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RESEARCH ARTICLE

Comparison of second lumbrical interosseous median and ulnar motor conduction study in population of subjects with idiopathic carpal tunnel syndrome and non-CTS hands-a cross-sectional study

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ABSTRACT

Background: Second lumbrical interosseous (2L-I) median-ulnar motor conduction study across wrist is pivotal in electrodiagnosis of carpal tunnel syndrome (CTS) in different grades of severity. 2L-I Median versus ulnar distal motor latency (DML) difference more than 0.5 milliseconds is used to diagnose median neuropathy at wrist. Other variables of study, namely, 2L DML, compound muscle action potential (CMAP) amplitude, CMAP duration, and conduction velocity (CV) remain less explored with few studies pressing for its role to substantiate CTS diagnosis. **Aims and Objectives:** Current cross-sectional study aimed to explore role of 2L-I DML, amplitude, duration, and CV in diagnosis of median neuropathy at wrist. **Materials and Methods:** Total 70, 37 clinically suspected CTS hands and 33 age, height, and weight matched non-CTS hands underwent 2L-I Median Ulnar motor conduction study. **Results:** Statistically significant difference ($P < 0.05$) in 2L median DML, CMAP amplitude, duration and CV between CTS and non-CTS hands along with 2L-I Median versus Ulnar DML difference. 2L DML and 2L-I DML difference variables showed better specificity and sensitivity: 83.78 and 93.91, respectively, in diagnosing CTS. **Conclusion:** We concluded that apart from 2L-I DML difference other variables such as DML, amplitude, duration, and CV may also play substantial role in evaluation of CTS and may be included as part of electrodiagnostic protocol.

KEY WORDS: Carpal Tunnel Syndrome; Motor Conduction Study; Neuropathy; Electrodiagnosis

INTRODUCTION

Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy.[1,2] Median nerve fibers undergo compression beneath the transverse carpal ligament.[3,4] It is very often referred to electrodiagnosis laboratory. There is a diversity of tests to locate median nerve slowing across wrist to confirm clinical CTS.[5] It helps in objective assessment.[6,7] Depending on test outcome, treatment protocol may vary.[8] As conventional motor sensory tests fail to detect mild severity other short segmental studies are adopted.[9] We need at least two such short segmental studies to be positive to label mild CTS.[10] These are median versus ulnar sensory or motor conduction across wrist. It has advantage of direct internal comparison where we presume ulnar nerve as normal and detect a slowing of the median nerve in relation to it. Changes in sensory nerve fibers occur earlier than motor fibers hence abnormality in SNCs precede MNCs.[2,3] Few studies reported 2L-INT distal motor latency difference (2LIDMLD) as more sensitive and specific test than sensory comparison tests. 2LIDMLD depicts a lesion delineation in 16% of hands in severe CTS cases where

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other tests like median compound muscle action potential (CMAPs) are not elicited[11] Few studies reported 2LIDMLD as most sensitive test to evaluate CTS in diabetes and uremic patients.[12,13] Ozben *et al*. observed that not only 2LIDMLD value but also 2L-Motor distal latency (2L-MDL) value too fairly supportive in CTS evaluation where median CMAPs from APB are unrecordable.[14] Although literature suggests sensory comparison tests have upper hand in diagnosis of mild CTS against motor tests, there are few studies that showed abnormalities in motor conduction tests equivocal with sensory tests. Hence, it is clear from literature that 2LIDMLD, 2L-MDL, and other newer motor comparison tests play important role in evaluation of different grades of CTS of different etiologies.

There is paucity of data on role of 2nd Lumbrical Median motor conduction study (2LMMCS) variables, namely, peak/onset latency of 2L-CMAP, duration of 2L-CMAP, amplitude of 2L-CMAP, and conduction velocity (CV) of median nerve elicited from 2L muscle. Current cross-sectional study was designed to assess role of 2LMMCS and first palmer interosseous ulnar motor conduction study (FPIUMCS) in electrodiagnosis of CTS. Specifically, we have compared 2LIDMLD, distal motor latency (DML), CMAP duration, CMAP amplitude, and CV of median and ulnar nerves from 2L and FPI muscle, respectively, among cases and controls. An attempt was also made to estimate diagnostic sensitivity, specificity, positive, and negative predictive value (NPV) of 2LIDMLD and 2LDML in diagnosis of median neuropathy at wrist.

