An electrodiagnostic technique for assessing palmar proper digital nerves of the hand

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BACKGROUND

The palmar proper digital nerves (PaPDNs) are the sensory terminal branches of the ulnar and median nerves. Two PaPDNs course along the sides of each finger, and they supply the palmar aspect of all fingers and the distal dorsal aspect of the first 3 fingers. The median PaPDNs branch from the 3 palmar divisions of the median nerve (PDMN). The ulnar PaPDNs derive from the superficial ulnar branch (SUB). Trauma of the palm of the hand and fingers is common and may involve the PDMNs, the SUB and its divisions, or the PaPDNs. Recent progress in microsurgical techniques for repairing and grafting peripheral nerves produces a consistently better outcome. Identification of PaPDN lesions after hand trauma is important to select patients who will undergo surgery, but there is no accepted electrodiagnostic technique for evaluating these nerves.

AIM OF THE STUDY

This study was designed to investigate the sensory nerve action potentials (SNAPs) obtained from selective antidromic stimulation of the PaPDNs. To this aim, we studied a group of normal subjects to derive normative data, compared them to those obtained from standard nerve conduction study, and investigated the selectivity of the stimulation technique and the effect of different recording electrode positions.

SUBJECTS AND METHODS

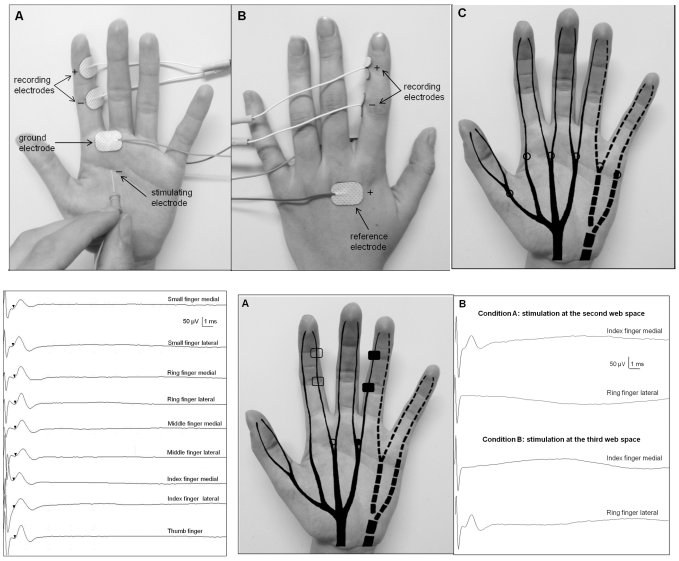
Participants. 14 normal controls (7 men, 45.5 ± 14.1 years, range: 28-70).

PaPDN stimulation. SNAPs were recorded in response to antidromic stimulation (duration 0.1 ms) of the PaPDNs. The stimulating cathode was placed in the webspace between the bases of 2 adjacent fingers in the distal part of the palm at the level of the metacarpophalangeal joint. The reference electrode was placed on the dorsum of the hand in the space between 2 adjacent metacarpophalangeal joints. The SNAPs were recorded (20 μV/division; band pass 10–2000 Hz) from a pair of 15 x 12 mm Ag-AgCl surface electrodes placed on the medial and lateral aspects of the fingers at the proximal and distal interphalangeal joints. The stimulus intensity was initially set at 0.5 mA and then increased by 0.5 mA steps until a supramaximal SNAP was recorded.

Mixed nerve stimulation at the wrist. To compare the selective antidromic PaPDN electrodiagnostic technique to a standard one, SNAPs from single PaPDNs of each finger were recorded with antidromic stimulation (0.1 ms, stimulus set at 1 mA, then increased by 1 mA until a supramaximal SNAP was recorded) of the ulnar and median nerves at the wrist with a bipolar stimulator. The recording electrode type and position, sensitivity, and band pass filters were the same as for selective PaPDN stimulation.

