Median versus ulnar medial thenar motor recording in diagnosis of carpal tunnel syndrome

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KeyWords
Carpal tunnel syndrome; Median nerve; Medial thenar motor; Medial thenar muscles; Ulnar nerve

Abstract  Aim of the work: This study proposed to assess the role of the median versus ulnar medial thenar motor (MTM) recording in supporting the diagnosis of carpal tunnel syndrome (CTS).

Patients and methods: The present study included 130 hands (70 CTS and 60 controls). Clinical examination was done for all patients. The following tests were done (using surface electrodes recording) for patients and control: (1) sensory nerve conduction studies: median nerve, ulnar nerve and median versus ulnar digit four sensory study; (2) motor nerve conduction studies: median nerve, ulnar nerve, median (second lumbrical) versus ulnar (interosseous) (2-LINT) motor study and median versus ulnar (MTM) study.

Results: The tests with higher sensitivity in diagnosing CTS were median versus ulnar (2-LINT) motor latency difference (87.1%), median versus ulnar (MTM) motor latency difference (80%) and median versus ulnar digit four sensory latency difference (91.4%). There was no statistically significant difference between median versus ulnar (MTM) motor latency difference with both median versus ulnar (2-LINT) motor latency difference and median versus ulnar digit four sensory latency difference ($P > 0.05$) as regards the confirmation of CTS.

Conclusions: Median versus ulnar (MTM) motor latency difference has high sensitivity and specificity for the diagnosis of CTS as for both median versus ulnar (2-LINT) motor latency difference and median versus ulnar digit four sensory latency difference. It can be considered a useful neurophysiological test to be used in combination with other median versus ulnar comparative tests for confirming the diagnosis of CTS beside other well known electrophysiological tests.

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1. Introduction

Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy in the body [1,2]. It is a median neuropathy at the wrist due to compression of the median nerve beneath the transverse carpal ligament [2–4].

Carpal tunnel syndrome is confirmed by the identification of abnormal median nerve conduction tests across the carpal tunnel. Nerve conduction tests are essential in the confirmation
of the diagnosis of suspected cases of CTS. These tests are objective tests that assess the physiological status of the median nerve across the carpal tunnel [5,6]. The results of electrophysiological tests lead to changes in the recommended management of CTS [7]. There are a variety of tests. They include motor and sensory conduction tests. They vary in sensitivity and specificity. In spite of that, the sensory tests are more sensitive and changes in it occur earlier, motor tests are usually recordable in advanced degree of CTS and in patients with peripheral polyneuropathy [2,8]. There are three motor tests that assess the median nerve across the wrist. Median motor conduction study measures the median proximal latency (DL) across the carpal tunnel to the abductor pollicis brevis (APB) muscle. This test has poor sensitivity for the diagnosis of CTS. The second test is the median (recording second lumbrical muscle) versus ulnar (recording the 1st palmar interosseous muscle) (2-LINT) motor latency comparative test. This test has better sensitivity than the previous one [3]. The third test is the median versus ulnar [medial thenar motor (MTM)] motor latency comparative test. They are scanty studies that assessed this test [2,3,9]. As regards the sensory conduction tests used for CTS, there are median sensory nerve conduction study, median versus ulnar digit four sensory latency difference and median versus radial digit one sensory latency difference [2,3].

Medial thenar motor site consists of two muscles. These muscles are the flexor pollicis brevis (FPB) and opponens pollicis (OP) muscles. The FPB muscle has two heads: superficial and deep heads. The motor nerve supply to the superficial head is median nerve and to the deep head is deep branch of ulnar nerve. The motor nerve supply to the OP muscle is a motor branch of median nerve and commonly associated by the deep branch of ulnar nerve [10]. Thus, these muscles have a dual median and ulnar innervations, which can be utilized for a new median versus ulnar motor latency comparative test similar to the median versus ulnar (2-LINT) motor comparative study [9,11]. The aim of the present study was to assess the role of the median versus ulnar (MTM recording) motor latency comparative test in supporting the diagnosis of CTS.