MATERIALS AND METHODS

Cases and Controls

Study included 37 hands with clinical evidence of idiopathic CTS attending orthopedic department OPD at a tertiary care institute in central Gujarat, India. 33 healthy hands were used as a control mostly from medical health workers, their relatives and patients' relatives. Study was conducted between January 2019 and December 2020. Clinical diagnosis of CTS was confirmed with the presence of at least one of the following primary symptoms if present: (i) Numbness, tingling or paresthesia in the median nerve territory, (ii) aggravation of symptoms by repetitive hand movements and relieved by rubbing or shaking, and (iii) nocturnal pain in hands presence of positive Tinel's sign and/or Phalen's sign.[15] Diabetic, endocrinal metabolic, or neurological disorder cases were excluded from the study. Among the available data of CTS patients referred to clinical neurophysiology laboratory, those fulfilled above criteria were considered for retrospective analysis.

Methods

All the CTS and non-CTS hands were clinically examined. The standardized semi quantitative clinical History-Objective (Hi-Ob) scale was used to stage (5 stages) the severity of CTS by integrating symptoms and signs.[16] Irrespective of stage of the disease, all CTS hands were included in CTS group and healthy hands were included in non-CTS group. Electrophysiological studies (NCV) were done using Aleron Portable EMG-EP 4-channel Machine manufactured by RMS recorders and Medicare Chandigarh India. For consistency in data collection, same technician performed recording in all participants under constant environmental conditions. Brief description of EDX study[17,18] 2LMMCS: Electrode placement followed belly-tendon montage with common site for both innervated muscles. Median nerve was stimulated at wrist and elbow [Figure 1].

We used similar settings that are used for 2nd Lumbrical-Interosseous motor latency comparison test. Standard settings for sweep speed, sensitivity, stimulus strength, and duration were used. Distal stimulation was done at wrist crease 10 cm from active electrode. Proximal stimulation was done at elbow. Distance between two sites was entered to automatically calculate CV of median nerve recorded from 2nd Lumbrical muscle. In same settings, FPIUMCS was also undertaken. Supramaximal strength of stimulus was used to elicit median and ulnar nerve CMAP response. Figure 2 shows CMAPs observed in median and ulnar motor study.

Data Acquisition and Analysis

Data for different variables, namely, DML, CMAP Amplitude, Duration of CMAP, and CV was obtained.

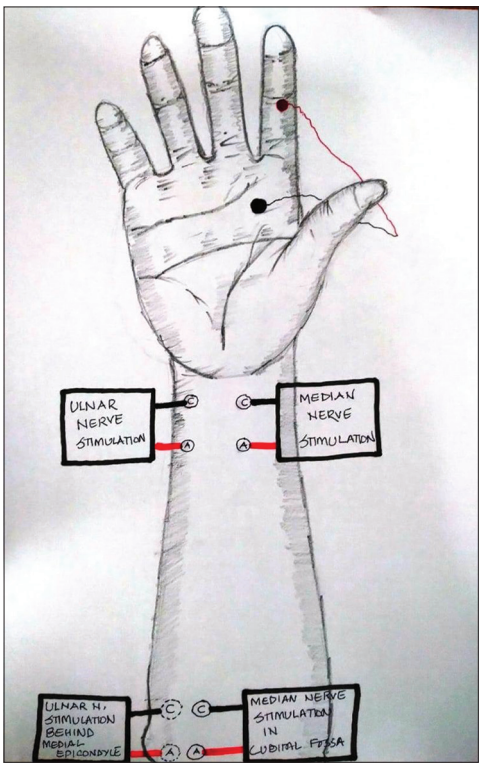

Figure 1: Second lumbrical interosseous median and ulnar motor nerve conduction study: Recording electrodes placement and Stimulation of nerve at wrist and elbow

