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Original Article

Study of motor and sensory nerve conduction of wrist palm and palm-finger segments of median nerve and studying their contribution in diagnosis of carpal tunnel syndrome

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Abstract

Objectives

Our object ive is to report a modified and simplified technique of sensory and motor segmental conduction studies to improve diagnostic sensitivity, especially in cases with mild carpal tunnel syndrome (CTS).

Patients and methods

Patients with suspected CTS referred to our electrophysiology laboratory and a control group were included. The data were collected prospectively. The following measurements made: median sensory conduction velocity wrist digit 1(W-1), median sensory conduction velocity wrist digit 3 (W-3), median wrist palm sensory conduction velocity (W-Ps), distoproximal ratio of velocity (D/P), median distal motor latency wrist (MDML) -APB (Abductor pollicis brevis), and median wrist -palm segment motor conduction velocity (W-Pm).

Results

The highest sensitivity test for an electrodiagnostic CTS diagnosis was D/P (63.7%), W-Pm (43.1%), W-Ps (39.2%), median distal motor latency (33.3%), median sensory conduction velocity wrist digit 1 (31.4%), and median sensory conduction velocity wrist digit 3 (29.4%), correspondingly. A total of 52 patients were diagnosed as having CTS electrophysiologically after containment of W-Ps, 58 patients were defined as having CTS after containment of W-Pm, and 55 patients were diagnosed as having CTS electrophysiologically after containment of D/P. Of 102 hands with CTS, 70 were defined as an electrophysiologically proven CTS using routine electrophysiologic tests together with D/P, W-Pm, and W-Ps segmental studies, increasing the sensitivity of diagnoses by nearly 55.5%.

Conclusion

The results of this study suggested that motor or sensory segmental studies have an important inputs in the diagnosis, particularly for mild cases of CTS.

Keywords: Carpal tunnel syndrome, segmental conduction study, Median nerve

Introduction

Carpal tunnel syndrome (CTS) is the most common and frequent entrapment neuropathy of the upper extremities, due to compression of the median nerve as it travels through the wrist at the carpal tunnel [1]. In patients with mild form of the CTS, electrophysiological studies with conventional technique may fail to detect any abnormalities [2].

In normal participants, conduction velocity along sensory nerve was the same from digit to palm and from palm to wrist. Severe slowing from palm to wrist in patients with the CTS was often associated with only slight slowing from digit to palm [3].

False-negative conduction studies may result from the masking of the slowing in the proximal segment by the

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normal conduction velocity in the distal part of the tunnel, as conduction abnormality is confined to the segment of the median nerve within the carpal tunnel in mild CTS cases. Therefore, wrist-palm studies are considered to provide a more sensitive means of electrophysiological diagnosis for CTS [4].

It is generally accepted that sensory nerve conduction studies are more sensitive than motor nerve conduction studies [5]. Transcarpal sensory and motor latencies have been used to diagnose CTS in addition to many other methods, and they are recommended to be performed when routine sensory and motor distal latencies are inconclusive to increase diagnostic yield [6].

In some studies, determining the sensory NCV across the palm-wrist segment has been introduced as the most sensitive diagnostic procedure for CTS, with a sensitivity ranging from 98.5 to 99% [7].

Aim

Our study aim was to examine the contribution of motor and sensory segmental conduction studies of the median nerve on the electrophysiological diagnosis of CTS.

Patients and methods

The study protocol was approved by the Ethnic Committee of GOTHI, and it included two groups. The first group included 100 patients with nocturnal numbness and tingling on the hand or hands. This was accepted as CTS. The second group included 68 healthy volunteers as a control group who had no neurological complaints of the upper extremity and were diagnosed with electrophysiologic examination, with age between 20 and 50 years. The two groups were picked up from the rheumatology outpatient clinic of Al-Mataria Teaching Hospital.

