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Axonal degeneration of the ulnar nerve secondary to carpal tunnel syndrome: fact or fiction?☆●

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Abstract

The distribution of sensory symptoms in carpal tunnel syndrome is strongly dependent on the degree of electrophysiological dysfunction of the median nerve. The association between carpal tunnel syndrome and ulnar nerve entrapment is still unclear. In this study, we measured ulnar nerve function in 82 patients with carpal tunnel syndrome. The patients were divided into group I with minimal carpal tunnel syndrome (*n* = 35) and group II with mild to moderate carpal tunnel syndrome (*n* = 47) according to electrophysiological data. Sixty-one age- and sex-matched subjects without carpal tunnel syndrome were used as a control group. There were no significant differences in ulnar sensory nerve peak latencies or conduction velocities from the 4th and 5th fingers between patients with carpal tunnel syndrome and the control group. The ulnar sensory nerve action potential amplitudes from the 4th and 5th fingers were lower in patients with carpal tunnel syndrome than in the control group. The ratios of the ulnar sensory nerve action potential amplitudes from the 4th and 5th fingers were almost the same in patients with carpal tunnel syndrome as in the control group. These findings indicate that in patients with minimal to moderate carpal tunnel syndrome, there is some electrophysiological evidence of traction on the adjacent ulnar nerve fibers. The findings do not indicate axonal degeneration of the ulnar nerve.

Key Words

neural regeneration; peripheral nerve injury; carpal tunnel syndrome; median nerve; extra-median symptoms; motor conduction; sensory conduction; ulnar nerve; ulnar amplitude ratio; neuroregeneration

Research Highlights

(1) This study focused on patients with minimal, mild, or moderate carpal tunnel syndrome.
(2) This study used the ratios of the ulnar sensory nerve action potential amplitudes from the 4th and 5th fingers to measure changes in ulnar nerve function secondary to carpal tunnel syndrome.
(3) The insignificant reduction in ulnar sensory nerve action potential amplitudes may have been caused by mechanical traction on the ulnar nerve fibers secondary to carpal tunnel syndrome.

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INTRODUCTION

Carpal tunnel syndrome is caused by entrapment of the median nerve under the transverse carpal ligament at the wrist, and is the most common nerve entrapment syndrome of the upper extremity[1]. Guyon's canal syndrome is less common. Carpal tunnel syndrome may have complex symptoms causing discomfort and disability[2] and affects up to 4% of the general population, with the highest incidence in late-middle-aged women[3]. The main clinical diagnostic criteria for carpal tunnel syndrome include sensory symptoms

in the median nerve territory[4]. Patients complain of nocturnal numbness, pain, tingling, and painful paresthesia in the 1st, 2nd, and 3rd fingers or in the whole hand. Forearm, shoulder, and neck symptoms are atypical[5]. Sometimes, pain extends to the ulnar nerve territory[6]. The distribution of sensory symptoms is strongly dependent on the degree of electrophysiological dysfunction of the median nerve. The association between carpal tunnel syndrome and ulnar nerve entrapment is still unclear[4].

This study used nerve conduction studies to evaluate axonal changes in the ulnar sensory nerve fibers from the 4th and 5th fingers, which may cause extra-median distribution of symptoms in patients with minimal, mild, or moderate carpal tunnel syndrome.

RESULTS

Quantitative analysis of subjects

Eighty-two patients were grouped according to the electrophysiological classification of carpal tunnel syndrome severity reported by *Padua et al* [7], as follows. Group I, minimal carpal tunnel syndrome (*n* = 35): abnormal median sensory nerve conduction or abnormal comparative median/ulnar sensory nerve conduction with normal median nerve distal motor latency; and group II, mild or moderate carpal tunnel syndrome (*n* = 47): abnormal finger/wrist median sensory nerve conduction velocity and abnormal median nerve distal motor latency (Figures 1, 2). Sixty-one subjects without carpal tunnel syndrome were used as a control group.

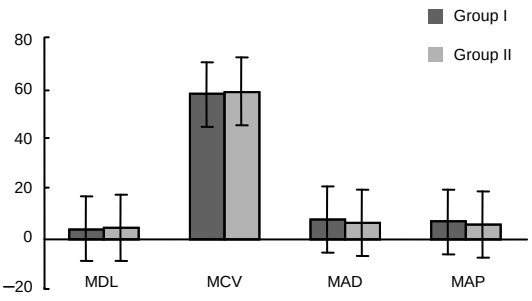

Figure 1 Results of median motor nerve studies in patients with carpal tunnel syndrome.

