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Does the Provocation Maneuvers Increase the Sensitivity of Sensory Nerve Conduction Studies in Diagnosis of Carpal Tunnel Syndrome?

Karpal Tünel Sendromu Tanısında Provokasyon Manevraları Duyusal Sinir İletim Çalışmalarının Duyarlılığını Arttırmakta mıdır?

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Summary

Objective: The aim of this study was to determine the sensitivity of sensory nerve conduction study (NCS) parameters in the diagnosis of carpal tunnel syndrome (CTS) and to explore if the use of provocative maneuvers improves their sensitivity.

Materials and Methods: In this prospective study, we included 85 consecutive cases (135 hands) that had signs and symptoms of CTS, and 100 control hands. Sensory NCS was performed in the neutral position and then the wrist was placed in flexion and 90° of extension for 1 min. Onset and peak latencies and velocities, negative peak duration and area, and peak amplitude were measured.

Results: The most sensitive parameters were onset latency (77%), and onset (72%) and peak velocities (72%) in neutral position. The flexion maneuver did not increase their sensitivity, however, negative peak area (10%) and amplitude (24%) sensitivities were higher in extended position than in neutral position.

Conclusion: The most sensitive NCS parameters were onset latency, and onset and peak velocities in neutral position. The extension maneuver was more sensitive than neutral position. *Turk J Phys Med Rehab 2012;58:307-11.*

Key Words: Carpal tunnel syndrome; parameters; provocation maneuvers; sensory nerve conduction study

Özet

Amaç: Bu çalışmanın amacı karpal tünel sendromu (KTS) tanısında duyusal sinir iletim çalışmaları parametrelerinin duyarlılığını ve provokasyon manevraları kullanıldığında bunların duyarlılığını nasıl artırdığını belirlemektir.

Gereç ve Yöntem: Bu prospektif çalışmaya KTS semptom ve bulguları olan 85 olgu (135 el) ve 100 kontrol el dahil edildi. Duyusal sinir iletim çalışmaları, nötral pozisyonda, el bileği fleksiyon ve 90 derece ekstansiyonda 1 dk pozisyonlandıktan sonra yapıldı. Başlangıç ve pik latansı ve hızları, negatif dalga süresi ve alanı ve pik amplitud ölçüldü.

Bulgular: En sensitif parametreler nötral pozisyonda başlangıç latansı (%77), başlangıç (%72) ve pik hızlarıydı (%72). Fleksiyon manevrası bunların duyarlılığını artırmadı; bununla beraber negatif pik alanı (%10) ve amplitüdlerin (%24) duyarlılığı ekstansiyon pozisyonunda nötral pozisyona göre daha yüksekti.

Sonuç: Nötral pozisyonda en duyarlı manevralar başlangıç latansı, başlangıç ve pik hızlarıydı. Ekstansiyon manevrası nötral pozisyondan daha duyarlıydı. *Türk Fiz Tıp Rehab Derg 2012;58:307-11.*

Anahtar Kelimeler: Karpal Tünel Sendromu; parametreler; provokasyon manevraları; duyusal sinir iletim çalışmaları

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Introduction

Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy of the upper extremity. The diagnosis is usually made on the basis of patient history, clinical examination, and electrophysiological test results. The most sensitive diagnostic test for CTS is the sensory nerve conduction study (NCS) (1- 6). Several electrodiagnostic techniques with comparable sensitivity and specificity have been recommended to confirm the clinical diagnosis of CTS (4,5). Conventional sensory nerve conduction velocity (NCV) over the finger-wrist segment is one of the most commonly used tests to investigate CTS, however assessment of NCV over the palm-wrist segment was shown to be superior to that of the conventional method (1-3). Thereby, the latter test has become the standard test in the workup of CTS patients (5). On the other hand, not uncommonly, there are some patients with clinical symptoms and signs suggestive of CTS who are not diagnosed with the use of standard electrodiagnostic techniques.