(1) Full history, clinical examination, and nerve conduction study of median nerve were analyzed.
(2) A 4-channel key point electromyography (Medtronic Dantec) USA was used for electrophysiological tests, all of which were performed by the same investigator.
(3) All sensory conduction measurements were performed antidromically. For the sensory conduction tests of the median nerve at the first finger, the active ring electrode was placed on the interphalangeal joint, whereas the reference ring electrode was placed on the distal phalanx, and median nerve was stimulated along its course at wrist level.
(4) For the sensory conduction tests of the median nerve at the third finger, the recorder ring electrode was placed in the middle of the middle phalanx of the third finger, whereas the reference ring electrode was placed in the middle of the distal phalanx. Separate stimulations were performed on the median nerve along its course at the wrist and palm.
(5) For the sensory conduction test of the ulnar nerve at the fifth finger, the recorder ring electrode was placed on the middle of the middle phalanx of the fifth finger, whereas the reference ring electrode was placed on the middle of the distal phalanx. The electrical stimulation was performed along the course of the ulnar nerve in the wrist.
(6) The filter was set at a low frequency of 20 Hz and high frequency of 2 kHz, sensitivity at 20 mV/division, and sweep speed at 1 ms/division. The skin temperature was maintained above 32°C.

Motor conduction studies

(1) The superficial electrode was placed on the APB muscle at the thenar edge for median nerve motor conduction studies. The reference Velcro ring electrode was attached to the middle of the distal phalanx. Electrical stimulations were performed along the course of the median nerve in the wrist and palm.
(2) For stimulations at the palm, the anode was placed on an imaginary line connecting the cathode and the metacarpophalangeal joint of the fifth finger. This distal placement of the anode was for avoiding the stimulation of the recurrent thenar nerve beneath the anode that enters APB. The activation of the recurrent thenar nerve under the anode and cathode may lead to inaccuracy of the latency [1].

For the motor conduction tests of the ulnar nerve, the superficial electrode was placed at the hypothenar edge on the abductor digiti minimi muscle. The reference Velcro ring electrode was placed on the middle of the middle phalanx of the fifth finger. The electrical stimulation was provided on the course of the ulnar nerve at the wrist. The latency of the compound muscle action potentials (CMAP) was recorded as the time from the onset of stimulus artifact to the onset of the potential. The filtering frequency range was 20–10 000 Hz.

The amplitude of CMAP was estimated from peak to peak. The sum of the negative and positive CMAP areas was recorded as the CMAP area.

(1) F wave response recording from median and ulnar nerves was performed and should be normal to exclude radiculopathy.
(2) We specified classification of cases according to Bland[8] neurophysiological grading scale for CTS as follows:
    (a) Extreme CTS: absence of thenar motor (and sensory) response.
    (b) Severe CTS: absence of median SNAPS (digit-wrist segment) and abnormal DML.
    (c) Moderate CTS: slowing of median digit-wrist segment and abnormal DML.
    (d) Mild CTS: slowing of median digit-wrist segment and normal DML.
    (e) Minimal CTS: ‘standard negative’ hands with abnormal comparative or segmental (<7–8 cm) tests.
    (f) Negative: normal findings in all tests (including comparative or segmental tests).

Inclusion criteria

The inclusion criteria were individuals with aged between 20 and 50 years showing the following:

(1) Completely normal neurological examination and electromyography, were included as control group.
(2) Patients with nocturnal numbness and tingling on the hand or hands were accepted as CTS.

Exclusion criteria

The exclusion criteria for both groups of patients were as follows:

Any patient complaining of polyneuropathy, plexopathy, or radiculopathy; presenting with systemic conditions associated with polyneuropathy or mononeuritis; and any patients with extreme or severe CTS.

Bilaterally, the following measurements and estimations were performed in all cases:

(1) Median nerve sensory conduction velocity wrist-first finger.
(2) Median nerve sensory conduction velocity wrist-finger third finger.
(3) Median nerve sensory conduction velocity palm-finger third finger (P-3).
(4) Median first finger sensory nerve action potential (SNAP) amplitude (W-1 amp).
(5) Median third finger SNAP amplitude (W-3 amp).
(6) Distoproximal amplitude ratio was calculated as follows: median SNAP2 amp obtained by palm stimulation divided by the median SNAP amp obtained by wrist stimulation (W-3 amp).
(7) Ulnar nerve sensory conduction velocity wrist-fifth finger (W-5).
(8) Ulnar sensory nerve action potential amplitude.
(9) Median distal motor latency wrist-APB.
(10) CMAP amplitude obtained by median motor stimulation at the wrist (CMAP1 amp).
(11) CMAP amplitude obtained by median motor stimulation at the palm (CMAP2 amp).
(12) Distoproximal amplitude ratio was estimated as follows: CMAP2 amp/CMAP1 amp.
(13) CMAP area obtained by the motor stimulation of the median nerve at the wrist (CMAP1 area).
(14) The CMAP area obtained by the motor stimulation of the median nerve at the palm (CMAP2 area).
(15) Ulnar nerve distal motor latency wrist–abductor digiti minimi.