Data are expressed as mean ± SD. Group I had minimal carpal tunnel syndrome, and group II had mild or moderate carpal tunnel syndrome. MDL: Motor nerve distal latency (ms); MCV: motor nerve conduction velocity (m/s); MAD: distal motor nerve action potential amplitude (mV); MAP: proximal motor nerve action potential amplitude (mV).

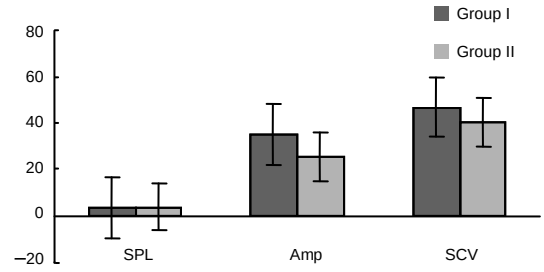

Figure 2 Results of median sensory nerve studies in patients with carpal tunnel syndrome.

Data are expressed as mean ± SD. Group I had minimal carpal tunnel syndrome, and group II had mild or moderate carpal tunnel syndrome. SPL: Sensory nerve peak latency (ms); Amp: sensory nerve action potential amplitude (mV); SCV: sensory nerve conduction velocity (m/s).

Background characteristics of the subjects

The 82 patients were 73 females (89%) and 9 males (11%) with a mean age of 41.9 ± 12.1 years, including 42 patients (51%) with unilateral symptoms and 40 (49%) with bilateral symptoms (Table 1).

Table 1 Background characteristics of patients with carpal tunnel syndrome and control group subjects

Variable	Group I	Group II	Controls
n	35	47	61
Age (mean±SD, year)	41.9±11.6	41.9±12.6	40.1±10.8
Sex (male/female, *n*)	4/31	5/42	6/55
Laterality (unilateral/bilateral, *n*)	23/12	19/28	48/13
Examined nerves (*n*)	47	75	74

Group I: Minimal carpal tunnel syndrome; group II: mild or moderate carpal tunnel syndrome.

Comparisons of sensory nerve test results for the 4th finger in patients with carpal tunnel syndrome

There were significant differences in the median and ulnar sensory nerve action potentials from the 4th finger in terms of peak latency, amplitude, and conduction velocity between groups I and II (all $P < 0.01$; Table 2).

Ulnar sensory nerve conduction studies for the 4th and 5th fingers in control group subjects

In the control group, there were no differences in ulnar sensory nerve action potentials in terms of peak latency ($P = 0.1$) or conduction velocity ($P = 0.13$) between the 4th and 5th fingers. The ulnar sensory nerve action potential amplitude was significantly lower from the 4th finger than from the 5th finger ($P < 0.001$), with a 4th/5th finger ratio of 0.61 (Table 3).

Table 2 Comparisons of median and ulnar sensory nerve test results for the 4th finger in patients with carpal tunnel syndrome and control subjects

	Controls	Group I	Group II	*P* value[a]
Median 4th SPL	2.85±0.28	3.53±0.50	3.79±0.64	
Ulnar 4th SPL	2.64±0.28	2.69±0.29	2.42±0.42	
Difference	0.19±0.18	0.89±0.34	1.37±0.59	< 0.01[b]
Median 4th Amp	27.8±10.1	24.4±0.29	14.54±7.73	
Ulnar 4th Amp	21.3±11.0	17.77±0.05	18.16±12.79	
Difference	9.0±11.5	6.66±13.53	–3.62±13.11	0.016[c]
Median 4th CV	Not calculated	43.7±4.3	35.01±9.92	
Ulnar 4th CV	Not calculated	58.4±8.97	58.36±15.74	
Difference	Not calculated	–14.7±8.57	–23.35±6.64	0.006[b]

Group I: Minimal carpal tunnel syndrome; group II: mild or moderate carpal tunnel syndrome. SPL: Sensory nerve peak latency (ms); Amp: sensory nerve action potential amplitude (mV); CV: sensory nerve conduction velocity (m/s). Data are expressed as mean ± SD. [a]Comparisons of the differences between the median and ulnar nerve responses recorded from the same 4th finger among the three groups studied, Student's *t*-test. There were significant differences among all three groups ([b]$P < 0.01$, [c]$P < 0.05$).