2. Patients and methods

2.1. Patients

The present cross sectional study included 48 patients (70 hands) with clinical evidence of idiopathic CTS who were consecutively recruited from those attending the Outpatient Clinic of Physical Medicine, Rheumatology and Rehabilitation Department, Main University Hospital, Alexandria Faculty of Medicine. The study included 44 apparently healthy volunteers (60 hands) as a control group. The volunteers included medical staff, their relatives and patients’ relatives. Clinical diagnosis of CTS was based on the presence of at least one of the following primary symptoms: (i) the presence of numbness, tingling or paresthesia in the median nerve distribution, (ii) the symptoms are precipitated by repetitive hand activities and relieved by resting, rubbing and shaking the hand, (iii) the presence of nocturnal awakening by these sensory manifestations. The clinical diagnosis of CTS was supported by the presence of positive Tinel’s sign and/or Phalen’s sign [12]. Exclusion criteria: diabetes mellitus, endocrine disorders, metabolic disorders and neurological disorders including peripheral neuropathy. The study was explained to the participants and informed consent was given by each. The study had been approved by the ethics committee of the Faculty of Medicine, Alexandria University, Egypt.

2.2. Methods

Clinical examination was done for all patients. The standardized semi-quantitative clinical History-Objective (Hi-Ob) scale was used to assess the CTS severity by integrating symptoms with clinical features. The Hi-Ob scale has 5 stages of severity. Stage 1: it represents the mildest form of CTS with the presence of nocturnal paresthesia only. Stage 2: the paresthesia occurs at day time with no objective sensory deficits. Stage 3: there is sensory deficit in the presence of nocturnal or diurnal symptoms. Stage 4: the presence of motor weakness with mild atrophy of median innervated thenar muscles. Stage 5: there is complete atrophy or plegia of median innervated thenar muscles [13].

Electrophysiological studies were conducted on a NIHON KOHDEN Neuropack MEB-7102 mobile unit with a two channel evoked potential/EMG measuring system (Nihon Kohden Corporation, Tokyo, Japan). Skin temperature at the site of the recording electrode was maintained around 32–34 °C by the mean of hot packs. The ground electrode was placed between the recording electrodes distally and the stimulation site proximally. Conduction distances were measured by a measuring tape with precision of 1 mm.

The study included the following:

2.2.1. (A) Sensory nerve conduction study

For all sensory conduction studies the following was applied: the sweep speed was 2 ms/division and the sensitivity was 10 μV/division. The filter bandwidth was 20 Hz–2 kHz. The bipolar stimulator had a production current ability of 50 mA. The pulse duration was 0.2 ms. Signal averaging was applied. Responses were recorded two times and were superimposed to ensure reproducibility. Supramaximal stimulation was ensured [14–16]. Measurements of sensory nerve action potential (SNAP) included latency (onset and peak) and conduction velocity (CV). The onset latency was measured from the stimulus artifact onset to the onset of initial negative deflection of the SNAP expressed in milliseconds. The onset latency was used to measure CV. The peak latency (PL) was measured from the stimulus artifact onset to the peak of the negative deflection expressed in milliseconds. The CV was measured in metre per second [16].

(i) Sensory nerve conduction study of the median nerve (recording digit two) by using antidiromic technique: An active recording surface disc electrode was attached to the palmar aspect of proximal phalanx of the second finger with the reference surface disc electrode 3 cm distal on the finger. Electrical stimulation was done at the wrist 14 cm proximal to the active recording electrode using a bipolar stimulator between flexor carpi radialis tendon and palmaris longus tendon. Conduction velocity was obtained for analysis [17].

(ii) Sensory nerve conduction study of the ulnar nerve (recording digit five) by using antidiromic technique: An active recording surface disc electrode was attached to the
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2.2.2. (B) Motor nerve conduction study

For all motor nerve conduction studies the following was applied: the sweep speed was 5 ms/division and the sensitivity was 5 mV/division. The filter bandwidth was 10 Hz–10 kHz. The bipolar stimulator had a production current ability of 50 mA. The pulse duration was 0.2 ms. Measurement included distal latency (DL). The DL was measured from the stimulus artifact onset to the onset of initial negative deflection of the compound muscle action potential (CMAP) expressed in milliseconds. Supramaximal stimulation was ensured [16].

