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ORIGINAL ARTICLE

The second lumbrical-interossei latency difference in carpal tunnel syndrome: Is it a mandatory or a dispensable test?

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KEYWORDS

Carpal tunnel syndrome;
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Abstract *Objective:* To assess the value of the 2L-INT latency difference in the electrodiagnosis of the carpal tunnel syndrome (CTS) and evaluate its sensitivity in comparison to other routine median motor and sensory studies.
Methods: The study was conducted on 100 hands with symptoms and signs suggestive of CTS and 100 non-CTS hands as the control group. All were subjected to routine median motor nerve conduction study with stimulation at midpalm, wrist and elbow, median-versus-radial sensory comparison study and Second lumbrical-versus-interosseus (2L-INT) motor comparison study.
Results: The results showed that the most sensitive tests were the median-radial sensory test and the 2LINT test and that both were correlated suggesting that the motor fibers of the median nerve can be compressed as early as sensory fibers.
Conclusion: The 2L-INT test is as sensitive and important as the median-radial sensory test.
Significance: We recommend the routine use of the 2L-INT test in clinically suspected cases of CTS especially in cases where routine median motor studies are normal together with the median-radial sensory test even if the sensory studies are normal.

Abbreviations: 2L-INT, second lumbrical interossei; APB, abductor pollicus brevis; CMAP, compound muscle action potential; CTS, carpal tunnel syndrome; DML, distal motor latency; EDX, electrodiagnostic; EMG, electromyography; NCS, nerve conduction study; SD, standard deviation; SNAP, sensory nerve action potential; ULN, upper limit of normal.

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1. Introduction

Median nerve entrapment at the wrist is the most common of all entrapment neuropathies and, consequently, is one of the most frequent reasons of referral to an electrodiagnostic study.

Carpal tunnel syndrome (CTS) is a constellation of symptoms associated with localized compression of the median nerve at the wrist resulting in mechanical compression and local ischemia[1]. Diagnosis is based upon symptoms of numbness, tingling and/or burning in the distribution of the median nerve in the hand. However, the symptoms are frequently documented outside the distribution of the median nerve as well. Repetitive hand activity may cause thickening of the synovial lining of the tendons that share the carpal tunnel with the median nerve[2,3].This increases the volume of tissue within the canal and leads to an increase in the baseline and the mechanical pressure within the carpal tunnel. The combination of ischemic changes and mechanical contact pressure over time, leads to changes in the myelin sheath and occasionally results in injury to the axon. This can be simply detected by conventional neurophysiologic testing such as standard nerve conduction studies (NCS). The exact symptoms or criteria for the diagnosis of CTS remains poorly defined. A consensus conference was organized that identified a combination of symptoms (numbness, tingling, burning and pain in combination with nocturnal symptoms) plus abnormal median nerve function based upon NCS to be the best 'gold standard' for the diagnosis of CTS[4].

The ability to confirm the diagnosis of CTS using electrodiagnostic techniques lies with testing the median nerve fiber across the wrist and comparing the latency and amplitude to normal conduction or comparison of the median nerve segment to some other nerve segment in the same hand that does not travel through the carpal tunnel (either ulnar or radial nerves)[5].

The diagnosis of a median mononeuropathy should not be based solely on a median motor or sensory evoked response using an absolute cutoff value. There are many influences on the amplitude and latency of an individual nerve, which could give a false positive result. Age, gender, obesity, finger diameter, concurrent systemic disease and temperature have all been demonstrated to have an impact on the absolute amplitude or latency of an evoked response in the hand[6–8]. The normative upper limits of normal for an individual nerve absolute latency response can range over 1.4 ms depending on age, gender and obesity[6]. These factors along with the influence of systemic disease are well controlled when the median nerve response is compared to another nerve segment that does not travel through the carpal tunnel or even to the corresponding median nerve in the other hand in unilateral cases[6].

The ulnar nerve is most commonly used for comparison. In such a case, identical distances between the stimulator and recording electrodes for the median and ulnar nerves are used. This technique creates an ideal internal control in which several variables are kept constant including temperature, age and nerve or muscle size. Accordingly, the only factor that varies here is traversing of the median nerve in the carpal tunnel, whereas the ulnar nerve does not. Thus, any preferential slowing of the median nerve can be attributed to conduction slowing the carpal tunnel[5].