All values were the numerical numbers and were stored in Microsoft excel sheet for analysis. Mean and standard deviation (SD) was obtained for each parameter in both groups. Reference values were also obtained as range, upper or lower limit of normal by addition or subtraction of two SD values in mean value. To compare statistically significant difference among different groups if any, we used Student's *t*-test. For all statistical purposes, level of significance (*P* value) was fixed at 0.05. Diagnostic sensitivity, specificity, positive and NPVs of 2LIDML difference and 2LDML were calculated. For other variables, there was no reference cutoff values hence were only compared among case and control to observe statistical significance difference if any. GraphPad Prism online software was used for analysis.

RESULTS

Total 70 hands, out of which 37 CTS and 33 Non-CTS were studied. Anthropometric and demographic profile is illustrated in Table 1. Except age, none other anthropometric measures among cases and controls showed any statistically significant difference. This suggests that any variation with regard to anthropometric variables among two groups were duly taken care of.

Median and ulnar motor conduction study variables elicited from 2L and FPI muscle were compared among cases and control hands as shown in Table 2. Statistically significant difference ($P < 0.05$) were observed in 2LMMCS variables and Median versus Ulnar- 2LIDMLD among CTS and Non-CTS hands. In 2LMMCS, DML and duration mean values were higher, amplitude and CV values were lower in CTS hands as compared to non-CTS hands. Furthermore, median versus Ulnar-2LIDMLD showed higher values of latency difference in cases compared to controls. Statistically no significant differences were observed in FPIUMCS variables of cases and controls.

Table 3 illustrates diagnostic value of 2LIDMLD and 2LDML in CTS patients. 2LIDMLD remains superior in predicting median neuropathy at wrist when compared with only DML recorded from 2nd Lumbrical muscle.

DISCUSSION

Inability of conventional NCS to detect Median neuropathy at wrist always encouraged researchers to search for other tests that could help in diagnosis of CTS especially "Mild one" where it is presumed that sensory fibers are involved much earlier sparing motor ones. Over a period of years in

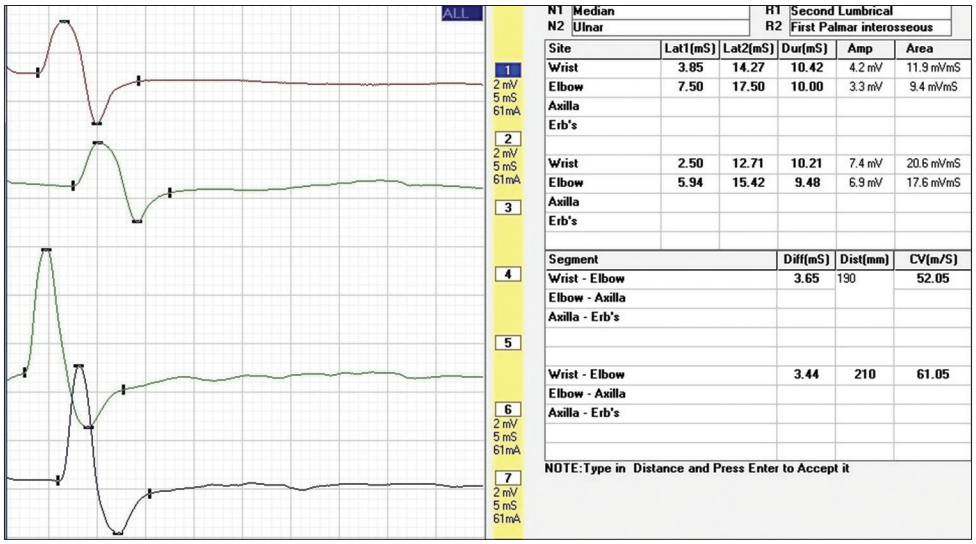

Figure 2: Real time graph of second lumbrical interosseous median and ulnar motor conduction study obtained from a participant