(i) Motor nerve conduction study of the median nerve: An active recording surface disc electrode was attached to the palmar aspect of proximal phalanx of the fifth finger with the reference surface disc electrode 3 cm distal on the finger. Electrical stimulation was done at the wrist crease using a bipolar stimulator just lateral to the flexor carpi ulnaris tendon 14 cm proximal to the active recording electrode. Conduction velocity was obtained for analysis [17].

(ii) Motor nerve conduction study of the ulnar nerve: An active recording surface disc electrode was placed over the flexor carpi radialis tendon and palmaris longus tendon. Place for ulnar nerve stimulation was just lateral to the flexor carpi ulnaris tendon. Place for median nerve stimulation was between flexor carpi radialis tendon and palmaris longus tendon. Place for ulnar nerve stimulation was just lateral to the flexor carpi ulnaris tendon. The difference between median PL and ulnar PL was obtained for analysis [16].

(iii) Median versus ulnar digit four sensory latency comparative study by using antidromic technique: An active recording surface disc electrode was attached to the palmar aspect of proximal phalanx of the fourth finger with the reference surface disc electrode 3 cm distal on the finger. Electrical stimulation was at the wrist using a bipolar stimulator 14 cm proximal to the active recording electrode for both nerves. Place of median nerve stimulation was between flexor carpi radialis tendon and palmaris longus tendon. Place for ulnar nerve stimulation was just lateral to the flexor carpi ulnaris tendon. The difference between median PL and ulnar PL was obtained for analysis [16].

(iv) Median versus ulnar (MTM) motor latency comparative study: The active recording surface disc electrode was placed over the junction of the middle and radial third of a line connecting the medial aspect of the first metacarpophalangeal joint with the pisiform bone and the reference surface disc electrode was placed just distal to the first metacarpophalangeal joint over the proximal phalanx of the thumb. Electrical stimulation of the median and ulnar nerves was done at the same site of their stimulation in the previous motor studies (over the wrist). The difference between median and ulnar MTM distal latencies was obtained for analysis (Fig. 1) [9].

Electrophysiological grading of the severity of CTS was rated according to Bland scale [18]. Bland scale is divided into 7 different grades, from grade zero to grade 6. Grade 0: shows no evidence of CTS electrophysiologically. Grade 1: very mild CTS detected by the presence of two abnormal sensitive comparative tests. Grade 2: mild CTS detected by delayed median sensory CV. Grade 3: moderate CTS detected by delayed median motor DL but less than 6.5 ms with preserved median SNAP. Grade 4: severe CTS detected by delayed median motor DL but less than 6.5 ms with absent median SNAP. Grade 5: very severe CTS detected by delayed median motor DL more than 6.5 ms. Grade 6: extremely severe CTS detected by delayed median motor DL with decreased median CMAP amplitude (surface CMAP amplitude is less than 0.2 mV) [18].
Statistical analysis of data was done by using the Statistical Package of Social Science (SPSS version 17) software [19]. Descriptive measures [count, frequency, minimum, maximum, mean and standard deviation (SD)] as well as analytic measures (t-test and Pearson Chi-square test) were used. Statistical significance was assigned to any P value at ≤0.05. The reference cut-off values of the electrophysiological studies were calculated by rounding the mean plus or minus two SD to measure the upper limit of normal or the lower limit of normal respectively. The sensitivity was calculated as the number of hands with a positive electrodiagnostic test and clinical evidence of CTS/number of hands with clinical evidence of CTS. The specificity was calculated as the number of hands of healthy subjects with a negative electrodiagnostic test/number of all hands of healthy subjects (control group). Positive predictive value was calculated as the number of CTS hands with a positive electrodiagnostic test/number of CTS hands and control hands with positive electrodiagnostic test. Negative predictive value was calculated as the number of control hands with a negative electrodiagnostic test/number of CTS hands and control hands with negative electrodiagnostic test.

