COMPARISON OF NERVE CONDUCTION PARAMETERS IN CLINICALLY SUSPECTED UNILATERAL CARPAL TUNNEL SYNDROME (CTS) CASES

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Abstract:

Background & Objectives: Carpal Tunnel Syndrome (CTS) is the most common entrapment neuropathy, usually resulting from compression of the median nerve at the wrist. Although symptoms may be unilateral, bilateral electrophysiological abnormalities are frequently observed. This study aimed to compare nerve conduction parameters between symptomatic and asymptomatic limbs in clinically unilateral CTS patients, and to evaluate these findings against regional normative data to assess potential subclinical involvement. **Methods:** A cross-sectional study was conducted on 27 patients with clinically unilateral CTS. Bilateral median nerve motor and sensory conduction studies were performed using the RMS EMG EP–MARK II system. Parameters recorded included distal latency, amplitude, and nerve conduction velocity (NCV). Statistical analysis was done using paired and unpaired t-tests; $p < 0.05$ was considered significant. **Results:** Symptomatic hands showed significantly prolonged distal motor latency ($p < 0.05$) and reduced CMAP amplitude, though the latter was not significant. Motor NCV was paradoxically higher in affected hands. Sensory conduction showed reduced amplitude and slowed NCV, but not significantly. Both hands had significantly lower motor NCVs than regional norms, indicating subclinical changes in asymptomatic limbs. **Interpretation & Conclusion:** Bilateral nerve conduction studies in unilateral CTS cases are recommended, as subclinical involvement of the contralateral limb is common and may benefit from early intervention.

Keywords: Carpal tunnel syndrome, nerve conduction study, unilateral CTS.

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Introduction:

Carpal Tunnel Syndrome (CTS) is the most common entrapment neuropathy, caused by compression of the median nerve beneath the flexor retinaculum at the wrist [1,2]. It presents clinically with tingling, numbness, and weakness in the hand, especially affecting the thumb, index, middle, and radial half of the ring finger. Risk factors include repetitive wrist movements, prolonged manual work, and female sex[1,3].

While CTS often presents unilaterally, electrophysiological studies reveal bilateral median nerve involvement in many cases, even when the contralateral limb is asymptomatic[4]. Subclinical abnormalities such as delayed distal latency or reduced conduction velocity in the unaffected limb suggest early or latent pathology[5].

Despite this, clinical focus is typically limited to the symptomatic hand, which may lead to underdiagnosis of bilateral or subclinical CTS. Moreover, recent regional data have highlighted physiological side-to-side differences in nerve conduction velocities, stressing the importance of accounting for natural variability when interpreting results [6].

The present study was undertaken to:

- Compare nerve conduction parameters between affected and unaffected limbs in clinically unilateral CTS cases.
- Detect early subclinical changes in asymptomatic limbs.
- Compare nerve conduction data of both limbs with regional normative values to assess the presence and extent of pathological deviation.
- Emphasize the clinical utility of bilateral nerve conduction studies for accurate diagnosis and early intervention.

Material and Methods:

Study Design and Setting: This cross-sectional observational study was conducted in the NCV–EMG Laboratory of the Department of Physiology, Government Medical College, Bhavnagar. Institutional Ethical Committee approval was obtained before starting the study (Approval No: 1269/2023), and written informed consent was taken from all participants. The study followed the ethical principles outlined in the Declaration of Helsinki (1975).

Participants: A total of 27 adult patients (aged ≥18 years), clinically suspected of having unilateral Carpal Tunnel Syndrome (CTS), were included. These patients were referred by the Department of Orthopedics, Sir T. General Hospital, Bhavnagar. Among them, 15 had right-hand involvement and 12 had left-hand involvement.

Inclusion Criteria: Age ≥18 years and Clinically suspected unilateral CTS cases

Exclusion Criteria: History of epilepsy, spinal or upper limb trauma,Pregnancy,Current vitamin B12 supplementation or medications affecting nerve conduction,Presence of cardiac pacemaker or limb implants,Substance abuse (e.g., cocaine)

Baseline Assessment: Demographic details such as age, height, weight, and BMI were recorded using WHO-standardized methods and calibrated equipment.

Nerve Conduction Studies: Electrophysiological testing was conducted using the RMS EMG EP–MARK II system (Recorders & Medicare Systems Pvt. Ltd., Chandigarh, India). Participants were examined in a relaxed supine position in a temperature-controlled room. Skin was cleaned with alcohol, and surface electrodes were placed using ECG gel and Micropore tape to maintain low impedance.

Motor Nerve Conduction (Median Nerve)[1,2]

Recording Site: Abductor Pollicis Brevis (APB) muscle,Active electrode over the muscle belly and Reference electrode 3 cm distal to the active electrode.

