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COMPARATIVE ANALYSIS OF VARIOUS ELECTROPHYSIOLOGICAL METHODS FOR THE DIAGNOSIS OF CARPAL TUNNEL SYNDROME

Neurology

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ABSTRACT

BACKGROUND: Patients with Mild Carpal tunnel syndrome (CTS) may not be picked up by routine nerve conduction methods. So, this study was performed to identify the most sensitive way to detect mild to moderate Carpal tunnel syndrome and to evaluate the sensitivity of different methods for diagnosis of carpal tunnel syndrome.

MATERIAL AND METHOD: We included sixty clinically confirmed CTS patients in our study. We recorded the clinical characteristics and laboratory features in a proforma. We also included sixty healthy age and sex-matched asymptomatic individuals as controls in our study. We excluded patients with underlying peripheral neuropathy. We included Median distal motor latency, Median distal sensory latency, Median-versus-ulnar 2nd Lumbrical-interossei comparison study, Median-versus-ulnar wrist-to-digit four comparison study, Median -versus- Radial thumb sensory study, Median-versus-ulnar motor distal latency difference, and Median-versus-ulnar sensory latency difference tests in our study.

RESULTS: Out of sixty patients, female: male ratio was 2.3:1, and the mean age was 44.28±11.41 years. The mean symptom duration was 0.76±0.03 years. Out of 42 females, 38(90.4%) were engaged in daily household activities. In patients group median nerve distal motor latency was 5.024±2.05 ms, whereas sensory latency was 3.53±0.75 ms. We found maximum sensitivity in Median-versus-ulnar wrist-to-digit four comparison study (90.19%). In Median-versus-Radial thumb sensory study sensitivity was 88.23%, followed by Median-versus-ulnar 2nd Lumbrical- interossei comparison study (86.27%). We found lowest sensitivity (72.55%) in Median distal motor latency test.

CONCLUSION: Electrophysiological tests including Median-versus-ulnar wrist-to-fourth digit comparison study, and comparative study of Median-versus-ulnar 2nd Lumbrical- interossei should be included to diagnose mild CTS patients with normal Median distal motor latency, and median distal sensory latency tests.

KEYWORDS

carpal tunnel syndrome, median nerve, electrophysiological tests

INTRODUCTION:

Carpal tunnel syndrome (CTS) is caused due to entrapment of the median nerve at the wrist, as it passes through the carpal tunnel. Women are more often affected as compared to men, and it usually involves dominant hand first. [1]

CTS is clinically characterized by pain and paresthesias over the lateral palm and the lateral 3 fingers. These paresthesias may result in a disturbed night time sleep, and patient usually shakes hands to get rid of them. If symptoms are not present in lateral 3 fingers, it is unlikely to be CTS. [2]

Patients may have paresthesia in the distribution of median nerve when the median nerve percussion is done at the wrist (Tinel sign), and paresthesia on flexing the hand at the wrist for 1 minute (Phalen sign), can aid in the diagnosis, but these signs are neither very sensitive nor specific. [3]

Higher prevalence of CTS has been found in certain occupations which involve frequent and repetitive hand movements, especially wrist flexion, or repetitive forceful grasping or pinching. CTS is diagnosed clinically and by various electrophysiological tests including conventional methods, i.e., Median distal motor latency, and Median distal sensory latency. In addition to conventional tests, various comparison tests including Median-versus-ulnar 2nd Lumbrical-interossei comparison study, Median-versus-ulnar wrist-to-digit four comparison study, Median -versus- Radial thumb sensory study, Median-versus-ulnar motor distal latency difference, Median- ulnar palmar mixed comparison study, Inching study, and Median-versus-ulnar sensory latency difference tests are done to confirm a diagnosis of CTS. [4]

So, early diagnosis of CTS is required to prevent sequelae of median nerve damage, as more severe manifestations are associated with a worse prognosis. [5] Various electrodiagnostic tests are available to establish the diagnosis of CTS. [6]

American Association of Neuromuscular and Electrodiagnostic Medicine quality assurance committee, concluded that median sensory nerve conduction tests were more sensitive than median motor conduction tests. They also found mixed palmar conduction study and median –versus-radial or ulnar sensory comparative study to be more sensitive. They recorded a sensitivity of 49 to 66%, and specificity of 97.5 to 100% in median nerve sensory study .Whereas, median distal motor latency had a sensitivity of 60 to 74% and specificity of 95 to 99%. [7]

So, this study was aimed to evaluate the sensitivity of various nerve conduction methods for the diagnosis of carpal tunnel syndrome and to evaluate the most sensitive method in patients with mild carpal tunnel syndrome. We also evaluated the association of CTS with household activities and its severity according to the body mass index.

