Original Article

# Evaluation and comparison of three most commonly used tests for electrodiagnosis of carpel tunnel syndrome in diabetic patients with or without clinical evidence of neurodeficit

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## Abstract

**Background and Aim:** Electrodiagnosis of carpel tunnel syndrome (CTS) becomes difficult with routine tests when CTS is severe with coexistent polyneuropathy. Diabetes cases often report with symptoms of CTS and peripheral neuropathy. There is lack of literature regarding diagnostic accuracy of electrodiagnostic (EDX) tests, including comparison tests in diabetic patients to diagnose CTS. Therefore, the present study was intended to evaluate and compare the diagnostic sensitivity and specificity of comparison tests in diabetics with or without clinical CTS.

**Methods:** The three commonly used median versus ulnar comparison tests viz., palm-wrist mixed comparison (PWMC), digit4-sensory onset latency comparison (D4SOLC) and 2lumbrical-interossie motor latency comparison (2L-IMLC) were used for diagnosis of CTS in these subjects. Fisher's exact test was applied to compare the differences in diagnosis between clinical and different EDX comparison tests.

**Results:** Prevalence of CTS with routine EDX tests and comparison tests was observed as 16% and 24%, respectively. Diagnostic sensitivity for PWMC, D4SOLC and 2L-IMLC was 69.23% 76.92%, and 92.31%, respectively. 2L-IMLC was observed as most sensitive and D4SOLC was observed as most specific comparison tests for EDX of CTS in diabetic patients.

**Conclusion:** Prevalence of CTS in diabetic patients increases with use of comparison tests. Hence, along with routine EDX tests, comparison tests may be included as part of EDX tests to evaluate CTS in these patients. 2L-IMLC test should preferably be adopted for screening CTS in diabetics.

**Key words:** Carpel tunnel syndrome, diabetic polyneuropathy, electrodiagnosis, nerve conduction study

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## INTRODUCTION

Carpel tunnel syndrome (CTS) occurs in 2% of the general population, 14% of diabetic subjects without diabetic neuropathy and 30% of diabetic subjects with diabetic polyneuropathy. The high sensitivity and specificity of nerve conduction studies (NCS) make them the most valuable diagnostic methods for CTS (80% sensitive). Among the electrodiagnostic (EDX) tests, comparison of distal motor or sensory latency of the median nerve to the ulnar nerve along with amplitude of the response is reported to be the most sensitive.[1] In patients with typical CTS, the median distal motor and sensory latencies, and F-wave minimum latencies, are moderately to markedly prolonged. However, there is a group of patients with clinical symptoms and signs of CTS in whom these routine studies are normal (approximately 10-25%

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of CTS patients). Diagnostic dilemma becomes more critical when severe CTS are accompanied by underlying polyneuropathy.[2] The diagnostic yield is observed to increase with the incorporation of median versus ulnar palm-wrist comparison tests and inching across wrist.[3] Comparison techniques were developed to adjunct the routine NCS in increasing the diagnostic sensitivity and specificity. For different studies and different grades of severity of CTS, diagnostic yields of different comparison tests vary.[4,5] There is paucity of data regarding evaluation of diagnostic sensitivity of comparison tests, among the population of subjects with diabetes mellitus. Therefore, in the present study, three most common median versus ulnar comparison tests viz. palm-wrist mixed comparison (PWMC), digit4-antidromic sensory onset latency comparison (D4ASOLC) and 2lumbrical-Interossie motor latency comparison (2L-IMLC) tests were performed to evaluate and compare the diagnostic sensitivity and specificity of these tests in a cohort of diabetics with or without clinically certain CTS.