Table 1: Anthropometric and demographic profile of CTS and non-CTS hands under study

Demographic and anthropometric measures	CTS Hands (14 male, 23 female, *n*=37) (Mean±2 SD)	Non-CTS Hands (21 male, 12 female, *n*=33) (Mean±2 SD)	Absolute *P* value
Age (years)	49.95±11.67	42.58±13.95	0.0188
Height (cm)	161.11±4.811	162.6±5.2	0.2676
Weight (kg)	64.76±13.76	61.7±8.05	0.2153
BMI (kg/m^2)	24.83±4.4	23.33±2.68	0.0950

CTS: Carpel tunnel syndrome, SD: Standard deviation, Kg: Kilogram, cm-centimeters, m-meters

Table 2: Second lumbrical MMCS and first palmer interosseous UMCS nerve conduction study comparison among CTS and Non-CTS hands

Type of motor conduction test	NCV study Variables	CTS hands (*n*=37)	Non-CTS hands (*n*=33)	Student's *t*-test *P* value
2LMMCS	DML	5.61±2.56	3.203±0.57	<0.05
	CMAP Amplitude	1.56±1.3	2.76±1.08	
	Duration	12.39±3.8	10.8±1.74	
	CV	48.9±11.79	56.27±5.95	
FPIUMCS	DML	3.17±0.4	3.183±0.52	>0.05
	CMAP Amplitude	4.73±2.3	5.0±1.67	
	Duration	11.27±1.95	12.36±2.25	<0.05
	CV	56.26±7.12	57.45±5.92	>0.05
Median versus Ulnar-2LIDMLD		2.438±7.12	0.02±0.341	<0.05

2LMMCS: Second Lumbrical median motor conduction study, FPIUMCS: First palmer interosseous ulnar motor conduction study, CTS: Carpel tunnel syndrome, DML: Distal motor latency, CMAP: Compound muscle action potential, CV: Conduction velocity, 2LIDMLD: Second Lumbrical Interosseous distal motor latency difference

Table 3: Predictors of median neuropathy at wrist and its diagnostic value in population/hands studied (*n*=70)

Predictors of median neuropathy at wrist	Sensitivity (%)	Specificity (%)	PPV %	NPV %	Population with Prevalence of CTS (%)
2LIDMLD	83.78	93.93	93.93	83.78	52.85
2LDML	83.78	81.81	83.77	81.82	52.85

2LIDMLD: Second Lumbrical Interosseous distal motor latency difference, 2LDML: Second Lumbrical distal motor latency, PPV: Positive predictive value, NPV: Negative predictive value

search of better techniques, comparison tests have played crucial role in the diagnosis of CTS.[19] It was established in a study that lumbrical innervating motor fibers are relatively preserved as compared to thenar muscle innervated fibers in severe CTS cases.[20] Hence, 2LIDMLD sparked curiosity as it not only showed superiority in diagnosis of mild CTS but also severe CTS where routine Median CMAPs were not elicited providing a window for comparison of conduction slowing at wrist.[14] Recently 2LIDMLD comparison was also used to demonstrate Martin-Gruber anastomosis by Pasuthamchat *et al*.[21] In current study, we further explored all the variables of 2LMMCS and FPIUMCS for larger understanding of the role it could play in supporting CTS diagnosis. Current study showed a novel approach to observe significant difference if any in 2LMMCS variables of CTS and non-CTS hands in addition to routine and established median versus Ulnar 2LIDMLD parameter. Interestingly, all four variables, namely, DML, CMAP amplitude, CMAP duration, and CV of median nerve elicited from 2nd Lumbrical showed significant differences ($P < 0.05$). It suggests that along with latency difference other variables of 2L-I median and ulnar MNC may play a significant additional role in diagnostic accuracy of median neuropathy at wrist. Prolonged DML and reduced CV suggest demyelination, reduced CMAPs suggest axonal loss and prolonged duration of CMAP suggests poor summation due to demyelination or axonal loss. Thus, other variables provide additional information regarding underlying pathophysiology for median neuropathy at wrist.

