Research Paper Medical Science

Comparative Study of Sensitivities of Various Electrodiagnostic Parameters in the Diagnosis of Carpal Tunnel Syndrome

Dr.Ch.Ramakrishna Rao | Associate Professor of Neurology, Siddhartha Medical College, Vijayawada

Dr.W.Maruthi | Associate Professor of Physiology, Guntur Medical College, Guntur

ABSTRACT

Introduction. Carpal Tunnel Syndrome is defined as a constellation of symptoms and signs due to median nerve compression in the carpal canal. The clinical presentations of Carpal Tunnel Syndrome are varied and the most common are acroparesthesias of median innervated fingers followed by thenar atrophy without sensory symptoms, acute carpal tunnel syndrome, and atypical descriptions of nerve compression symptoms. As histopathological proof of local median nerve disease is unavailable as a diagnostic source, the diagnosis of Carpal Tunnel Syndrome is essentially clinical, supported by electrodiagnosis.Aim. To compare the sensitivities of various motor and sensory electrophysiological parameters in the diagnosis of carpal tunnel syndrome. Methods. The study included 55 consecutive patients with symptoms suggestive of carpal tunnel syndrome (83 symptomatic hands) who attended the Neurology outpatient department. Electrodiagnostic studies were carried out by surface recording and stimulation. Recording electrodes were disk electrodes made of silver for motor nerve studies and orthodromic sensory studies and Velcro ring electrodes for the antidromic sensory studies. Electro diagnosis is performed with motor nerve conduction studies and sensory nerve conduction studies and their relative sensitivities are studied. The parameters studied are 1. Median Motor Distal Latency (Median DML), 2. Median-Ulnar Distal Motor Latency Difference (M-U DML Difference), 3. Wrist-Palm Median Motor Conduction Velocity (W-P Median MCV), 4. Median Antidromic Sensory Distal Latency (Median DSL), 5. Median Othodromic (80 mm segment) Sensory Latency, 6. Median-Ulnar Palm-Wrist (80 mm segment) Orthorhombic Sensory Latency Difference, 7. Median Palm-Wrist Othodromic Sensory Conduction Velocity (Median P-W SCV).Results. The test results were compared with normative data. Among the 83 symptomatic hands, 76 (91.56%) were found to have at least one abnormal electrophysiologic study and 7 (8.43%) were found to have normal electrophysiologic results for all parameters tested. The parameter of Wrist-Palm median motor conduction velocity has emerged as the most sensitive test among other electro diagnostic parameters.Conclusions. The motor conduction studies can be equally sensitive including the DMl and W-P MNCV. The study of W-P MNCV is no more difficult as made out in earlier studies, with improvement in technique. Even in the presence of dominant sensory symptoms and signs and minimal motor fingings, the abnormalities of the motor conduction studies can be significant and diagnostic. In the patient with suspected carpal tunnel syndrome, in whom the DML and DSL were within normal limits, the study of W-P motor conductions will increase the diagnostic yield.

KEYWORDS | Carpal Tunnel Syndrome, Acroparesthesias, Phalen's sign, Tinel's sign, Electro diagnosis

Introduction

Carpal Tunnel Syndrome is defined as a constellation of symptoms and signs due to median nerve compression in the carpal canal. The clinical presentations of Carpal Tunnel Syndrome are varied and the most common are acroparesthesias[1] of median innervated fingers followed by thenar atrophy without sensory symptoms, acute carpal tunnel syndrome, and atypical descriptions of nerve compression symptoms. As histopathological proof of local median nerve disease is unavailable as a diagnostic source, the diagnosis of Carpal Tunnel Syndrome is essentially clinical, supported by electrodiagnosis. A careful history is the first step towards diagnosis of Carpal Tunnel Syndrome. Without strong historical support for the diagnosis, reliance on physical examination or on tests such as nerve conduction studies invites error. Patients frequently characterize the paresthesias as their "hand going to sleep" or "cutting off circulation". Clinically, the diagnosis of Carpal Tunnel Syndrome is more likely when the sensory changes are limited to, or at least include two or three median innervated digits. Symptoms characteristically develop insidiously. Initially, the sensory symptoms are intermittent and mostly nocturnal, and with time, the sensory symptoms become constant and even present during the day. Patients with Carpal Tunnel Syndrome commonly report stiffness, clumsiness, and even weakness of their hands, usually before they have developed any motor or sensory functional deficit detectable by formal neurologic examination. In patients with Carpal Tunnel Syndrome, physical findings are an indication of the severity of median nerve dysfunction. The thenar weakness usually does not occur until sensory loss is marked. Thenar weakness is rarer than sensory loss and the thenar atrophy is even less common. Weakness of the abductor pollicis brevis (APB) is the most sensitive motor sign of Carpal Tunnel Syndrome. APB is the least likely of the thenar muscles to receive ulnar innervation. A number of provocative tests have been used to elicit neurologic abnormalities. In Phalen's sign, patient is asked to hold the forearms vertically and to allow both hands to drop into complete flexion at the wrist for approximately one minute. An individual who has a positive Phalen's sign reports numbness or paresthesias in the distribution of the median nerve within one minute of sustained wrist flexion. Phalen's test is positive in about 74% of hands with Carpal Tunnel Syndrome. In Tinel's sign, percussion over the median nerve at wrist elicits tingling sensation in the distribution of the nerve and this sign is present in over 73% of hands with Carpal Tunnel Syndrome.