One of these precise comparison studies is the second lumbrical-interosseous (2L-INT) latency difference. It is a motor conduction technique that was initially described as being fairly valuable in the diagnosis of CTS[9]. Over the past years, its value has been conflictingly addressed, as there are studies supporting their high diagnostic sensitivity in CTS[10,11], whereas others report a much lower sensitivity[12,13].

Other studies acknowledged that the ability of this technique to localize the median nerve lesion at the wrist in patients with absent abductor pollicus brevis (APB) response represents its major advantage over conventional studies[9–11]. Additionally, it has been recently proposed that this test may help to reduce the number of steps commonly needed to investigate patients with suspected CTS[14].

The aim of this study was to compare the 2L-INT study with routine motor conduction studies, midpalmar motor study and median-versus-radial sensory study in cases with suspected CTS to determine its value and sensitivity.

2. Materials and methods

The study was conducted on 100 hands of patients (a total of 60 patients) with clinical diagnosis of CTS. The affected hand was included whether it was one or both hands of the same patient. In 40 patients, both hands were symptomatic and were included in the study and in 20 patients, the only unilateral symptomatic hand was included. Clinical suspicion was based on symptoms of nocturnal or activity-related pain and/or paresthesia in the median nerve distribution or whole hand with clinical examination showing hypoesthesia in median nerve distribution with or without weakness of thumb abduction and/or opposition ± atrophy of thenar muscles in addition to positive Tinel and/or Phalen's sign.

A control group of 100 non-CTS hands (50 healthy individuals not complaining of any sensory or motor symptoms in the hand and with free neurological examination and negative tests of CTS) were also included. The non symptomatic hands of patients with symptoms suggestive of unilateral CTS were not included in the control group to standardize the controls.

Patients with cervical radiculopathy, peripheral neuropathy and traumatic nerve injuries were excluded from the study, also patients with Diabetes Mellitus.

Exclusion was based on clinical assessment, radiological findings and nerve conduction with F-wave studies.

The study was conducted at the Physical Medicine & Rehabilitation Department at the Ain Shams Hospital (Cairo, Egypt) using Toennies Neuroscreen Plus made by Toennies of Germany. In motor studies, responses were recorded at a sweep speed of 5 ms/division and a gain of 4 mV. In Sensory studies, sweep was adjusted at 2 ms and gain at 20 uV. Temperature was kept constant through all the tests at 33–34 °C.

Consent was taken from all patients and controls after explaining the procedure in detail.

The electrophysiological studies done for both patients and control group (according to Preston & Shapiro, 2005) were:

- Routine median motor nerve conduction study:
- Recorded from Abductor Pollicus Brevis (APB) muscle and stimulated at the wrist (middle of the wrist between the Flexor Carpi Radialis and Palmaris Longus tendons) and at the elbow (Antecubital fossa over the brachial artery pulse). Distal distance was standardized at 7 cm. Distal

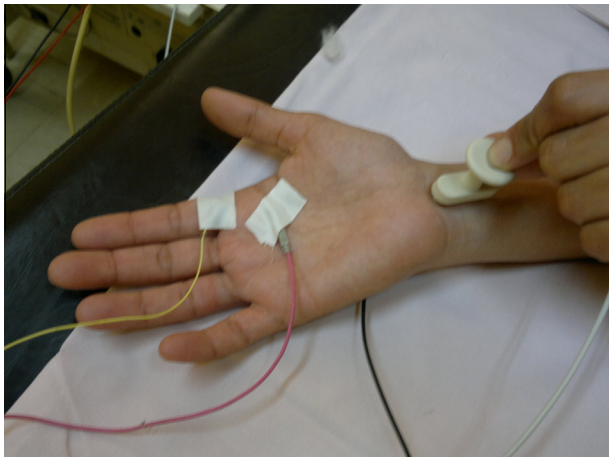

Figure 1A Technique of stimulation of the median nerve with recording from 2nd lumbrical.