## MATERIALS AND METHODS

The present cross-sectional study was done in clinical neurophysiology laboratory, Mahatma Gandhi Institute of Medical Sciences, Sevagram, Wardha. The population was selected from patients attending medicine out-patient department at a rural hospital in central India with supportive inclusion and exclusion criteria under supervision of consultant Physician. We included 53 diabetic patients (type 1 and type 2) after appropriate clinical and minimum supportive laboratory investigation with or without clinical evidence of neuropathy and/or carpal tunnel syndrome. Cases of hypothyroidism, rheumatoid arthritis, acromegaly, hemodialysis, treated CTS, occupational CTS were excluded from the study. Furthermore, obese, alcoholics and pregnant women were kept out of the study to minimize the confounders. Further, they were categorized into diabetics with clinically certain and non-certain CTS. The study was carried out during the period extending from January 2009 to December 2010. Each diabetic patient went through the detailed bilateral upper limb routine NCS as well as comparison studies between median and ulnar nerves. Demographic features like age, gender were noted. Written informed consent was taken from subjects before EDX evaluation. Permission was obtained from institutional human ethics committee and study was carried out according to world medical association declaration of Helsinki.

### Brief procedure

A detailed bilateral upper limb NCS comprising of median and ulnar motor conduction using belly-tendon montage, median and ulnar sensory conduction (antidromic sensory conduction), and median and ulnar F waves study, after supramaximal stimulation of median and ulnar nerve at the wrist was done. Three commonly used median versus ulnar comparison tests viz., PWMC, D4ASOLC and 2L-IMLC were also performed. Real-time recordings obtained by three different comparision tests are shown in Figures 1-3. Note the difference in the pattern of SNAPs and CAMPs in responce to stimulation at different location.

### Electrophysiological diagnosis of carpel tunnel syndrome

The case-to-case diagnosis of CTS was made using following cut-off values: (i) Routine electrophysiological tests: Median motor distal latency > 4.4 ms, median sensory latency > 3.5 ms, ulnar motor distal latency > 3.3 ms, ulnar sensory latency > 3.1 ms. (ii) Comparison studies: Significant latency difference in (a) PWMC NCS > 0.4 ms, (b) digit 4 sensory comparison study > 0.5 ms and (c) 2$^{nd}$ lumbrical-interossei comparison study > 0.5 ms. Standard procedures and electromyograph setting were followed for all the EDX procedures as mentioned by Preston and Shapiro.[6]

### Statistical analysis of data

GraphPad prism software trial version 6, GraphPad software inc 7825 Fay Avenue La Jolla CA, 92037, USA was used for analysis. Data were expressed as mean, percentage, and range. Fisher's exact test was applied to compare the differences in diagnosis between clinical and different EDX comparison tests. Statistically, significant difference was set at $P < 0.05$. Diagnostic sensitivity, specificity, positive and negative predictive values (NPV) were obtained for different EDX tests.

## RESULTS

Totally 53 diabetic patients (30 male and 23 female) with a mean age and age range 51 years and 30–60 years respectively underwent EDX tests both routine and comparison. Out of 53 cases, clinically certain CTS were present in 13 and absent in 40 patients. With routine EDX tests and its established laboratory criteria, only 8 cases were confirmed to have median neuropathy at wrist. When further evaluated by comparison tests, all the 13 cases were confirmed to have CTS. For the convenience, we have expressed CTS either present or absent case-wise although in 4 cases, it was bilaterally present. Table 1 depicts the frequency of CTS with routine and comparison tests along with its grades of severity.[7]

Tables 2-4 depicts contingency tables for PWMC, D4ASOLC and 2L-IMLC studies. We observed that among the three tests, 2L-IMLC was positive in 20, PWMC was positive in 16 and D4ASOLC was positive in 14 cases. Diagnostic sensitivity, specificity, positive and NPV for the three common comparison tests are summarized

in Table 5. We observed that 2L-IMLC test was most sensitive, whereas D4ASOLC test was most specific for the diagnosis of CTS in diabetic patients.