There is no gold standard for the diagnosis of Carpal Tunnel Syndrome. The absence of a gold standard is to be expected for a syndrome with varied clinical manifestations, varied causes, and incompletely understood pathophysiology.

Electrodiagnostic tests are invaluable aids to the diagnosis of Carpal Tunnel Syndrome. In addition to assisting in the diagnosis, they are helpful in characterizing the severity of the

median neuropathy, investigating the patient for alternative or co-existing forms of neurologic pathology, and providing a baseline for evaluating the results of therapy. However, the electrodiagnostic test results must always be interpreted in clinical context. The routinely performed electrodiagnostic tests are motor nerve conduction studies and sensory nerve conduction studies.

Despite the abundant variety of available electrodiagnostic tests, carpal tunnel syndrome remains a clinical diagnosis. The test results can support the diagnosis but can never make the diagnosis by themselves. There is no test that is always abnormal in every patient who has carpal tunnel syndrome. A less sensitive test is occasionally abnormal when a more sensitive test is normal.

In patients with carpal tunnel syndrome, the correlation between symptoms, signs, and electrodiagnostic findings is imperfect. Nonetheless, there are trends relating the severity of clinical disease and the severity of electrodiagnostic abnormalities. Symptoms that correlate best with nerve conduction results include – Nocturnal awakening, morning symptoms, relief from shaking the hand on awakening, typical median innervated sensory distribution of paresthesias, and history of benefiting from wrist splinting. In contrast, symptoms that correlate less well with nerve conduction results include – Hand pain, clumsiness, and weakness.

Nerve conduction studies are more likely to be abnormal in patients with longer duration of symptoms. Clinical thenar weakness is more likely to be present if there is prolonged median DML, low amplitude thenar CMAP. The clinical sensory examination is often normal despite mild to moderate abnormalities of sensory conduction. If the clinical sensory examination is abnormal, sensory conduction studies usually show slowed conduction, often with decreased amplitude of the SNAP. Patients with constant rather than intermittent symptoms are more likely to have abnormal nerve conduction findings.

Methods

The study included 55 consecutive patients with symptoms suggestive of carpal tunnel syndrome (83 symptomatic hands) who attended the Neurology outpatient department. Patients were diagnosed clinically based on the presence of symptoms and signs, including numbness, tingling, clumsiness or weakness and nocturnal awakening with paresthesias, in median nerve distribution. The diagnosis was often supported by a positive Phalen's or Tinel's sign.

Among the 55 patients (83 symptomatic hands) included for analysis 42 were women and 13 were men (Fig.1). The mean age of the patients was 41.55 years. Symptoms included paresthesias in 81 hands (97.59%), weakness in 22 hands (26.51%) (Fig.2). There were 55 symptomatic hands with positive Phalen's sign (66.26%) and 43 symptomatic hands with positive Tinel's sign (51.81%) (Fig.3)

Fig. 1 Sex Distrubtion in Carpal Tunnel Syndrome (%)

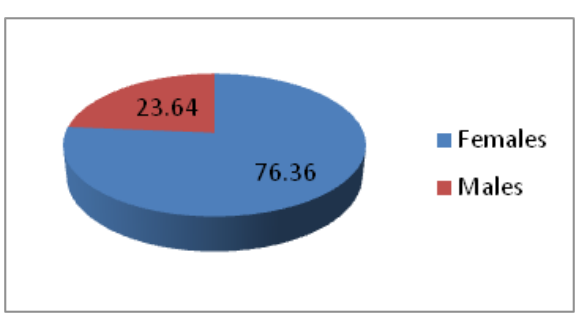


Fig.2 Symptom Distribution in Carpal tunnel syndrome

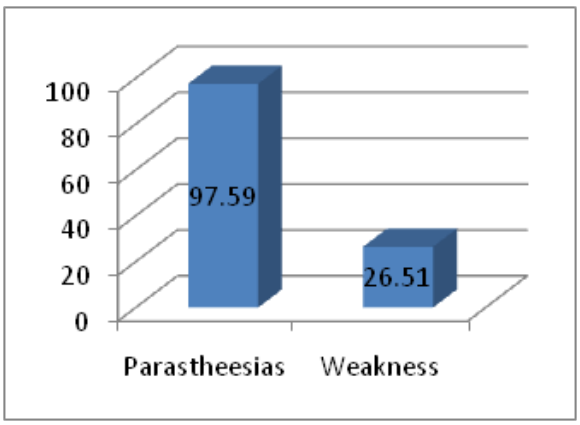


Fig .3 Clinical Sign –Distribution in carpal tunnel syndrome

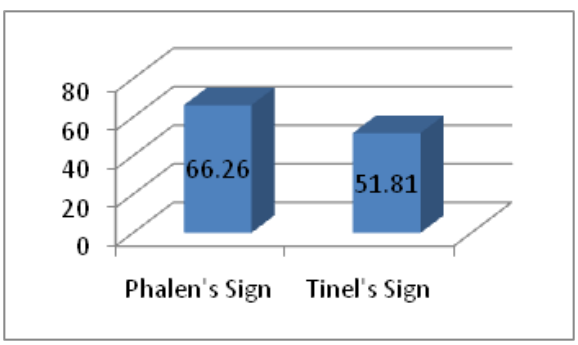


Figure: 4

1. APB [Recording site]
2. APB [Reference site]
3. ADM [Recording site]
4. ADM [Reference site]
5. 2nd Dig [Recording site]
6. 2nd Dig [Reference site]
7. 5th Dig [Recording site]
8. 5th Dig [Reference site]
9. Median N. stimulation site [cathode]
10. Ulnar N. stimulation site [cathode]
11. Midpalmar stimulation site

