Electrodiagnosis of Common Mononeuropathies

Median, Ulnar, and Fibular (Peroneal) Neuropathies

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KEYWORDS

• Median nerve • Ulnar nerve • Fibular nerve • Peroneal nerve • Mononeuropathy
• Carpal tunnel syndrome • Ulnar neuropathy at the elbow

KEY POINTS

- Standard electrodiagnostic techniques are recommended for the initial assessment of common mononeuropathies.
- Electrodiagnostic studies, including routine nerve conduction studies and comparison studies with higher sensitivity, are useful to assess for carpal tunnel syndrome or median mononeuropathy at the wrist.
- Ulnar neuropathy at the elbow diagnosis may require short segment stimulation analysis across the elbow.
- Fibular nerve entrapment may affect the common fibular nerve, but instances of isolated deep fibular or superficial fibular neuropathy may occur.
- Neuromuscular ultrasound examination has become an important tool to evaluate compressive mononeuropathies; neuromuscular ultrasound examination adds sensitivity and can evaluate for anatomic abnormalities contributing to a mononeuropathy.

INTRODUCTION

Several peripheral nerves are prone to compression at entrapment sites, including the median nerve at the wrist, ulnar nerve neuropathy at the elbow (UNE), and fibular (peroneal) nerve at the fibular head. Compression may occur when a nerve is superficial, neighboring a bony structure, pulled or stretched from repetitive use of a limb, or entrapped by overlying structures (eg, transverse carpal ligament). Other factors,

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such as associated weight loss in fibular (peroneal) neuropathies or diabetes, may predispose a nerve to compression. Electrodiagnosis (EDX) studies are useful tools in the evaluation of compressive mononeuropathies. EDX testing can confirm the presence of injury to a nerve, localize the site of injury along the nerve, determine the severity of the injury, and determine the degree of recovery, all of which are valuable in the diagnosis and management of mononeuropathies. This article reviews the EDX assessment and features of the most common compressive mononeuropathies.

MEDIAN NEUROPATHY AT THE WRIST (CARPAL TUNNEL SYNDROME)

Median neuropathy at the wrist is the most common compressive neuropathy encountered in neuromuscular clinics, with an incidence of 376 per 100,000 person-years.[1] The median nerve originates from the ventral rami of the C5 to T1 cervical roots. Sensory fibers course to the spinal cord through the lateral cord, upper and middle trunks, and C6 to C7 roots. Motor fibers are derived from the C6 to T1 roots, with the innervation to the thenar eminence muscles derived from the C8 to T1 roots, lower trunk, and medial cord (**Fig. 1**). The nerve supplies several forearm muscles before coursing through the carpal tunnel at the wrist, between the flexor retinaculum and the carpal bones.[1,2] The nerve divides and gives off the recurrent motor branch, which innervates the thenar muscles, and continues in the hand to innervate the first 2 lumbricals. Sensory fibers form the digital cutaneous nerves to the first 3, and the lateral one-half of the fourth digits.[1,2]

Compression of the median nerve within the carpal tunnel may cause carpal tunnel syndrome (CTS), with patients experiencing numbness, tingling, burning, and/or pain within the median dermatomal distribution. Predisposing factors for compression include rheumatoid arthritis, ganglion cysts, osteophytes, hereditary neuropathy with liability to pressure palsies, and other medical conditions such as diabetes, pregnancy, hypothyroidism, acromegaly, and amyloidosis.

Role of Electrodiagnostic Evaluation

CTS is a clinically defined syndrome, but EDX studies are important to confirm a process involving the median nerve at the wrist, assess the severity of nerve injury, exclude other mimicking disorders such as cervical radiculopathy or proximal median neuropathy, and evaluate for other superimposed processes, such as a more diffuse polyneuropathy.[1] Although EDX is sensitive for detecting injury to the median nerve at the wrist, approximately 5% to 25% of patients who meet the clinical criteria for CTS have normal routine EDX studies.[3–5] In patients with clinically suspected CTS in whom routine nerve conduction studies (NCS) are normal, more advanced studies, including comparison studies, increase the sensitivity for detecting mild CTS.[4–6] Although additional studies increase the sensitivity, the risk for false positives is also increased and may be between 5% and 46%.[1,5,7]

The hallmark EDX features in CTS is focal nerve slowing, indicating demyelinating, at the wrist, which is identified by prolonged distal latencies or slowed conduction velocities in the distal nerve segments of sensory (and often motor) nerves. A comprehensive CTS practice parameter from 2002 reviews the EDX protocol for evaluating CTS.[5] Using this protocol, a sensitivity of 85% and specificity of 95% can be achieved in diagnosing CTS.[5] Many EDX studies are available to assess CTS, and in most cases the routine sensory and motor NCS are sufficient to establish the diagnosis[4,8,9] (**Table 1**). However, in some circumstances, routine studies do not identify focal slowing and more advanced techniques or calculated indices can be used.[4,6] No single technique or index has been shown to be superior to others.[9]