Ulnar sensory nerve conduction studies for the 4th and 5th fingers in patients with carpal tunnel syndrome

There were no significant differences in ulnar sensory nerve action potentials from the 4th and 5th fingers in terms of peak latency or conduction velocity between group I or group II, and the control group. The ulnar sensory nerve action potential amplitudes from the 4th and 5th fingers were slightly, but not significantly, decreased in both group I ($P = 0.15$ and $P = 0.10$, respectively) and group II ($P = 0.79$ and $P = 0.46$, respectively). The ratios of the ulnar sensory nerve action potential amplitudes from the 4th and 5th fingers were almost the same in all three groups (Table 3).

DISCUSSION

This study focused on patients with confirmed minimal, mild, or moderate carpal tunnel syndrome only. These patients were selectively studied because previous studies demonstrated that severe carpal tunnel syndrome is associated with pure median nerve distribution of symptoms[8], whereas patients with mild carpal tunnel syndrome usually report symptoms in the whole hand[9]. There is evidence that patients with sensory symptoms in all fingers have enlargement of the hand representation in the sensory cortex[10]. Some authors[9, 11-12] have suggested that changes in plasticity in the cortical and/or subcortical areas (possibly caused by peripheral de-afferentation and/or ectopic activity due to median nerve compression) may contribute to the radiation of sensory symptoms in carpal tunnel syndrome.

The first retrospective study[13] of concomitant ulnar nerve entrapment in patients with carpal tunnel syndrome performed in 1973 reported that 44% of patients with carpal tunnel syndrome had ulnar nerve entrapment at the wrist, 39% had decreased ulnar sensory nerve action potential amplitudes, and 4.8% had decreased amplitude and prolonged latency of ulnar sensory nerve action potentials. Symptoms in the 5th finger of patients with median nerve compression in the carpal tunnel could be explained by crossover of median and ulnar sensory nerve fibers at the level of the 7th and 8th cervical roots.

Table 3 Ulnar sensory nerve conduction studies for the 4th and 5th fingers

Ulnar sensory nerve	To the 4th finger	To the 5th finger	Diff	Ratio	*P* value[a]	
					4th finger	5th finger
Group I						
SPL	2.69±0.29	2.31±0.35	–0.30±0.41			
Amp	17.77±10.05	26.93±18.2	9.00±8.15	0.65	0.15	0.10
CV	58.40±8.97	56.67±7.61	–2.00±1.36			
Group II						
SPL	2.42±0.42	2.46±0.30	0±0.12			
Amp	18.16±2.79	31.87±27.13	14.00±14.34	0.57	0.79	0.45
CV	58.36±15.74	56.86±5.64	–1.00±10.1			
Control						
SPL	2.69±0.28	2.59±0.22	–1.00±0.06			
Amp	20.31±9.22	33.04±13.9	13.00±4.68	0.61		
CV	62.24±9.62	56.86±5.71	–5.00±3.91			

Group I: Minimal carpal tunnel syndrome; group II: mild or moderate carpal tunnel syndrome. SPL: Sensory nerve peak latency (ms); Amp: sensory nerve action potential amplitude (mV); CV: sensory nerve conduction velocity (m/s); Diff: difference between the 4th and 5th fingers; Ratio: sensory nerve action potential amplitude from the 4th finger divided by the sensory nerve action potential amplitude from the 5th finger. Data are expressed as mean ± SD. The sensory nerve action potential amplitude was significantly smaller in the 4th finger than in the 5th finger ($P < 0.001$). [a]Student's *t*-test.

In a retrospective review, 12 out of 14 cases (86%) of idiopathic ulnar tunnel syndrome at the wrist were associated with carpal tunnel syndrome[14]. Although this result suggests an association between idiopathic ulnar tunnel syndrome and carpal tunnel syndrome, the authors stated that their analysis did not confirm clinical relevance or a significant statistical relationship between these two conditions[6]. Gozke *et al* [15] conducted a cross-sectional study of 53 patients with carpal tunnel syndrome and reported that more than 18% had some degree of ulnar nerve entrapment at the wrist.

