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### Original Work

## Early diagnosis of Carpal Tunnel Syndrome (CTS) in Indian patients by nerve conduction studies

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**ABSTRACT:** The present study was carried out for early confirmation of clinically diagnosed patients of Carpal Tunnel Syndrome (CTS) by electro-diagnostic tests which included motor conduction, sensory conduction studies and F-wave studies. The aim of the study was early confirmation of clinically suspected patients of CTS by motor and sensory conduction studies of median and ulnar nerves. Eighty subjects of age group 30-50 years (40 clinically suspected patients of CTS, 40 as control group) were studied. Motor and Sensory conduction velocities, distal motor and sensory latencies and F wave latencies of median and ulnar nerves were performed using RMS EMG EP Mark –II. Statistically significant ( $P < 0.001$ ) slowing of motor conduction velocities for both nerves was seen in the CTS group as compared to control group. Decrease in sensory conduction velocity was more pronounced in CTS group as compared to Control group. Statistically significant ( $P < 0.001$ ) increase in distal motor and sensory latencies was also observed for both median and ulnar nerves in the CTS group as compared to Control group, with more increase in distal motor latency than sensory latency. Increase in F wave latencies of both nerves was seen in the CTS group. Electrophysiological studies confirmed the early diagnosis of CTS with a high degree of sensitivity. Present results confirm selective slowing of sensory & motor conduction within wrist to palm segment in patients of CTS which is attributable to compression by the transverse carpal ligament or to a disease process of the terminal segment.

**KEY WORDS:** Nerve entrapments; Median neuropathy; Electro-physiological diagnosis; Distal and motor sensory latencies; Palm wrist conduction

### INTRODUCTION

Carpel tunnel syndrome (CTS) is the commonest median nerve entrapment neuropathy with preponderance in females. The median nerve passes with 9 digital flexor tendons through the carpal tunnel, of diameter 2-2.5 cm, bounded by carpal bones and transverse ligaments attached to scaphoid, trapezoid and hamate. Carpal tunnel

syndrome (tardy median palsy) results from compression of the median nerve within the carpal tunnel. It occurs most often in patients between 30 and 60 years of age and is 5 times more common in women than in men. Many factors are implicated in the causation and aggravation of the carpal tunnel syndrome. Old, overweight and physically inactive people, any condition that crowds or reduces the capacity of the carpal tunnel may initiate the symptoms; a misaligned Colles fracture and edema from infection or trauma, post traumatic arthritis or tumorous conditions such as a ganglion, lipoma or xanthoma are among the most common causes of

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Carpal Tunnel Syndrome. Systemic conditions such as obesity, diabetes, thyroid dysfunction, amyloidosis and Raynaud's syndrome are sometimes associated with the syndrome. Aberrant muscles of the forearm and thrombosis of the median artery contribute to median nerve compression. The syndrome frequently is associated with non-specific teno-synovial edema and rheumatoid tenosynovitis<sup>1</sup>. Clinical features include pain and paresthesias in the hand, which aggravates at night<sup>2</sup>. Passive flexion or hyperextension of the affected hand at the wrist for more than one minute may worsen the symptoms<sup>3</sup>. Simpson's original contribution on carpal tunnel syndrome, demonstrating focal slowing at the wrist, paved the way for clinical conduction studies of this entity<sup>4</sup> (Simpson 1956). Early work yielded a higher sensitivity of sensory nerve conduction testing than studies of the motor axons<sup>5-8</sup>. The sensory and motor axons show a comparable incidence of abnormalities, in addition, often encountering selective involvement of motor fibres, with normal sensory conduction or vice versa<sup>9</sup>. Electrophysiological procedures have, however, become very sensitive that they can not only confirm the clinical diagnosis in most patients but also detect an incidental finding in some asymptomatic subjects<sup>10</sup>. The American Academy of Neurology has recently defined the standards, guidelines and options for electro-diagnostic studies of CTS based on a formal literature review<sup>8</sup>. F-wave studies are also important in the diagnosis of CTS<sup>11</sup>. F wave is a late response resulting from antidromic activation of motor neurons involving conduction to and from spinal cord and occurs at interface between peripheral and central nervous systems. The present study was carried out for early confirmation of clinically diagnosed patients of CTS by electro-diagnostic tests which included motor conduction, sensory conduction studies and F-wave studies.