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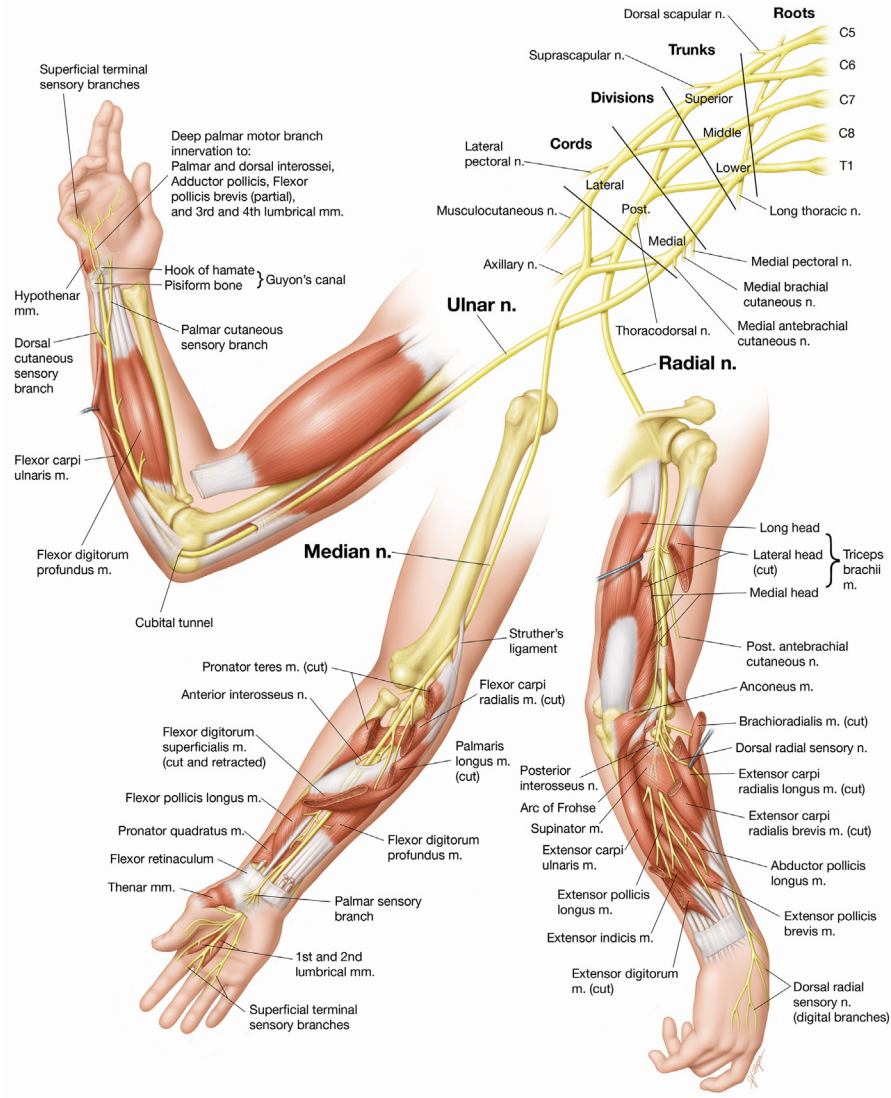

Fig. 1. Median, ulnar, and radial nerves and their origin from the brachial plexus. (*From* Dimberg EL. "Electrodiagnostic Evaluation of Ulnar Neuropathy and Other Upper Extremity Mononeuropathies." Neurol Clin 30 (2012), 479-503 as modified from the original (Neurology board review: an illustrated study guide. Rochester [MN]: Mayo Clinic Scientific Press and Boca Raton: Informa Healthcare USA; 2008); used with permission of Mayo Foundation for Medical Education and Research, all rights reserved.)

Routine Nerve Conduction Studies

Routine median motor NCS, recording from the thenar muscles, are performed to establish the presence of demyelination of the median nerve at wrist and assess disease severity.[1,5] Prolonged distal latencies with no or minimal conduction velocities slowing in the forearm localizes the lesion to the carpal tunnel, in the absence of similar

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Table 1
Studies used to evaluate for CTS

	ABN Value[a]	Sensitivity	Specificity
Sensory + mixed			
Median antidromic (digit 2)	Latency >3.6 ms Amplitude >15 μV Conduction velocities of >56 m/s	65%	98%
Orthodromic palmar study	Latency difference >0.3 ms	71%	97%
Median-ulnar (ring finger) antidromic (Ringdiff)	Latency difference >0.4 ms	85%	97%
Median-radial (thumb) antidromic (Thumbdiff)	Latency difference >0.5 ms	65%	99%
Combined sensory index (CSI)	>1 ms	83%	
Motor			
Median motor over APB	Latency >4.5 ms Amplitude <4 mV Conduction velocities of >48 m/s	63% 44%–55%	
Median-ulnar lumbrical vs interosseous study	Latency difference >0.5 ms		

[a] Reference values are laboratory dependent.

changes in other nerves.[1,5] In more severe disease characterized by axonal loss, low compound muscle action potential (CMAP) amplitudes may occur.

