Improvement of Diagnostic Rate of Carpal Tunnel Syndrome with Additional Median-to-ulnar Comparative Nerve Conduction Studies

Yuh-Jen Wang, Sui-Hing Yan

Abstract-

Purpose: The aim of this study is to assess whether additional median -to-ulnar comparative tests will improve the diagnostic rate of carpal tunnel syndrome (CTS).

Methods: We recruited 248 hands of 162 CTS patients, and 166 hands of 83 controls. One hundred and sixty-eight (68%) symptomatic hands had abnormal median distal latencies or palm-wrist latencies. We performed three additional comparative tests in the remaining symptomatic hands and the non-CTS hands. The first test compared median distal motor latency (MDL) recorded from the second lumbrical muscle (2L) and ulnar distal latency recorded from interossei muscles (INT) (2L-INT). The second test compared median and ulnar antidromic sensory latencies (MS-US). And the third test compared median and ulnar nerve latencies in the palm-to-wrist segment (PM-PU).

Results: In control subjects, upper limits of median-to-ulnar differences were: 2L-INT= 0.4ms, MS-US= 0.5 ms, PM-PU= 0.4ms. In CTS patients with normal conventional electrodiagnostic methods, MS-US difference showed the lowest sensitivity (21.3%). The diagnostic sensitivity of 2L-INT was 27.5% and PM-PU 47.5%. With PM-PU test, additional 15.3% diagnostic rate could be got.

Conclusion: For CTS patients with normal results from the standard methods, PM-PU is a good additional comparative test to further improve diagnostic rate.

Key Words: carpal tunnel syndrome, eletrodiagnosis, median, ulnar

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INTRODUCTION

Carpal tunnel syndrome (CTS) is a clinical syndrome of numbness, weakness, and pain in the fingers and wrist, associated with median nerve compression at the wrist. It is the most commonly nerve compression syndrome[1]. In Taiwan, at least fifteen thousand people have CTS[2]. CTS is basically diagnosed on clinical examinations and electrodiagnostic studies(EDX). Patients often have Tinel's sign, Phalen's sign, flick sign, and positive provocative tests, such as Durkan's test[3]. The conventional standard EDX for CTS requires

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demonstration abnormal median nerve conduction tests across the wrist[4,5]. Although there are many established EDX methods to diagnose CTS[1,6], many patients still have negative EDX[6,7].

Early diagnosis of CTS is important to exclude other causes[8] and to prevent further nerve damage. The more severe the CTS condition, the worse the prognosis will be[9]. In Taiwan, with the high accessibility of medical care system, more patients receive earlier EDX with mild CTS than before. Hence, conventional EDX for CTS is not sufficient. The aim of this study was to assess the sensitivity of three additional median-to-ulnar comparative tests in CTS patients with normal conventional EDX in order to improve the EDX of CTS. We wanted to explore if higher diagnostic sensitivity of CTS could be obtained.

METHODS

Subjects: We collected 162 consecutive clinically confirmed CTS patients with 248 symptomatic hands. Eighty-six patients had bilateral CTS, 49 on right hand, and 27 on left side. Diagnosis of CTS was based on previously reported criteria: (1) nocturnal or activity-related pain or dysesthesia limited to the hand; (2) sensory deficit or reduced two point discrimination in median nerve distribution; (3) isolated atrophy of the abductor pollicis brevis muscle (APB); and (4) positive Phalen's or Tinel's signs. The diagnosis was suspected when the patients complained of painful dysesthesia in the sensory area of the median nerve and one of the criteria 2-4 was fulfilled[10]. Patients with diabetes mellitus, polyneuropathy, wrist trauma and /or endocrine disease were excluded.

We also analyzed 166 hands from 83 asymptomatic volunteers, who showed no clinical sign and symptoms of peripheral nervous system and normal motor and sensory conduction studies of the median and ulnar nerves as controls. Patients with normal median distal latencies and wrist -palm latencies and normal controls received additional three comparative tests.