It is known that intracarpal pressure generally changes with wrist flexion and extension (7). Increased interstitial fluid pressure causes the capillaries to collapse and interferes with perfusion of the median nerve. Thus, flexion and extension maneuvers have been used as provocative maneuvers in patients with clinically suspected CTS (7-10). Some studies indicated that provocative tests might increase the diagnostic sensitivity and specificity of electrodiagnostic studies (8,9,11), however, others have reported conflicting results (12,13).

In the present study, sensory conduction velocities of the median nerve were studied from digit to palm and from palm to wrist segments and, abnormal wrist-palm sensory nerve conduction was used as the diagnostic method to confirm CTS in patients with signs and symptoms of CTS. Subsequently, we aimed to determine (a) the sensitivity and specificity of sensory NCS parameters in diagnosing CTS, and (b) to explore if provocative maneuvers improve their sensitivity in those patients.

Material and Methods

The study included 85 patients (135 hands) with clinical features indicative of CTS (presence of paresthesia, tingling, and pain in the median nerve distribution for at least 1 month, and nocturnal symptoms 3 times per week). Normative data for electrophysiological studies were derived from 50 healthy volunteers (100 hands) who had no risk factors for neuropathy and no abnormalities in neurological examination. Prior to the study, all patients underwent a systematic evaluation, including medical history and systemic and neurological examinations. Patients with a history of CTS surgery, abnormal innervation, polyneuropathy and/or radiculopathy, or pacemaker use, and pregnant women were excluded from the study.

All NCSs were performed by the same investigators (I.A. and G.S.) with the subjects lying in a supine position and using a Medelec Synergy (EMG v.11.3 software) machine. The median and ulnar motor responses, including F-waves, were recorded from the abductor pollicis brevis and abductor digiti minimi muscles, respectively. Distal latency, amplitude, and NCV were recorded. Median and ulnar sensory nerves were recorded antidromically in neutral position, following flexion and extension maneuvers. In all, 8 trials were averaged to obtain a final response. Ulnar sensory NCS from the 5th digit was obtained initially in neutral position, with stimulation at the wrist. For median sensory NCS, the recording electrode was placed over the index finger. The median nerve was first stimulated at the palm approximately 5 cm distal to the distal crease of the forearm and, a sensory nerve action potential (SNAP) was obtained. Subsequently, the nerve was stimulated at the wrist approximately 3 cm proximal to the distal crease of the forearm and a second SNAP was obtained (2). After baseline testing in the neutral position, the wrist was placed in flexion for 1 min. Immediately after 1 min of the flexion maneuver, the wrist was returned to neutral position and stimulated again. Lastly, the same testing method was repeated after the wrist was placed into 90° of extension for 1 min (Figure 1). As any movement of the recording or stimulation side might alter the parameters of the waveform, the recording and stimulating electrodes were firmly attached over the skin. Maximum attention was given to protect the baseline distance between the electrodes to stimulate the nerve from the same area and to protect the electrode stability. Onset and peak latency, onset and peak velocity, negative peak duration, negative peak area, and baseline-to-peak amplitudes were recorded. Latencies were measured to the onset of the first negative deflection and to the negative peak. Velocities were calculated using the onset and peak latencies. Sensory NCV of the median nerve from palm to wrist segment was calculated automatically by the EMG device. Negative peak duration was considered as the interval from the first deflection of the waveform from the baseline to its final return to baseline. Negative peak area was calculated as the integrated area between the negative peak and the line connecting the first and second positive peaks. Amplitude of the SNAP was measured from the baseline to the negative peak. A standard orthotic device was used to maintain the wrist either in extension or in flexion. In hands with clinically diagnosed CTS, we confirmed the diagnosis by assessing NCV over the palm-wrist segment (5,6).