In this study, we added some traditional tests to improve the sensitivity of early diagnosis of CTS with calculation of the following (Figs. 1, 2):

(1) Median nerve sensory conduction velocity wrist-palm (W-Ps) calculated as follows: (wrist-palm distance) (mm)/(W-3 latency-P-3 latency) (ms).
(2) Distoproximal velocity ratio (D/P) calculated as follows: (P-3)/(W-Ps).
(3) Median wrist segment motor conduction velocity (W-Pm) calculated as follows: the CMAP1 from wrist stimulation and the CMAP2 from palm stimulation recorded (wrist-palm distance) (mm)/(CMAP1 latency-CMAP2 latency) (ms).
(4) Distoproximal area ratio (CMAP2 area/CMAP1 area) [9].

Statistical analysis

All tabulated data were expressed as mean ± SD. Comparisons between patients and control groups were done by using the Students *t* test. For all statistical tests, significance was done using the correlation coefficient (*r*) test in which significance is defined as level of *P* value of less than 0.05. Computations were done using an SPSS statistical program, version 12, and graphs were assessed using Microsoft excel XP version21, Chicago, USA.

Results

In our results, 100 patients with nocturnal numbness and tingling of one hand or hands were diagnosed as CTS using different tests of electrodiagnosis. All our patients were recorded from the less affected side and only two patients had bilateral mild CTS, so the number of hands that were studied and diagnosed as CTS was 102. A total of 80 patients were females and 22 patients were males, with mean age of 38.2 ± 8.2 and 34.4 ± 10.6 years, respectively, with no statistically significant difference between both sexes (*P*=0.19). The second group including 68 healthy control individuals; only 32 had bilateral normal electrophysiologic study, so the number of normal hands studied was 100. A total of 54 patients were females and 14 were males, with mean age of 36.54 ± 9.6 and 35.5 ± 11.05 years, respectively, with no statistically significant differences between both sexes (*P*=0.17). There were no statistically significant differences between both similar sexes in the two groups (*P*=1.77), for females, and for males (*P*=0.41). Results of different techniques are summarized in Table 1. It illustrates statistically significant differences between patients and control groups and statistical significance regarding W-Pm, W-Ps, W-1, D/P, and W-3 (*P*>0.01).

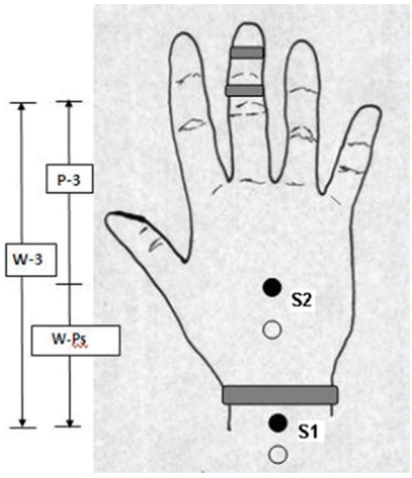

Figure 1: Median sensory segmental nerve conduction study.