The median motor NCS are often normal in mild CTS, are less sensitive than median sensory NCS, and sensory NCS are almost always affected before motor NCS. There are multiple sensory or mixed NCS options, each with benefits and technical challenges. The median antidromic NCS, recording from the index finger, is a routine study and is useful to establish the integrity of sensory fibers.[5] Although distal latency prolongation is typical, polyneuropathy can also result in prolonged sensory DLs and comparison to nonmedian nerves is important.[1,5] Because the median antidromic NCS tests a longer nerve segment than midpalmar studies, in mild CTS with only slight focal demyelination, the sensitivity of antidromic studies is decreased . The median orthodromic mixed NCS assesses a shorter nerve segment (usually 8 cm), which increases the sensitivity of detecting mild slowing. However, this study has more technical challenges, such as stimulus artifact, which makes it more difficult than antidromic studies.

Advanced Techniques

Lumbrical recording

In patients with a severe median neuropathy at the wrist with degeneration of most or all axons, no CMAP response may be recorded from the thenar muscles. In this situation, localization to the wrist cannot be made because an absent response could also be seen with a more proximal median neuropathy. Detecting conduction slowing across the wrist can sometimes be accomplished by recording from second lumbrical (median innervated), because the fibers to that muscle are relatively spared compared with fibers to the thenar muscles. This technique compares the median CMAP latency from the second lumbrical to the ulnar CMAP latency recording from the second palmar interossei. A latency difference of greater than 0.5 ms is abnormal.[10–12]

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Segmental palmar studies

The median NCS can also be performed with segmental, across palmar stimulation (Fig. 2). This testing is most useful in the context of a low amplitude median sensory nerve action potential (SNAP), because it may help to distinguish CTS from a more diffuse polyneuropathy. Because segments of the median nerve outside the carpal tunnel should conduct relatively normally in CTS, if both intracarpal and distal segments are abnormal, there is more likely a diffuse process such as neuropathy.[1] Also, in the presence of conduction block in the carpal tunnel, stimulation of the distal segment will yield a larger SNAP. Neuropraxia (focal segmental demyelination) is present if the amplitude of the proximal median SNAP is 50% or more of the distal SNAP.[1]

Short segment stimulation across the wrist

Sensory short segment stimulation ("inching") across wrist can be performed to assess very focal slowing or conduction block. Technical challenges include risk of stimulating overlapping sites and stimulation artifact. A peak latency difference of 0.5 ms or more between 2 inching sites is considered abnormal.[13]

Comparison Studies

Studies that compare the median sensory latencies with other nerves in the same hand are more sensitive in the diagnosis of CTS than only an absolute median nerve latency.[1,4,5,14,15] Comparison studies allow one to assess the focality of a median nerve injury using the patient as their own control. Comparison studies include median and ulnar antidromic (fourth digit recording), median and radial antidromic (thumb recording), and median–ulnar orthodromic (palmar) mixed NCS (see Table 1).

Combined sensory index

Multiple comparison studies can be combined into a sensory index (combined sensory index). Originally described by Robinson and colleagues,[7] this index is the sum of latency differences of the first digit (thumb) difference + fourth digit (ring) difference + palmar difference studies.[1] A sum of greater than 0.9 ms is abnormal. It has a reported sensitivity of 83% and specificity of 95%. However, because multiple comparisons are used to evaluate for focal entrapment, it increases the risk of a type 1 error (false positive). In contrast, if more than 1 finding is abnormal, it decreases the risk of type 1 error.[7]

Needle Electromyography

Needle electromyography (EMG) is important to help define the severity and degree of denervation, as well as to exclude other conditions such as proximal median neuropathy, cervical radiculopathy, or brachial plexopathy. Needle EMG of the thenar muscles is rarely abnormal if motor NCS are normal.[16] With severe CTS, needle EMG may assist with prognostication by assessing the degree of denervation (fibrillation potentials) and reinnervation.[5]

Carpal Tunnel Syndrome Grading

Many grading systems for assessing the severity of CTS have been developed using either EDX criteria alone or a combination of clinical and EDX criteria.[17–20] Most EDX grading scales incorporate the degree of sensory and motor NCS abnormalities, including the presence of conduction slowing (suggesting neuropraxis) or amplitude reduction (suggesting axonotmesis/neurotmesis). The grading systems have been questioned owing to a lack of correlation between the patient's clinical and electrophysiologic severity.[21] Treatment decisions should be based on clinical judgment and the consistent use of 1 system, rather than arbitrary applications. There is a

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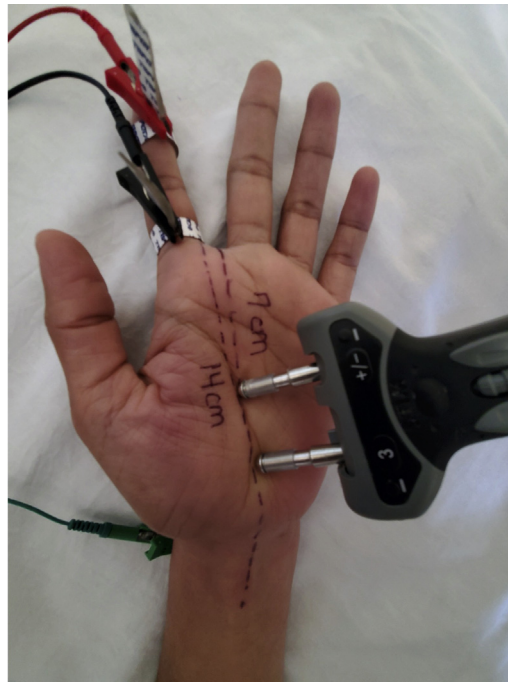