In the present study, we used the ratios of the ulnar sensory nerve action potential amplitudes from the 4th and 5th fingers to evaluate ulnar nerve changes secondary to carpal tunnel syndrome. Although the ulnar sensory nerve action potentials were reduced in amplitude in patients with carpal tunnel syndrome, this reduction was not statistically significant, and the 4th/5th finger amplitude ratios were not significantly different between patients with carpal tunnel syndrome and the control group. The ulnar sensory nerve peak latencies were relatively prolonged in patients with early carpal tunnel syndrome, but this difference was not statistically significant. Differences in ulnar sensory nerve conduction velocities were not significant because the values were within the normal range in all groups. These results suggest that sustained compression of the adjacent ulnar sensory fibers by the enlarged carpal tunnel may result in minimal axonal changes in the ulnar nerve, but they do not indicate concomitant ulnar nerve entrapment.

The distal segment of the ulnar nerve is vulnerable to external compression[16]. Increased pressure in the carpal tunnel may affect the adjacent Guyon's canal, causing indirect compression of ulnar nerve axons. Increased traction on the transverse carpal ligament secondary to increased pressure in the carpal tunnel may also cause compression of the ulnar nerve[2]. The transverse carpal ligament and the roof of the carpal tunnel form the medial wall and floor of Guyon's canal. We speculate that the insignificant reduction in ulnar sensory nerve action potential amplitudes may have been caused by traction on the adjacent ulnar nerve fibers.

In conclusion, there is some electrophysiological evidence that in patients with minimal to moderate carpal tunnel syndrome, there may be traction on the adjacent ulnar nerve fibers. The evidence does not indicate frank entrapment of the ulnar nerve.

SUBJECTS AND METHODS

Design

A retrospective clinical study.

Time and setting

This study was performed at the Clinical Neurophysiology Unit, Kasr Alaini Hospital, Cairo University, Egypt between May and December 2010.

Subjects

We recruited patients with idiopathic carpal tunnel syndrome with and without extra-median symptoms who were from the Clinical Neurophysiology Unit of Kasr Alaini Hospital, Egypt between May and December 2010. The diagnosis of carpal tunnel syndrome was according to the criteria of the American Academy of Neurology 1993 guidelines[17]. Patients were excluded if they had a history or clinical signs suggesting systemic disease; clinical or electrophysiological signs suggesting myelopathy, polyneuropathy, radiculopathy, myopathy, or other neurological disease; or another condition (such as wrist fracture or pregnancy) predisposing to carpal tunnel syndrome. Sixty-one age- and sex-matched subjects without carpal tunnel syndrome who were seen at the same clinic were used as a control group.

Methods

"Key point" electromyography (Keypoint software V5.13 for Windows 2000/XP/Vista/7, model 9031A006, 2 channels, Denmark) was performed. Surface recording electrodes (Ag/AgCl) were placed over the motor point of the abductor pollicis brevis muscle (3 cm inter-electrode distance) to test median nerve function. Electrical stimuli were delivered by a constant current stimulator through bipolar surface electrodes (2 cm inter-electrode distance, cathode distal). Stimulus intensity was increased in steps until the maximum M-wave was obtained. Median nerve distal motor latency was measured with a distance of 7 cm between the stimulation point of the nerve at the wrist and the active recording electrode over the abductor pollicis brevis muscle. Median nerve motor conduction velocity was calculated from the elbow to the wrist. Compound muscle action potential amplitudes were measured from baseline to negative peak. Antidromic sensory nerve action potentials were recorded (active recording electrode on the distal phalanx) for the median nerve from the 2nd finger at a distance of 13 cm and for the ulnar nerve from the 5th

finger at a distance of 11 cm. Sensory nerve action potential peak latency, conduction velocity, and amplitude were calculated.

Comparative sensory studies between the median and ulnar nerves from the 4th finger over a distance of 12 cm were also performed. A difference in sensory action potential peak latency of more than 0.5 ms (calculated manually) was considered significant. The ratios of the ulnar sensory nerve action potential amplitudes from the 4th and 5th fingers were calculated manually. Palmar temperature was not measured, but all subjects were given time to equilibrate in a warm room before testing to minimize the effects of temperature on the recordings.