Selectivity of PaPDN stimulation. To investigate the selectivity of PaPDN stimulation, the second and third webspaces were studied. In condition A, the second webspace was stimulated and we recorded SNAPs from the medial index finger PaPDN (test response, open rectangles) and the lateral ring finger PaPDN (control response, closed rectangles). In condition B, the third webspace was stimulated (closed circle), and SNAPs were recorded from the lateral ring finger PaPDN (test response, closed rectangles) and the medial index finger PaPDN (control response, open rectangles). In both conditions, stimulation was increased to twice the intensity that could achieve maximal SNAP amplitude in the test response. In case of selective PaPDN stimulation, a SNAP was to be expected in the test response but not in the control response. However, the presence of a SNAP in the control response would indicate either non-selective PaPDN stimulation (i.e. stimulation of PaPDNs from 2 contiguous PDMNs) or the presence of a volume-conducted response.

Effect of recording electrode position. We examined the effect of the position of surface electrode on the amplitude of the PaPDN SNAPs. The second webspace was stimulated, and the amplitude of the medial index finger PaPDN SNAPs was recorded from 2 pairs of surface electrodes placed on the medial (test response) and lateral (control response) sides of the index finger.

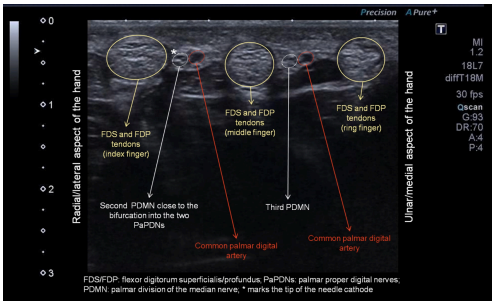


PaPDNs SNAP amplitude

PaPDN	Right side†	Left side†	L/R ratio*
Small finger medial	32.7 [25.9–41.6]	33.1 [25.7– 42.5]	1.0 ± 0.2
Small finger lateral	33.6 [26.1–43.3]	35.0 [28.5– 42.6]	1.1 ± 0.2
Ring finger medial	33.1 [25.7–42.7]	34.3 [27.7–42.3]	1.0 ± 0.2
Ring finger lateral	35.2 [25.2–47.3]	34.8 [25.4–47.7]	1.0 ± 0.1
Middle finger medial	36.1 [27.3–47.8]	35.7 [28.0–45.5]	1.0 ± 0.2
Middle finger lateral	33.1 [26.7–41.2]	35.2 [27.4–45.1]	1.1 ± 0.2
Index finger medial	35.3 [26.6–47.0]	35.2 [28.7–43.5]	1.0 ± 0.1
Index finger lateral	32.8 [24.8–43.2]	33.8 [28.1–40.7]	1.0 ± 0.2
Thumb*	32.7 [28.1–40.7]	33.2 [25.1–43.9]	1.0 ± 0.2

PaPDNs SNAP latency and SNCV

	Right side		Left side	
PaPDN	SNAP latency (ms)	SNCV (m/s)	SNAP latency (ms)	SNCV (m/s)
Small finger medial	1.0 ± 0.1	58.4 ± 4.7	0.9 ± 0.1	58.3 ± 3.9
Small finger lateral	0.9 ± 0.1	58.1 ± 4.0	0.9 ± 0.1	59.4 ± 4.1
Ring finger medial	1.1 ± 0.2	59.1 ± 5.0	1.0 ± 0.2	58.1 ± 4.4
Ring finger lateral	1.0 ± 0.2	57.9 ± 3.8	1.1 ± 0.2	58.9 ± 4.3
Middle finger medial	1.1 ± 0.2	58.8 ± 4.2	1.0 ± 0.2	58.5 ± 4.4
Middle finger lateral	1.0 ± 0.2	58.0 ± 6.5	1.0 ± 0.2	59.1 ± 3.8
Index finger medial	1.1 ± 0.1	59.3 ± 4.2	1.0 ± 0.1	58.7 ± 4.1
Index finger lateral	1.1 ± 0.1	58.9 ± 3.8	0.9 ± 0.1	58.4 ± 3.7
Thumb*	1.0 ± 0.1	58.2 ± 3.7	0.9 ± 0.1	58.5 ± 4.2