Fig. 2. Setup for segmental median palmar NCS.

positive correlation between CTS severity based on grading and improvement with surgical outcome.[6,17,22] A correlation between EDX severity and surgical outcome has also been shown.[8]

Electrodiagnostic Findings after Carpal Tunnel Syndrome Release

NCS are performed postoperatively in patients who have no clinical improvement after carpal tunnel release surgery or who develop symptoms again later in life. NCS may be important to evaluate for inadequate decompression or recurrence of entrapment. NCS are the only objective way to determine and quantify improvement after decompression. After surgery, improvement in electrophysiologic severity is seen in about 82% to 88% of patients at 6 to 9 months.[23] However, this finding may not correlate with symptom improvement. Sensory and motor latencies improve at 6 and 12 months respectively, but some slowing may persist in both latencies at 12 months in 80% of cases.[24] Because latencies improve but may not return to normal in most cases, recurrence of median nerve entrapment can only be diagnosed by comparing preoperative and postoperative NCS.

Neuromuscular Ultrasound Examination

Neuromuscular ultrasound (NMUS) examinations have become an important adjunct to EDX for evaluation of CTS. NMUS can confirm the diagnosis of CTS, detect mass lesions or structural abnormalities, and identify anatomic variants.[25–27] The cross-sectional area (CSA) of the nerve is measured at the wrist and a CSA ratio comparing wrist to forearm is calculated (**Fig. 3**). Many studies have shown a similar sensitivity and specificity of NMUS examination to EDX[26] and therefore NMUS examination is

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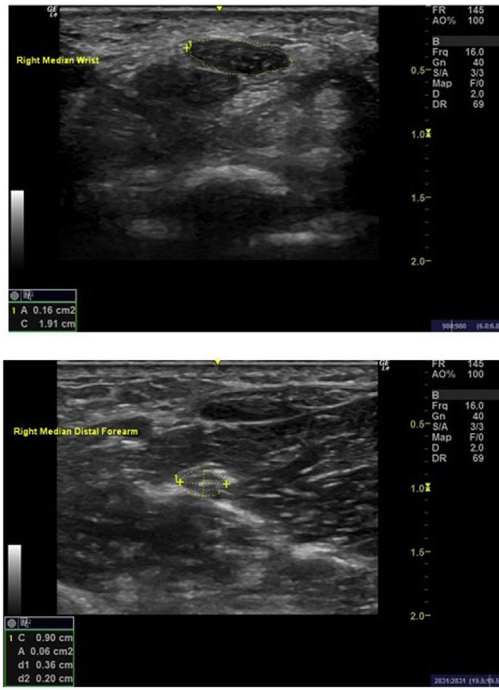

Fig. 3. Ultrasound examination of the median nerve at the wrist. (*Top*) Median nerve at the wrist. Enlarged median cross-sectional area (CSA) of 16 mm^2 at the wrist. (*Bottom*) Median nerve in forearm (CSA 6 mm^2). (*Courtesy of* Katalin Scherer, MD.)

considered an adjunct to EDX studies.[26,27] In rare cases, NMUS examination may detect enlargement of the median nerve when EDX is normal.[27]

ULNAR NEUROPATHY

The ulnar nerve is the second most common mononeuropathy, and most commonly occurs owing to compression or subluxation at the elbow (UNE).[28] The ulnar nerve may be injured at the retrocondylar groove, humeroulnar arcade (ie, cubital tunnel), or, less commonly, at Guyon's canal at the wrist.[29–32] Although UNE can often be diagnosed by clinical examination, clinical localization is not always accurate.[28,33] Thus, EDX is an important tool to localize the site of nerve injury, assess severity, exclude other localizations (eg, C8 root or plexus), and help to guide management.[34,35]

The ulnar nerve derives from the C8 to T1 nerve roots, the lower trunk and medial cord.[28,33] There are no branches in the arm. The nerve passes in the retrocondylar groove and enters the cubital tunnel under the humeroulnar arcade approximately 2 to 3 cm distal to the medial epicondyle[30] (see **Fig. 1**; **Fig. 4**). In the forearm, the ulnar nerve innervates the medial portion of the flexor digitorum profundus (digits III and IV) and the flexor carpi ulnaris and gives off the dorsal ulnar cutaneous sensory branch, which supplies the dorsomedial hand.[30,32] At the wrist, it enters Guyon's canal, divides into a superficial branch (supplying the palmaris brevis muscle and the palmar sensation to the fifth and medial fourth digits), and a deep motor branch (innervating the ulnar hand muscles).[31,36]

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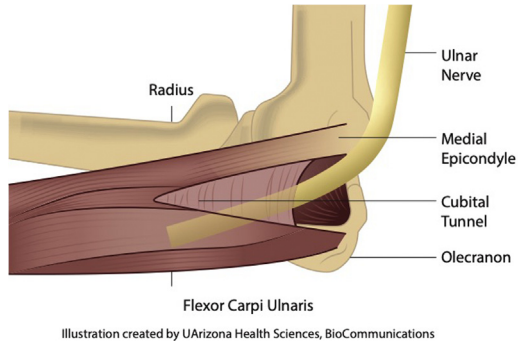

Fig. 4. Ulnar nerve at the elbow.