Table 1: The comparative test results in patients with carpal tunnel syndrome and controls regarding conduction velocities and latencies

	Control (n=68) [mean±SD, (range)] (mean±2SD)	Patients with CTS (n=100) (mean±SD)	P
MDL-W	2.9±0.65 (1.6-4.21)	3.6±0.58	0.01
PSL-W1	1.8±0.68 (0.45-3.1)	3.38±0.68	0.01
PSL-W-3	2.12±0.55 (1.12-3.2)	3.52±0.75	0.01
W-Pm (m/s)	53.9±7.8 (38.3-69.5)	48.6±14.3	0.001
W-1 (m/s)	60.56±7.38 (45.8-75.3)	49.21±10.98	0.01
W-3 (m/s)	59.48±6.6 (46.28-72.7)	55.7±13.07	0.01
P3 (m/s)	67.1±6.4 (54.3-79.9)	65.6±8.1	0.16
W-Ps (m/s)	58.7±9.74 (39.3-78.1)	42.2±12.53	0.00
D/P	1.02±0.05 (0.72-1.12)	1.3±0.42	0.04
MDML	3.01±0.41 (2.2-3.81)	2.92±0.34	0.84
W-5	61.3±6.81 (47.7-74.9)	59.6±6.2	0.06
UDML	2.4±0.45 (1.5-3.3)	3.6±0.58	0.06

CTS, carpal tunnel syndrome; D/P, median nerve sensory distoproximal velocity ratio; MDL-W1, median motor distal latency; MDML, median motor distal latency; P-3, median nerve sensory conduction velocity in palm-finger segment; PSL-W1, peak sensory latency of median nerve of the first finger; PSL-W1, peak sensory latency of median nerve of the third finger; UDML, ulnar motor distal latency; W-1, median nerve sensory conduction velocity in the first finger; W-3, median nerve sensory conduction velocity in the third finger; W-5, ulnar nerve sensory conduction velocity; W-Pm, median wrist palm motor velocity; W-Ps, median nerve sensory wrist-palm conduction velocity.

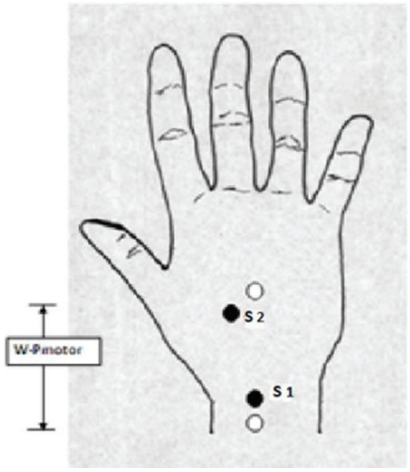

Figure 2: Median motor segmental nerve conduction study. Distoproximal velocity ratio=P-3/W-P. W-P, median wrist-palm sensory conduction velocity

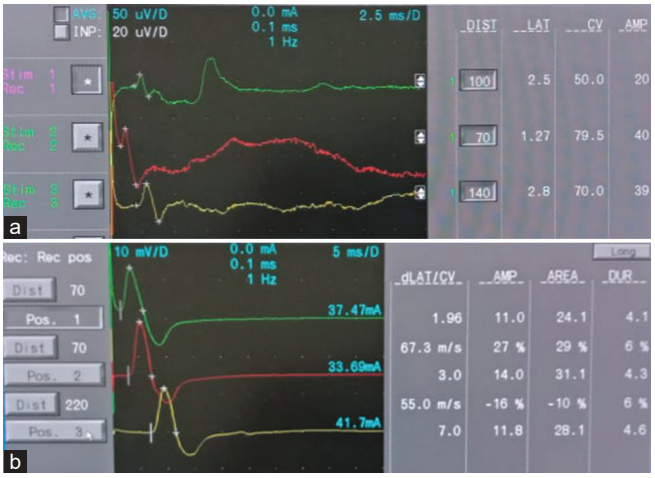

Figure 3: (a)Showed normal neurophysiologic parameters of sensory (b)Showed normal neurophysiologic parameters of motor study of median nerve

Our results showed a statistically significant difference between patients and control group regarding CMAP1 amp, CMAP1 area, SNAP amp, and SNAP2 amp/W-3 amp, with P value less than 0.01, as seen in Tables 2 and 3 and Figs. 3 and 4.

The highest sensitivity tests were median sensory distoproximal velocity ratio (63.7%), the median motor third finger wrist palm segment velocity (43.1%), median sensory wrist-palm velocity (39.2%), median motor distal latency (33.3%), median sensory first finger velocity (31.4%), and median sensory third finger velocity (29.4%).

