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Median Versus Ulnar Sensory and Motor Latency Difference in Early Diagnosis of Carpal Tunnel Syndrome

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ABSTRACT

Aim: This study proposed to detect sensitivity of different electrophysiological techniques in early diagnosis of Carpal Tunnel Syndrome (CTS) compared to the standard technique as Median Sensory Latency.

Method and Instrument: The present study included 70 hands (40 hands with clinical evidence of idiopathic CTS and 30 hands as control group). The following tests were done for both groups: 1- Sensory nerve conduction study: median nerve, ulnar nerve, median versus ulnar latency difference between second and fifth digits, median versus ulnar latency difference (ring finger) 2- Motor nerve conduction study: median nerve, ulnar nerve, median versus ulnar motor latency difference.

Findings: The most sensitive (92%) two tests were median-ulnar sensory latency difference recorded from second and fifth digits and median-ulnar sensory latency difference recorded from fourth digit, while median-ulnar motor latency difference and median motor latency showed lowest sensitivity (61, 53%) respectively.

Conclusion: Median-ulnar sensory latency difference recorded from digit two and digit five and that recorded from digit 4 have highest sensitivity for early detection of CTS.

Keywords: Carpal Tunnel Syndrome; Median Versus Ulnar Latency Differences; Nerve Conduction Study.

Introduction

Carpal Tunnel Syndrome (CTS), the most common entrapment neuropathy of the upper extremity, is caused by compression of the median nerve at wrist. The diagnosis of CTS is mainly based on typical symptoms in disease history and signs in physical examination. However, electro diagnostic studies are helpful when the classic defining features of CTS are obscure [1].

In electrophysiological practice, numerous conduction parameters are used. The traditionally used ones deal with transcarpal sensory and motor conduction measures of median nerve. Prolongation of median nerve distal motor latency and decrease of compound muscle action potential amplitude over Abductor Pollicis Brevis (APB), elongation of wrist-to-digit or wrist-to-palm median nerve distal sensory latency are helpful in the electrodiagnosis of CTS. However, the previous studies showed a wide range of sensitivity and specificity for them [1].

Difference between distal sensory latencies of median and ulnar nerves and difference between distal motor latencies of median and ulnar nerves are commonly used nerve conduction parameters for early diagnosis of CTS. These are having high degree of sensitivity and specificity [2].

The aim of the present study was to detect sensitivity of each electrophysiological technique compared to the standard technique to detect the most sensitive test in early diagnosis of CTS.

Method and Instruments

The present cross sectional study included 40 patients (40

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hands) with clinical evidence of idiopathic CTS who were recruited from those attending the outpatient clinic of Physical Medicine, Rheumatology and Rehabilitation outpatient Department, Cairo University Hospital, Egypt. The diagnosed CTS patients were compared to 30 control subjects (30 hands) who were recruited from National Institute of Neuromotor system. Their age and sex were matched. The study took place in the period from June 2017 to July 2018. The inclusion criteria were as clinical diagnosis of CTS which was based on the presence of at least one of the following symptoms with disease duration ranged from one to six months**:** These criteria were as the presence of numbness, tingling or paraesthesia in the median nerve distribution, (ii) the symptoms are precipitated by repetitive hand activities and relieved by rubbing and shaking the hand, (iii) the presence of nocturnal awakening by these sensory manifestations. The clinical diagnosis was supported by positive Tinel's and/or Phalen's sign. Exclusion criteria were as patients with relevant systemic conditions such as diabetes mellitus, renal impairment, rheumatoid arthritis, hypothyroidism, cervical spine disease and neurological disorders including peripheral neuropathy or nerve injury. The study was explained to the participants and an informed consent was given by each.

To do the study, all patients included in the study were subjected to the following:

Full history taking: Current symptoms of CTS e.g numbness, tingling, pain and nocturnal awakening, symptoms suggestive of severe CTS such as (grip weakness and dropping things) and duration of symptoms.

Thorough clinical examination like neurological examination

- Sensory: diminished pin-prick sensation in median innervated fingers
- Motor: weakness of the Abductor Pollicise Brevis muscle.
- Provocative tests:- Phalen maneuver: the patient is asked to hold his/her wrist in complete and forced flexion (pushing the dorsal surfaces of both hands together) for 30 seconds. If the hand symptoms are reproduced, then the test is positive [3].
- Tinel sign: the test is positive if there is reproduction of the patient's hand symptoms when the wrist is percussed on the volar surface[3].