Patients with UNE present with subacute to chronic paresthesias of the fourth and fifth digits with some radiation into the hand. Although patients may perceive radiation into the forearm, objective sensory changes in the medial forearm sensory would indicate a more proximal localization (eg, medial cord/lower trunk or C8–T1 nerve root). The clinical findings of compression at Guyon's canal can seem similar to UNE, although sensation to the dorsum of the hand is spared.[31,36]

Role of Electrodiagnostic Evaluation

The goals of EDX testing in suspected UNE are to (1) confirm the presence of an ulnar neuropathy, (2) localize the site of injury along the nerve, (3) exclude other lesions/pathology such as polyneuropathy, C8 radiculopathy, or brachial plexopathy, (4) assess the pathophysiology (ie, demyelinating or axonal loss), (5) define the temporal course, and (6) define severity.[28,29] EDX studies have a high specificity but relatively low sensitivity for identifying UNE.[29,37,38]

NCS are the most useful techniques to confirm and localize an ulnar neuropathy[28,29,33] (**Table 2**). Routine ulnar motor and sensory NCS may be sufficient to identify the general region of nerve involvement, although advanced techniques (such as short segment studies) are often needed in mild cases or to more precisely localize the site of injury.[39] Although sensory NCS are usually affected earlier than motor NCS, motor NCS are more helpful to more precisely localize the injury around the elbow since they can better identify focal conduction block or a small latency shift.[29,32,36]

Routine Nerve Conduction Studies

Routine ulnar CMAPs are performed with recording from the abductor digiti minimi with stimulation at the wrist, below the elbow, and above the elbow sites.[29] The criteria for confirmation of UNE include absolute conduction velocities in the below the elbow–above the elbow segment less than 50 m/s or greater than 10 m/s slowing in the below the elbow–above the elbow segment compared with the wrist–below the elbow segment. A conduction block is suspected if the CMAP amplitude and area decreases by greater than 20% between below the elbow and above the elbow sites.[29,40] A recent study has highlighted statistical errors that may occur when strict diagnostic criteria are used; therefore, a graduated system based on pretest probability is recommended.[34,41,42]

The ulnar sensory antidromic NCS (recording fifth digit) assesses the ulnar sensory axons that course across the elbow. In demyelinating UNE, conduction velocity slowing in the sensory fibers may be seen; in more severe injury with axon loss, the SNAP amplitude is decreased. Sensory NCS findings are less useful at localizing the site of

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Table 2
Electrodiagnostic findings in ulnar neuropathies and other mimickers

	Ulnar Nerve				
	Deep Motor Branch (Hand)	Guyon's Canal	Elbow	Medial Cord/ Lower Trunk	C8 Root
NCS					
Ulnar motor (abductor digiti minimi)	N	ABN	ABN	ABN	ABN
Ulnar motor (first dorsal interosseous)	ABN	ABN	ABN	ABN	ABN
Ulnar sensory (fifth digit)	N	ABN	ABN	ABN	N
Dorsal ulnar cutaneous	N	N	ABN	ABN	N
Needle EMG					
First dorsal interosseous	ABN	ABN	ABN	ABN	ABN
Abductor digiti minimi	N	ABN	ABN	ABN	ABN
Flexor carpi ulnaris	N	N	May be ABN	ABN	ABN
Abductor policis brevis	N	N	N	ABN	ABN

Abbreviations: ABN, abnormal; N, normal.

injury along the nerve because the conduction block is more difficult to identify in sensory nerves. The ulnar SNAP may also be abnormal in lower trunk/medial cord plexopathies but is normal in C8/T1 radiculopathies. If Guyon's canal compression is suspected, the dorsal ulnar cutaneous sensory study should be performed.[29,36] In the setting of absent or decreased amplitude ulnar sensory antidromic studies, a normal dorsal ulnar cutaneous localizes the lesion at or distal to the wrist.

Advanced Nerve Conduction Studies

First dorsal interosseous recording

If no abnormality is identified on routine ulnar motor NCS recording from the abductor digiti minimi but the clinical suspicion is strong, recording from the first dorsal interosseous may increase sensitivity for detecting UNE.[28,41] In addition, abductor digiti minimi CMAPs may be normal in lesions affecting the deep palmar branch, but the first dorsal interosseous CMAPs will be affected. For suspected ulnar neuropathies at the wrist, ulnar CMAP to the first dorsal interosseous and dorsal ulnar cutaneous sensory are important to aid in localization.[29]

Short segment motor stimulation

A short segment study (inching) is a useful technique to localize more precisely the site of nerve compression by identifying a very focal area of demyelination, as identified by a focal latency shift or conduction block.[29] Several recent papers have evaluated the sensitivity and specificity of short segment studies.[40,42,43] Multiple studies have validated this technique, but have not agreed on the most common compression site; however, the most common site of maximal prolongation in latency or decrease in amplitude seems to be either just proximal or distal to the medial epicondyle[40,42,43] (**Fig. 5**).