A total of five tests had a specificity and positive predictive value of 100%: median sensory first finger velocity, median sensory third finger distal to proximal velocity ratio, median sensory third finger velocity, median sensory third finger wrist-palm segment velocity, and median motor wrist-palm segment velocity; however, median motor of third finger distal amplitude to proximal amplitude ratio test, and median sensory of third finger distal amplitude to proximal amplitude ratio test had a specificity and positive predictive value of 99 and 91.6%, respectively, and 98 and 88.2%, respectively.

The tests with highest negative predictive value included median sensory distoproximal velocity ratio (72.9%), median motor wrist-palm velocity (63.2%), the median sensory third finger wrist palm segment velocity (61.7%), median motor distal latency (59%), median sensory first finger velocity (58.8%), and median sensory third finger velocity (58.1%).

In the present study, the number of patients with CTS with sensory conduction block, as the SNAP2 amp/W-3 amp more than 1.6 patients, was 15 patients, with specificity of 98%, and

the number of patients with CTS with motor conduction block, as CMAP2 amp/CMAP1 amp more than 1.3, was 11 patients, with specificity of 99% (Table 4).

In our study the number of affected hands diagnosed with ordinary electrophysiological studies (i.e. median sensory1st finger velocity, median sensory 3rd finger velocity, median motor distal latency) were only 45 hands. 11 mild cases presenting with only sensory CTS, and 34 moderate cases presenting with both motor and sensory CTS. When the sensory wrist-palm velocity was added to these tests, the number of hands with abnormality increased to 52 affected hands; when the motor wrist-palm velocity was added, this number increased to 58 affected hands; and when median sensory third finger distoproximal velocity ratio was added, this number increased to 65 affected hands. The use of all modified electrophysiological tests allowed diagnosis of cases with minimal grade CTS which were lost when using only simplified tests; these raised the number of affected hands with CTS to 70 of the 102 hands.

In our study, we found that there is a significant positive correlation between age and SNAP2 amp/W-3 amp amplitude ratio and with CMAP2 amp/CMAP1 amp ratio (r=0.267 and

Table 2: Amplitude and area results of electrophysiologic study in controls and patients with carpal tunnel syndrome

	Control (n=68) (mean±SD) (mean±2SD)	Patients with CTS (n=100) (mean±SD)	P
CMAP1 amp	11.94±3.6 (4.7-19.1)	8.32±2.37	0.00
CMAP2 amp/CMAP1 amp	1.14±0.1 (0.94-1.34)	1.2±0.3	0.86
CMAP1 area	33.8±11.8 (10.2-57.4)	24.82±5.3	0.00
CMAP2 area/CMAP1 area	1.23±0.33 (0.56-1.8)	1.11±0.31	0.68
SNAP amp	42.1±15.1 (12.1-72.1)	20.56±15.7	0.00
SNAP2 amp/W-3 amp	1.2±0.3 (0.6-1.6)	1.07±0.44	0.01

CMAP, compound muscle action potential; CTS, carpal tunnel syndrome; SNAP, sensory nerve action potential; W-3, median nerve sensory conduction velocity in the third finger.

Table 3: The sensitivity, specificity, positive predictive value, and negative predictive value of the tests for diagnosis of carpal tunnel syndrome

Tests	Abnormality criteria	Sensitivity [n (%)]	Specificity (%)	PPV (%)	NPV (%)
D/P	>1.1	65 (63.7)	100	100	72.9
W-Pm (m/s)	<38.3	44 (43.1)	100	100	63.2
W-Ps (m/s)	<39.3	40 (39.2)	100	100	61
MDML	>3.8	34 (33.3)	98	94.4	59
W-1 (m/s)	<45.8	32 (31.37)	100	100	58.8
W-3 (m/s)	<46.3	30 (29.41)	100	100	58.1
SNAP2 amp/W-3 amp	>1.6	15 (14.7)	98	88.2	55.7
CMAP2 amp/CMAP1 amp	>1.3	11 (10.8)	99	91.6.2	52.1
CMAP2 area/CMAP1 area	>1.8	6 (5.8)	97	66.6	50.3
SNAP amp	<12.1	3 (2.94)	98	60	49.7
CMAP1 amp	<4.7	2 (1.96)	96	33.3	48.9
W-5	<47.7	-2 (1.96)	92	20	47.9
UDML	>3.3	0	92	16.6	47.9
CMAP1 area	<10.2	0	94	12.5	47.9

CMAP, compound muscle action potential; D/P, median nerve sensory distoproximal velocity ratio; MDML, median distal motor latency; SNAP, sensory nerve action potential; UDML, ulnar motor distal latency; W-1, median nerve sensory conduction velocity in the first finger; W-3, median nerve sensory conduction velocity in the third finger; W-Pm, median wrist palm motor velocity; W-Ps, median nerve sensory wrist-palm conduction velocity.