## DISCUSSION

In the present study, we observed that, frequency of CTS by electrophysiological examination using three comparison tests of median and ulnar nerves was found to be 24.53% [Table 1]. Comparison tests were found to be more valuable in diagnosis of mild grade of CTS as compared to routine electrophysiological tests, whereas in moderate and severe grade of CTS, the percentage of diagnosis by both routine and comparison tests was apparently similar. Among the three comparison tests, lumbrical-interossei study was found to be most sensitive (sensitivity = 92.31%) and digit 4 comparison study most specific (specificity = 90%). Positive predictability value (71.43%) and overall test accuracy (86.79%) was maximum in digit 4 comparison study ($P < 0.05$) [Table 5].

**Table 1:** Prevalence of CTS according to grades of severity with routine versus comparison studies

| Grades of severity | Prevalence of CTS | |
|---|---|---|
| | With routine NCS | With comparison study |
| Mild | 2 (3.77) | 6 (11.32) |
| Mild-moderate | 1 (1.89) | 2 (3.77) |
| Moderate | 2 (3.77) | 2 (3.77) |
| Severe | 3 (5.66) | 3 (5.66) |
| Total | 8 (15.09) | 13 (24.53) |

Values in parenthesis indicate percentage. CTS: Carpel tunnel syndrome, NCS: Nerve conduction studies

**Table 2:** Palm-wrist mixed comparison study

| | CTS present | CTS absent | Total | Fisher exact test - two-tailed |
|---|---|---|---|---|
| Test positive | 9 | 7 | 16 | $P<0.05^{\dagger}$ |
| Test negative | 4 | 33 | 37 | |
| Total | 13 | 40 | 53 | |

CTS: carpel tunnel syndrome. †Statistically significant difference between diagnosis by clinical and comparison test

**Table 3:** Digit4-sensory onset latency comparison study

| | CTS present | CTS absent | Total | Fisher exact test - two-tailed |
|---|---|---|---|---|
| Test positive | 10 | 4 | 14 | $P<0.05^{\dagger}$ |
| Test negative | 3 | 36 | 39 | |
| Total | 13 | 40 | 53 | |

CTS: Carpel tunnel syndrome. †Statistically significant difference between diagnosis by clinical and comparison test

**Table 4:** 2lumbrical-interossie motor latency comparison study

| | CTS present | CTS absent | Total | Fisher exact test - two-tailed |
|---|---|---|---|---|
| Test positive | 12 | 8 | 20 | $P<0.05^{\dagger}$ |
| Test negative | 1 | 32 | 33 | |
| Total | 13 | 40 | 53 | |

CTS: Carpel tunnel syndrome. †Statistically significant difference between diagnosis by clinical and comparison test

In previous studies,[8-10] palm-wrist comparison study was documented as the most sensitive technique with sensitivity for each study, 61%, 75% and 75% in the diagnosis of CTS respectively. These varying results among studies may be explained by the difference in their inclusion criteria and sample size. This is in contrast to our finding that the lumbrical-interossei study was the most sensitive (sensitivity = 92.31%) comparison test. Cho and Cho found that among the electrodiagnostic tests, comparison of distal motor or sensory latency of the median nerve to the ulnar nerve along with amplitude of the response was the most sensitive test.[1] Our observation are in agreement with those done by Meena *et al*., who found sensitivity and specificity of lumbrical-interossei study, palm–wrist comparison study were 85.60% and 96.67%, 68.80% and 96.10% respectively.[2] They concluded that in severe CTS, and CTS with polyneuropathy, lumbrical-interossei study was the most sensitive test while in mild CTS lumbrical-interossei and palm–wrist comparison study were equally sensitive. In the present study, most cases were moderate to severe CTS; that may be the reason why lumbrical interossei comparison test is more sensitive. Literature search documents only one such a study that included diabetic CTS patients and concluded that lumbrical-interossei comparison study can identify CTS in diabetic polyneuropathy patients better than any other tests.[11] Löscher *et al*. documented 2L-IMLC study as a sensitive, quicker, convenient, and cost-effective tool to localize the lesion in median neuropathy at wrist when other EDX methods fail.[12]