### 3. Results

The present study included 70 clinically diagnosed CTS hands that were obtained from 48 patients [39 women (81.25%) and 9 men (18.75%)]. Their mean age was 41.82 ± 11.57 years (ranged from 21 to 77 years). The control group consisted of 60 healthy individuals [29 women (65.90%) and 15 men (34.19%)]. Their mean age was 41.33 ± 11.51 years (ranged from 21 to 77 years). There were no statistically significant differences between patients and control group as regards gender (X² = 0.808, P = 0.808) and age (t = −0.244, P = 0.808).

The clinical characteristics of the patients are summarized in Table 1. Grade 2 Hi-Ob scale and grade 2 (mild) Bland score were the commonest grades. Each one constituted 38.57%. The distribution of CTS patients according to Hi-Ob scale was as follows: (i) there 14 CTS hands (20%) had grade 1; (ii) 27 hands (38.57%) had grade 2; (iii) 18 hands (25.71%) had grade 3; and (iv) 11 hands (15.72%) hand grade 4. The CTS hands covered all grades of Hi-Ob scale. The distribution of CTS patients according to Bland score was as follows: (i) there 4 hands (5.72%) had grade 0; (ii) 13 hands (18.57%) had grade 1; (iii) 27 hands (38.57%) had grade 2; (iv) 15 hands (21.42%) had grade 3; (v) 2 hands (2.86%) had grade 4; (vi) 6 hands (8.57%) had grade 5; and (vii) 3 hands (4.29%) had grade 6. The CTS hands covered all Bland score grades of CTS electrophysiological severity. Bilateral affection was present in 22 patients (45.83%).

Median motor study recording MTM muscles showed a CMAP with an initial negative deflection in 69 hands (98.57%) among patients and 59 hands (98.33%) among control group. Ulnar motor study recording MTM muscles showed a CMAP with an initial negative deflection in all hands (100%) among patients and among control group. The results of the nerve conduction study of all nerves in the present study are shown in Table 2. The differences in all parameters of sensory and motor median nerve studies between CTS patients and control subjects were statistically significant. There were no statistically significant differences between patients and control group as regards parameters of ulnar sensory and motor studies. This excluded the presence of peripheral polyneuropathy among the CTS patient group.

Reference values for all electrophysiological tests parameters obtained from the control group and their sensitivities, specificities, positive predictive values and negative predictive values are presented in Table 3. Illustrations of median versus ulnar MTM and median versus ulnar 2-LINT obtained from a control subject and CTS patients are shown in Fig. 2.

The electrophysiological tests of highest sensitivity in confirming CTS were median versus ulnar digit four sensory latency difference, median versus ulnar (2-LINT) motor latency difference and median versus ulnar (MTM) motor latency difference (91.4%, 87.1% and 80%, respectively). The electrophysiological test of lowest sensitivity in confirming CTS was median DL (38.6%). The specificities of all tests were more than 96.5%.

The highest sensitivity (92.8%) and the highest negative predictive value (92.3%) were obtained when the results of any two tests out of the three median versus ulnar comparative tests [median versus ulnar digit four sensory latency difference, median versus ulnar (2-LINT) motor latency difference and median versus ulnar (MTM) motor latency difference] were abnormal for confirming CTS. This was associated with specificity and positive predictive value of 100%.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Clinical characteristics of carpal tunnel syndrome patients and control subjects.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical characteristics</td>
<td>CTS patients (n = 48)</td>
</tr>
<tr>
<td>N (%)</td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>39 (81.25)</td>
</tr>
<tr>
<td>Side (right/left)</td>
<td>39 (55.71)/31 (44.29)</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>41.82 ± 11.57</td>
</tr>
<tr>
<td>Duration (years)</td>
<td>3.23 ± 2.36</td>
</tr>
<tr>
<td>Median (range)</td>
<td></td>
</tr>
<tr>
<td>Hi-Ob scale</td>
<td>2 (1–4)</td>
</tr>
<tr>
<td>Bland grading</td>
<td>2 (0–6)</td>
</tr>
</tbody>
</table>

CTS, carpal tunnel syndrome; Hi-Ob, clinical History-Objective scale; N, number of hands; NA, not applicable. X² = value of chi-square Test. t = value of t-test. *P is significant at ≤0.05.
Table 2  Comparison of different nerve conduction study parameters between carpal tunnel syndrome patients and control subjects.