Table 4: Comparison between specificity and sensitivity of simplified tests and addition of modified tests in early diagnosis of carpal tunnel syndrome

Test	Sensitivity [n (%)]	Specificity (%)	PPV (%)	NPV (%)
Ordinary tests (W-1+W-3+MDML)	44.1 (45)	98	95.7	63.2
Ordinary tests and W-Ps (m/s)	50.9 (52)	98	96.2	66.2
Ordinary tests and W-Pm (m/s)	56.9 (58)	98	96.6	69.1
Ordinary tests and D/P	63.7 (65)	98	97	72.6
Tests	68.6 (70)	98	97.2	75.4

D/P, median nerve sensory distoproximal velocity ratio; MDML, median distal motor latency; NPV, negative predictive value; PPV, positive predictive value; W-1, median nerve sensory conduction velocity in the first finger; W-3, median nerve sensory conduction velocity in the third finger; W-Pm, median wrist palm motor velocity; W-Ps, median nerve sensory wrist-palm conduction velocity.

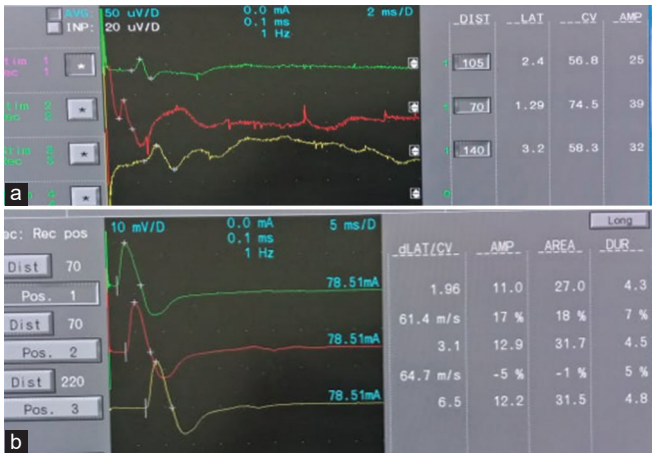

Figure 4: Showed sensory data of patient with mild carpal tunnel syndrome. (a) D/P=1.3-W-P s=35 ms-SNAP2 amp/W-3Amp=1.2 Showed motor data of patient with mild carpal tunnel syndrome. (b) W-Pm=67.3 ms-CMAP2 amp/CMAP1 amp=0.9

r=0.269, respectively; *P*<0.01). Moreover, there is a significant positive correlation between age and SNAW1 amp and SNAW3 amp (*r*=0.39 and *r*=0.42, respectively; *P*<0.01).

Discussion

It is important to increase understanding about CTS which makes it possible to have electrodiagnosis of these patients in their earlier stages of the disease. In this group, up to 40% of the patients with typical symptoms yet may have no electrodiagnostic evidence of CTS [10].

Two-segment technique is one of the most important modified tests (sensory or motor W-P conduction velocity), because this method can accurately determine the involved segment of median nerve, particularly in the early stages of the disease [9].

Pathology of CTS is confined to carpal tunnel and 2–4 cm distally, especially during the onset of the disease. Nerve conduction study in long distances recording from W-1 or W3 including proximal and distal segments may show no abnormality, because an almost normal distal segment could prevent detection of any little abnormality in proximal segment [11]. Otherwise, using just a long distance for nerve conduction study (14 cm) may yield a false abnormality owing to an underlying neuropathy in distal segments other than in the carpal tunnel itself. Another advantage of two-segment study is the ability to compare median sensory nerve amplitude by stimulation of the wrist and palm as well as assessing any probability of conduction block [12].