SUBJECTS AND METHODS:

We included 60 patients in clinically diagnosed CTS. Patients were diagnosed clinically by criteria given by Vogt et al. [8], which included;

(a) pain or paresthesia in hand (nocturnal or activity related)
(b) reduced two-point discrimination or sensory impairment in the distribution of the median nerve
(c) Isolated atrophied abductor pollicis Brevis muscle
(d) Positive tinel or Phalen sign

Patients were suspected of having CTS if they had (a) along with one criterion from b to d.

We recorded clinical features and laboratory parameters in a proforma. 60 asymptomatic individuals (age and sex matched) also included as controls in our study. We excluded patients with underlying peripheral polyneuropathy. Recorders and medicath sciences machine was used to perform nerve conduction studies. Skin temperature was maintained above 32°Celsius.

Following electrodiagnostic tests were carried out in all patients:

[1] Median distal motor latency
[2] Median distal sensory latency
[3] Median-versus-ulnar 2nd Lumbrical-interossei comparison study
[4] Median-versus-ulnar wrist-to-digit four comparison study
[5] Median -versus- Radial thumb sensory study
[6] Median-versus-ulnar motor distal latency difference
[7] Median-versus-ulnar sensory latency difference

Disc electrodes were used for mixed nerve studies, and ring electrodes were used for sensory studies. We placed a ground electrode between stimulating and recording electrodes. Supramaximal stimulation was given in all tests.

Machine setting: Pulse duration - 0.05/0.1 millisecond (ms) for

sensory and mixed nerve, and 0.2/0.5 ms for motor nerve, Filter: 20 Hz and 2 kHz.

[1]. Median distal motor latency [9]

The median nerve stimulation was given at the wrist between tendons of Palmaris longus and flexor carpi radialis. Disc recording electrode was kept over the abductor pollicis Brevis (APB) muscle. A fixed distance of 7 cm was kept between the recording electrode and cathode of the stimulator. Motor distal latency longer than 4.0 ms was considered abnormal.

[2]. Median distal sensory latency [9]

The sensory nerve action potentials were activated at the index finger by stimualting the median nerve at the wrist. We used a fix distance of 13 cm from the cathode of the stimulator and the ring recording electrode, which was placed over the metacarpal-phalangeal joint of index finger. Reference ring electrode was placed 3-4 cm distal to the recording electrode over the distal interphalangeal joint. Distal sensory latency longer than 3.0 ms was considered abnormal.

[3]. Median-versus-ulnar 2nd Lumbrical-interossei comparison study [9,10]

Median distal motor latency recorded over the 2nd lumbrical muscle was compared to the ulnar motor latency, which was recorded over the second intersossei muscle. The recording electrode was placed slightly lateral to the midpoint of the third metacarpal bone. The reference electrode was placed distally over the metacarpal-phalangeal joint of the second digit. Recording of compound muscle action potentials was done from the second lumbrical and interossei muscles, respectively after stimulation of the median and ulnar nerves at the wrist. We used an equal distance of 10 cm for both nerves. A median–ulnar distal latency difference of >0.5 msec was considered abnormal.

[4]. Median-versus-ulnar wrist to digit four comparison study [9,10]

Median and ulnar nerve stimulation was delivered at the wrist. Ring recording electrode was placed over the metacarpal-phalangeal joint of the ring finger, and a reference electrode was placed 3-4 cm distally over the distal interphalangeal joint. A fixed12 cm distance was used between the cathode of the stimulator and the ring recording electrode, and sensory distal latencies of the median and ulnar nerve were recorded. The difference in peak latencies of >0.4 msec was considered as abnormal.

[5]. Median-versus-radial thumb sensory study [9,10]

The median nerve stimulation was delivered at the wrist, and the radial nerve was stimulated at the distal mid radius. Recording electrode was placed over the first metacarpal-phalangeal joint, and the reference electrode was placed 3 cm distally at the distal interphalangeal joint. A fixed distance of 12 cm was used between the ring recording electrode and the stimulator. The difference in peak latencies of >0.5 msec was considered as abnormal.

[6]. Median-versus-ulnar motor distal latency difference [9]

The median nerve was stimulated at the wrist to activate the compound muscle action potential of abductor pollicis brevis muscle. Ulnar nerve stimulation was delivered at the wrist to activate compound muscle action potential of abductor digiti minimi. The difference in latencies of >1.1 msec was considered as abnormal.

[7]. Median-versus-ulnar sensory latency difference [9]

Median nerve was stimulated at the wrist to activate sensory action potentials at the index finger. Similarly, ulnar nerve stimulation was delivered at the wrist, while recording at the little finger. A fixed distance of 13 cm was kept between the cathode of the stimulator and recording electrode that was placed around the proximal interphalangeal joint of the index finger, and little finger respectively. The difference in latencies of >0.2 msec was considered as abnormal.