<table>
<thead>
<tr>
<th>Nerve conduction study parameters</th>
<th>CTS patients mean ± SD</th>
<th>Control subjects mean ± SD</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDL (ms)</td>
<td>4.36 ± 1.57</td>
<td>3.31 ± 0.47</td>
<td>-5.010</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>UDL (ms)</td>
<td>2.66 ± 0.37</td>
<td>2.60 ± 0.36</td>
<td>-0.861</td>
<td>0.391</td>
</tr>
<tr>
<td>M-U2-LINT (ms)</td>
<td>1.47 ± 1.52</td>
<td>0.19 ± 0.20</td>
<td>-6.483</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>M-U-MTM (ms)</td>
<td>1.81 ± 2.09</td>
<td>0.13 ± 0.24</td>
<td>-6.208</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>MSCV (m/s)</td>
<td>42.64 ± 9.01</td>
<td>53.57 ± 4.67</td>
<td>8.392</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>USCV (m/s)</td>
<td>54.45 ± 4.74</td>
<td>55.16 ± 4.78</td>
<td>0.848</td>
<td>0.398</td>
</tr>
<tr>
<td>M-UPLD4 (ms)</td>
<td>1.35 ± 0.92</td>
<td>0.15 ± 0.20</td>
<td>-9.853</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

MDL, median distal latency; UDL, ulnar distal latency; M-U2-LINT, median (recording 2nd lumbrical muscle) versus ulnar (recording the 1st palmar interosseous muscle) motor latency difference; M-U-MTM, median versus ulnar medial thenar motor latency difference; MSCV, median sensory conduction velocity; USCV, ulnar sensory conduction velocity; M-UPLD4, median versus ulnar digit four sensory latency difference; t = value of t-test. * P is significant at ≤0.05.

Table 3  Determined reference cut-off values for different electrophysiological studies and their sensitivities, specificities, positive predictive values and negative predictive values.

<table>
<thead>
<tr>
<th>Electrophysiological tests parameter</th>
<th>Mean ± SD</th>
<th>NL</th>
<th>Rounded NL</th>
<th>Sens (%)</th>
<th>Spec (%)</th>
<th>PPV (%)</th>
<th>NPV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDL (ms)</td>
<td>3.31 ± 0.47</td>
<td>4.25</td>
<td>4.3</td>
<td>38.6</td>
<td>98.3</td>
<td>96.4</td>
<td>57.8</td>
</tr>
<tr>
<td>M-U2-LINT (ms)</td>
<td>0.19 ± 0.20</td>
<td>0.59</td>
<td>0.6</td>
<td>87.1</td>
<td>98.3</td>
<td>98.4</td>
<td>86.8</td>
</tr>
<tr>
<td>M-U-MTM (ms)</td>
<td>0.13 ± 0.24</td>
<td>0.61</td>
<td>0.6</td>
<td>87.1</td>
<td>98.3</td>
<td>98.4</td>
<td>86.8</td>
</tr>
<tr>
<td>MSCV (m/s)</td>
<td>53.57 ± 4.67</td>
<td>44.23</td>
<td>44.2</td>
<td>64.3</td>
<td>100.0</td>
<td>100.0</td>
<td>70.6</td>
</tr>
<tr>
<td>M-UPLD4 (ms)</td>
<td>0.15 ± 0.20</td>
<td>0.55</td>
<td>0.6</td>
<td>91.4</td>
<td>98.3</td>
<td>98.8</td>
<td>90.8</td>
</tr>
</tbody>
</table>

MDL, median distal latency; M-U2-LINT, median (recording 2nd lumbrical muscle) versus ulnar (recording the 1st palmar interosseous muscle) motor latency difference; M-U-MTM, median versus ulnar medial thenar motor latency difference; MSCV, median sensory conduction velocity; M-UPLD4, median versus ulnar digit four sensory latency difference; SD, standard deviation; NL, upper (for latency) or lower (for conduction velocity) limit of normal; Sens, sensitivity; Spec, specificity; PPV, positive predictive value; NPV, negative predictive value.