In our study, we showed that distoproximal ratio technique had highest sensitivity when compared with sensory or motor W-P conduction velocity (two-segment technique). Other study disagrees with our study, where the authors found that the diagnostic value of distoproximal technique was lower than that in two-segment and relatively slow techniques and higher than long-segment study and two-segment. The two-segment technique had the highest sensitivity of 98.8% [13]. Moreover, Sharma *et al.*[10] reported that the wrist digit 1 median sensory NCV study was superior to distoproximal ratio technique. With a cut-off point of less than or equal to 45.9, sensitivity and specificity of the first technique were higher (89.5 and 98.6%, respectively).

In agreement with our results, Padua *et al.*[14] studied 43 patients (50 hands) and 36 healthy volunteers (40 hands), and the sensitivity of routine electrophysiological tests was compared with that of the distoproximal velocity ratio; they found that the test with the lowest sensitivity was the median nerve distal motor latency (44%). On the contrary, the sensitivity of the median nerve first finger sensory velocity was 66%, and the sensitivity of the median nerve third finger sensory velocity was 64%. In 38 (76%) hands with CTS of the 50 tested hands, the median nerve sensory conduction velocity was below 45 m/s. In that study, the test with the highest diagnostic value was the distoproximal velocity ratio, which was below 1.0 among 40 control hands, whereas above 1.0 in 49 of the 50 hands with CTS (sensitivity 98%).

This differences in results in Sharma's series compared with our study and similar study may be owing to a higher cutoff point (1.2 vs. 1.1). We selected a cut-off point with the highest sensitivity to diminish the rate of false-negative results and also, earlier diagnosis of CTS. This was already recommended by electrodiagnostic reference [12].

In our study, we confirmed that although the median motor wrist palm segment conduction velocity had high sensitivity (43.1%) compared with median sensory wrist-palm conduction velocity (39.2%), the highest sensitivity tests were median sensory distoproximal conduction velocity ratio (63.7%).

In another study by Chang *et al.* [5], the sensitivity of the wrist-palm segment motor conduction velocity was compared with other sensory conduction techniques. In 32 (8.9%) of the 360 hands, electrophysiological tests were normal. The tests with highest sensitivity were as follows: median-ulnar sensory latency difference (87.2%), median-radial sensory latency difference (86.7%), wrist-palm motor conduction velocity (81.7%), wrist palm sensory conduction time (80.8%), and wrist-palm sensory conduction velocity (73.6%). Thus, although wrist-palm segment motor conduction velocity was more sensitive than the sensory conduction time, a comparison of the sensory latency differences between the median and radial or ulnar nerves provided the highest sensitivity.

On the contrary, other studies found that the highest sensitivity tests for an electrodiagnosis of CTS were W-Pm (38%), D/P (33.3%), median distal motor latency (33.3%), W-3 (31%), W-1 (31%), and W-Ps (24%), correspondingly. A total of 21 patients were diagnosed as having CTS electrophysiologically after inclusion of D/P and 24 patients were defined as having CTS after inclusion of W-Pm. Of 42 hands with CTS, 25 were defined as an electrophysiologically proven CTS using routine electrophysiologic tests together with both D/P and W-Pm segmental studies. That is, diagnostic sensitivity increased nearly by 50%, concluding that motor or

sensory segmental studies have an important contribution to the diagnosis, particularly for mild patients [9].

In a study by Chang *et al.*[1] involving wrist-palm segment motor conduction velocity, the results of the electrophysiological tests were compared in 160 hands with CTS. In 139 (87%) and 129 (81%) hands, the wrist-palm segment motor and sensory conduction velocity were abnormal, respectively. In 92% of the cases, at least one of these two tests yielded an abnormal result. They concluded that the wrist-palm segment motor conduction velocity appeared to be a more sensitive as compared with the sensory conduction velocity, and suggested that the combined use of these two tests may improve the diagnostic yield.

