Posterior interosseous neuropathy: the diagnostic benefits of a multimodal approach to investigation

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Key Clinical Message
Posterior interosseous neuropathy should be considered in patients presenting with finger and wrist drop and no sensory deficit. Clinical and electrophysiological assessments are key to a diagnosis. MRI may disclose etiological information not available to clinical or neurophysiological assessment, and should be thought of as a complementary diagnostic tool.

Keywords
electromyography and electroneurography, magnetic resonance imaging, neurophysiology, posterior interosseous neuropathy, radial nerve lesion.

Introduction
Posterior interosseous neuropathy (PIN), or posterior interosseous nerve syndrome, is a rare although treatable cause of finger and wrist drop, with estimated annual incidence of 0.003% [1]. It is an important diagnosis to consider as patients often respond well to either conservative measures or timely surgical intervention, which has reported favorable outcomes in between 75 and 97% [2, 3] of selected cases. PIN may result from nerve compression, either spontaneous or secondary to external masses such as ganglions, lipomas, or a rheumatoid pannus affecting the radiocapitellar joint. Other causes include trauma, iatrogenic injury or, it has been suggested, as a form of brachial neuritis [4, 5]. The nerve can be also rarely involved in multifocal motor neuropathy, lead toxicity, or vasculitis. Five potential sites of compression are reported:

1. Fibrous tissue of the anterior capsule of the radiocapitellar joint.
2. Recurrent radial vessels at the level of the radial neck (“the leash of Henry”).
3. The proximal edge of extensor carpi radialis brevis (ECRB).
4. A fibrous band at the proximal edge of supinator (“the Arcade of Frohse”).
5. The distal supinator margin.

Detailed understanding of the anatomy of the radial nerve helps explain the clinical presentation. The posterior interosseous nerve is a deep continuation of the deep radial motor nerve, one of two terminal branches arising 3–4 cm proximally to the supinator muscle in the forearm. The other terminal branch, the superficial nerve, carries sensory cutaneous fibers. The deep radial motor branch first supplies the extensor carpi radialis brevis muscle (ECRB) in some individuals and the supinator. Traditionally, the deep branch is referred to as the posterior interosseous nerve upon piercing the supinator, carrying motor fibers to the muscles of the posterior component of the forearm (with the notable exceptions of extensor carpi radialis longus and brachioradialis, which both receive direct radial innervation) as well as deep sensory fibers to the interosseous membrane and wrist capsule. Patients typically present with complete weakness of finger extension and milder wrist extension weakness, because of the preserved action of the extensor carpi radialis longus (ECRL). As a result of unopposed ECRL action, the wrist...
deviates radially in extension. Elbow extension, which is weakened in radial neuropathy at the spiral groove, is unaffected. Since radial sensory fibers are carried in the superficial radial sensory nerve, patients have no cutaneous sensory deficit, although may complain of forearm pain because of involvement of deep sensory fibers. Neurophysiological examination is thought to be essential to support the clinical diagnosis [6], demonstrating abnormal patterns exclusively in muscles innervated by the posterior interosseous nerve. It can also help rule out alternative diagnoses, particularly more proximal nerve or plexus lesions, listed in Table 1. Neuroimaging with MRI can have a significant complementary role, demonstrating acute or chronic muscle denervation and also providing additional information regarding local anatomical structures, thus shedding light on etiological factors which often remain hidden to the neurophysiological exploration. Here, we present two cases of PIN, demonstrating variations in clinical presentation and the impact of joint neurophysiological assessment and neuroimaging on diagnosis and management decisions.

Case 1

A 19-year-old woman was referred to our neurophysiology laboratory from her general practitioner. She reported a 3- to 4-month history of difficulty extending the index finger and thumb of the right hand. She had no sensory symptoms. Past medical history and family history were unremarkable. Weakness developed spontaneously with no history of trauma. She was unable to extend the metacarpophalangeal (MCP) joint of the right thumb or index finger. She was, however, able to extend the proximal interphalangeal joint of the index finger, indicating intact lumbrical function. Finger extension was slightly weak. Tenodesis effect, which involves observation of finger movement during passive wrist extension, indicated extensor tendons were intact. All other finger movements were normal. Neurological examination was otherwise unremarkable. A clinical diagnosis of posterior interosseous nerve syndrome was suspected and a tailored neurophysiological assessment was performed, detailed in Table 2. Motor responses of the radial nerve recorded from the extensor indicis proprius (EIP) muscles show relatively reduced amplitude on the affected site. Sensory responses were normal. Electromyography was performed 3- to 4-months after symptoms onset found abnormal posterior interosseous-innervated muscles. No abnormality was found in nonradial-innervated forearm muscles and radial-innervated muscles above the bifurcation of the radial nerve. Preservation of sensory responses was the main clue to further localize the process. The findings were felt to be consistent with a right posterior interosseous, subacute to chronic, axonal nerve lesion. Interestingly, not all muscles innervated by the posterior interosseous nerve were equally affected, suggesting a partial selective involvement of nerve fibers with relative fascicular sparing and explaining the clinical weakness limited to the index finger. She proceeded to MRI (Fig. 1), which found isovolumetric edema-like signal change in the extensor digitorum communis (EDC) muscle belly without fatty atrophy, indicating denervation occurring in recent months. No site of external compression was found and a spontaneous PIN was diagnosed. She was then referred to an orthopedic specialist who decided to explore the posterior interosseous nerve, finding swollen veins distal to the supinator, suggestive of compression. The proximal edge of the supinator muscle was released and the patient is now recovering with the help of physiotherapy.