Stimulation Sites: S1:Wrist (3 cm proximal to the distal wrist crease),S2:Elbow (over the brachial artery)

Parameters Recorded: Distal and proximal latency (ms), amplitude (mV), and motor conduction velocity (m/s)

Sensory Nerve Conduction (Antidromic Method)[1,2]

Recording Electrodes: Active at Proximal interphalangeal joint of the second digit and Reference at Distal phalanx of the same digit

Stimulation Site: Between the wrist crease and Palmaris Longus tendon

Parameters Recorded: Peak latency (ms), amplitude (µV), and sensory conduction velocity (m/s)

Evoked responses were stored digitally. The software automatically calculated latency, amplitude, and conduction velocity using precise inter-electrode distances.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using Jamovi version 2.6.23. Descriptive statistics were presented as mean ± standard deviation (SD). Comparisons were made using paired and unpaired Student's t-tests. A p-value < 0.05 was considered statistically significant.

Result:

The study included 27 patients clinically suspected of unilateral Carpal Tunnel Syndrome (CTS), with the aim of comparing electrophysiological parameters between affected and unaffected hands, and evaluating these against regional normative data to detect potential subclinical involvement.

Demographic Profile of Study Participants :Among the 27 participants, the majority were females (74.07% ,n=20), and 7 male (25.93%). The mean age of participants was 40.7 ± 10.42 years. The average height was 152.3 ± 17.46 cm, weight 62.1 ± 11.98 kg, and BMI 27.0 ± 4.79 kg/m², suggesting a trend toward overweight status (Table 1)[7].

Motor Nerve Conduction Parameters:Comparison between affected and unaffected hands revealed a significantly prolonged distal motor latency (p < 0.05) in CTS-affected hands. Although CMAP amplitudes were lower in affected hands, the differences were not statistically significant. Interestingly, motor nerve conduction velocity (MNCV) was significantly higher in affected hands compared to unaffected ones (p = 0.04) (Table 1).

Table 1. Comparison of Median Motor Nerve Conduction Parameters between CTS-Affected and Unaffected Hands (N = 27 Paired Hands)

Parameter	Unaffected Hands (Mean ± SD)	CTS-Affected Hands (Mean ± SD)	p-value
Distal Motor Latency (ms)	3.07 ± 0.28	3.78 ± 0.86	<0.05*
Proximal Motor Latency (ms)	7.63 ± 0.64	8.13 ± 0.95	0.05
CMAP Amplitude (Wrist) (mV)	14.66 ± 4.51	11.68 ± 5.25	0.44
CMAP Amplitude (Elbow) (mV)	11.96 ± 4.54	10.19 ± 4.94	0.67
MNCV (m/s)	55.62 ± 5.73	59.64 ± 8.62	0.04*

*p < 0.05 indicates statistical significance

Sensory Nerve Conduction Parameters

Sensory responses were not recordable in 5 cases (3 left, 2 right), hence data from 22 affected hands were analyzed. CTS-affected hands showed lower sensory nerve action potential (SNAP) amplitude, prolonged latency, and reduced sensory conduction velocity (SNCV), but none of these differences reached statistical significance (Table 2).

Table 2. Comparison of Median Sensory Nerve Conduction Parameters between Affected and Unaffected Hands in Unilateral CTS Cases

Parameter	Unaffected Hands (N = 27) Mean ± SD	CTS-Affected Hands (N = 22) Mean ± SD	p-value
Amplitude (µV)	42.14 ± 23.08	36.72 ± 19.71	0.46
Latency (ms)	2.40 ± 0.44	2.88 ± 0.45	0.94
SNCV (m/s)	50.68 ± 8.23	42.41 ± 7.82	0.82

Comparison with Regional Normative Data

Both CTS-affected and unaffected hands showed significantly lower MNCVs compared to side-specific regional normative values (p < 0.001). For instance, on the right side, MNCV was 58 m/s in affected hands and 53.6 m/s in unaffected hands, versus a normative value of 63.09 m/s. Left-sided values followed a similar trend. In contrast, SNCVs were also lower but did not differ significantly from normative values (Table 3). These findings indicate possible subclinical bilateral motor involvement in clinically unilateral CTS cases.

Table 3. Comparison of Median Nerve Conduction Velocities (MNCV and SNCV) in CTS-Affected and Unaffected Hands with Region-Specific Normative Values

Parameter	A:Normal Reference Values (N=86) (Mean ± SD)	B: CTS-Unaffected Hands	p-value (A vs B)	C: CTS-Affected Hands	p-value (A vs C)
Right MNCV (m/s) (UH:	63.09 ± 1.89	53.6 ± 6.29	<0.001	58 ± 5.43	<0.001

n=12)(AH: n=15)					
Left MNCV (m/s) (UH: n=15)(AH: n=12)	62.15 ± 2.11	57.2 ± 4.88	<0.001	61.7 ± 11.4	<0.001
Right SNCV (m/s) (UH: n=12)(AH: n=13)	54.63 ± 7.06	52.5 ± 6.77	0.95	42.2 ± 7.76	0.58
Left SNCV (m/s) (UH: n=15)(AH: n=9)	55.38 ± 6.98	49.2 ± 9.22	0.12	42.6 ± 8.37	0.38

AH: affected hands UH: Unaffected hands
p=<0.05 statistically significant

Discussion: Carpal Tunnel Syndrome (CTS) is the most prevalent entrapment neuropathy, caused by compression of the median nerve within the carpal tunnel. The pathophysiology involves increased intra-tunnel pressure leading to ischemia, segmental demyelination, and, in chronic cases, axonal degeneration. In this study, nerve conduction parameters of both affected and clinically unaffected limbs were analyzed in unilateral CTS cases and compared with regional normative data from healthy adults in Bhavnagar.