Electrophysiology (nerve conduction studies): All patients had bilateral nerve conduction studies using a Nicolet Viking IV (Madison, WI) eletromyography (EMG) machine. The skin temperature of the hand was maintained at or above 32˚C. All patients were studied with multiple EDX for CTS as follows: all latencies except median distal motor latency (MDL) were measured to the negative peak. Amplitude was measured from the baseline to the peak of negative deflection. All tests were using the same EMG instrument with percutaneous supramaximal response. Pulse duration was 0.05/0.1 ms for sensory and mixed nerve stimulation and 0.2/0.5 ms for motor nerve stimulation. The filters were set at 20 Hz and 2 kHz. The sweep speed was set at 1 ms per division. The bar electrodes or one-centimeter disc recordings were used for mixed nerve studies and ring electrodes for sensory studies. A ground electrode was placed on the dorsum of the hand.

1. Median sensory distal latency (SDL): The stimulation delivered on median nerve at wrist activates antidromic sensory action potentials at the index finger. We used a fixed 14 cm distance from the ring recording electrode (G1) that was placed on the midportion of the proximal phalanx and a reference ring electrode (G2) on the midportion of the middle phalanx of the same finger, 3 cm from the active electrode.

2. Median motor distal latency: Median nerve stimulation was delivered at wrist in order to activate the compound muscular action potential at the thenar eminence. We used a fixed 8 cm distance from the disc recording electrodes that were placed over the belly of APB muscle (recording, cathode) and just distal to the metacarpophalangeal joint (reference, anode).

3. Mixed median palm latency (MMIX): Median nerve stimulation was delivered at the palm (mixed nerve) in order to activate orthodromically mainly sensory action potentials at the wrist. We used a fixed 8 cm distance from the bar recording electrode that was placed at the wrist (cathode distal).

4. Sensory median-ulnar difference (MS-US): Median nerve stimulation was delivered at wrist in order to activate antidromic sensory action potentials at the index finger. We used a fixed 14 cm distance from the ring recording electrodes that were placed around the proximal recording (cathode) and distal (reference,

anode) interphalangeal joints. In the same way, ulnar nerve stimulation was delivered at wrist (ulnar edge) and recording at the small finger.

5. Mixed median-ulnar palm latency difference (PM-PU): Supramaximal stimulation was delivered in the palm, between the second and third metacarpal bones for the median nerve and between the fourth and fifth metacarpals for the ulnar nerve. Latencies were obtained by placing a bar electrode (3 cm interelectrode spacing) over the median and ulnar nerves at the wrist, with 8 cm between stimulation and recording sites (reference more proximal).

6. Distal latency differences between second lumbrical and interossei (2L-INT): Median and ulnar nerves were supramaximally stimulated at the wrist at identical linear distances (11cm) from the recording electrodes. Latencies were obtained by placing the recording electrode just lateral to the midpoint of the third metacarpal. The reference was placed over the proximal interphalangeal joint of digit 2.

Statistics: Descriptive statistics, including the mean, maximum, minimum, and standard deviation were applied to each nerve conduction value and differences between median and ulnar latencies. Upper and lower limits of controls for each test were calculated by rounding the mean ± 2 standard deviations. The two-tailed student's t-test was used for comparative statistic. Sensitivity of each test was calculated as number of hands with positive test and CTS/ number of hands with CTS x 100. Comparison between percentages was performed by the Mc Nemar test.