Case 2

An 80-year-old man was referred by his general practitioner to our neurophysiology laboratory for assessment. He complained of poorly localized left forearm pain with complete weakness of extension of all fingers of the left hand. This had developed over 16–18 months with no history of preceding trauma. He had muscle wasting of the posterior compartment of the left forearm, complete weakness of extension of the thumb, and all fingers of the hand at the MCP joints, and was only able to extend the wrist against gravity. No sensory deficit was found. Neuropathological examination (see Table 3 found normal radial sensory responses and low-amplitude CMAP recording from EIP. Nerve conduction studies were otherwise normal. Electromyography showed severe active denervation limited to posterior interosseous-innervated forearm muscles. Studies supported an axonal lesion of the posterior interosseous nerve but failed to define the exact site of the lesion. Theoretically, the lesion could be
at or proximal to the takeoff of motor branches to the most proximal muscle affected. This is a common limitation when the pathophysiology is primary axonal loss which is often the case in PIN. The patient was sent for MRI (see Fig. 2) which demonstrated loss of muscle volume in the posterior forearm compartment with mild isovolumetric edema in supinator and EIP. Fatty infiltration of extensor pollicis longus (EPL) and abductor pollicis longus (APL) was noted, indicating a process of several months duration which was congruent with the electrophysiological findings. Prominence of the medio-proximal edge of ECRB indicated a potential site of nerve compression. A diagnosis of a spontaneous PIN secondary to compression by ECRB was made. In light of the severe abnormalities on neurophysiological assessment and the site of compression found on imaging, the patient was referred to discuss surgical intervention. Unfortunately, follow-up in this case is missing.

**Discussion**

Our two patients demonstrate variability in the presentation of PIN, and highlight the crucial role of neurophysiological assessment in securing the diagnosis. However, they also illustrate the important complementary role of MRI which can confirm the electro-clinical impression and add etiological information. Our first patient illustrates the phenomenon of partial nerve lesions. In this case, neurophysiological abnormalities correlated with the pattern of weakness, with the most significant changes found in EIP. The most common sites of compression seen in PIN, however, are located proximally to branches to other wrist and finger extensors. The absence of significant abnormalities in these muscles may lead to inaccurate assumptions regarding the localization of a lesion, or even misdiagnosis because the fascicular sparing and proximal reinnervation may not suggest a more proximal lesion along the posterior interosseous nerve. MRI

**Table 2. Key neurophysiological findings for case 1.**

| Nerve conduction studies | Right | | | Amplitude (μV) | CV (m/s) | | | Left | | | Amplitude (μV) | CV (m/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site | Latency (ms) | | | | | | | Latency (ms) | | | | | |
| Radial sensory (antidromic) | 1.62 | 26 | 62 | 1.58 | 22 | 63 |
| Radial Motor from EIP | 2.0 | 1.1 | / | 2.1 | 6.6 | / |

**Concentric needle electromyography**

| Muscle | Spontaneous activity | Recruitment pattern | Duration | Amplitude | Polyphasia |
|---|---|---|---|---|---|
| Right EIP | Fibs and PSWs | Reduced | Increased | Increased | Increased |
| Right ECR* | Nil | Slightly reduced | Increased | Increased | Increased |
| Right EDC | Nil | Slightly reduced | Increased | Increased | Increased |
| Right BR | Nil | Normal | Normal | Normal | Normal |
| Right FPL | Nil | Normal | Normal | Normal | Normal |
| Right FDI | Nil | Normal | Normal | Normal | Normal |

EIP, extensor indicis proprius; ECR, extensor carpi radialis; EDC, extensor digitorum communis; BR, brachioradialis; FPL, flexor pollicis longus; Fibs, fibrillation potentials; PSWs, positive sharp waves.