We observed that the overall prevalence of CTS increased from 15% to 24% when comparison methods were

**Table 5:** Diagnostic sensitivity, specificity, PPV, and NPV of median versus ulnar comparison studies

| EDX study | Sensitivity | Specificity | PPV | NPV | Test accuracy | Likelihood ratio |
|---|---|---|---|---|---|---|
| PWMC | 69.23 | 82.50 | 56.25 | 89.19 | 79.24 | 3.95 |
| D4ASOLC | 76.92 | 90 | 71.43 | 92.31 | 86.79 | 7.69 |
| 2L-IMLC | 92.31 | 80 | 60 | 96.97 | 83.01 | 4.61 |

EDX: Electrodiagnostic, PPV: Positive predictive value, NPV: negative predictive value, PWMC: Palm-wrist mixed comparison, D4ASOLC: Digit 4-antidromic sensory onset latency comparison, 2L-IMLC: 2lumbrical-interossie motor latency comparison

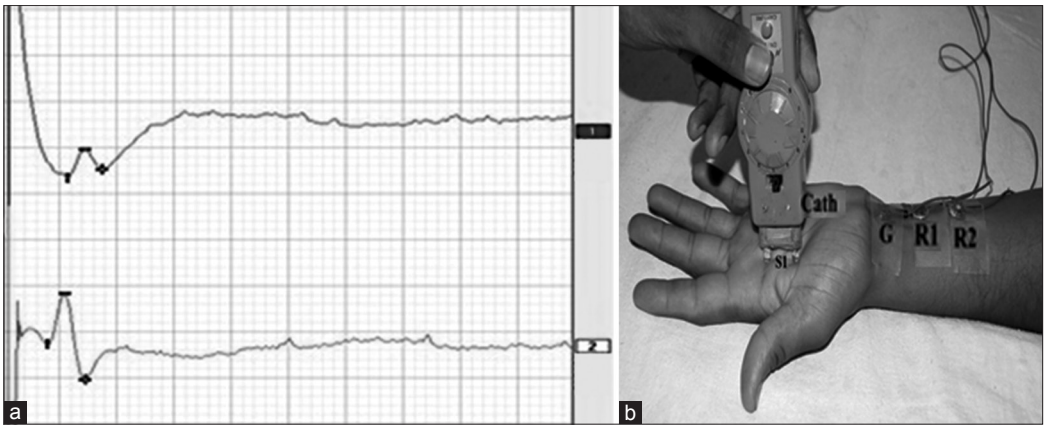


**Figure 1:** Sensory nerve action potentials (SNAPs) obtained from median versus ulnar palm to wrist mixed comparison (PWMC) study. (a) Median and ulnar nerve recording in PWMC, (b) position of electrodes and stimulator (S1) (R1-Active electrode, R2-Reference electrode, G-Ground electrode)

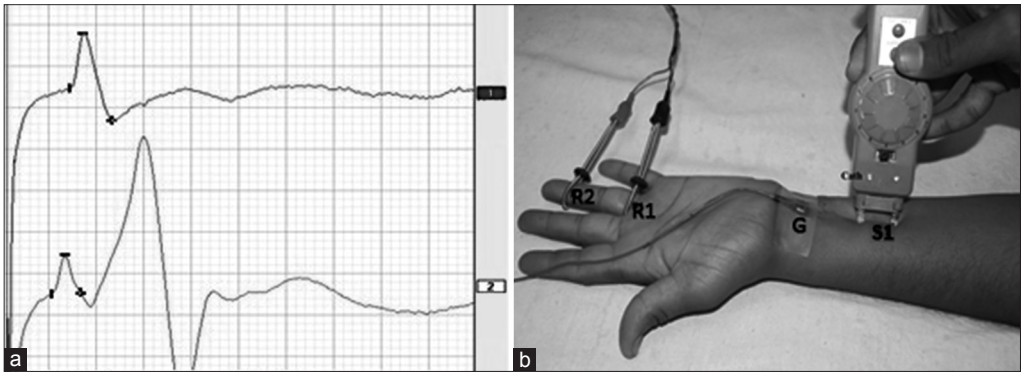


**Figure 2:** Sensory nerve action potentials (SNAPs) obtained from median versus ulnar digit4 sensory latencies study (D4ASOLC). (a) Median and ulnar nerve recording in D4ASOLC, (b) position of electrodes and stimulator (S1) (R1-Active electrode, R2-Reference electrode, G-Ground electrode)