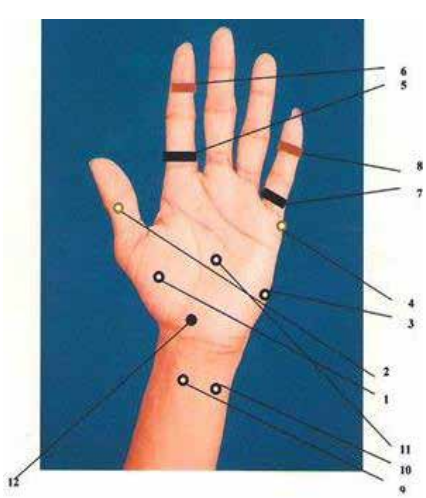


Figure 4. Depiction of Median ulnar Stimulation
Fig 5. Median ulnar Palm wrist orthrodromic Stimulation.

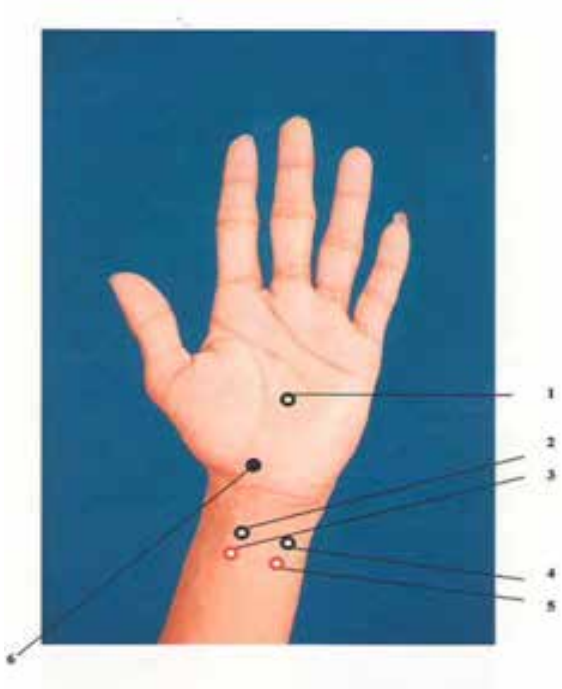
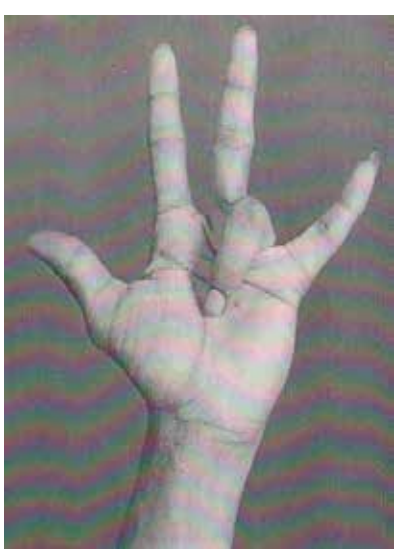


Figure 5.
1. Palmar stimulation site
2.Median N. [Recording site]
3. Median N. [Reference site]
4. Ulnar N. [Recording site]
5. Ulnar N [Reference site]
6. Ground electrode site

Figure: 6
The site of palmar stimulation of the median nerve for motor conduction. The flexed ring finger points to the approximate stimulation site.



Electrodiagnostic studies were carried out by surface recording and stimulation. Recording electrodes were disk electrodes made of silver for motor nerve studies and orthodromic sensory studies and Velcro ring electrodes for the antidromic sensory studies. The skin temperature of the hand was maintained at 32° C. As the comparative studies minimize confounding personal factors, such as age and temperature, that decrease diagnostic sensitivity by increasing the variation in healthy subjects, in the present study, we have compared the median motor distal latency, median wrist-palm motor conduction velocity, and median palm-wrist (80 mm segment) orthodromic sensory latency with those of the ipsilateral ulnar nerve and their differences were calculated and taken as parameters to study their sensitiveness in the diagnosis of carpal tunnel syndrome. The motor conductions are in turn compared with the ipsilateral sensory conductions to know the relative sensitivity of one over the other in the diagnosis of carpal tunnel syndrome.