RESULTS

The mean age of the patient group was 50.1±12.8 years old (range 24-82) and the control group was varied from 48.5 ± 12.5 years old (range 24-76). Out of the 248 symptomatic hands studied, 168(67.7%) hands had at

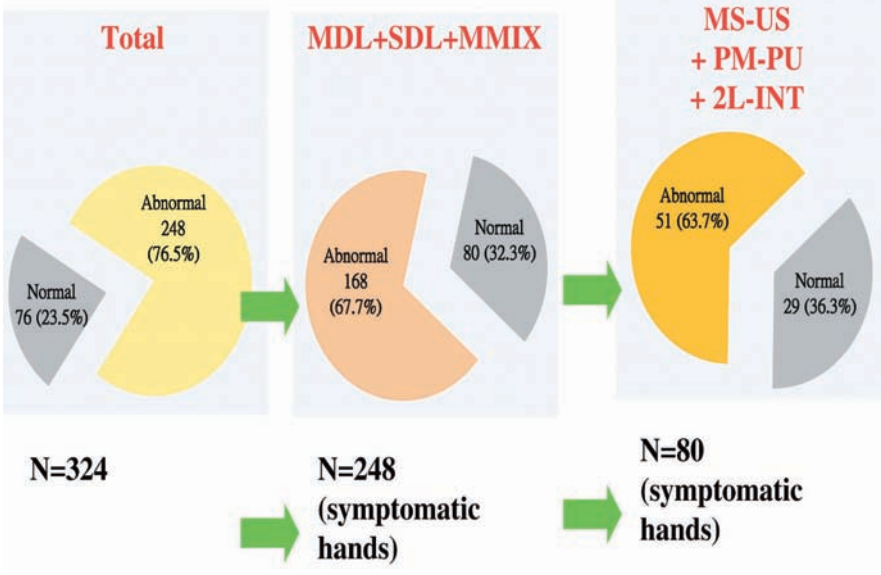

Figure 1. The distribution of electrodiagnostic studies Initially, total 324 hands were evaluated, including 248 symptomatic hands and 76 asymptomatic hands. Conventional electrodiagnostic methods showed abnormalities in 67.7% symptomatic hands. Additional electrodiagnostic methods could detect further 63.7% symptomatic hands with normal conventional methods.

MDL: median distal motor latency

SDL: median sensory distal latency MMIX: median mixed latency after palmar stimulation

MS-US:difference between median and ulnar sensory latency recorded from second digit and little finger

PM-PU:difference between median and ulnar mixed latencies after palmar stimulation

2L-INT: difference between median and ulnar motor latency recorded from second lumbrical and interosse

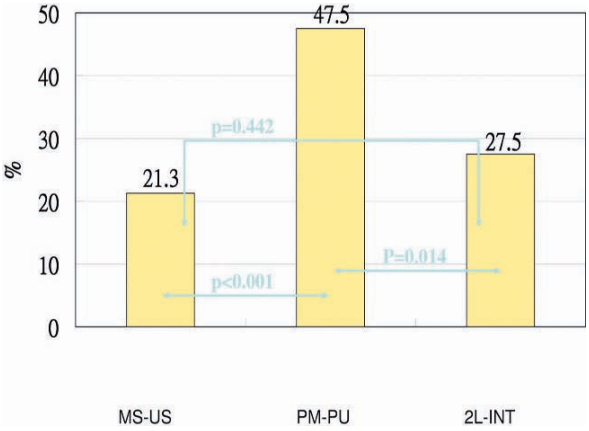

Figure 2. The Diagnostic rate of the additional comparative techniques
The PM-PU had the highest sensitivity to detect carpal tunnel syndrome and had significant difference from MS-US and 2L-INT.
MS-US: difference between median and ulnar sensory latency recorded from second digit and little finger
PM-PU: difference between median and ulnar mixed latencies after palmar stimulation
2L-INT: difference between median and ulnar motor latency recorded from second lumbrical and interossei

least one of the followings; abnormal median MDL, absence or prolonged median SDL, or abnormal MMIX. The remaining 80(32.3%) symptomatic hands (70% women) and 166 control hands (74% women) received additional three tests: 2L-INT, MS-US, and PM-PU.