There was a statistically significant difference as regards the confirmation of CTS (sensitivity) between median versus ulnar (MTM) motor latency difference and median DL ($\chi^2 = 4.356$, $P = 0.037$), as well as median versus ulnar (MTM) motor latency difference and median sensory CV ($\chi^2 = 6.222$, $P = 0.013$). There was no statistically significant difference between median versus ulnar (MTM) motor latency difference with both median versus ulnar (2-LINT) motor latency difference and median versus ulnar digit four sensory latency difference ($\chi^2 = 3.857$, $P = 0.071$; $\chi^2 = 0.729$, $P = 0.393$, respectively) as regards the confirmation of CTS.

There were three hands (4.28%) that had only a single comparative test abnormality [one hand had abnormal median versus ulnar (MTM) motor latency difference and median DL ($\chi^2 = 4.356$, $P = 0.037$), as well as median versus ulnar (MTM) motor latency difference and median sensory CV ($\chi^2 = 6.222$, $P = 0.013$). There was no statistically significant difference between median versus ulnar (MTM) motor latency difference with both median versus ulnar (2-LINT) motor latency difference and median versus ulnar digit four sensory latency difference ($\chi^2 = 3.857$, $P = 0.071$; $\chi^2 = 0.729$, $P = 0.393$, respectively) as regards the confirmation of CTS.

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There were only two hands (2.85%) that had no comparative test abnormality. There was one hand (1.42%) with absent median CMAP recording APB, still had MTM and 2-LINT responses which were abnormally prolonged.

There were statistically significant positive correlations between median versus ulnar (MTM) motor latency difference and median DL, median versus ulnar (2-LINT) motor latency difference, and median versus ulnar digit four sensory latency difference ($r = 0.607$, $P < 0.0001$; $r = 0.857$, $P < 0.0001$; $r = 0.434$, $P < 0.0001$ respectively). While, there was statistically significant negative correlation between median versus ulnar (MTM) motor latency difference and median sensory CV ($r = -0.323$, $P = 0.009$).

4. Discussion

Carpal tunnel syndrome is the most common cause of referral to electrodiagnosis laboratory. There is a diversity of electrophysiological techniques that are utilized to assess median nerve conduction across carpal tunnel. Slowing of the median nerve across the carpal tunnel is the electrophysiological confirmation of clinical CTS [20]. These electrophysiological tests are the routine median motor and sensory conduction studies. Unfortunately, these routine conventional electrophysiological tests can be normal in CTS. The use of other more sensitive electrophysiological techniques to confirm the diagnosis of CTS is utilized [21]. In this circumstance, the presence of at least two abnormal sensitive electrophysiological techniques for the diagnosis of CTS is required [22]. These are comparative
tests that compare the median sensory or motor conduction across carpal tunnel with an adjacent nerve in the same hand which does not pass through the carpal tunnel and presumed to be normal. This provides a direct internal comparison. The effect of temperature, age and even the effects of superimposed diseases are controlled by these comparative studies. In this case, the comparative nerve can act as a reference to compare the median nerve conduction with it, and to detect a relative slowing of the median nerve in relation to it. The commonest reference nerve is the ulnar nerve. This results in three comparative tests: median versus ulnar (2-LINT) motor latency difference and median versus ulnar (MTR) motor latency difference. There was a significant negative correlation between median latency difference and median versus ulnar palm to wrist mixed latency difference, as well as, the median versus radial digit one sensory latency difference [2]. The median versus ulnar (MTM) motor latency difference is a new median motor comparative test [9]. The assessment of this test in supporting the diagnosis of CTS was the aim of the present study.