The methods followed for the motor and sensory nerve conduction studies and the comparative studies are as below and depicted in Figs. 4 and 5. Median and Ulnar distal motor latency. Median and ulnar motor studies were performed by recording the Compound Muscle Action Potential (CMAP) from the abductor pollicis brevis and abductor digiti minimi respectively, with Gl (recording electrode) placed over the muscle belly and G2 (reference electrode) placed over the distal tendinous insertion. The median and ulnar nerves were stimulated at the wrist 7 cm proximal to the Gl and at the elbow. The stimulation site of 7 cm, for the median nerve, proximal to the Gl was measured as two lines, one from the Gl to the midpoint of the distal wrist crease and a second line from the distal wrist crease to the point of stimulation and as one line for ulnar wrist stimulation. A ground electrode was placed near the distal crease of the hand. All responses were supramaximal, and distal motor latencies (DML) to the onset were measured as well as amplitude from baseline to negative peak. The latency differences between the median-thenar and ulnar-hypothenar (M-U) were calculated. Wrist-Palm median motor conduction velocity.To stimulate the median motor fibers in the palm, the cathode was initially placed at a point in the palm as for the mid palm sensory stimulation. This site for palmar stimulation is approximated by asking the patient to flex the ring finger; the flexed finger points to the point in the palm that is chosen for stimulation (Fig. 6). A more exact site of stimulation was determined by starting slightly distal to this point in the palm and slowly moving the stimulating cathode proximally until stimulation elicits a twitch of the median thenar muscles. The anode is distal to the cathode directed toward the base of the fifth digit. This was done to avoid depolarizing the recurrent thenar nerve to abductor pollicis brevis under the anode. If unnecessary activation of the recurrent thenar nerve under the anode occurs, it might cause an erroneously short latency. For the calculation of the W-P motor conduction velocity (MCV), the distance between the mid-palm and wrist stimulation varied individually as a result of the variable course of the recurrent motor branch to the APB, unlike the fixed distance (80 mm) used for the calculation of P-W sensory conduction velocity (SCV). The distance ranged from 85 to 95 mm and occasionally it was 100 mm for some patients with larger hands. When mid-palm stimulation is performed, the nature of the thenar twitch was carefully observed, because stimulation of the deep branch of the ulnar nerve could also generate a motor response recorded over the thenar eminence. Stimulus intensity at the palmar site was slowly increased to maximally stimulate the recurrent median motor nerve while avoiding the threshold for deep ulnar nerve stimulation. Thenar twitch was checked and thumb adduction was prevented. The CMAP waveform configuration and initial deflection from palm and wrist stimulation were compared. If an adduction of the thenar twitch and a change in the CMAP waveform configuration occurred as a result of co-stimulation of the deep branch of the ulnar nerve, the stimulation electrodes were repositioned in roughly 1-mm increments toward the thenar eminence until an abduction twitch was achieved. A stimulus was considered maximal if there was no increase in the CMAP amplitude despite an increasing intensity of the stimulus. We measured the latency differences at wrist and palm stimulation and calculated the W-P MCV (Table 1). Median distal sensory latency (Median SDL).Median sensory nerve action potentials were determined by antidromic stimulation at the wrist 140 mm proximal (index finger) to the recording electrode placed over the proximal phalanx of the index finger

(G1), with the reference electrode placed 4 cm distally (G2). The placement of the ground electrode was the same as for motor studies. Supramaximal responses were obtained and distal sensory latencies (SDL) to the onset as well as amplitude from baseline to negative peak were measured. All sensory responses were averaged ten times to obtain clear onset latencies. Palm-Wrist sensory nerve conduction studies. The wrist-palm orthodromic median and ulnar sensory conduction studies were performed by supramaximal stimulation at the mid-palm and recording the sensory nerve action potentials (SNAPs) at a fixed distance of 80 mm segment transcarpally from the median and ulnar nerves. The sensory latencies and thereby sensory nerve conduction velocities were calculated for the median and ulnar nerves (Table 2). Palm-Wrist Orthodromic (80 mm segment) median sensory latency and sensory conduction velocity (P-W median SCV).For this study, the supramaximal stimulation was given at the mid-palm and the sensory nerve action potentials were recorded at the wrist proximally at a fixed distance of 80 mm. The sensory latencies were recorded. The palm-wrist median orthodromic sensory conduction velocity was calculated from the distance and latencies. Median-Ulnar

Table 1. Method of measuring Wrist-Palm motor conduction velocity (W-P median MCV). The latency difference between the wrist and mid-palm stimulations was calculated. The distance between the two points is calculated. By dividing the distance with the latency difference, the wrist-to-palm motor conduction velocity was achieved.

Latency with wrist stimulation	a
Latency with palm stimulation	b
Latency difference between the wrist and mid-palm stimulation	(a-b)
Distance between the wrist and palm segment	c
Wrist-to-palm motor conduction velocity	c ÷ (a-b)

palm-wrist (80 mm segment) orthodromic sensory latency difference.

Table 2. Method of measuring Palm-wrist (80 mm segment) sensory conduction velocity

Latency with palm stimulation	a
Distance between the palm and wrist segment	c
Palm-to-wrist sensory conduction velocity	c ÷ a

This study refers to the comparison of sensory latencies of median and ulnar nerves following stimulation of the nerves in the palm and recording from the respective nerves at wrist at a distance of 80 mm from the point of stimulation. The difference in latency between median and ulnar nerves is less than 0.4 ms in 96% of normal individuals (Jackson and Clifford 1989).

Descriptive statistics, including Mean and Standard deviation, were applied to each nerve conduction value. Abnormal values were defined as the Mean ± 2 SD calculated for the controls. Sensitivity of each test was calculated as number of hands with a positive test and clinical CTS/number of hands with clinical CTS × 100%.

During the study period, forty controls were studied using the electrodiagnostic techniques using electrodiagnostic parameters narrated above. The mean values ± SD are summarized in table 3.

Results

A total of 55 patients (83 symptomatic hands) were included for study and analysis. The sensitivity of each test was calculated using clinical criteria as a gold standard. The test results were compared with normative data. Among the 83 symptomatic hands, 76 (91.56%) were found to have at least one abnormal electrophysiologic study and 7 (8.43%) were found to have normal electrophysiologic results for all parameters tested. This distribution is shown in the figure7. The sensitivities of individual parameters are shown in table 4 and are depicted in figure 8.