Electrophysiological studies

These tests were conducted on a Tru Trace machine software version 1.6 with a two channel EMG.

All tests rely on maximal stimulation for motor nerve and submaximal stimulation for sensory nerve. Technique is antidromic for sensory nerve. The sweep time was set at 5ms/ division for the motor tests and at 2ms/ division for the sensory tests. The sensitivity was set at 5mV/ division for the motor tests and at 10 μV / division for the sensory tests.

The electrophysiological studies done for both patients and control group according to Preston & Shapiro [4] were as following;

(i)Median sensory nerve conduction study (digit two): An active recording ring electrode was placed over the palmar aspect of proximal phalanx of the second finger with the reference ring 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 radials tendon and palmaris longus tendon. Distal latency > 3.5ms and amplitude < 20 μv were considered abnormal.

(ii) Ulnar sensory nerve conduction study (digit five): An active recording ring electrode was placed over the palmar aspect of proximal phalanx of the fifth finger with the reference ring electrode 3 cm distal on the finger. Electrical stimulation was

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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. Distal latency >3.1ms and amplitude < 17 μv were considered abnormal.

(iii) Median versus ulnar sensory latency comparative (digit four) (Ring finger test) study: An active recording ring electrode was placed over the palmar aspect of proximal phalanx of the fourth finger with the reference ring electrode 3 cm distal on the finger. Electrical stimulation of the median and ulnar nerves was done at the same site of their stimulation in the previous sensory studies (over the wrist). The differences between median and ulnar latencies were obtained for analysis. Difference > 0.5 was considered abnormal.

(iv)Median versus ulnar sensory latency difference: The difference between median (digit 2) and ulnar (digit 5) sensory latencies was obtained for analysis. It was calculated by subtraction of the ulnar latency from the median latency. Difference > 0.5 was considered abnormal.

(v) Median motor nerve conduction study: An active recording surface disc electrode was attached over the ABP muscle belly and the reference surface disc electrode over the first finger metacarpophalangeal joint. Electrical stimulation of the median nerve was done at 7 cm proximal to the active recording electrode at the wrist between the flexor carpi radials tendon and palmaris longus tendon. Distal latency and amplitude were obtained for analysis. Distal latency > 4.4ms and compound muscle action potential (CMAP) amplitude < 4 mV were considered abnormal.

(vi) Ulnar motor nerve conduction study: An active recording surface disc electrode was attached over the abductor digiti minimi muscle belly and the reference surface disc electrode over the fifth finger metacarpophalangeal joint. Electrical stimulation of the ulnar nerve was done at 7 cm proximal to the active recording electrode at the wrist crease just lateral to the flexor carpi ulnaris tendon. Distal latency and amplitude were obtained for analysis. Distal latency > 3.3ms and CMAP amplitude < 6.0 mV were considered abnormal.

(vii) Median versus ulnar motor latency difference study: The difference between median (recorded from thenar muscle) and ulnar (recorded from hypothenar muscle) distal latencies was obtained for analysis. It was calculated by subtraction of the ulnar latency from the median latency. Difference > 1.2 was considered abnormal [5].

Statistical analysis

All data were tabulated and subjected to statistical analysis using the statistical package of social science (SPSS version 17). Quantitative variables were expressed by mean and standard deviation. Qualitative variables were expressed by percentage Statistical differences between independent two groups (patients and control) were tested using two tailed student's T test. Correlations were done to test for linear relations between variables using pearson correlation test. P-values at <0.05 were considered statistically significant.

According to the following equation the sensitivity and specificity were described :[4]

Sensitivity is calculated through the number of patients with true positive test/ (true positive +false negative patients).

Specificity is calculated through the number of patients with true negative test/ (true negative +false positive patients).

Taking into consideration that the standard test for diagnosis of early CTS is the median sensory distal latency more than 3.5 ms).

Findings

The present study assessed 40 clinically diagnosed CTS patients, included 35 females

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(87.5%) and 5 male (12.5%). Their age was ranged from (21 to 55) years, with a mean age 35.4± 7.9. The control group consisted of 30 healthy asymptomatic subjects, 26 females (87.5%) and 4 male (13.3%). Their age was ranged from (20 to 55) years, with a mean age (30.5 ± 7.5). There was no statistically significant difference between patients and control groups as regards age (P=0.1) and sex (P=0.9). Table 1 shows demographic data of patients and control groups.