## METHODOLOGY

### Subjects

The present study was carried out in the Department of Physiology, Pt. B.D. Sharma University of Health Sciences, Rohtak on 80 subjects (40 of which were clinically suspected patients of CTS, 40 as control group) using RMS EMG EP Mark -II. Subjects affected by diabetes mellitus, nerve injuries and wrist fractures were excluded. Only the dominant hand was studied in the control group and the symptomatic hand in the CTS group. Informed consent was taken from each subject before the study was undertaken. The settings of RMS EMG EP Mark-II appended as appendix 1.

## Procedures

Parameters considered were:

- Motor conduction studies: Median and ulnar conduction velocities and their motor distal latencies.
- Sensory conduction studies: Sensory median and conduction velocities and their sensory latencies by antidromic stimulation.
- F wave latencies of median and ulnar nerves. (Figure 1)

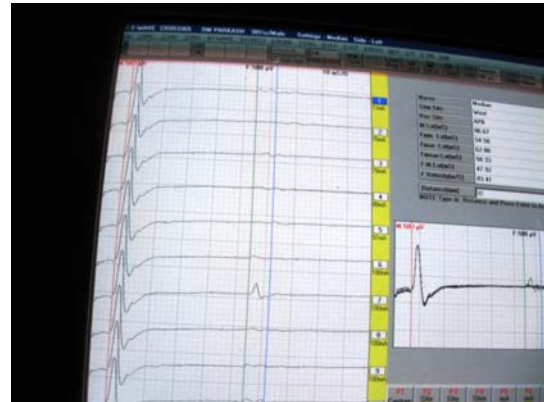


Figure 1: Recording of F wave latency

Criteria for electro-diagnosis of CTS included<sup>12</sup>:

- Distal median motor latency > 4.4 msec.
- Difference between Distal motor latency of median and ulnar nerve > 1.1 msec.
- Difference between Distal sensory latency of median and ulnar nerve > 0.2 msec.
- Palmar wrist conduction: i.e. difference between median and ulnar sensory latency across 8cm > 0.4 msec.

Placement of electrodes<sup>12</sup>:

1. *Stimulation points for the Median nerve (motor)*
  - S<sub>1</sub> – placed at wrist between Palmaris longus and flexor carpi radialis.
  - S<sub>2</sub> – placed at elbow crease, medial to biceps tendon.
  - Ground electrode- dorsum of hand.
  - Recording electrode- active electrode at the valley of abductor pollicis brevis.
  - Reference electrode- tendon of abductor pollicis brevis.
2. *Stimulation points for the Ulnar nerve (motor)*
  - S<sub>1</sub> – placed at wrist at the second distal most crease just medial/lateral to flexor carpi ulnaris.
  - S<sub>2</sub> – placed slightly above the ulnar groove at the elbow.
  - Ground electrode- dorsum of hand.
  - Recording electrode- active electrode at the valley of abductor digiti minimi.
  - Reference electrode- distal to the active electrode.

3. Stimulation points for the Median nerve (sensory)

- Antidromic surface stimulation is performed at the wrist between Palmaris longus and flexor carpi radialis tendons at second distal most crease.
- Ground electrode- dorsum of hand.
- Recording electrode- Ring electrodes are used. Active electrode at proximal inter-phalangeal joint of the 2<sup>nd</sup> digit.
- Reference electrode- around distal phalynx of the same digit.

4. Stimulation points for the Ulnar nerve (sensory)

- Antidromic surface stimulation is performed at the wrist between either medial/lateral to flexor carpi ulnaris tendon at the second distal most crease.
- Ground electrode- dorsum of hand.
- Recording electrode- Ring electrodes are used. Active electrode around the proximal inter-phalangeal joint of the 5<sup>th</sup> digit.

- Reference electrode- Around distal phalynx of the 5<sup>th</sup> digit.

5. Recording of F wave latency

- Can be recorded from any dorsal muscle by giving supramaximal stimulus to the appropriate nerve.

Control values were obtained from the 40 control group patients who were asymptomatic for CTS.

Statistical Analyses

The standard statistical procedure unpaired t-test was used to compare values in both control and CTS groups and 'p' value was derived (p<0.001).

RESULTS

In this study, on 40 patients with CTS suspected on clinical basis, 30 fulfilled the criteria set for nerve conduction studies, while 10 subjects did not do so.

Table 1 depicts the mean ± standard deviation of conduction studies of all parameters in meter/second in the wrist segment.