During the testing procedures, the room temperature was maintained at an average of 25 °C and skin temperature was maintained between 31 and 34 °C in all subjects. The filter band pass was 3 Hz-5 kHz for the motor studies and 20 Hz-2 kHz for sensory studies. Stimulus duration was 0.1 ms, sweep speed was 5 ms/division for the motor studies and 2 ms/division for the sensory studies. Supramaximal stimulation was applied to obtain optimal compound muscle action potentials. Bipolar surface electrodes were used to stimulate the nerves and to record the potentials from the muscles or nerves during the conduction studies. The ground electrode was attached to the limb being tested and was placed between the stimulating and recording electrodes.

According to the electrophysiological data, the patients were divided into 2 groups. Group 1 consisted of hands with both clinically and electrophysiologically confirmed CTS. Symptomatic hands with normal NCS according to the electrophysiological diagnostic criteria for CTS were evaluated in group 2. The study protocol complied with the Helsinki Declaration of human rights and was approved by the local Ethics Committee. All patients and controls provided informed consent to participate in the study.

Statistical Analysis

Continuous variables were compared using Student's t-test or the Mann-Whitney U test for normal and non-normal distributions, respectively. Categorical variables were compared using Fisher's exact test or chi-square, as appropriate. A p value less than 0.05 was considered significant. All data are presented as mean ± standard deviation (SD). The upper or lower limits of normal NCS values were obtained from the control group by calculating mean±2 SD. Values not within this range were considered abnormal.

Results

In all, 85 patients (135 hands) and 50 healthy subjects (100 hands) were evaluated. The mean age of the patients (6 male, 79 female) was 44.3±9.7 years, versus 42.4±9 years in the control group (8 male, 42 female). There was no significant difference in age, sex, weight, height, body mass index, or hand dominancy between the patients and controls (p>0.05). The mean duration of neuropathic symptoms at the time of evaluation was 13.84±17.44 months.

To test the normal distribution of electrophysiological findings in the neutral, flexion, and extension positions, we used the Kolmogorov-Smirnov test. As p was >0.05, normal distribution was confirmed. Electrophysiological findings for the sensory median nerve parameters of the control subjects are shown in Table 1. None of the evaluated parameters were significantly different among the controls (p>0.05 for all maneuvers).

Among the 135 hands of the 85 patients with clinically diagnosed CTS, 100 hands (74%) showed abnormality according to the electrophysiological diagnostic criteria for CTS (group 1). There were 35 symptomatic hands (26%) with normal NCS (group 2). While all of the evaluated electrophysiological parameters in group 1 were significantly different than in group 2 and controls in all positions, there was no difference between group 2 and control subjects. Onset latency, and onset and peak velocities in the neutral position were the most sensitive parameters in diagnosing CTS in group 1 (Table 2). None of the evaluated parameters in the flexion position was more sensitive than in the neutral position (Table 3). The neutral position was more sensitive than the extension maneuver in detecting abnormality in onset latency and in onset and peak velocities. In contrast, the sensitivity of negative peak latency and area, and the amplitude was significantly higher in extended position than in neutral position (Table 3). However, the increases in sensitivity were modest and assessment of these parameters was not superior for detecting individual abnormality. In addition for almost all of the parameters, the extension maneuver was more sensitive than the flexion maneuver in diagnosing CTS.

Among the patients with symptomatic hands, none had any abnormal result for the other evaluated NCSs (i.e. motor nerve conduction and F-wave studies for the median and ulnar motor nerves, and ulnar sensory nerve conduction studies with the neutral, flexion, and extension maneuvers).

Discussion

In the present study, we initially investigated the sensitivity of sensory NCS parameters in the diagnosis of CTS. Subsequently, we evaluated the effect of flexion and extension maneuvers on these parameters. As a result, we reached two main findings: First, we demonstrated that onset latency with onset and peak velocities in neutral position were the most sensitive parameters in the diagnosis of CTS. Second, neutral position and the flexion and extension maneuvers of the wrist had different effects on these parameters. Performing wrist flexion maneuvers did not contribute to the diagnosis of CTS. On the contrary, in some aspects of the parameters, the extension maneuver was moderately more sensitive than neutral position.