Clinical characteristics showed that all patients complained for about one to six months duration of illness with a mean of 5.2 months. 40 patients (100%) had numbness along distribution of median nerve which increased by activity and decreased by hand shaking, 34 patients (85%) had nocturnal numbness, 34 patients (85%) had positive tinel sign, 38 patients (95%) had positive phalen sign, 2 patients (5%) had negative tinel and phalen sign. Unilateral affection was present in all patients.

The results of different nerve conduction parameters between the two studied groups are shown in Table 2. The differences in all parameters of sensory and motor median nerve studies between the two groups were highly statistically significant. There was no statistically significant difference between the two groups as regards parameters of ulnar sensory and motor studies. This excluded the presence of peripheral polyneuropathy among the CTS patients group.

The sensitivity of different electrophysiological parameters are shown in Table 3. The highest sensitivity (92%) in confirming early CTS were median-ulnar sensory latency difference (M-USLD) (digit 2&5) and median-ulnar sensory latency difference (M-USLDF (digit four)). While tests of lowest sensitivity were the median-ulnar motor latency difference (M-UMLD) (61%) and median motor latency (MML) (53%).

Table 4 shows statistically significant positive correlations between both (MUSLD and MUSLDF) and standard MSL ($p < 0.05$), while there were no statistically significant correlations between both (MUSLD and MUSLDF) and standard MML ($p > 0.05$).

Discussion

Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy in the body for which nerve conduction studies (NCSs) are performed [6,7]. There is a diversity of electrophysiological techniques that are utilized to assess median nerve conduction across carpal tunnel. The median motor and sensory conduction studies are the routine study. Unfortunately, these routine conventional electrophysiological tests can be normal in CTS. The use of other more sensitive comparative techniques to confirm

Table 1) Demographic data of patients and control groups

		Group 1 Patients No. = 40	Group 2 Control No. = 30	P-value	Significance
Age (year)	Mean ±SD	35.4 ± 7.9	30.5 ± 7.5	0.1	NS
	Range	21 – 55	20 – 55		
Sex	Males	5 (12.5 %)	4 (13.3 %)	0.9	NS
	Females	35 (87.5 %)	26 (87.5 %)		

Significant if ($P < 0.05$), NS: non significant

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Table 2) Comparison of different nerve conduction parameters between the two studied groups

Group / Parameters	Group 1 (Patients) No= 40 *Mean± SD*	Group 2 (Control) No =30 *Mean± SD*	P-value	Significance
MSL (ms)	3.1±0.49	2.1±0.18	< 0.001	sig
MSA (µv)	12.2±4.7	18.8±4.7	< 0.001	sig
USL (ms)	2.0±0.3	1.9±0.18	0.067	
USA (µv)	12.8±4.6	14.4±5.2	0.19	
M-USLD (ms)	1.0±0.4	0.2±0.11	< 0.001	sig
M-USLDF (ms)	1.01±0.47	0.17±0.11	< 0.001	sig
MML (ms)	3.5±0.33	3.04±0.32	< 0.001	sig
MMA (mv)	10.1±3.05	11.3±2.16	0.069	
UML (ms)	2.3±0.3	2.4±0.29	0.13	
UMA (mv)	9.8±1.8	9.9±1.8	0.738	
M-UMLD (ms)	1.15±0.3	0.5±0.19	< 0.001	sig

MSL: median sensory latency , MSA: median sensory amplitude , USL: ulnar sensory latency, USA : ulnar sensory amplitude, M-USLD: median ulnar sensory latency diffierence second & fifth digit, M-USLDF: median ulnar sensory latency diffierence fourth digit, MML: median motor latency, MMA: median motor amplitude, UML: ulnar motor latency, UMA: ulnar motor amplitude, M-UMLD: median ulnar motor latency difference, ms:milisecond, µv; microvolt.

the diagnosis of CTS is utilized [8].

These comparative tests compare the median sensory or motor conduction across carpal tunnel with ulnar nerve, 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 [8].

This study was designed to determine the sensitivity of different electrodiagnostic tests to confirm the clinically suspected patients with early CTS.

Themedianversusulnarsensorycomparative test is used in diagnosis of very mild CTS, i.e. when the routine median sensory and motor studies are within normal [8]. Previous publications involving the electro diagnosis of CTS have reported a wide range of results for the sensitivity of median-ulnar sensory latency difference (56% to 100%) compared to 92% in ours [9,10,11]. Presumably, the wide variation in the sensitivity of these studies is the result of patients' selection factors and sample size.