Table 1: Mean ± Standard deviation of conduction studies of all parameters in meter/second in the wrist segment

Parameters ↓	MOTOR				SENSORY				Diff. b/w DML (M-U) Motor Con	Diff. b/w DML M-U Sens. Con	Diff. b/w M-U Sens. Latency across 8 cm. Con
	MEDIAN		ULNAR		MEDIAN		ULNAR				
	Con	CTS	Con	CTS	Con	CTS	Con	CTS			
MCV (m/s)	57.32 ± 5.20	48.2 ± 7.12	57.4 ± 5.5	48.24 ± 4.19	52.56 ± 4.86	39.56 ± 9.26	52.48 ± 4.46	39.04 ± 8.8	0.765 ± 0.48	0.166 ± 0.42	0.3 ± 0.13
DML (ms)	3.38 ± 0.37	5.2 ± 0.74	2.55 ± 0.47	2.63 ± 0.51	2.72 ± 0.55	4.18 ± 1.74	2.55 ± 0.55	2.60 ± 1.13	3.040 ± 0.707	1.53 ± 1.43	0.5 ± .21
F wave latency (ms)	31 ± 5.1	35 ± 8.7	29 ± 4.2	33 ± 7.4							

Statistically significant (p < 0.001) slowing of motor conduction velocities for both median and ulnar nerves was seen in the CTS group (all the 30 clinically suspected patients) as compared to control group (30 control subjects). The values (mean ± standard deviation) of conduction velocity for the CTS group for median and ulnar nerves

respectively were 48.2 ± 7.12 and 48.24 ± 4.19 m/sec while the corresponding values in the case of the control group were 57.32 ± 5.20 and 52.48 ± 4.46 m/sec respectively. The decrease in sensory conduction velocity was more pronounced in CTS group as compared to Control group i.e. 39.56 ± 9.26 and 39.04 ± 8.85 m/sec in the CTS group for

median and ulnar nerves and  $52.56 \pm 4.86$  and  $52.48 \pm 4.46$  m/sec in the Control group for median and ulnar nerves respectively.

**Table 2** shows the values of T-tests (unpaired) for all parameters in wrist segment comparing control with CTS group. Statistically significant ( $P < 0.001$ ) increase in distal motor & sensory latencies was also observed for both median & ulnar nerves in the CTS group as compared to Control group, with more increase in distal motor latency than

sensory latency. Statistically significant ( $P < 0.001$ ) increase in difference between distal sensory latency of median and ulnar nerves was observed. Statistically significant ( $P < 0.001$ ) increase in difference between median and ulnar nerve sensory latency across 8 cm. of palmar wrist conduction was seen. Statistically significant ( $P < 0.001$ ) increase in F wave latency of both median and ulnar nerves was also recorded.

**Table 2: Values of T-test (unpaired) for all parameters in wrist segment comparing control with CTS group**

Parameters ↓	MOTOR		SENSORY		Diff. b/w DML (M-U) Motor Con/CTS	Diff. b/w DML (M-U) Sensory Con/CTS	Diff. b/w M-U Sens. Latency across 8 cm. Con
	Median Con/CTS	Ulnar Con/CTS	Median Con/CTS	Ulnar Con/CTS			
MCV (m/s)	4.56E-06	2.81E-08	1.20E-07	1.63E-08	1.05E-16	1.96E-05	2.84329E-21
DML (ms)	5.26E-15	0.004226	0.00022	0.831391			
F-wave latency (ms)	1.18076E-27	1.75941E-14					

**Abbreviations:** Con = control group; CTS = carpal tunnel syndrome group; DML = Distal motor latency; (M-U) = Median - ulnar; Sens. = sensory; MCV = motor conduction velocity; (m/s) = meter/seconds; ms = milliseconds

## DISCUSSION

### Median motor and sensory nerve conduction

The present study's results show decrease in median motor and sensory nerve conduction across the wrist. Similar results were obtained by Kimura<sup>9</sup> but the decrease in sensory conduction velocity was statistically significantly more pronounced in the CTS group which again is consistent with the observations of Melvin et al<sup>5</sup>, Thomas et al<sup>6</sup>, Buchthal et al<sup>7</sup>, Murthy et al<sup>8</sup> and Panda et al<sup>13</sup>.

### Median and ulnar motor nerve latency

The difference between the median and ulnar motor nerves latency measurement with palmar stimulation in patients with CTS is another parameter of diagnostic value. Normally the difference is 1.1 m/sec but in the CTS group, this difference exceeds 1.1 msec. The above observation correlates well with the findings of Mishra et al<sup>12</sup> and Kuntzer<sup>14</sup>.