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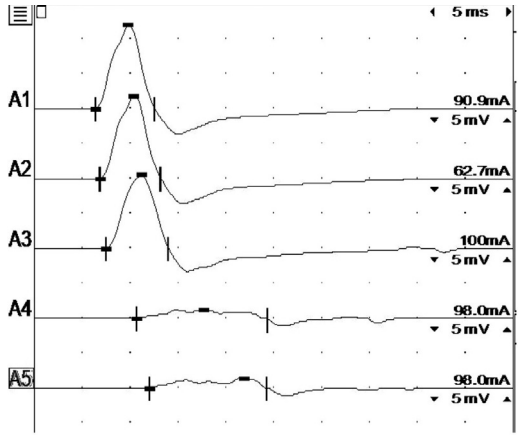

Fig. 5. Ulnar motor inching technique, showing a conduction block 1 cm proximal to medial epicondyle (between stimulation sites A3 and A4). (*Courtesy of* Devon Rubin, MD.)

Short segment sensory stimulation

In up to 20% of patients with clinical features consistent with mild UNE, routine NCS and even motor short segment studies may be insensitive to identify an abnormality.[40,42] Vazquez do Campo and colleagues[39] published a pilot study evaluating sensory 2-cm short segment studies across the elbow recording from the fifth digit, which improved the sensitivity of diagnosing UNE. Values of more than a 0.7-ms latency shift or a more than 15% decrease in amplitude were proposed.[39]

Needle Electromyography

Needle EMG is less helpful than NCS at precisely localizing the site of involvement along the ulnar nerve, but is useful to assess the severity and exclude other localizations (eg, C8 radiculopathy or brachial plexopathy).[29] Needle EMG is often normal if the underlying pathology is mild demyelination or only sensory fibers are involved. Needle EMG may demonstrate only decreased recruitment if there is focal conduction block without axonal loss, or fibrillation potentials and/or long duration motor unit potentials in axonal loss.[37,44] Proximal ulnar-innervated muscles (flexor carpi ulnaris or flexor digitorum profundus) may be normal on needle EMG owing to fascicular involvement or branching to those muscles proximal to the elbow.[28,29,44]

Neuromuscular Ultrasound Examination in Ulnar Nerve Neuropathy at the Elbow

NMUS examination can improve the sensitivity of diagnosing UNE.[25,38,42,45–47] An ulnar nerve circumference of more than 11 mm^2 or a ratio of ulnar nerve at the elbow to the wrist of more than 1.4 are considered abnormal[38,47] (**Fig. 6**). Ultrasound examination alone, without EDX, has been shown to have high sensitivity and specificity.[40,42] However, ultrasound examination does not provide information on severity or physiologic nerve function. Therefore, EDX and NMUS examination are complementary.[43,46]

FIBULAR (PERONEAL) NEUROPATHY

Compression of the common fibular nerve at the fibular head is the most common compression neuropathy of the lower extremity.[48–50] Causes include frequent leg crossing, prolonged kneeling, or significant weight loss (slimmer's palsy). Clinically,

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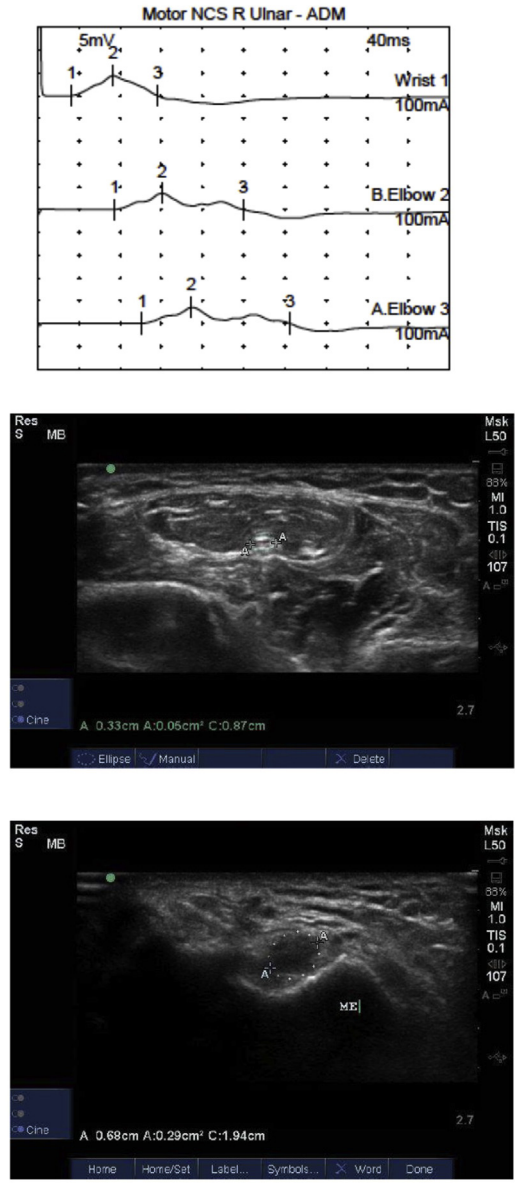