Fig.7. Sensivitiy of Electrophysiological studies in CTS.

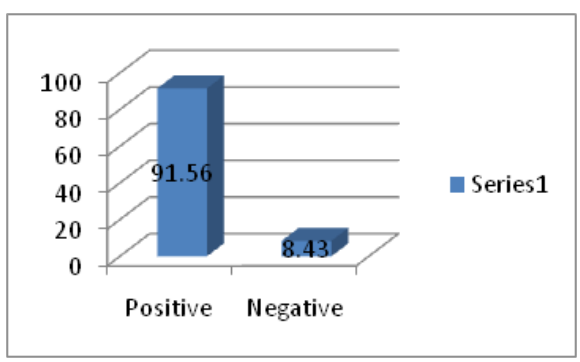


Fig : 8 Distribution sensitivity of each electrophysiologic parameter in CTS (%)

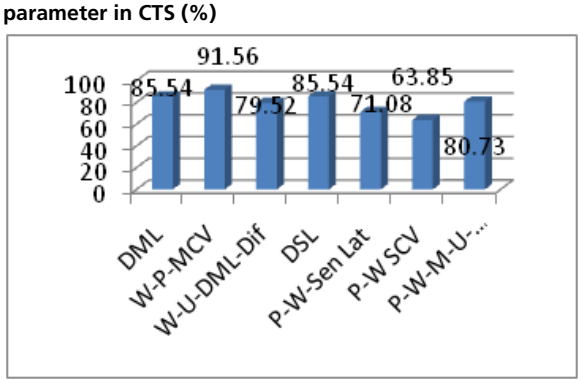


Table 3. Electrophysiologic data on 40 healthy controls (40 hands)

	Electrophysiologic parameters	Normal limits (mean ± 2 SD)
1	W-P motor conduction velocity, (m/s)	> 44.66 m/s
2	Median distal motor latency, (ms)	<4.13 ms
3	Median-Ulnar distal motor latency difference, (ms)	< 1.54 ms
4	Median distal sensory latency, (ms)	<2.89 ms
5	Median P-W orthodromic sensory conduction velocity, (m/s)	> 46.56 m/s
6	M-U P-W (80 mm segment) orthodromic sensory latency difference (ms)	<0.3 ms
7	Median P-W orthodromic (80 mm segment) sensory latency	< 1.59 ms

Median motor distal latency (< 4.13 ms) - 12 hands (14.46%) had normal MDL, and 71 hands had abnormally delayed MDL. The sensitivity of MDL was 85.54%.

Wrist-Palm median motor conduction velocity (> 44.66 m/s) - Seven hands (8.43%) had normal W-P median MCV, and seventy-six hands had abnormally slowed W-P median MCV. The sensitivity of W-P median MCV was 91.56%.

Median-ulnar distal motor latency difference (< 1.54 ms) - Seventeen hands (20.48%) had normal M-U distal motor latency difference, and sixty-six hands had abnormally prolonged median-ulnar distal motor latency difference. The sensitivity of median-ulnar distal motor latency difference was 79.52%.

Median (antidromic) distal sensory latency (< 2.89 ms) - Twelve hands (14.46%) had normal SDL, and seventy-one hands had abnormally delayed SDL. The sensitivity of SDL was 85.54%.

Median palm-wrist (80-mm segment) orthodromic sensory latency (< 1.59 ms) - 24 hands (28.92%) had normal sensory latency and 59 hands had delayed sensory latency. The sensitivity of this parameter was 71.09%.

Median palm-wrist (80 mm segment) orthodromic sensory conduction velocity (> 46.56 m/s) - Thirty hands (36.14%) had normal palm-wrist orthodromic sensory conduction velocity, and fifty-three hands had abnormally slowed palm-wrist orthodromic sensory conduction velocity. The sensitivity of palm-wrist orthodromic sensory conduction velocity was 63.85%.

Median-ulnar palm-wrist (80 mm segment) orthodromic sensory latency difference (< 0.3 ms) - Sixteen hands (19.28%) had normal median-ulnar palm-wrist (80 mm segment) orthodromic sensory latency difference, and sixty-seven hands had abnormally prolonged M-U palm-wrist (80 mm segment) orthodromic sensory latency difference. The sensitivity of M-U palm-wrist (80 mm segment) orthodromic sensory latency difference was 80.72%.

Table 4. Comparison of sensitivities of motor and sensory conduction studies

Electro diagnostic parameter	Positive hands	Sensitivity (%)
Median motor distal latency	71	85.54
Wrist-Palm median motor conduction velocity	76	91.56
Median-ulnar distal motor latency difference	66	79.52
Median (antidromic) distal sensory latency	71	85.54
Median P-W (80-mm segment) orthodromic sensory latency	59	71.09
Median P-W (80 mm segment) orthodromic SCV	53	63.85
M-U P-W (80 mm segment) orthodromic sensory latency difference	67	80.72

Discussion

Carpal tunnel syndrome is the most common entrapment neuropathy of the upper limbs and the most frequent source of referral to the electrodiagnostic laboratory. Acroparesthesias of the hands are the most common presenting symptoms of carpal syndrome. The diagnosis is more likely to be carpal tunnel syndrome when the sensory changes are limted to, or at least include, two or three median innervated digits. Because there are several peripherial and CNS causes of acroparesthesias, electrodiagnosis is required before surgical intervention can be considered, Yet, a careful history is the first step toward diagnosis of carpal tunnel syndrome. On the strong background of historical support, electrodiagnostis studies are of established value in the diagnosis of carpal tunnel syndrome.[6,7] There are patients with symptoms and signs suggestive of carpal tunnel syndrome that remain difficult to diagnose even using standard electrodiagnostic techniques, however. There seems to be a discrepancy between motor and sensory involvement in the carpal tunnel syndrome[7,9,11,12,14,15]. It seems there is differential involvement of nerve fibers in the median nerve in carpal tunnel syndrome as supported by the fact of abundant proportion of sensory nerve fibers in the nerve and also the frequent and predominant sensory symptoms with which the patients with carpal tunnel syndrome seek medical attention.