*Although extensor carpi radialis longus receives direct radial innervation, extensor carpi radialis brevis may be innervated from the posterior interosseous nerve. It can be difficult to distinguish between the two on neurophysiological assessment, explaining the findings in this study.

**Figure 1.** Isovolumetric edema-like signal change in the extensor digitorum communis (EDC) muscle belly without fatty atrophy, indicating denervation occurring in recent months.
findings of abnormality in other posterior interosseous-innervated forearm muscles complemented the neurophysiological findings, improving diagnostic certainty. The role of MRI in peripheral nerve disease has received attention since 1990s [7], and in both our patients, selective changes in the appearance of posterior interosseous-innervated muscles provided further support to the diagnosis of PIN. Muscle denervation can be detected with chronologically consecutive appearance on MRI, with hyperintense appearance on T2-weighted images visible from 48 h, followed months later by loss of muscle volume with fatty amyotrophic changes seen on T1-weighted images [8]. Our second patient once again illustrates the role of MRI in providing additional anatomical information and precise localization of a lesion. The pathophysiology of PIN very rarely consists of pure demyelination, and it is most often reported as a result of axonal damage. Abnormalities on EMG were found in posterior interosseous-innervated muscles, but sparing brachioradialis. This leads to the conclusion that the axonal lesion is likely to lie distal to the motor branch innervating brachioradialis. The symmetrical radial sensory responses help further localize a lesion to the posterior interosseous nerve. However, it was not possible either to determine the precise site of the lesion, or to distinguish between spontaneous compression and compression secondary to an external mass lesion. This information was secured on MRI, identifying a prominent proximal border of ECRB as the probable site of nerve compression, which in turn assisted management decisions dictating the need of surgical exploration.

**Conclusion**

We report two cases of a rare but potentially treatable cause of finger and wrist drop. Neurophysiological assessment is crucial in the investigation of suspected cases of PIN, although does have limitations. As a

### Table 3. Key neurophysiological findings for case 2.

| Nerve conduction studies | Latency (ms) | Amplitude (μV) | CV (m/s) | Latency (ms) | Amplitude (μV) | CV (m/s) |
|--------------------------|-------------|----------------|----------|-------------|----------------|----------|
| Radial sensory (antidromic) | 1.9 | 21 | 54 | 2.00 | 25 | 55 |
| Radial Motor from EIP | 2.3 | 8.3 | / | 2.5 | 1.1 | / |

| Concentric needle electromyography | Spontaneous activity | Recruitment pattern | Duration | Amplitude | Polymasia |
|-----------------------------------|---------------------|---------------------|----------|-----------|-----------|
| Left EIP | Fibs and PSWs | Discrete | Increased | Increased | Increased |
| Left FDI | Nil | Normal | Normal | Normal | Normal |
| Left APB | Nil | Normal | Normal | Normal | Normal |
| Left EDC | Fibs and PSWs | Reduced | Increased | Increased | Increased |
| Left ECR | Nil | Normal | Normal | Normal | Normal |
| Left BR | Nil | Normal | Normal | Normal | Normal |
| Left FPL | Nil | Normal | Normal | Normal | Normal |

EIP, extensor indicis proprius; ECR, extensor carpi radialis; EDC, extensor digitorum communis; BR, brachioradialis; FPL, flexor pollicis longus; FDI, first dorsal interosseous; APB, abductor pollicis brevis; Fibs, fibrillation potentials; PSWs, positive sharp waves.
primarily axonal neuropathy, it is difficult to localize the exact site of compression. It is also not possible to differentiate between spontaneous compression and compression secondary to an external mass lesion. MRI may support the neurophysiological findings and provide useful additional anatomical information in patients considered for surgical intervention. As MRI becomes more widely available, it is likely to have an expanding role in the diagnosis of peripheral nerve disorders including PIN. The main limitation of these case reports is that ultrasound studies were not available since they were not requested by the referring physician. Management of patient with upper limb nerve compressive syndrome is often fragmented between primary care and different specialist in the secondary setting. We believe ultrasound studies would have provided perhaps similar useful information and it would have been interesting to compare the US and MRI findings. Moreover, it was not possible to retrieve clinical information on the outcome of the second patient although we know that he was referred for surgical exploration. However, these cases have inspired us to explore the potential benefit of a multimodality diagnostic workup. Electrophysiology has probably been the traditional and only diagnostic station for peripheral nerve compressions but we feel that an integrated approach with imaging modalities such as MRI is going to be much more rewarding and useful. Future direction in our laboratory will be to strengthen our collaboration with the radiology team and develop an in situ ultrasonography service. We also hope to be able to provide more complete diagnostic information to the referring and treating physician hoping that an integrated diagnostic workup may lead to an integrated care pathway.

Conflicts of Interest

None declared.

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