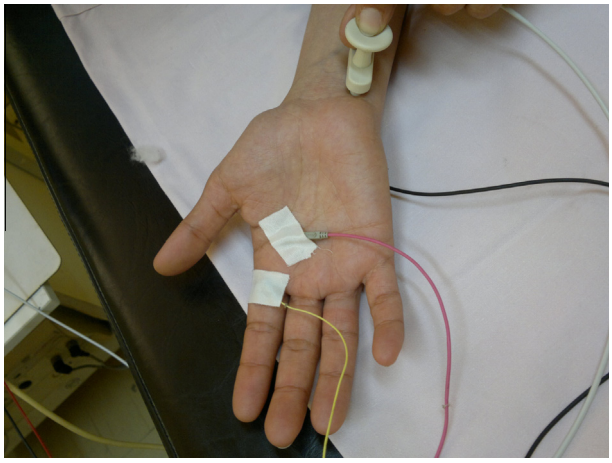

Figure 1B Technique of stimulation of the ulnar nerve with recording from interosseus muscle.

motor latency, amplitude and conduction velocity were determined. Distal motor latency > 4.4 ms and CMAP amplitude < 4 mV were considered abnormal.

- Routine ulnar motor nerve conduction study to exclude more widespread polyneuropathy:
- Recording was done on Abductor Digiti Minimi and the ulnar nerve was stimulated at the wrist (medial wrist adjacent to Flexor Carpi Ulnaris tendon) with distal distance standardized at 7 cm, below the elbow (3–4 cm distal to medial epicondyle) and above the elbow (10–12 cm from below elbow site). Distal Latency > 3.3 ms and Amplitude < 6 mV were considered abnormal.
- Mid palmar stimulation: Motor nerve conduction study of the median nerve was done while recording as usual from APB but stimulating the median nerve 7 cm distal to the wrist site (on a line drawn from the median wrist to the web space between the index and middle fingers). Mid-palm/wrist amplitude ratio of CMAP was determined. Ratio > 1.2 was considered abnormal and indicated an element of conduction block.
- Median-versus-Radial sensory comparison study. Both nerves were stimulated at the wrist using identical distances, with recording ring electrodes over digit 1 (over the MCP joint) and G2 over the interphalangeal joint. The median nerve was stimulated at the wrist in the usual site and the radial nerve was stimulated at the wrist along the lateral border of the radial bone. Peak latencies of SNAPs of both nerves were compared. Latency difference > 0.5 ms was considered abnormal.

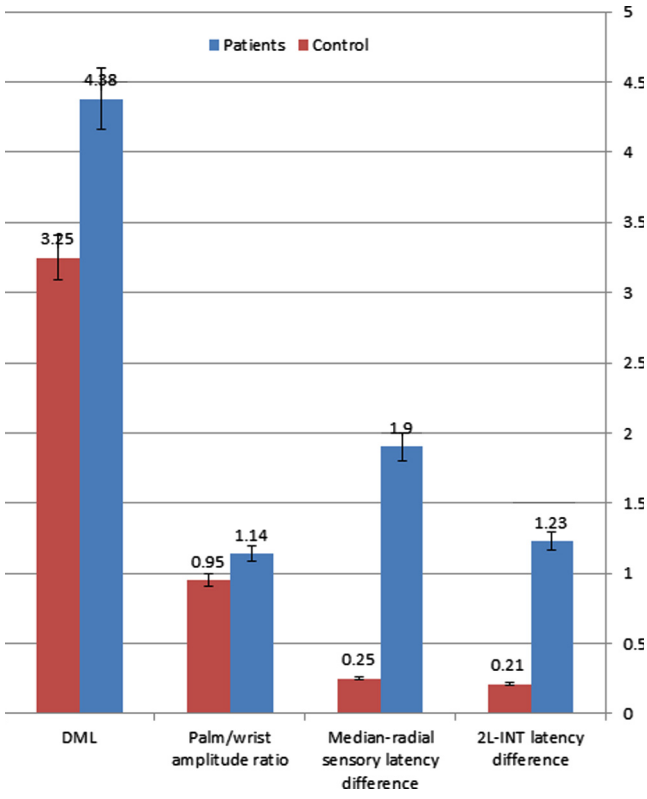

Figure 2 Comparison of electrophysiological studies values between patient and control groups.

Table 1 Range, mean and SD of the electrophysiological studies and *t*-test results in CTS and control groups.