It is generally accepted that median sensory conductions are more sensitive than motor conductions in the electro diagnosis of carpal tunnel syndrome [6,11,14,21,22]. The lack of sensitivity of median motor studies may be a result of sparing of the motor fibers compared with the sensory fibers or the inability of standard median motor electrodiagnostic techniques to detect an abnormality[9,10,15,17] In the conventional motor conduction studies, long motor axons in the wrist-to-abductor pollicis brevis segment rather than those in the wrist-to-palm segment are used to determine conduction velocity or latency differences that could reduce sensitivity .[9,10,15,17]

In the present study, an attempt is made to evaluate various conduction techniques for measuring median motor and sensory conductions by stimulating the nerve at the wrist and in the mid-plam (past its compression) and thereby to determine the relative sensitivity of each test over the other, in the diag-

nosis of carpal tunnel syndrome.

In the present study, out of the 83 symptomatic hands studied, weakness as a symptom figured in only 22 hands, accounting for 26.51% of the symptomatic hands. Again, the symptom of paresthesias figured in 81 hands accounting for 97.59% of the symptomatic hands. The patients came out with the complaint of weakness on questioning only and the weakness was in the form of mild loss of dexterity on increased use of the hand. There was evidence of mild weakness of the thumb and particularly, the abduction was tested. There was no clinical evidence of thenar atrophy. Thus, the motor symptoms in the present study population were mild and infrequent and the signs were unobvious.

With respect to motor nerve conduction studies, the median motor distal latency, the median-ulnar motor distal latency difference and median motor wrist-palm conduction velocity were studied. In the present study of median distal motor latency (median DML), seventy-one hands had abnormally prolonged MDL and the sensitivity of median DML was 85.54%, which is significantly higher than reported in literature. The diagnostic sensitivity of median DML is considered lower for the following reasons – 1. The measurement of median DML is of the overall conduction of the nerve impulse in the distal segment of the nerve which comprises both the compressed part underneath the flexor retinaculum and the non-compressed part past the transverse carpal ligament, where the delayed conduction in the compressed part can be compensated or masked, if not completely, by the conduction in the distal segment of the median nerve past the transverse carpal ligament. 2. The median DML may be influenced by any delay between arrival of the nerve action potential at the terminal unmyelinated axonal branches and the activation of the muscle across the neuromuscular junction (a normal phenomenon) in addition to the median neuropathy at the carpal tunnel in the carpal tunnel syndrome. 3. On the top of the above two limitations, there may be unpredictable differential compression of motor and sensory fibers in the carpal tunnel syndrome which may constantly contaminate the sensitivity of every motor/sensory conduction study to which the median DML is not an exception.

To overcome some of the above limitations, the segmental studies of the median nerve were conducted and comparisons of conduction between other nerves like ipsilateral ulnar nerve with that of median nerve were done as superior diagnostic techniques.

In the present study, the sensitivity of median DML is equal to that of median DSL indicating that the motor conduction study, if not superior, is in no way inferior to the sensory conduction study.

In the present study of median-ulnar distal motor latency difference, sixty-six hands had abnormally prolonged median-ulnar motor distal latency difference and the sensitivity of median-ulnar motor distal latency differences was 79.52%, which is nearly equal to the sensitivity of median DML. It is interesting to note that the sensitivity of this is nearly equal to that of its counterpart study, the median-ulnar palm-wrist (80mm segment) orthodromic sensory latency difference (80.72%), in the sensory nerve conduction studies.

When wrist-palm median motor conduction velocity (median W-P MCV) was evaluated, seventy-six hands had abnormally slowed velocity and its sensitivity was 91.56%, which has the highest sensitivity among various parameters studied, including both the motor and sensory conductions in the present study. To date only few studies have investigated segmental motor conduction techniques ([9,15,17,18,19,20,24]). Although segmental W-P MCV was first used as a diagnostic method 23 years ago, it was not widely used as a routine examination, because palmar stimulation of the recurrent motor thenar branch may produce variable results. Furthermore, this technique had the inherent difficulty of co-stimulation of the deep branch of ulnar nerve and the thenar muscle. With improvement in the stimulation technique and changing the position of the anode electrode, as described above, these difficulties have been overcome. The wrist-palm segment ranged from 90 to 100 mm with which the W-P MCV data were quite consistent. Based on the results of this present study, the measurement of W-P MCV is not a difficult procedure and can be applied routinely in the electro diagnosis of carpal tunnel syndrome.