Table 4 illustrates comparison of various 2LI motor conduction studies in CTS patients from the literature with that of current study.[22-29] To best of our knowledge, no study explored role of duration of CMAP and CV of median, ulnar nerve elicited from 2L-I, only few[23,25] explored role of DML and CMAP amplitude along with latency difference, and some[22,27,28] added role of DML with latency difference. Rest all studies in the literature comment regarding role of 2LIDML difference in diagnosing different grades of CTS.[24,26,29,14]

Findings from current study were corroborative with few studies[25,26,28] and varied from other studies so far as 2LIDMLD values are concerned. This may be attributed to variability in type of population, sample size, distal stimulation site, reference cutoff values, etc. Literature suggests, diagnostic sensitivity, specificity, PPV, and NPV of 2L-I plays role in diagnosing all grades of CTS.

Limitations of this Study

No gender matching among cases and controls and small sample size remains major study drawback. 2L MNC normative data were collected from very small sample size.

Table 4: Comparison of Second Lumbrical Interosseous motor conduction study from literature with the present study[22-29]

Name and year of study	Sample size	2LISMLD	Other variables of 2LMMCS	Sensitivity and specificity	Positive and negative predictive value	Remarks
Current study, Ghugare *et al*. 2021	Cases and controls 70, CTS hands 37	Cases: 2.438±7.12 Controls: 0.02±0.341	DML: 5.61±2.56 Amplitude: 1.56±1.3	2LDMLD 83.78%, 93.73% DML 83.78; 81.81	2LDMLD 93.93%, 83.78% DML 83.77; 81.82	Case control study including other variables of 2L muscle
Kasius *et al*., 2019	Cases and control 209, CTS hands 162	Cases: 1.86±1.79 Controls: 0.08±0.53	DML: 3.63±1.67	2LDMLD 58.2%; 95.7%		
Yilmaz *et al*., 2017	174 cases, 80 controls	Cases: 1.4±1.3; controls: 0.1±0.2	DML: 4.6±1.4; Amplitude: 2.2±1.4	2LDMLD 76%; 63%	82%; 54%	
Chaurasia *et al*. 2017	100	Cases: 0.7±0.3				
Lee *et al*., 2016	401	Cases: 4.53±2.63; range-0.5to 10.2	DML: 7.7±2.77; amplitude: 0.73±0.56	2LDMLD 88.8%; 96.4%		
Kanikannan *et al*., 2015	Cases-92; 100 controls	2.29±1.72		2LDMLD 88.32%; 94.36%	96%; 86.6	HRUS and NCV comparison-case control study
Lee *et al*. 2013	Cases-67	Cases: 5.58±1.77	DML: 3.13±1.99			Mild, moderate and severe degree cases: Prospective study
Ozben *et al*., 2012	Cases: 375			2LDMLD-89.4%; 84.4% DML-87.3%; 70.7%		Used 2LDML as additional tool to support CTS in severe cases.
Boonyapisit *et al*., 2002	Cases-28			2LIDMLD-92.8%		Only severe CTS hands were examined
Loscher *et al*. 2000	Cases: 450; controls 100			2LIDMLD-97.5%		2L response recorded where routine sensory motor response absent

2LIDMLD: Second Lumbrical Interosseous distal motor latency difference, CTS: Carpel tunnel syndrome, NPV: Negative predictive value, DML: Distal motor latency, 2LMMCS: Second Lumbrical median motor conduction study

CONCLUSION

Study illustrates the role of 2L-INT DML, CMAP amplitude, duration, and CV of median-ulnar motor conduction test as an important adjunct in CTS evaluation. Significant differences among all variables between median and ulnar nerve suggests, these variables may also be the part of 2L-I study during evaluation of cases.

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