The electrophysiological study	Patients		Control		*t*	*P*	S
	Range	Mean ± SD	Range	Mean ± SD			
Median DML	2.5–7.6	4.38 ± 1.16	2.3–4.2	3.25 ± 0.47	8.94	< 0.001	Sig.
Palm/wrist CMAP amplitude	0.6–4	1.15 ± 0.46	0.7–1.2	0.95 ± 0.12	4.42	< 0.001	Sig.
Median-radial sensory latency difference	0.1–3.1	1.9 ± 0.66	0–0.5	0.25 ± 0.14	12.27	< 0.001	Sig.
2L-INT latency difference	0.1–3.9	1.23 ± 0.93	0–0.5	0.21 ± 0.14	10.81	< 0.001	Sig.

Table 2 Sensitivity of the electrophysiological studies.

Electrophysiological test	No. of hands in which test is abnormal	Sensitivity (%)
Median DML	47	47
Palm/wrist CMAP amplitude	26	26
Median-radial sensory latency difference	82	82
2L-INT latency difference	83	83

- Median second lumbrical-versus-ulnar interossei distal motor comparison study (2L-INT). The active recording electrode (G1) was placed just lateral to the midpoint of the third metacarpal with the reference electrode (G2) over the proximal interphalangeal joint of the second digit, median and ulnar nerves were stimulated at the wrist. Identical distances between the stimulation and recording were used (8–10 cm). Normally, the lumbrical CMAP has different morphology and lower amplitude than the interossei. Distal motor latency of median and ulnar nerves was compared and latency difference was determined. Latency difference >0.5 ms was considered abnormal (Figs.1A, and B).

2.1. Statistical analysis

Unpaired Student's *t*-test was used to compare the results between the patient and control groups.

Correlations between the 2L-INT test and standard tests were examined using the Spearman's rank correlation coefficient. All tests were two tailed and statistical significance was set at $P < 0.05$.

3. Results

The study included 100 hands (60 patients) with clinical signs suggestive of CTS and 100 non-CTS hands (50 individuals) served as the control group. Diagnosis of the carpal tunnel syndrome was based on clinical findings. All patients were recruited from Physical Medicine, Rheumatology & Rehabilitation Department, the Ain Shams Hospital.

The Patient group consisted of 81 females and 19 males and their ages ranged from 24 to 73 with a mean of 39.9 years. The control group consisted of 83 females and 17 males. Their ages ranged from 26 to 63 years with a mean of 41.4 years. There