A significant female predominance in the study aligns with earlier reports, such as those by. Mondelli et al. reported a higher incidence of Carpal Tunnel Syndrome in females, attributing it to hormonal influences and anatomical differences that may predispose women to median nerve compression at the wrist[3]. This demographic trend adds validity to the study population.

In the motor conduction analysis, the CTS-affected hands showed significantly prolonged distal latency, confirming focal demyelination at the wrist, a hallmark of CTS. Demyelination disrupts saltatory conduction and delays the transmission of impulses, particularly evident in distal latency prolongation. CMAP amplitudes were reduced in affected limbs, though not significantly, suggesting that axonal involvement was not prominent or was in the early stage. Notably, motor nerve conduction velocity (MNCV) was paradoxically higher in CTS-affected hands . This may reflect the preserved forearm segment, typical in early CTS, where the pathology is localized distally and spares the proximal myelinated fibers. Ajola et al. reported similar inter-limb variability in healthy participants, with higher NCVs in the dominant (right) limb—mirrored here, since 15 of 27 CTS cases were right-sided[6].

Sensory nerve conduction trends toward reduced amplitude, increased latency, and slower NCV in CTS-affected limbs were observed. These findings are consistent with early sensory fiber demyelination due to their higher susceptibility to compression and ischemia. Though not statistically significant—likely due to early-stage disease or small sample size—5 out of 27 hands (2 right, 3 left) were non-recordable, indicating advanced sensory compromise or axonal degeneration. Kimura and Mishra & Kalita emphasize that non-recordability often signals severe nerve dysfunction[2]. Hoogstins et al. (2013) also stressed the importance of contralateral testing, noting that many patients presenting unilaterally had abnormal distal sensory latency in the asymptomatic limb[8].

Comparisons with normative data revealed significantly reduced MNCV in both CTS-affected and unaffected limbs ($p < 0.001$), supporting the presence of bilateral electrophysiological changes. This suggests that even clinically silent limbs may have begun undergoing focal demyelination, consistent with the progressive nature of CTS. This aligns with Bodofsky et al. (2001), who found that even in unilateral clinical presentations, the contralateral limb often exhibits subclinical abnormalities[9]. The findings of Lewańska et al.

further support this, demonstrating frequent bilateral involvement in idiopathic CTS[10]. Subramanian and Rajendran (2025) reported proximal slowing in CTS patients, suggesting pathology can extend beyond the wrist[4]. Parikh et al. also observed subtle bilateral conduction deficits in subclinical CTS cases, corroborating our findings[5].

These observations underscore the complexity of CTS electrodiagnosis and advocate for routine bilateral nerve conduction studies, combined with local normative data, to enhance early detection and clinical management.

A key strength of study is its focused evaluation of clinically unilateral CTS cases, enabling intra-subject comparison between affected and unaffected limbs, thereby minimizing inter-individual variability. The use of region-specific normative data from healthy adults in Bhavnagar enhances diagnostic relevance, and the standardized methodology using a single RMS EMG EP–MARK II system ensures consistency. Inclusion of both motor and sensory parameters, along with detection of non-recordable responses, offers a comprehensive electrophysiological profile and highlights subclinical bilateral involvement. However, the study's small sample size (N = 27) limits generalizability and statistical power. Its cross-sectional design precludes assessment of progression or response to treatment. Lack of baseline pre-symptomatic data and absence of symptom severity grading reduce the ability to correlate clinical and electrophysiological findings. Moreover, limb dominance and activity level variations were not separately analyzed, which may influence conduction parameters.

Conclusion:

We observed that in clinically unilateral Carpal Tunnel Syndrome (CTS) cases, affected hands exhibited classical electrophysiological abnormalities such as prolonged distal motor latency and reduced sensory nerve conduction velocity. Interestingly, even the asymptomatic hands demonstrated significantly lower motor nerve conduction velocities when compared with normative data, suggesting bilateral subclinical involvement. Additionally, the presence of non-recordable sensory responses in a subset of affected hands reflects varying degrees of disease severity. Based on these findings, we suggest that bilateral nerve conduction studies should routinely be performed in all suspected CTS cases, even when symptoms are unilateral, regardless of symptom laterality, to enable early detection and intervention. Lastly, further large-scale, longitudinal studies are warranted to better characterize the progression of subclinical CTS and refine early diagnostic criteria for optimal clinical management.

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Conflict of Interest: None