DISCUSSION

In all the normal controls, SNAPs could be easily obtained for each medial and lateral PaPDN of each finger except the thumb. For anatomical reasons the 2 PaPDNs of the thumb bifurcate from the division of the lateral PDMN at the metacarpophalangeal joint and cannot be stimulated separately. The average SNAP amplitude ranged from 32.7 to 35.7μV; the average SNAP latency to onset ranged from 0.9 to 1.1 ms; and the average SNCV to onset ranged from 58.0 to 59.3 m/s. Our findings can provide normal data for documenting not only complete lesions of PaPDNs but also partial damage and/or separate them according to prevalent demyelinating or axonal damage. Among the subject variables we tested, only age turned out to significantly influence SNAP amplitude.

Comparison of data from PaPDN and mixed nerve stimulation showed that SNAPs to webspace stimulation were larger than those to wrist stimulation. When mixed nerves at the wrist were studied, selective stimulation of a single PaPDN could be obtained only for the ring finger, where the medial and lateral PaPDN derive from the ulnar and median nerves, respectively. In the ring finger, the SNAP amplitudes to mixed nerve stimulation at the wrist were approximately half of those obtained by PaPDN stimulation at the webspace. In the thumb, where the lateral and medial PaPDNs could not be stimulated separately at the wrist or in the webspace, SNAPs to mixed nerve stimulation were approximately 60% of those to PaPDN stimulation. In the small, middle, and index fingers, where the 2PaPDNs were stimulated together at the wrist, SNAPs to webspace stimulation were similar or slightly larger than those to wrist stimulation, even though a single PaPDN was stimulated in the former and simultaneous stimulation of 2 PaPDNs occurred in the latter. The presence of smaller SNAPs to wrist than webspace stimulation is in accordance with previous inching studies of the median nerve through the palm, where SNAP amplitude to distal palm stimulation was approximately 50% of that to wrist stimulation. Our data are also in keeping with the notion that conduction distance has a strong influence on SNAP amplitude, which decreases with increasing distance following a power relationship with an exponent of 1.4 to 1.7 due to temporal dispersion with decreased summation and increased phase cancellation.

We found that our technique selectively stimulated PaPDNs at the webspace, because no SNAP was evoked in the control condition even at twice the intensity that could achieve maximal SNAP amplitude in the test condition. Ultrasound data documented that the needle electrode was very close to the stimulated nerve and distant from the nerve not intended to be stimulated. These findings, together with the low stimulation intensity needed to achieve a supramaximal SNAP, suggest that the technique resulted in near-nerve stimulation. Selectivity of webspace stimulation is a strong point in favor of our technique in comparison with wrist stimulation, which cannot evoke a SNAP from a single PaPDN except for the ring finger.

The position of the electrodes on the medial or lateral side of the finger influenced the amplitude of recorded SNAP, in that the SNAP amplitude on the stimulated side was approximately twice (range: 1.5 to 5 times) as large as on the opposite side of the finger. These results are in accordance with a previous study and indicate the presence of a potential pitfall with ring electrodes. As a consequence, to enhance the specificity of SNAP findings to webspace stimulation, we favor the use of a pair of lateralized surface electrodes instead of classical ring ones.

This technique was applied to 2 patients with selective damage of a PaPDN after traumatic lesions in the palm or fingers. In both patients, standard nerve conduction study to mixed nerve stimulation at the wrist yielded inconclusive findings. In contrast, application of selective stimulation at the webspace clearly documented the PaPDN damage. Not only the absence of the PaPDN SNAP, but also its reduction, was associated with the presence of a nerve lesion that was confirmed at surgical exploration in both patients.