One interesting feature of the present study is that sensory symptoms like paresthesias appeared in 81 hands (97.59%) and weakness co-existing with sensory symptoms in 22 hands (26.51%) of the total 83 symptomatic hands. Yet, even in the face of mild motor symptoms, the median W-P MCV has emerged as the most sensitive test in the electro diagnosis of CTS suggesting that motor conduction is more commonly effected than originally thought. This finding goes against the conventional notion that motor conduction testing is less sensitive than sensory axon testing[11,14,21,22]. Among the motor nerve conduction studies in the present study, wrist-palm motor conduction velocity is more sensitive than the median DML, as a test for carpal tunnel syndrome. In this respect, the present study is in conformity with the other studies.

The common clinical notion in the neurological disorders that the motor symptoms appear late in the disease is also found true in the carpal tunnel syndrome in this present study. In the face of unobvious clinical motor signs also, the motor involvement in median neuropathy in the carpal tunnel is brought out by unequivocal, highest sensitive median W-P MCV study.

With respect to sensory nerve conduction studies, the median antidromic distal sensory latency, median P-W (80mm segment) orthodromic sensory latency, M-U palm-wrist (80 mm segment) orthodromic sensory latency difference and median P-W orthodromic sensory conduction velocity studies were performed.

The American Association of Electrodiagnostic Medicine (AAEM), the American Academy of Neurology (AAN), and the American Academy of physical Medicine and Rehabilitation (AAPMR) (1993, 2002), who offered practice parameters for electrodiagnostic laboratory confirmation of carpal tunnel syndrome, have recommended the median sensory nerve conduction study across the wrist with a conduction distance of 13 to 14 cm as the initial step in the electrodiagnosis of carpal tunnel syndrome.[2,5] Thus, the sensory nerve conduction studies were given primacy over the motor nerve conduction studies.

In the present study of median antidromic distal sensory latency, 71 hands had abnormally prolonged SDL and the sensitivity of SDL was 85.54%. To compare, the sensitivity of the median SDL is equal to its counterpart study (median MDL) in the motor nerve conduction studies. Thus the motor conduction studies are proved to be equally efficacious in the electro diagnosis of carpal tunnel syndrome.

In the present study of median palm-wrist (80 mm segment) orthodromic sensory latency, 59 hands had abnormally prolonged sensory latency and its sensitivity was 71.09%. To obviate the confounding factors such as temperature and technical differences, the median palm-wrist orthodromic sensory latency was compared to that of ulnar nerve across the identical segment. With this the sensitivity of the P-W median-ulnar (80 mm segment) sensory latency difference rose to 80.72%. This is nearly equal to that of M-U distal motor latency difference (79.52%).

In this study, the sensitivity of distal sensory latency in the diagnosis of carpal tunnel syndrome was equal to that of distal motor latency. While evaluating the transcarpal sensory conductions, the sensitivities of orthodromic sensory latency and SCV of 80 mm segment have proved to be less sensitive i.e., 71.08% and 63.85% respectively. This apparent discrepancy compared to the earlier studies, which showed that sen-

sory conductions are superior to motor conductions, could have been due to selection of patient populations and technical differences. To obviate this discrepancy, P-W median-ulnar sensory latency difference was calculated [normal - < 0.3 msec (mean ± 2 SD)]. The sensitivity of this parameter rose to 80.72, canceling out any confounding factors that could have contributed to earlier discrepancy (24).

In fact, motor conduction is sometimes selectively involved when sensory conduction remains normal, although the reverse is often true. The lower sensitivity of conventional motor conduction studies might well be a result of a normal palm-to-muscle segment masking the slowing across the carpal tunnel and the normal delay at the neuro-muscular junction in the impulse transmission[6,7,8,9,10,11,12,14,15,17,24.]

These problems were overcome in this present study with the much-refined median wrist-palm segment study with highest sensitivity in the electro diagnosis of carpal tunnel syndrome.

The high diagnostic yield of median W-P MCV in this study cannot be attributed to the higher percentage of abnormalities in the median DML hands. In fact, the sensitivities of median DML and that of median DSL were identical. Thus, it was not likely that the high sensitivity of W-P MCV resulted from selection bias.[3]

The high abnormal rate of W-P MCV in the diagnosis of CTS can be explained by the intraneural topography of motor fibers or by the course of the recurrent motor thenar branch. The recurrent motor branch lies superficially in the most volar-radial quadrant (34). Median nerve compression at the carpal tunnel preferentially impairs fibers near the compression site and is not equal over the whole nerve. The anteromedial and anterolateral fascicles seem to be more susceptible when compared with fibers located more centrally. This may partially explain why the motor fibers to the APB are injured first. Variation in the course of the recurrent thenar branch in the carpal tunnel, as was mentioned earlier, may explain why some carpal tunnel syndrome patients present with predominant compression of the recurrent motor branch rather than the sensory fibers.

Conclusions

The median wrist-palm motor conduction velocity is more sensitive of all the parameters studied in the diagnosis of carpal tunnel syndrome. The median DML and the median DSL are equal in their sensitiveness next only to that of median W-P MNCV in the diagnosis of carpal tunnel syndrome. Latency differences, both sensory and motor, between different nerves in the same hand across identical segments cancel out confounding factors and increase the sensitivity. The motor conduction studies can be equally sensitive including the DMl and W-P MNCV. The study of W-P MNCV is no more difficult as made out in earlier studies, with improvement in technique. Even in the presence of dominant sensory symptoms and signs and minimal motor fingings, the abnornmalities of the motor conduction studies can be significant and diagnostic. In the patient with suspected carpal tunnel syndrome, in whom the DML and DSl were within normal limits, the study of W-P motor conductions will increase the diagnostic yield.