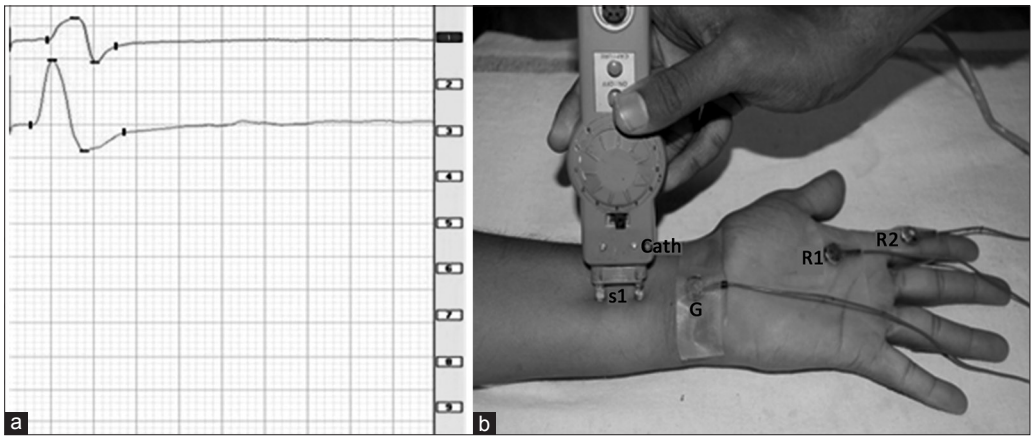


**Figure 3:** Compound muscle action potential (cAMP) obtained from median versus ulnar second lumbrical-interossei comparison study 2l Lumbrical-interossie motor latency comparison (2L-IMLC). (a) Median and ulnar nerve recording in 2L-IMLC, (b) position of electrodes and stimulator (S1) (R1-Active electrode, R2-Reference electrode, G-Ground electrode)

employed [Table 1]. Routine NCS had moderate sensitivity and specificity and a low positive predictive value in population-based CTS, whereas median versus ulnar palm wrist comparison tests exhibits highest diagnostic accuracy.[13] Standard motor and sensory electrodiagnostic studies of the median and ulnar nerve have their limitations in localizing a severe median neuropathy at the wrist. The diagnostic dilemma becomes more obvious when the patient has a co-existing peripheral polyneuropathy showing abnormalities in both median and ulnar NCS.

This scenario is more common in diabetic patients. With few exceptions, it is evident that lumbrical-interossei is the novel technique for the electrodiagnosis of CTS in moderate to severe cases.[13-15] Meena *et al*. have observed that, the sensitivity of 2L-IMLC was similar to PWMC in mild CTS cases.[2] This is in agreement with our observations, with 12 out of 13 CTS positive cases diagnosed by 2L-IMLC study including 3 mild cases. It is believed that the motor fibers, which are protected from compression in mild cases create the dilemma in their diagnosis. Further studies with mild CTS cases of larger sample size evaluated by 2L-IMLC may be needed to answer this question.

## CONCLUSION

The prevalence of CTS in diabetics increases if comparison EDX tests are used with routine tests. 2L-IMLC test is a highly sensitive and D4ASOLC test is highly specific for EDX evaluation of CTS in these patients. Of the three comparison tests compared, 2L-IMLC test should be included as a part of EDX screening test for CTS in diabetes mellitus.

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