Another study disagreed with our study. It found that median-radial and median-ulnar sensory latency differences were the tests with highest sensitivity (84.3 and 85.7%, respectively). The other tests and their sensitivities are as follows: the wrist-palm segment sensory conduction time (77.0%), median distal sensory latency (74.3%), wrist-palm segment motor conduction velocity (69.1%), distoproximal conduction time difference (63%), distal motor latency (61.3%), and the distoproximal conduction time ratio (46.5%). These authors recommended the use of these comparative tests instead of segmental studies, in patients with normal median sensory distal latency and median motor distal latency results [15].

Moreover, Lew *et al*.[16] compared long-segment technique (wrist digit) and two-segment study (including 7–14 cm technique) with short-segment technique (median mixed palm-wrist NCV), and found that the last technique turned out to be the most sensitive method.

Our results are similar to that of Padua *et al.* [14]. The results of the conduction tests in patients with CTS in both studies are closer to normal values, which may be explained by the inclusion of milder cases of CTS. All patients in our study, that is, 102 symptomatic hands from 100 patients, described symptoms such as paresthesia involving the whole hand or the first four fingers that awakened the patients and that relieved with moving or shaking of the hand or by suspending the hand at the bed-side. Only 23 patients had permanent physical examination findings extending into day hours. On the contrary, the addition of D/P, W-Pm, and W-Ps to the standard three tests (i.e. W-1, W-3, and DML) improved the sensitivity of electrophysiological tests from 44.1 to 68.6%, implying an ~55.5% increase in diagnostic sensitivity.

Sheu *et al.*[17] found that the distoproximal latency ratio of the median third finger sensory conduction was the most sensitive test (77.9%) in their study, followed by the median-radial sensory latency difference (74.0%) and median-ulnar sensory latency difference (70.2%). The authors proposed that segmental tests provided a more practical and more sensitive means of diagnosis versus tests based on comparison.

Because milder cases of CTS were included in our study, it may be assumed that segmental tests may be associated with a significant diagnostic contribution, particularly in very mild cases. Entrapment neuropathies may also lead to slowing of the conduction through segmental demyelination as well as conduction block in some patients. As entrapment neuropathies represent chronic conditions, conduction block is significantly less frequent as compared with the slowing of the conduction. In this study, 15 patients in sensory conduction tests and six patients in motor conduction tests had conduction block at the wrist segment.

Some studies confirmed that a reduction in conduction velocity from proximal to distal segments is a physiological phenomenon, so in our study, some healthy individuals had slower median nerve conduction velocity at the wrist level as compared with more distal segments [18]. Despite this, the conduction velocity may also slow down owing to presence of segments with anatomic narrowing even in healthy participants, as clearly exemplified by the ulnar nerve conduction. In healthy individuals, a motor nerve conduction velocity of 63 m/s in the arm and 61 m/s in the forearm is reduced to 51 m/s at the elbow segment [19].

Some studies examining the segmental conduction in the median nerve found that a slowing down of motor or sensory conduction was shown in healthy individuals at the level of the wrist-palm. In our study, the sensory D/P among healthy controls was between 0.72 and 1.12. Although Padua *et al.*[14] suggested that these ratio should always be less than 1, some healthy individuals may also have a ratio greater than 1, with a ± 2 SD (0.6 and 1.3) among their healthy controls [9].

In our study, we found that aging related to conduction block, as well as decreased conduction velocity at palm-finger segment; these results were most probably owing to the aging slows median nerve sensory conduction on wrist.

Similar results were detected by authors when SNAP amp of the median, ulnar, superficial radial, superficial peroneal, and sural nerves were studied in 105 healthy participants. SNAP amp were shown to decrease with age in all five nerves. Females had greater SNAP amp than males in the upper limb nerves (median, ulnar, and radial). They concluded that age was strongly correlated with SNAP amp in the nerves tested [20].

Similar findings were observed by Huang *et al.* [21], who studied 101 healthy participants and found the change with age was greater in the median than in the ulnar nerve. Female participants or those with lower weight had been found as having higher median and ulnar SNAP amp.

Conclusion

Finally, we concluded that the distoproximal conduction velocity ratio of the median third finger sensory conduction was the most sensitive test compared with other motor or sensory segmental studies and proposed that segmental tests provided a more practical and more sensitive means of diagnosis versus ordinary tests, particularly for mild cases of CTS.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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