has the potential to be compressed by normal variations of anatomy as well as abnormalities. Major sources of entrapment include the proximal and distal edges of the supinator muscle, a vascular network of the recurrent radial artery known as the leash of Henry, found to be prominent in our patient, the medial aspect of the extensor carpi radialis brevis, and the capsule-tendon-aponeurosis of the humeroradial joint.
The most common site of entrapment involves the proximal aspect of the supinator muscle known as the arcade of Frohse.\textsuperscript{5} The most proximal aspect of the superficial head of the supinator may be tendinous in some individuals and may form a fibrous arch.\textsuperscript{2} A tendinous arcade of Frohse alone or a tendinous arch in addition to abnormalities including a space-occupying lesion such as lipoma\textsuperscript{6} or edema\textsuperscript{2} and synovitis from rheumatoid arthritis may also be a cause of compression.\textsuperscript{1,7} In our case, the exact relationship between the hypertrophy of the pannus and the subsequent symptoms was uncertain. It is possible that the intra-articular pannus caused some mass effect in the region of the arcade of Frohse. We are unable to provide an explanation for electromyographic studies that showed evidence of radial denervation at the spiral groove proximal to the arcade of Frohse. Imaging studies, including sonography and MRI, showed no abnormality proximal to the elbow joint. At surgery, the elbow joint was not entered, but a fibrous constricting band and vessels in the arcade of Frohse were identified as the cause of entrapment.

Compression of the PIN can manifest as two clinically different entities. One entity is predominantly characterized by forearm pain without muscle weakness, known as radial tunnel syndrome. Our patient's symptoms corresponded to the other entity, characterized by painless motor weakness in the distribution of the PIN.\textsuperscript{3} Early case reports by Spinner\textsuperscript{2} and Capener\textsuperscript{6} described PIN syndrome with painless onset of paralysis involving extensors of the thumb and fingers with no sensory disturbances. Radial deviation of the wrist is sometimes present on wrist extension, which is often unaffected because the extensor carpi radialis is often spared.\textsuperscript{7}

Magnetic resonance imaging is useful in detecting neuropathies because of its high-resolution depiction of nerves and its ability to distinguish causes of mechanical compression. The arcade of Frohse has been identified on MRI as a low–signal intensity band at the proximal edge of the supinator.\textsuperscript{3} However, diagnosis of PIN paralysis on MRI is mostly based on a muscle denervation pattern showing increased signal intensity on T2-weighted and short-tau inversion recovery images,\textsuperscript{8,9} allowing localization of the nerve lesion.\textsuperscript{3} With time, these muscles may undergo continued atrophy and fatty infiltration easily visible on MRI.\textsuperscript{8,9} Recent studies, however, have not shown a strong correlation...
between MRI and clinical findings of peripheral neuropathies, especially when only direct signs of nerve abnormalities, including an increased signal intensity or nerve thickening, were present. The correlation was strongest when secondary signs of nerve abnormalities, including denervation edema around muscle and muscle atrophy, were also noted, most commonly

Figure 3. Magnetic resonance images. Top, Sagittal fat-suppressed T2-weighted image showing an extensive inflammatory pannus within the elbow both anteriorly and posteriorly (arrows). Center, Axial T1-weighted image of the elbow at a similar level as on sonography through the arcade of Frohse showing an enlarged DBRN (long arrow). Note the extensive pannus at the elbow joint (short arrows). Bottom, Corresponding axial fat-suppressed T2-weighted image at a similar level as in the center image showing an extensive inflammatory pannus intra-articularly (short arrows) and an edematous DBRN (long arrow).

Figure 4. Intraoperative images. Top, Intact vascular leash of Henry shown supported by an instrument (arrows). Bottom, Division and electrocauterization of the vascular leash of Henry (long arrow). Swelling of the DBRN is shown both proximal and distal to the visible region of compression from the vascular tether (short arrows). Br indicates brachioradialis; and Ecr, extensor carpi radialis longus and brevis.
within the supinator. Denervation changes on MRI vary based on the muscle group. The subacute phase of denervation lasts from 4 weeks to 1 year, with the sensitivity on MRI increased the later the imaging. Some of these pitfalls may be avoided by attempting sonographic diagnosis of neuropathies.

The radial nerve can be easily visualized on modern sonographic equipment both above and at the elbow, but there is little discussion in the literature regarding visualization of entrapment at the arcade of Frohse. In healthy individuals, nerves are oval to round on transverse scans and echogenic tubular structures on longitudinal scans with hypoechoic areas representing fascicles and a hyperechoic background of epineurium. They can be distinguished from surrounding muscle and subcutaneous fat by their relative hyperechogenicity. The nerves can be distinguished from muscles and tendons by their relative immobility during dynamic imaging and by the fibrillar pattern of hyperechogenicity and hypoechogenicity seen in tendons.

As in our case, the sonographic characteristics of an entrapped nerve include diffuse or focal thickening of the nerve and decreased echogenicity relative to a healthy nerve. The pathophysiologic mechanism of nerve thickening involves a response to compression that includes endoneurial edema, inflammation, fibrosis, demyelination axonal loss, and remyelination with eventual thickening of the perineurium and endothelium. Increased nerve thickening can be characterized by an increase in the transverse breadth and area on sonography and can correlate with a decreased motor amplitude on electrophysiologic studies.

Sonography also has the ability to visualize mass lesions, including cysts, ganglions, and tumors, which may be the source of entrapment. Problematic areas with sonography include its operator dependence, requiring correct positioning of the transducer, and its difficulty in imaging more deeply situated nerves.

Magnetic resonance imaging allows visualization of nerves with its superb soft tissue contrast and multiplanar resolution. Magnetic resonance imaging has the greatest impact in therapy of patients with neuropathies of unclear origin. However, it has a much larger field of view with decreased spatial resolution compared with sonography. If we had repeated the MRI examination with a smaller field of view, we might have improved visualization of the radial nerve. In our case, the nerve was much better visualized on sonography. Diagnosis of entrapment via sonography has advantages over other imaging modalities in that it is fast, safe, painless, and inexpensive.

To summarize, in this case, we were able to effectively visualize entrapment of the PIN using both MRI and sonography. We obtained surgical confirmation of compression near the arcade of Frohse, which was subsequently released. The cause of compression included a fibrous constricting band and the vascular network of the recurrent radial artery known as the leash of Henry. In our case, sonography in particular allowed precise localization of the lesion for accurate surgical exposure with minimal difficulty.

References

Posterior Interosseous Nerve Entrapment at the Arcade of Frohse