Similar to our findings, Hegab et al. and kodama et al. showed that M-USLDF was reported as one of the highest sensitivity for electrophysiological tests (92%, 93% respectively) [3, 12] .

While our study showed the same highest sensitivity (92%) for both MUSLD and MUSLDF, Aygul et al. reported that, the most

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Table 3) The calculated sensitivity of different electrophysiological parameters

Electrophysiological Parameters	Sensitivity (%)
M-USLD (ms)	92
M-USLDF(ms)	92
M-UMLD (ms)	61
MML (ms)	53

M-USLD: median ulnar sensory latency diffierence (digit 2&5), M-USLDF: median ulnar sensory latency diffierence (digit 4), M-UMLD: median ulnar motor latency difference, MML: median motor latency, ms:milisecond.

Table 4) Correlation between MUSLD, MUSLDF and other different parameters

Parameters	M-USLD		M-USLDF	
	r	p	r	p
M ML	0.178	0.271	0.235	0.145
M SL	0.772	<0.001*	0.386	0.014*

Significant if p value <0.05
M-USLD: median ulnar sensory latency diffierence (digit 2&5), M-USLDF: median ulnar sensory latency diffierence (digit 4), MML: median motor latency, MSL: median sensory latency.

sensitive parameter was MUSLDF followed by MUSLD (77%, 73%) respectively [13]. This is due to preferential compression of fibers from the fourth digit, as it is localized in the outer margin of median nerve [14]. In another study, M-USLD showed higher sensitivity than M-USLDF (89.4, 84.7%) respectively in early CTS involvement **[15].** They reported that fibers in the central portion of the median nerve may also be affected as early as the others (peripheral) and that the distribution and severity of median nerve entrapment may involve median nerve distal branches differently. This divergence of the results reflects no uniform involvement of the median nerve in the early period of the entrapment process.

The comparative motor studies between median and ulnar motor latencies with thenar and hypothenar recording have been described, but have not been widely adopted during clinical testing for CTS due to a low diagnostic sensitivity [5,16]. In the present study, Median-ulnar motor latency difference (M-UMLD) had a low sensitivity (61%) in diagnosis of early CTS. This agrees with Aygul et al. who reported sensitivity (66%) [13]. A higher sensitivity (80%) than ours was reported by Saba in 2015, this could be explained by the inclusion criteria of his patients where they covered all Bland score grades of CTS electrophysiological severity [17].

The median motor latency (MML) was of lowest sensitivity (53%) in the current study, this is in accordance with Tawfik et al. (47%) [18]. They reported that the routine MML is not an adequately reliable test. Accordingly, if it is reported within normal values, other tests should still be done. Similarly, many other studies [19,20,21] also revealed a low sensitivity of MML.

Considering the Characteristic findings in the electrophysiological diagnosis of early CTS, there were increase in distal sensory and motor latency of the median nerve, decrease

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in median SNAP amplitude and slowing sensory conduction of median nerve in patients compared to controls [2,18,22,23]. The findings in our study also showed that the difference in motor distal latency, sensory distal latency and SNAP amplitude of the median nerve were significantly different in patients compared to controls.

The current study did not detect any difference in ulnar sensory and motor latency between patients and control similar to that reported by previous studies [24, 25]. This indicate that median versus ulnar sensory and motor comparative study was accurate for assessment of early median neuropathy at wrist.

The present study showed significant positive correlations between both (MUSLD and MUSLDF) and standard MSL, this positive correlations implicates that sensory fibers were affected in early entrapment of median nerve. The absent correlation between both (MUSLD and MUSLDF) and standard MML together with low sensitivity of MML supports the recent trend to do more sensitive tests in the cases of normal routine median motor study.

In conclusion, the early diagnosis of carpal tunnel syndrome is important and largely dependent on median- ulnar comparison tests such as the median versus ulnar sensory latency difference recorded from digit 4 as well as median versus ulnar sensory latency difference recorded from digit 2 and digit 5. The sensory comparative study is more sensitive than the motor comparative study.

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Ethical permission

The study was described to participants and they were assured that their participation was voluntary.

Conflicts of Interests

There is no conflict of Interest.

Author's contribution:

HD, SAR and MK designed the study. HD analyzed and interpreted the data. SAR and MS participated in data collection and data management. HD and MK were major contributors in writing the manuscript. All authors read and approved the final manuscript.

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