The results of normal controls are summarized in Table 1. There were only two hands with mildly prolonged SDL according to our laboratory's criteria. We used cutting point as MS-US = 0.5 ms, MP-UP = 0.4ms, 2L-INT = 0.4ms. The results of patients were shown in figure 1. Combing all six tests, a total of 88.3% symptomatic hands had at least one abnormal findings, which meant that an additional 21.6% diagnosed rate was obtained as result of these three comparative tests. We also compared the diagnosed sensitive rate of these three tests (figure 2). The MS-US difference showed the lowest sensitivity being >0.5 ms (21.3 %) in CTS patients with normal conventional EDX. The 2L-INT was >0.4ms in 27.5 % of hands and PM-PU was >0.4ms in 47.5 % of hands. MP-UP had much greater sensitivity compared with both L2-INT and MS-US (P=0.014 and P<0.001). The sensitivity of MS-US was no significance compared with L2-INT (P=0.442). The diagnostic sensitivity of conventional EDX with PM-PU was 83%.

DISCUSSION

EDX is helpful to forecast surgical prognosis of CTS[11]. The prognosis of CTS depends on different treatment strategies[12] and clinical severity[9]. Early identification of CTS is essential because it is associated with a

.**Table 1.** The electrodiagnostic data of 166 hands of 83 asymptomatic volunteers

	Number	Mean (ms)	SD	Range (ms)	Mean + 2 SD(ms)	Abnormal (ms)
MDL (ms)	166	3.50	0.34	2.7-4.1	4.19	>4.2
SDL (ms)	166	2.67	0.27	2.1-3.4	3.20	>3.2
MMIX (ms)	166	1.56	0.18	1.2-2.0	1.92	>2.0
MS-US (ms)	166	0.12	0.16	0.1-0.5	0.45	>0.5
PM-PU (ms)	146	0.22	0.08	0.1-0.4	0.38	>0.4
2L-INT (ms)	140	0.13	0.14	0.0-0.4	0.40	> 0.4

SD: standard deviation

MDL: median distal motor latency

SDL : median sensory distal latency

MMIX : median mixed latency after palmar stimulation

MS-US : difference between median and ulnar sensory latency recorded from second digit and little finger

PM-PU : difference between median and ulnar mixed latencies after palmar stimulation

2L-INT : difference between median and ulnar motor latency recorded from second lumbrical and interossei

better prognosis[13]. Our study founded that one more simple test (PM-PU) can contribute significantly to the diagnosed rate of CTS.

The conventional EDX diagnostic rate for CTS is around 60-85%[4,14]. Currently, there are many EDX methods suggested to improve the diagnosis of CTS[1,4,6,14]. Albeit many EDX methods present, the diagnosed rate for CTS is still unsatisfied. These methods have variable sensitivity and specificity. According to the guidelines suggested by American Association of Electrodiagnostic Medicine, in patients suspected of CTS, the standard EDX included 1. a median sensory nerve conduction study (NCS) across the wrist with a conduction distance of 13 cm to 14 cm; 2. a median sensory NCS across the wrist with a conduction distance greater than 8 cm; 3. a motor NCS of the median nerve recording from the thenar muscle and of one other nerve in the symptomatic limb to include measurement of distal latency. CTS patients with normal initial median sensory nerve conduction study cross the wrist should receive comparison of median and ulnar mixed nerve conduction tests between wrist and palm[4]. This is compatible with our findings although no cumulative diagnosed rate is present in the guideline.

Some studies showed the PM-PU difference and not the prior method for CTS[4,15]. Lee et al found that latency subtraction from median-ring to ulnar-ring recordings having the highest diagnostic value in CTS patients with normal conventional EDX; however, the study did not check the palm-wrist distal latency [14]. This study revealed higher sensitivity of comparison median/ulnar palm-wrist latency than comparison median/ulnar latency, wrist-ring finger[16]. This may be due to the different of cut-off point adopted[15]. Actually, different cut-off point as 0.5ms had been advocated[17].

Based on the findings of our study, we recommend that PM-PU test should be arranged for clinical CTS patients with normal initially conventional EDX. The PM-PU test is not time consuming and can be easily performed. The background bias is low because both tested median nerve and reference ulnar nerve are done in the same hand. We believe our results present a valuable way to achieve a higher CTS diagnosis rate.

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