Patients were graded according to the severity in the mild, moderate, and severe category according to the criteria given by Herrmann and Logigian [11]

1. Mild: prolonged median motor and sensory distal latencies only
2. Moderate: latency prolongation with a mild reduction of SNAP or CMAP
3. Severe: unrecordable median SNAP or severe reduction of CMAP with active denervation or severe chronic denervation/ reinnervation

Statistics

Statistical analysis was done using Descriptive analysis. Mean, and the standard deviation was calculated, which were applied to all nerve conduction tests. Student's t-test (two-tailed) was used for comparative analysis. We calculated the sensitivity of each test, as well as a comparison between various tests, were performed. We could not calculate the false positive values, as we do not have any standard gold test for comparison.

RESULTS

The patient's group had a mean age of 44.28±11.41 years. Bilateral symptoms were present in 46 (76.6%) patients. The mean symptom duration was 0.76±0.03 years. 14(23.3%) patients had hypothyroidism. Male: female ratio was1: 2.3. Out of 42 females, 38(90.4%) were engaged in daily household activities. In our study, out of 60 patients, 24 (40%) patients were in the 31-40 year age group (36.75±2.60), so this age group was more prone to CTS in our study. [Table 1]

Table 2 shows the comparison of various nerve conduction test results among cases and control groups. In mild CTS patient's group, median nerve distal motor latency was 4.29±0.82 ms, and median nerve distal sensory latency was 3.45±0.63 ms. The Median-versus-ulnar 2nd Lumbrical- interossei comparison study revealed a latency difference of 1.33±0.69 ms. Median-versus-ulnar wrist-to-digit four comparison study showed a latency difference of 1.08±0.69 ms. In Median -versus- Radial thumb sensory study latency difference was 0.94±0.29 ms. Median-versus-ulnar motor distal latency difference was 1.62±0.76 ms. Median-versus-ulnar sensory latency difference was 1.12±0.77 ms. Out of 120 hands (60 patients) examined, 102 were symptomatic. Out of 102 hands, 68 had mild, 13 had moderate, and 21 had severe CTS. [Table 3]

Out of 102 hands, Median motor distal latency test was positive in 74 hands. Median distal sensory latency test was positive in 80 hands, Median-versus-ulnar 2nd Lumbrical- interossei comparison study was positive in 88 hands. Median-versus-ulnar wrist-to-digit four comparison study was positive in 92 hands, Median -versus- Radial thumb sensory study was positive in 90 hands, Median-versus-ulnar motor distal latency difference test was positive in 82 hands, and Median-versus-ulnar sensory latency difference test was positive in 84 hands. [Table 3]

Highest sensitivity was observed in digit four comparison study (90.19%). Median -versus- Radial thumb sensory study showed a sensitivity of 88.23%, followed by 2nd Lumbrical- interossei comparison study (86.27%). Median-versus-ulnar sensory latency difference test had a sensitivity of 82.35%. Median-versus-ulnar motor distal latency difference test had a sensitivity of 80.4%, followed by Median distal sensory latency test with a sensitivity of 78.43%. Median distal motor latency test had the lowest sensitivity (72.55%). [Table 3]

Patients with mild CTS had a low Body mass index (BMI) of 26.47±1.34. Patients with moderate CTS had a mean BMI of 29.56±2.12. BMI was highest (32.28±2.86) in severe CTS patients. The difference in BMI with an increase in the severity of CTS was found to be statistically significant. ($p<0.05$)

Table 1: Clinical characteristics of the cases

		Male (18)	female (42)	total (60)
Age (mean in years)		41.78±7.08	45.36±12.75	44.28±11.41
	21-30	28±0.0	28.75±1.5	28.6±1.34
	31-40	37.28±3.30	36.52±2.34	36.75±2.60
	41-50	43.28±2.21	45.44±2.55	44.5±2.58
	51-60	53.33±2.30	58.5±2.38	56.28±3.49
	61-70	NIL	65.75±2.76	65.75±2.76
Duration of illness (years)		0.79	0.74	0.76±0.03
Hypothyroidism		2	12	14
Tinel sign		8	32	40
Phalen sign		10	34	44
Wasting		4	12	16