Statistical analysis

All statistical analyses were performed using Microsoft Excel 2003 (Microsoft Corporation, New York, NY, USA) and SPSS 15.0 software (SPSS, Chicago, IL, USA). The Student's *t*-test was used to analyze comparisons. A *P* value of less than 0.05 was considered statistically significant.

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Author contributions: Radwa Mahmoud Azmy and Amira Ahmed Labib performed the research, analyzed the data, and wrote the paper. Saly Hassan Elkholy designed the study, collected data, conducted statistical analyses, and critically revised the paper. All authors approved the final version of the paper.

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Author statements: The manuscript is original, has not been submitted to and is not under consideration by another publication, has not been previously published in any language or any form, including electronic, and contains no disclosure of confidential information or authorship/patent application disputations.

REFERENCES

[1] Ozdemir O, Calisaneller T, Gulsen S, et al. Ulnar nerve entrapment in Guyon's canal due to recurrent carpal tunnel syndrome: case report. Turk Neurosurg. 2011;21: 435-437.

[2] Ginanneschi F, Dominici F, Milani P, et al. Evidence of altered motor axon properties of the ulnar nerve in carpal tunnel syndrome. Clin Neurophysiol. 2007;118: 1569-1576.

[3] Ghali J, Murugasu A, Day T, et al. Carpal tunnel syndrome in fabry disease. JIMD Rep. 2012;2:17-23.

[4] Wilder-Smith EP, Ng ES, Chan YH, et al. Sensory distribution indicates severity of median nerve damage in carpal tunnel syndrome. Clin Neurophysiol. 2008;119: 1619-1625.

[5] Nora DB, Becker J, Ehlers JA, et al. Clinical features of 1039 patients with neurophysiological diagnosis of carpal tunnel syndrome. Clin Neurol Neurosurg. 2004;107:64-69.

[6] Moghtaderi A, Ghafarpoor M. The dilemma of ulnar nerve entrapment at wrist in carpal tunnel syndrome. Clin Neurol Neurosurg. 2009;111:151-155.

[7] Padua L, Lo Monaco M, Padua R, et al. Neurophysiological classification of carpal tunnel syndrome: assessment of 600 symptomatic hands. J Neurol Sci. 1997;18:145-150.

[8] Caliandro P, La Torre G, Aprile I, et al. Distribution of paresthesias in carpal tunnel syndrome reflects the degree of nerve damage at wrist. Clin Neurophysiol. 2006; 117:228-231.

[9] Zanette G, Marani S, Tamburin S. Extra-median spread of sensory symptoms in carpal tunnel syndrome suggests the presence of pain-related mechanisms. Pain. 2006;122:264-270.

[10] Tecchio F, Padua L, Aprile I, et al. Carpal tunnel syndrome modifies sensory hand cortical somatotopy: a MEG study. Hum Brain Mapp. 2002;17:28-36.

[11] Charcur M, Milligan ED, Gazda LS, et al. A new model of sciatic inflammatory neuritis (SIN): induction of unilateral and bilateral mechanical allodynia following acute unilateral peri-sciatic immune activation in rats. Pain. 2001;94:231-244.

[12] Malan TP, Ossipov MH, Gardell LR, et al. Extraterritorial neuropathic pain correlates with multisegmental elevation of spinal dynorphin in nerve-injured rats. Pain. 2000;86: 185-194.

[13] Sedal L, McLeod JG, Walsh JC. Ulnar nerve lesions associated with the carpal tunnel syndrome. J Neurol Neurosurg Psychiatry. 1973;36:118-123.

[14] Murata K, Shih JT, Tsai TM. Causes of ulnar tunnel syndrome: a retrospective study of 31 subjects. J Hand Surg. 2003;28:647-651.

[15] Gozke E, Dortcan N, Kocer A, et al. Ulnar nerve entrapment at wrist associated with carpal tunnel syndrome. Neurophysiol Clin. 2003;33:219-222.

[16] Ablove RH, Moy OJ, Peimer CA, et al. Pressure changes in Guyon's canal after carpal tunnel release. J Hand Surg Br. 1996;21:664-665.

[17] Guidelines for ethical behavior relating to clinical practice issues in electrodiagnostic medicine. American Association of Electrodiagnostic Medicine. Muscle Nerve. 1994;17:965-967.

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