### The distal latency of median nerve

The distal latency of median nerve recorded from abductor pollicis brevis stimulating 3 cms. Proximal to distal crease of the wrist in patients with CTS exceeds 4.4 msec which is inconsistent with the results of Kimura<sup>9</sup>, Mills<sup>15</sup> and Murthy et al<sup>8</sup>. The distal median motor latency is more as compared to ulnar nerve in the CTS group.

### Palmar wrist conduction

Palmar wrist conduction refers to the comparison of sensory latencies of median and ulnar nerves following stimulation of the nerves in palm with recording from the respective nerves at wrist at a distance of 8 cms. from the point of stimulation. The difference in latency between median and ulnar nerves is  $< 0.4$  m/sec in a normal individual. In the instant study, this difference is  $> 0.4$  m/sec in the CTS group which is in tune with the work of Jackson<sup>16</sup> and Mills<sup>15</sup>.

### Distal sensory latency of median and ulnar nerves

Statistically significant increase in the difference between distal sensory latency of median and ulnar nerves was observed, which is consistent with the results of Mishra et al<sup>12</sup>.

### F wave latencies

F wave has been found to be a sensitive measure of CTS. The present study also shows statistically significant increase in F wave latencies of median and ulnar nerves. This observation is consistent with the findings of McLeod<sup>11</sup>. Similarly, the results of the present study in relation to criteria for diagnosing CTS are similar to those of Mishra et al<sup>12</sup>.

### The CTS group

The usefulness of median nerve conduction studies in the diagnosis of CTS was first described by Simpson in 1956<sup>4</sup>. Gilliatt and Sears later recognized the value of sensory conduction studies<sup>17</sup>. The median nerve abnormalities in CTS are focal and localized to the segment of the median nerve in the carpal tunnel. This has been confirmed by Brown by intra-operative studies<sup>18</sup>. The results in the CTS group confirm selective slowing of sensory and motor conduction within wrist to palm segment which is attributable to compression by the transverse carpal ligament or to a disease process of the terminal segment<sup>19</sup>. The distinction between the two is potentially important in differentiating Carpal Tunnel Syndrome from a distal neuropathy in which median nerve may be more intensely affected in the terminal portion as shown by Casey et al<sup>20</sup> who studied digital neurons in Diabetes Mellitus.

### CONCLUSION

Electrodiagnostic studies confirmed the diagnosis of CTS with a high degree of sensitivity. It is a very effective method for the early confirmation of CTS so that early treatment modalities can be started according to the sensitivity of grading suggested by Herrmann and Logigian<sup>21</sup>. Median nerve conduction abnormalities in CTS are focal & localized to the segment of the median nerve in the carpal tunnel. Present results in the CTS confirm selective slowing of sensory and motor conduction within wrist to palm segment which is attributable to compression by the transverse carpal ligament or to a disease process of the terminal segment. The decrease in the sensory conduction velocity of the median nerve suggests more severe nerve compression which reduces the amplitude of the sensory nerve action potential and prolongs the

latency to a greater extent<sup>22</sup>. Statistically significant increase in F wave latencies of median and ulnar nerves was noted in the CTS group as the carpal tunnel syndrome (CTS) provides a model for analyzing the effects of focal nerve injury on F waves. F wave determination, as a simple and valuable method, allows the discrimination between demyelinating injury and axonal degeneration and increases the diagnostic yield in CTS<sup>23</sup>.

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### Appendix 1

Setting of RMS EMG Machine for recording of motor conduction velocity of median and ulnar nerves	Setting of RMS EMG machine for recording of Sensory conduction velocity of median and ulnar nerves
1. Sensitivity: 2 mV	1. Sensitivity: 50 mV
2. Low frequency filter: 2 Hz	2. Low frequency filter: 2 Hz
3. High frequency filter: 10 K Hz	3. High frequency filter: 5 K Hz
4. Sweep speed: 5 mS/duration	4. Sweep speed: 5 mS/duration
5. Mode: Single	5. Mode: Single
6. Duration: 100 micro-seconds	6. Duration: 100 micro-seconds
7. Control: Remote	7. Control: Remote
8. Range: 100 mA	8. Range: 25 mA
9. Count: Infinite	9. Count: Infinite
10. Pause: 0	10. Pause: 0
11. Rate: 1 Hz	11. Rate: 1 Hz

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