The medial thenar muscles (MTM) are two muscles which are FPB and OP. Both of them are supplied by median and ulnar nerves. Anatomical researches showed that about 10% of the MTM muscles have pure ulnar innervation [11]. The presence of Martin-Gruber anastomosis which is motor fibres communicate the median nerve to the ulnar nerve in the forearm segment, can be a potential pitfall when using the median versus ulnar (MTM) motor latency comparative test [16]. The current study showed that the MTM muscles had true dual innervations by both the median and ulnar nerves. The MTM recording is a reliable site to be used in situations that other comparative tests cannot be performed as due to finger amputation or with skin lesions over the area of recording the comparative test [9]. This can be present in case of amputation of the index finger in which the median versus ulnar (2-LINT) motor latency difference test cannot be performed; in case of amputation of the little finger in which the median versus ulnar digit four sensory latency comparative study cannot be performed; and in case of amputation of the thumb in which the median versus radial digit one sensory latency comparative study cannot be performed.

The median motor fibres supplying the MTM muscles were frequently affected among CTS patients. The median versus ulnar (MTM) motor latency difference was significantly prolonged among CTS patients in comparison to control. The specificity of this comparative test was high and it was similar to other electrophysiological techniques used in assessment of CTS. The current study showed that the sensitivity of this comparative test was high but still less than median versus ulnar (2-LINT) motor latency difference test and median versus ulnar sensory digit four latency difference test in a non statistically significant fashion, which are known in literature to have high sensitivity and specificity [23]. But, its sensitivity was better in a significance way than median DL as well as median sensory CV.

The median versus ulnar comparative tests allow the highest accuracy for the diagnosis of CTS [24]. When two comparative tests agree either normal or abnormal, it lowers the risk of false negative or false positive results. If the two tests do not agree with each other or they are borderline, the use of an extra comparative test can help in reaching the proper diagnosis [2,25]. This was proved in the current study. The highest sensitivity (92.8%) was obtained when the results of two out of three median versus ulnar comparative tests; ulnar digit four sensory latency difference, median versus ulnar (2-LINT) motor latency difference and median versus ulnar (MTM) motor latency difference; were abnormal. This was associated with the highest specificity (100%).

There were significant positive correlations between median versus ulnar (MTM) motor latency difference and median DL, median versus ulnar (2-LINT) motor latency difference and median versus ulnar digit four sensory latency difference. There was a significant negative correlation between median versus ulnar (MTM) motor latency difference and median sensory CV. These significant correlations indicated that different types of median nerve fibres (i.e. sensory and motor) were equally involved at the same time.

Figure 2  Sample tracings showing the CMAP responses in a control subject and two patients with CTS. (1) Sample tracings from a control subject of a healthy control volunteer. Trace (A) median 2-L response; trace (B) ulnar INT response; trace (C) median MTM response; and trace (D) ulnar MTM response. (2) Sample tracings from a patient with CTS who had abnormal median versus ulnar (2-LINT) motor latency difference and median versus ulnar (MTR) motor latency difference. Trace (A) Delayed median 2-L response; trace (B) normal ulnar INT response; trace (C) delayed median MTM response; and trace (D) normal ulnar MTM response. (3) Sample tracings from another patient with CTS who had normal median versus ulnar (2-LINT) motor latency difference but abnormal median versus ulnar (MTR) motor latency difference. Trace (A) Normal median 2-L response; trace (B) normal ulnar INT response; trace (C) delayed median MTM response; and trace (D) normal ulnar MTM response.
Increased sensitivity and specificity of the median versus ulnar (MTM) motor latency difference could be related to the uniform nerve fibre affection allow the severity spectrum of CTS in addition to minimal variation among controls [9]. The specificities of different tests were high which indicates the ability of these tests to correctly identify all subjects who do not exceed the cut-off value. The sensitivities of median DL and median sensory CV were relatively low in the current study. This could be due to the inclusion of a great number of patients with very mild (18.57%) and mild (38.57%) degrees of CTS and partially due to the increased variability of data which increased SD among them.

The high sensitivity of the median versus ulnar digit four sensory latency difference is due to the preferential compression of the median sensory branch supplying the lateral half of the ring finger. It is localized in the anterolateral and anteromedial parts of the median nerve where median nerve compression occurs at the distal portion of the carpal tunnel before the division of motor and sensory branches. The low sensitivity of median sensory CV can be due to relatively less involvement of the median digital branches supplying the second digit in early mild CTS. They arise from the posterior aspect of the median nerve [26].