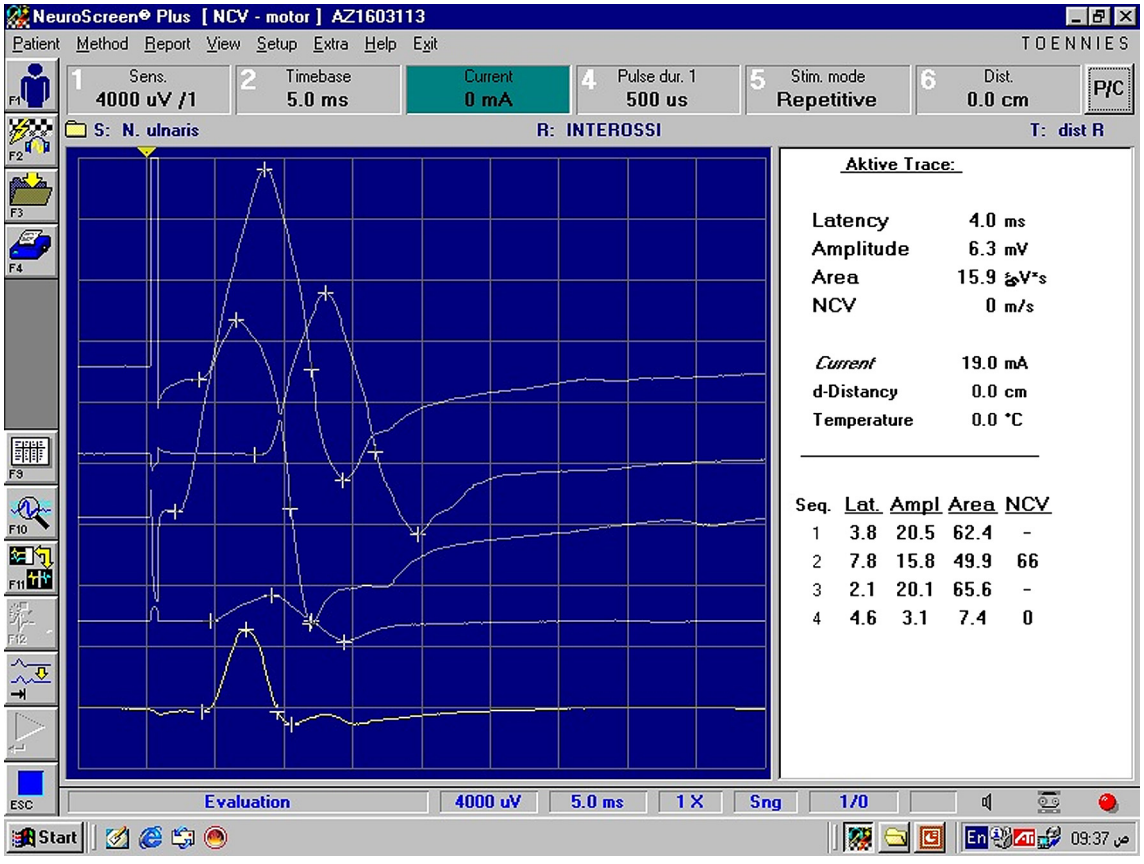

Figure 3 Routine median motor conduction study, median plamar study and 2ndlumbrical-interossei motor comparison study in a patient with symptoms suggestive of the capral tunnel syndrome showing abnormal 2L-INT latency difference (Difference = 0.6 ms) in presence of normal routine motor conduction study and palmar study. No remarks found in XML Order!!!Trace 1: Median nerve distal stimulation recording from abductor pollicus brevis (APB) showing within average parameters. *Trace* 2: Median nerve proximal stimulation recording from APB showing within average parameters. *Trace 3*: Median nerve palmar stimulation recording form APB showing average parameters. *Trace 4*: Median nerve wrist stimulation recording from 2nd lumbrical muscle showing CMAP latency = 4.6 ms *Trace* 5 (active trace): Ulnar nerve wrist stimulation recording from interosseus muscle showing CMAP latency = 4ms.