Fig. 6. Ulnar neuropathy at the elbow. (*Top*) Ulnar NCS with low amplitudes and temporal dispersion owing to axonal loss. (*Middle*) Ultrasound examination of the ulnar nerve under the flexor carpi ulnaris with normal CSA 5 mm^2. (*Bottom*) Enlarged ulnar nerve CSA of 29 mm^2 adjacent to the medial epicondyle. (*Courtesy of* Katalin Scherer, MD.)

patients present with weakness of foot dorsiflexion and eversion and numbness over the lateral leg and dorsum of foot.[50,51]

The fibular nerve contains axons originating in the L4 to L5 roots, which course through the lumbosacral plexus and sciatic nerve to form the common peroneal nerve

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Table 3
Electrodiagnostic findings in fibular neuropathies and mimickers

	Fibular Neuropathy						
	Deep Fibular (Ankle)	Deep Fibular (Leg)	Superficial Fibular (Ankle)	Superficial Fibular (Leg)	Common Fibular	Sciatic Nerve	L5 Root
NCS							
Fibular motor (extensor digitorum brevis)	ABN	ABN	N	N	ABN	ABN	ABN
Fibular motor (AT)	N	ABN	N	N	ABN	ABN	ABN
Superficial fibular sensory	N	N	ABN	ABN	ABN	ABN	N
Needle electromyography							
Anterior tibialis	N	ABN	N	N	ABN	ABN	ABN
Peroneus longus/brevis	N	N	N	ABN	ABN	ABN	ABN
Biceps femoris, short head	N	N	N	N	N	ABN	ABN
Gluteus medius	N	N	N	N	N	N	ABN

Abbreviations: ABN, abnormal; AT, anterior tibialis; N, normal.

in the distal thigh. In the thigh, the fibular nerve gives off a branch to the short head of the biceps femoris and then courses posterior and distal to the fibular head, which is the most common site of compression.[50–52] The nerve divides into 2 branches, namely, the deep and superficial branches.[49,51] The deep branch innervates foot extensors, including the extensor digitorum brevis and the tibialis anterior, extensor digitorum longus, and peroneus tertius.[49] The superficial branch innervates the peroneus longus and brevis and divides into the medial and lateral dorsal cutaneous branches, supplying sensation to the entire dorsum of the foot, except for the first and second digit interspace, which is supplied by the deep fibular nerve.[49,52]

Role of Electrodiagnostic Testing

Electrodiagnostic evaluation of fibular neuropathy helps to confirm the diagnosis, localize the site of involvement along the nerve, determine which fibular branches are involved, assess severity, and exclude other localizations (eg, L5 radiculopathy or sciatic neuropathy)[1,48,53] (**Table 3**). A combination of NCS and needle EMG help to define those features.

Routine Nerve Conduction Studies

As discussed in the 2005 American Association of Neuromuscular Electrodiagnostic Medicine practice parameter, the fibular nerve EDX studies have not been standardized.[53–55] Injury to the common fibular nerve may cause focal demyelination, which is manifest on NCS as conduction velocities slowing or conduction block at the fibular head, or axonal loss, which is manifest by low amplitudes. If only the deep fibular branch is involved, motor NCS to the extensor digitorum brevis and/or tibialis anterior may be involved but superficial fibular sensory NCS will be spared. In contrast, superficial fibular neuropathies may have normal motor NCS but abnormal superficial fibular SNAP.[51,53,56]

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The criteria for abnormality on the fibular motor NCS include greater than 20% drop in amplitude at the fibular head compared with the ankle.[44,50] Other studies use a combination of findings, including a 50% decrease in amplitude at the knee compared with distal amplitude or conduction velocity slowing of more than 10 m/s in the across fibular head segment (knee–fibular head) compared with below the fibular head segment (fibular head–ankle)[53,54,57](**Fig. 7**). If the CMAP amplitude at ankle is low (<2 mV), localization may be difficult because focal slowing or conduction block (CB) may not be identified.[53,54] Recording from the tibialis anterior, which may be relatively spared compared with the extensor digitorum brevis, may assist in identifying focal slowing or CB at the fibular head.[51,53]

The superficial fibular sensory NCS will be the only sensory NCS that is abnormal in fibular neuropathies characterized by axonal loss and involving the common or superficial fibular nerves, but will be spared in conditions involving only the deep branch.[54,56] Furthermore, in common fibular neuropathies characterized by CB, the superficial fibular SNAP may be normal because stimulation is usually performed at a site distal to the block.[53,56]

Needle Electromyography

Needle EMG helps to define the temporal course of the injury, severity, degree of axonal loss, and degree of reinnervation.[48,51] Needle examination of muscles supplied by the deep and superficial branches is important to localize the lesion. Furthermore, when all fibular leg muscles are abnormal and focal slowing or block is not identified at the fibular head, examination of the short head of the biceps femoris is important to identify the most proximal site of the injury. Because all fibular muscles are supplied by the L5 root, other nonfibular L5 muscles should be examined to exclude an L5 radiculopathy.