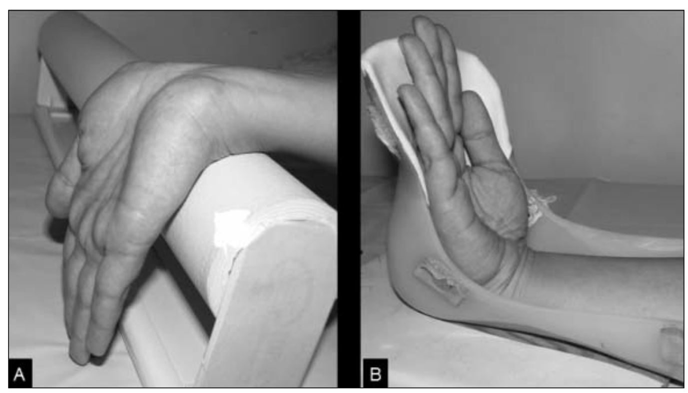

Figure 1. Flexion and (b) extension maneuvers

Table 1. Electrophysiological data of median sensory nerve conduction studies in Control, Group 1 and Group 2 subjects.

	Control			Group 2			Group 1		
	NP	FP	EP	NP	FP	EP	NP	FP	EP
OL (ms)	2.46±0.19	2.44±0.23	2.44±0.25	2..48±0.2	2..40±0.2	2..50±0.3	3.13±0.4	3.02±0.4	3.10±0.4
NPL (ms)	3.24±0.33	3.23±0.30	3.30±0.24	3.32±0.2	3.26± 0.3	3.35±0.3	3.98±0.6	3.88±0.6	4.00±0.6
NPD (ms)	2.12±0.31	2.1±0.38	2.09±0.29	2.10±0.3	1.99±0.3	2.02±0.3	2.25±0.4	2.18±0.4	2.32±0.4
NPA	37.9±12.1	36.2±13.1	37.5±10.2	34.5±12.8	32.2±12.2	31.7±12.1	29.04±9.9	27.1±11.1	29.2±10.7
Amp (µV)	38.9±12.1	37.3±13.1	38.8±10.96	32.9±10.7	31.1± 11.1	30.1±10.9	24.57±9.1	24.3±10.1	24.48±9.4
OV (m/s)	58.38±6.7	57.9±7.46	60.5±5.23	55.7±5.1	47.69±5.5	58.72±7.1	39.40±7.1	37.65±6.6	48.33±6.1
PV (m/s)	36.95±3.3	35.1±5.27	35.2±3.93	36.0±3.4	35.40±4.2	45.23±3.7	27.61±4.7	29.07±5.1	37.52±4.9

NP, neutral position; FP, flexion position; EP, extension position; OL, onset latency; NPL, negative peak latency; NPD, negative peak duration; NPA, negative peak area; Amp, amplitude; OV, onset velocity; PV, peak velocity

Studies on the influence of provocative maneuvers on electrophysiological studies have reported conflicting results (7,9,12,13,15). One study (15) reported that the flexion maneuver for 5 min did not yield a significant difference between electrophysiologically diagnosed CTS patients and healthy controls. In another study (12) Phalen's and Tinel's tests, and wrist extension and pressure exertion maneuvers were performed to increase the sensitivity of electrophysiological methods and the researchers reported that these tests did not provide any additional benefit. On the other hand, some studies reported findings that highlighted the value of maneuvers in the detection of CTS (8,16,17). One study (8) reported that 15 min of flexion maneuver induced the clinical signs and electrophysiological findings of CTS. In another study (18), 14 patients with probable CTS and 12 control subjects were evaluated following extension or flexion of the wrist with the aid of an orthotic device for 5 and 10 min. Prolongation of distal latency was observed in both groups, however, the greatest increment was observed in the CTS patients following 5 min of wrist flexion. The latest study (17) reported that in patients with clinical signs of CTS and normal routine electrodiagnostic test, wrist flexion for 5 min leaded to a valuable change in NCV and sensory latency of median nerve.