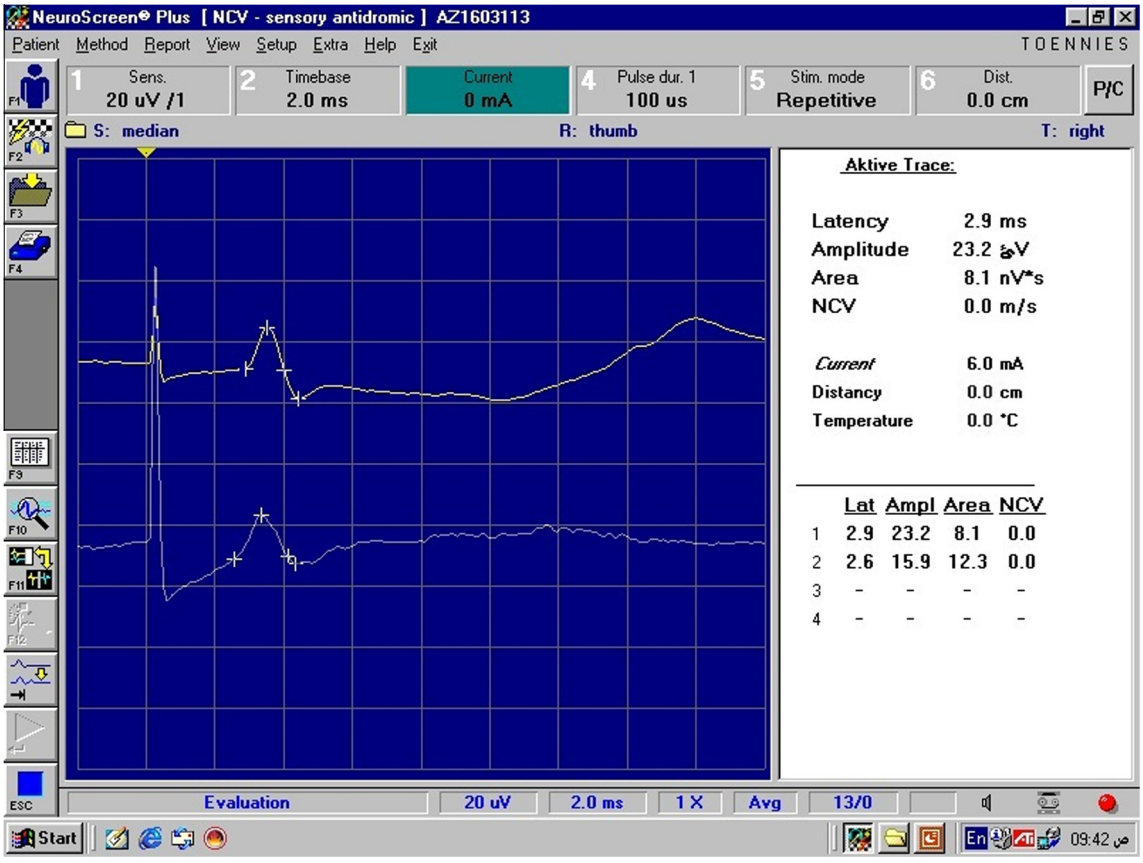

Figure 4 Median-versus-radial sensory comparison study showing normal median-radial sensory latency difference in the same patient previously shown in Fig. 3 (Difference = 0.3 ms). *Trace 1*: Median sensory study with stimulation at wrist and recording form thumb with SNAP latency = 2.9 ms *Trace 2*: Radial sensory study with stimulation at wrist and recording from thumb with SNAP latency-2.6 ms.

Table 3 Correlation between 2L-INT latency difference and other electrophysiological studies.

Variables	2L-INT latency difference		
	r	*P*	S
Median DML	0.69	0	NS
Palm/wrist CMAP amplitude	0.36	0.002	Sig.
Median-radial sensory latency difference	0.49	<0.001	HS

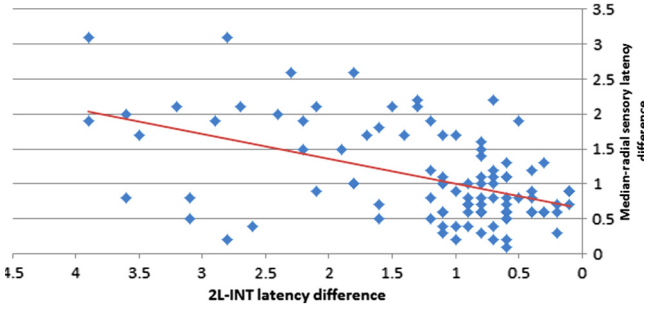

Figure 5 Correlation between 2L-INT latency difference and Median-radial sensory latency difference.

was no significant difference regarding age between patient and control groups ($P = 0.2$).

Duration of symptoms ranged from 1 to 8 months with a mean of 3.9 months.

The symptoms' onset was gradual and progressive in all patients.

52 out of 60 patients were right handed and 8 were left handed. In 54 patients (90%), the symptoms and signs of the carpal tunnel syndrome were present in the dominant hand.

90 % of patients had nocturnal pain and paresthesia which was partially relieved by hand shaking, 10% of patients were complaining mainly of activity-related pain with paresthesia and occasional nocturnal pain. The distribution of paresthesia was the lateral three fingers in 83% of cases and in 17%, it took the distribution of the whole hand.

By examination, hypothesia was found in 94 hands along the lateral 3 fingers, while in 6 hands the sensory examination was normal. Weakness of abductor pollicus brevis was found in 15 hands with mild thenar atrophy. Tinel and Phalen's tests were positive in 85 hands and in 15 hands, the Tinel test was positive with negative phalen.

The results of the electrophysiological tests done on the patients and controls are shown in Table 1 and Fig. 2.

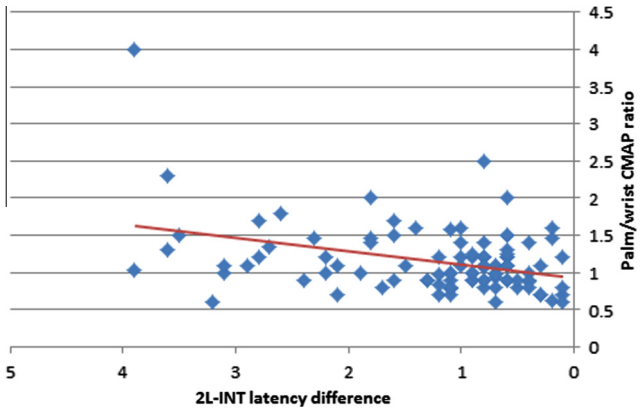

Figure 6 Correlation between 2L-INT latency difference and Palm/wrist CMAP amplitude.