Table 2: Results of various electrodiagnostic tests in cases and controls

Nerve conduction test	Cases (n=120 hands)			Controls (n=80 hands)	P (Significance)
	mild (68 hands)	moderate (13 hands)	severe (21 hands)		
Median distal motor latency(ms)	4.29±0.82	5.58±0.67	8.73±2.07	3.36±0.24	<0.001
Median distal sensory latency(ms)	3.45±0.63	4.70±0.54	6.58±2.10	2.64±0.18	<0.001
Median-versus-ulnar 2nd Lumbrical- interossei comparison study (ms)	1.33±0.69	3.18±1.03	5.55±2.09	0.42±0.06	<0.001
Median-versus-ulnar wrist-to-digit four comparison study (ms)	1.08±0.69	2.15±0.64	3.09±0.78	0.1±0.02	<0.001
Median -versus- Radial thumb sensory study(ms)	0.94±0.29	1.84±0.59	2.16±0.25	0.32±0.07	<0.001
Median-versus-ulnar motor distal latency difference (ms)	1.62±0.76	3.09±0.82	5.92±2.37	0.8±0.02	<0.001
Median-versus-ulnar sensory latency difference (ms)	1.12±0.77	2.16±0.78	3.19±0.85	0.14±0.03	<0.001

Table 3: Results of different nerve conduction tests in cases

Nerve conduction test	Mild (68 hands)	Moderate (13 hands)	Severe (21 hands)	Total Positive	Sensitivity (%)
Median distal motor latency	40	13	21	74	72.55
Median distal sensory latency	46	13	21	80	78.43
Median-versus-ulnar 2nd Lumbrical-interossei comparison study	54	13	21	88	86.27
Median-versus-ulnar wrist-to-digit four comparison study	58	13	21	92	90.19
Median -versus- Radial thumb sensory study	56	13	21	90	88.23
Median-versus-ulnar motor distal latency difference	48	13	21	82	80.4
Median-versus-ulnar sensory latency difference	50	13	21	84	82.35

DISCUSSION

The most accurate diagnosis of CTS can be established by a combined approach including detailed clinical history, examination, and electrodiagnostic tests. Though we do not have any gold standard diagnostic test for CTS, objective diagnosis of CTS is commonly established by various electrodiagnostic tests.[2]

The median distal motor latency and median sensory latency test are the basic electrodiagnostic tests used in the diagnosis of CTS. However, these tests cannot confirm mild CTS. They have a sensitivity ranging from 60 to 74 % for median distal motor latency, and a sensitivity of 50 to 66 % for median distal sensory latency. [7] In our study the sensitivities of these tests were 72.55% and 78.43% respectively. So, more sensitive tests are further required to detect mild CTS patients.

According to the guidelines proposed by the American Association of Electrodiagnostic Medicine, nerve conduction tests in patients suspected of CTS should include 1. Median nerve sensory conduction study across the wrist, keeping the conduction distance of 13 cm to 14 cm. 2. If the initial test is normal: median-versus-ulnar sensory latency difference, or median -versus- radial thumb sensory study, or mixed nerve conduction studies across the wrist should be done. 3. Comparison of median nerve motor distal latency with the recording of distal latency in one another nerve in the affected limb. [12]

Studies conducted by Uncini A et al. [13], [14] and Cioni R et al. [15] have shown that Median-versus-ulnar wrist to-digit four comparison study highly sensitive in detecting CTS. This test had a sensitivity of 90.19% in our study, and it also detected maximum patients with mild CTS.

Previous studies have shown that Median -versus- Radial thumb sensory study and Median-versus-ulnar sensory latency difference test have a sensitivity of 82 to 86 % in diagnosing CTS. [7], [16] this is in accordance with our study results.

Median-versus-ulnar-2nd Lumbrical- interossei comparison study had a sensitivity of 86.27% in our study, which is in accordance with the previous study done by Moon et al. [17], in which they found a sensitivity of 85%. However, this test had a sensitivity of 97.5 % in a study done by Loschner et al. [18], which may be due to the different epidemiological profile of the patients. We also observed the superiority of Median-versus-ulnar sensory latency difference test as compared to the Median distal sensory latency test.

We also observed that severity of CTS increases with increase in body mass index; this result was as per the study done by Werner et al. [19] Female patients predominated in our study, and 90.4 % of them were engaged in household activities. So, this may be hypothesized that repeated exposure of hands in household activities is also a predisposing factor for CTS. A study by Andrea et al. [20] also found similar results.

CONCLUSIONS

Standard nerve conduction tests including median distal motor latency and Median distal sensory latency tests are less sensitive in detecting mild CTS. Electrophysiological tests including Median-versus-ulnar wrist-to-fourth digit comparison study, Median-versus-ulnar 2nd Lumbrical- interossei comparison study, and median-versus-radial thumb sensory study should be included to diagnose mild CTS patients with normal Median distal motor latency, and median distal sensory latency tests.

Limitations of the study

Our study population was small so the results of the study may not be applied to the whole population. We did not include median-ulnar palmar mixed comparison study and Inching method in our study. However, we have incorporated more sensitive tests, including Digit four comparison study, Median-versus- Radial thumb sensory study, and 2nd Lumbrical- interossei comparison test in our study.

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