Advanced Studies

Short segment stimulation

Short segment stimulation (inching) with stimulation in 2-cm segments across the fibular head may be more sensitive than routine NCS in identifying focal slowing.[55] Inching can be performed recording from the extensor digitorum brevis or the tibialis anterior.

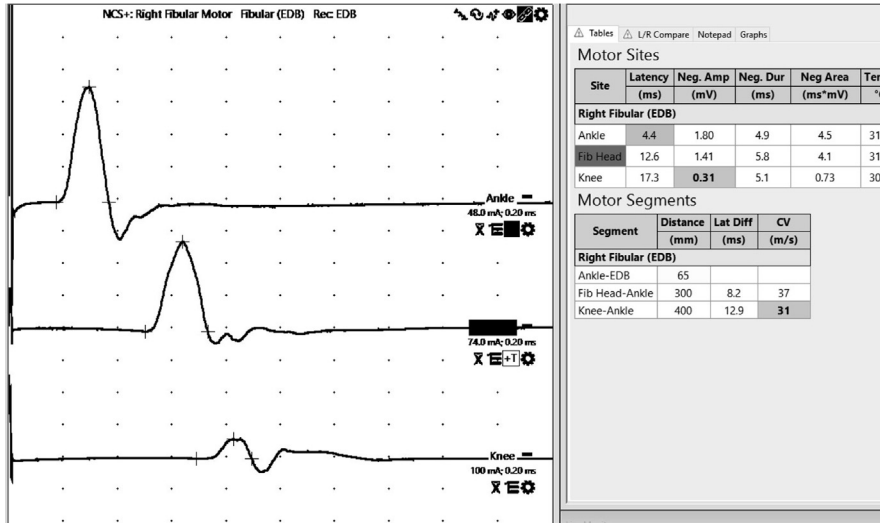

Fig. 7. Fibular motor NCS demonstrating a conduction block at the fibular head.

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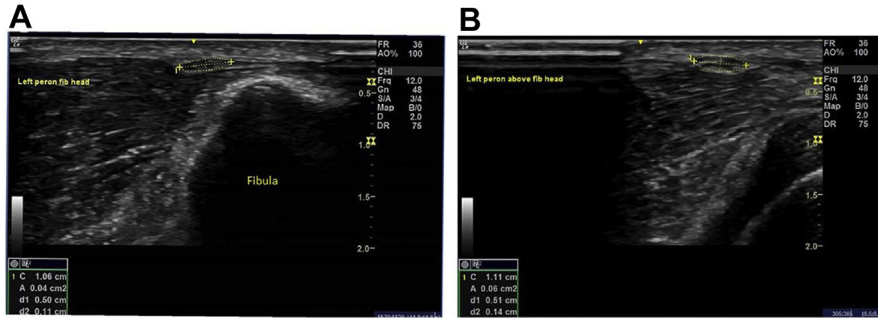

Fig. 8. Ultrasound examination of a normal fibular nerve at (*A*) fibular head (nerve CSA 4 mm^2) and (*B*) the knee (nerve CSA 6 mm^2). (*Courtesy of* Katalin Scherer, MD.)

Neuromuscular Ultrasound Examination

Ultrasound examination, assessing the CSA of the nerve at the fibular head, can complement EDX testing, and enlargement of the fibular CSA supports a fibular mononeuropathy[50,57] (**Fig. 8**). Furthermore, NMUS examination can occasionally identify structural processes as the cause of the fibular neuropathy.[57,58] Ganglion cysts have been reported to occur in up to 18% of confirmed fibular neuropathy.[58]

SUMMARY

The median, ulnar, and fibular nerves are the most commonly injured peripheral nerves. Electrodiagnostic testing plays an important role in assessing these mononeuropathies. Although routinely performed NCS and needle EMG studies may be sufficient to provide the necessary localization and information about the nerve function, in some case, more advanced techniques are necessary. The addition of NMUS examination promises to assist with localization and demonstration of any potential underlying structural abnormality.

CLINICS CARE POINTS

Median Neuropathy:
- Comparison studies can be more sensitive than routine nerve conduction studies in diagnosing carpal tunnel syndrome.
- Neuromuscular ultrasound can be used to confirm, diagnose or evaluate for any structural etiologies for median neuropathy at the wrist.

Ulnar neuropathy:
- In patients with a strong clinical suspicion of ulnar neuropathy at the elbow and normal routine ulnar motor study with recording from Abductor digiti minimi, recording from First dorsal interrossei may increase sensitivity.
- Short segment (inching studies) is a useful technique to precisely localize the site of ulnar nerve compression at elbow.
- Neuromuscular ultrasound is an useful adjunct test to improve sensitivity for diagnosing UNE.

Fibular neuropathy:
- The fibular head is the most common site of compression for common fibular neuropathies, but sometimes isolated superficial or deep branches of the peroneal nerve may be involved.

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- Neuromuscular ultrasound can complement EDX testing and may help identify structural processes like ganglion cysts as cause of fibular neuropathies.

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