In the control non-CTS hands, the mean of 2L-INT latency difference was 0.21 ± 0.14 ms, the upper limit of normal (ULN) value was set at 2SD giving a cutoff value of 0.49 ms, corresponding to the widely accepted value of abnormality (>0.5 ms). The 2L-INT test was normal in all control hands.

There was a statistical significant difference between patient and control groups as regards Median distal motor latency, Palm/wrist CMAP amplitude, median-radial sensory latency difference and 2nd lumbrical-interossei latency difference ($P < 0.001$).

DML of the median nerve was abnormal in 47 hands out of 100 with a clinical diagnosis of CTS, Palm/wrist CMAP amplitude ratio was abnormal in 26 patients, Median-radial sensory latency difference was abnormal in 82 hands and 2L-INT motor latency difference was abnormal in 83 hands giving a sensitivity of 47 %, 26 %, 82 % and 83 % respectively (Table 2).

Among the 83 CTS hands in which the 2L-INT test was abnormal, three of them had also abnormal median DML only, twenty had median-radial sensory tests abnormal in the presence of normal median DML. In nine hands, the 2L-INT test was the only abnormal test in the presence of other normal tests (Figs. 3 and 4).

The study showed significant positive correlation of 2L-INT latency difference with each Palm/wrist amplitude ratio and median-radial sensory latency difference ($P < 0.05$) while there was no significant correlation between 2L-INT latency difference and median DML ($P > 0.05$) (Table 3, Figs. 5 and 6).

4. Discussion

Carpal tunnel syndrome is one of the most common entrapment neuropathies and is a common referral to electrodiagnotic (EDX) labs. Many EDX tests are used for diagnosis including routine motor and sensory nerve conduction studies in addition to more sensitive tests. One of these tests is the 2L-INT motor comparison study. In practical work most labs commonly use the routine motor study, midpalm and median-versus-radial sensory comparison study while the 2L-INT is not commonly used. In this study, we tried to assess the value of this test and to determine whether it should be done routinely in all cases of CTS or not.

As regards the control values, the upper limit of normal (ULN) of 2L-INT in our study was 0.5 ms, this is similar to values reported by other studies by Loscher and his colleagues. On the other hand, Preston and Logigian, 1994 & Sheean et al., 1995, reported that 0.4 ms is the upper limit of normal (ULN) in their study.

In the present study, the most two sensitive tests were the 2L-INT motor study (83%) and median-radial sensory study (82%). Surprisingly, the median DML was of low sensitivity (47%) which implies that the routine median DML is not an adequately reliable test. Accordingly, if it is reported within normal values, other tests should still be done. Similarly, many other studies as Loscher et al., 2000 & Sheean et al., 1995 & Preston and Logigian in 1994 also revealed a low sensitivity of DML and a higher sensitivity of sensory median-radial and 2L-INT studies.

The present study showed significant positive correlation between 2L-INT latency difference and each of Palm/wrist CMAP amplitude and median-radial sensory latency difference while there was no significant correlation with median DML. Although, each of the 2L-INT latency differences and median-radial sensory latency differences assesses different roots of the median nerve with different types of fibers (sensory and motor), the positive correlation between them implicates that the motor fibers were equally affected at the same time as the sensory fibers. But in some circumstances, it is not necessary (although theoretically it is) that the compression of one obligates the compression of the other as shown in our study in which the 2L-INT test was the only abnormal test despite other normal tests including the median-radial sensory latency difference. The absent correlation between 2L-INT latency difference and median DML together with low sensitivity of median DML supports the recent trend to do more sensitive tests in the cases of normal routine median motor study.

Among the 83 CTS hands in which the 2L-INT test was abnormal, three of them had the median DML as the only other abnormal test, twenty had median-radial sensory tests that were abnormal in presence of normal median DML. In nine hands, the 2L-INT test was the only abnormal test in presence of other normal tests and in one hand only, the palm/wrist CMAP ratio was the only abnormal test. These results denote that all tests are complementary to each other and no single test can substitute the other tests.

These results denote that the motor fibers to the second lumbrical muscle are as sensitive as the sensory fibers and can be subjected to early mild median nerve compression even before it causes delay in DML. Thus, the fact that sensory fibers are the first to be affected is not as absolute as we previously believed. Hence, motor fibers can be affected as early as the sensory fibers.

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