REFERENCES

1.Carpal Tunnel Syndrome and Other Disorders of the Median Nerve, 2nd Edition. Richard B. Rosenbaum, M.D & Jose L. Ochoa, M.D,, Ph.D., D.Sc. Page No. 31 | 2.The American Association of Electrodiagnostic Medicine, the American Academy of Neurology and the American Academy of Physical Medicine and Rehabilitation. Practice parameters for electrodiagnostic studies in carpal tunnel syndrome: summary statement. Muscle Nerve 1993; 16: 1390 – 91 | 3.Carpal Tunnel Syndrome and Other Disorders of the Median Nerve, 2IK Edition. Richard B. Rosenbaum, M.D & Jose L. Ochoa, M.D.. Ph.D.. D.Sc. Page No. 144 | 4. Carpal Tunnel Syndrome and Other Disorders of the Median Nerve, 2nd Edition. Richard B. Rosenbaum, M.D & Jose L. Ochoa, M.D., Ph.D., D.Sc. Page No. 148 | 5.Practice parameter: Electrodiagnostic studies in carpal tunnel syndrome: Report of The American Association of Electrodiagnostic Medicine, American Academy of Neurology and the American Academy of Physical Medicine and Rehabilitation. Neurology 58 June (1 of 2) 2002; 1589 - 1592. | 6. American Academy of Electrodiagnostic Medicine Quality Assurance Committee. Literature review of the usefulness of nerve conduction studies and electromyography for the evaluation of patients with carpal tunnel syndrome. Muscle Nerve 1993; 16:1392- 1414 | 7. Stevens JC. The electrodiagnosis of carpal tunnel syndrome. Muscle Nerve 1997; 20: 1477- 1486 | 8.Felsenthal G, Spindler H. Palmar conduction time of median and ulnar nerves of normal subjects and patients with carpal tunnel syndrome. Am J Phys Med 1979;25:131 - 138 | 9.Kimura J. A method for determining median nerve conduction velocity across the carpal tunnel. J Neurol Sci 1978;38:1 - 10 | 10.Kimura J. The carpal tunnel syndrome: localization of conduction abnormalities within the distal segment of the median nerve. Brain. 1979;102:619-635 | 11.Cioni R, Passero S, Paradiso C, Giannini F, Battistini N, Rushworth G. Diagnostic specificity of motor and sensory nerve conduction variables in early detection of carpal tunnel syndrome. J Neurol 1989;236:208 - 213 | 12. Jackson DA, Clifford JC. Electrodiagnosis of mild carpal tunnel syndrome. Arch Phys Med Rehabil 1989;70:199 - 204 | 13. Uncini A, DiMuzio A, Awad J, Manente G, Tafuro M, Gambi D. Sensitivity of three median-to-ulnar comparative tests in diagnosis of mild carpal tunnel syndrome. Muscle Nerve 1993;16:1366 - 1373 | 14.Kuntzer T. Carpal tunnel syndrome inlOO patients. Sensitivity, specificity of multi-neurophysiological procedures and estimation of axonal loss of motor, sensory and sympathetic median nerve fibers. J Neurol Sci 1994; 127:221 -229 | 15.Ross MA, Kimura J. AAEM case report #2: the carpal tunnel syndrome. Muscle Nerve 1995; 18:567 - 573 | 16. Sander HW, Quinto C, Saadeh PB, Chakroverthy S, Sensitive median-ulnar motor comparative techniques in carpal tunnel syndrome. Muscle Nerve 1999;22:88 -98 | 17. Di Guglielmo G, Torrieri F, Repaci M, Uncini A, Conduction block and segmental velocities in carpal tunnel syndrome. Electroencephalogr Clin Neurophysiol 1997;105:321 -327 | 18. Pease WS, Cunningham ML, Walsh WE, Johnson EW. Determining neurapraxia in carpal tunnel syndrome. Am J Phys Med Rehabil 1988;3: 117-119 | 19. Lesser EA, Venkatesh S, Preston DC. Logigian EL. Stimulation distal to the lesion in patients with carpal tunnel syndrome. Muscle Nerve 1995; 18:503 507 | 20.M.-H Chang, MD; S.-J Wei, MT; H.-L. Chiang, MT; H.-M. Wang, MT; P. F. Hsieh, MD; and S.-Y Huang, MD. Comparison of motor conduction techniques in the diagnosis of carpal tunnel syndrome. Neurology 58 June (lof 2) 2002:1603 - 1607 | 21. Murthy JMK, Meena AK. Carpal tunnel syndrome - electrodiagnostic aspects of fifty-seven symptomatic hands. Neurol India. 1999 Dec;47 (4):272 - 275 | 22. Aydin G, Keles I, Ozbudak Demir S, Baysal Al. Sensitivity of median sensory nerve conduction tests in digital branches for the diagnosis of carpal tunnel syndrome. Am J Phys Med Rehabil. 2004 Jan;83 (1): 17 - 21 | 23.Concannon MJ, Gainor B, Petroski GF, Puckett CL. The predictive value of electrodiagnostic studies in carpal tunnel syndrom. Plast Reconstr Surg. 1997 Nov;100(6): 1452- 1458 | 24. Walter RJ, Murray NM. Transcarpal motor conduction velocity in carpal tunnel syndrome. Muscle Nerve 2001 Jul;24 (7):966 - 968. |