The current study is in accordance with Smith et al. [9]. They studied the MTM recording in CTS among 40 patients [26 women (69%); their mean age was 45 years. The cut-off reference value, sensitivity and specificity of median versus ulnar (MTM) latency difference were 0.4 ms, 76.1% and 94.9% respectively. They reported that median DL had the lowest sensitivity in confirming the diagnosis of CTS. However, the cut-off reference value of median versus ulnar (MTM) latency difference was longer in the current study; the sensitivity and specificity were comparable. The difference in the cut-off reference value between the present study and Smith et al. can be due to the difference in the method of calculation of the cut-off reference value between of the two studies [9].

Uncini et al. [27] reported the reference cut-off values of median versus ulnar (2-LINT) motor latency difference test was <0.6 ms and that of median versus ulnar digit four sensory latency difference test was <0.5 ms. They reported the sensitivity of median versus ulnar (2-LINT) motor latency difference test to be 10% and that of median versus ulnar digit four sensory latency difference test was 77%. The current study is not in agreement with Uncini et al. [27]. This could be due to the difference in the inclusion criteria between the current study and Uncini et al. study [27].

Uncini et al. [28] reported that median versus ulnar digit four sensory latency difference test had the highest sensitivity in comparison to median DL and median sensory study to digit two [28]. This was in agreement with the present study.

The current study is in agreement with Martinez [29], Padua et al. [30] and Tawfik et al. [31]. Martinez [29] and Padua et al. [30] reported that median DL had the lowest diagnostic yield in the diagnosis of CTS. Tawfik et al. [31] reported that median DL sensitivity was 47% and that median versus ulnar (2-LINT) motor latency difference had the highest sensitivity of 83%.

The current study is in accordance with Padua et al. [32] and Celik and Guven [33]. Padua et al. reported that median sensory study had low sensitivity in the diagnosis of CTS [32]. Celik and Guven reported that median sensory CV of the digit two had sensitivity of 81.5% while median versus ulnar digit four sensory latency difference had a sensitivity of 92% [33].

The MTM recording is a reliable site to be used as a median versus ulnar comparative test. The median motor fibres to medial thenar muscles were found to be spared in severe degree of CTS. This is similar to the median nerve motor fibres supplying the second lumbrical muscle which were found to be more centrally located within the median nerve in comparison to the median motor fibres to the APB muscle which are located peripherally [34]. This can be the explanation of preservation of the median motor fibres supplying medial thenar muscles [35].

In spite of that the median motor fibres to medial thenar muscles are spared from axonal loss in severe degree CTS, they are vulnerable to demyelinating lesion with conduction slowing found in early CTS. This is similar to the median nerve fibres supplying the second lumbrical muscle. The cause of this unique finding is still unclear [35].

The accurate method to diagnose CTS is to combine the characteristic clinical manifestations with the results of electrophysiological studies [36]. Therefore, all the electrophysiological tests assessing CTS are complementary to each other. There is no single test that can take the upper hand on the others. The current study had two limitations. First one was the inadequate number of patients with very mild CTS (Grade 1 Bland score) which constituted 18.57%. Very mild CTS patients are the main target of using electrophysiological comparative studies for their diagnosis. Second one was the scanty number of CTS patients with unobtainable median CMAP. This could be due to the medical awareness of patients about CTS with early seeking medical advice.

In conclusion, the median versus ulnar (MTM) motor latency difference has high sensitivity and specificity for the diagnosis of CTS as for both median versus ulnar (2-LINT) motor latency difference and median versus ulnar digit four sensory latency difference. It can be considered a useful neurophysiological test to be used in combination with other median versus ulnar comparative tests for confirming the diagnosis of CTS beside other well known electrophysiological tests. The current study would like to suggest its use in combination with other comparative tests in confirming the diagnosis of CTS electrophysiologically. The data presented in the current study were derived from a single electrodiagnostic laboratory. Further research is recommended on validity and generalizability of the current results.

Conflict of interest

None declared.

References