In the light of these findings, researchers argued that this procedure might increase the sensitivity in symptomatic cases with negative electrophysiological study results, but observation of similar results in healthy individuals indicated the low specificity of this maneuver (7). Werner et al. (19) reported that the use of the extension maneuver resulted in significantly higher intracarpal canal hydrostatic pressure as compared to the flexion maneuver. They also reported that the pressure began to increase within 10 s of the extension maneuver and continued to increase throughout 2 min duration of the maneuver. Additionally, they demonstrated that with the extension maneuver, patients with CTS had prolonged NPL and a modest drop in amplitude vs. controls.

In comparison with previous studies that recommend utilization of provocative maneuvers in electrophysiological studies of CTS, our study included a larger sample of subjects. In the CTS patients we observed that onset latency, onset velocity, and peak velocity were the most sensitive parameters in the neutral position. Performing the flexion maneuver for 1 min had no beneficial effect on the diagnosis of CTS, however, for some of the evaluated parameters, the extension maneuver that was applied for the same time period was moderately different than the neutral position. There is no specific recommended time period to apply these maneuvers and prolongation of time period may change the intercarpal canal pressure and may change the results of NCS. In our study, we applied these maneuvers for 1 min, because we thought that they might easily be performed within 1 minute in daily practice. Additionally, 1 min of time had the same length with

Table 2. Diagnostic values of electrophysiological parameters in different positions in patients.

	Neutral		Flexion		Extension	
	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
OL	77	100	56	93.1	64	100
NPL	48	100	51	96.6	53	96.6
NPD	11	96.5	3	96.6	16	100
NPA	3	100	3	100	10	100
Amp	13	100	6	100	24	100
OV	72	100	24	96.6	60	96.6
PV	72	100	18	96.6	46	93.1

OL, onset latency; NPL, negative peak latency; NPD, negative peak duration; NPA, negative peak area; Amp, amplitude; OV, onset velocity; PV, peak velocity

Table 3. Comparison of sensitivities of electrophysiologic data in neutral, flexion and extension positions in patients.

Parameter	Positive Hands with Maneuvers (n)									Sensitivities (%)		
	Neu (n)	Fle (n)	p	Neu (n)	Ext (n)	p	Fle (n)	Ext (n)	p	Neu	Fle	Ext
OL	77	56	0.002	77	64	0.044	77	64	0.044	77	56	64
NPL	48	51	0.671	48	53	0.659	51	53	0.777	48	51	53
NPD	11	3	0.027	11	16	0.301	3	16	0.002	11	3	16
NPA	3	3	1.000	3	10	0.045	3	10	0.045	3	3	10
Amp	13	6	0.091	13	24	0.045	6	24	0.000	13	6	24
OV	72	24	0.000	72	60	0.073	24	60	0.000	72	24	60
PV	72	18	0.000	72	46	0.000	18	46	0.000	72	18	46

n, number; Neu, neutral; Fle, flexion; Ext, extension; OL, onset latency; NPL, negative peak latency; NPD, negative peak duration; NPA, negative peak area; Amp, amplitude; OV, onset velocity; PV, peak velocity the duration of the clinical test (i.e. Phalen's test). Although evaluating NCS with wrist maneuvers was capable of objectively measuring the parameters and the values obtained were reproducible, the fact that the evaluators were not blinded to the patients is one of the limitations of the current study. Thus, further investigations using blind comparison may be necessary to confirm our results. It is noteworthy that other studies reported provocation maneuvers effectively used for longer durations than we did, i.e. 5, 10, and 15 min. Therefore, performing the extension maneuver for more than 1 min might result in a more dramatic alteration in the parameters and might increase their sensitivity, however, this would be an excessively time-consuming method for use in daily practice.

In conclusion, evaluating NCS in the neutral position provided the most sensitive parameters in patients with clinically and electrophysiologically diagnosed CTS. Assessment of median sensory NCS with the extension maneuver for 1 min produced some results that were different than those obtained in the neutral position. Nonetheless, the differences were modest and had no clinical utility.

Conflict of Interest:

Authors reported no conflicts of interest.

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