The Effect of Electrodiagnostic Findings on Clinical and Functional Status in Carpal Tunnel Syndrome

Karpal Tünel Sendromunda Elektrodiagnostik Bulguların Klinik ve Fonksiyonel Durum Üzerine Etkisi

Gülnur TAŞÇI BOZBAŞ[1], Ayşe İYİYAPICI ÜNÜBOL[2], Ömer Faruk ŞENDUR[1], Gülcan GÜRER[1]

[1]Adnan Menderes University Medical School, Physical Medicine and Rehabilitation Department, Aydin, Turkey
[2]Private Medinova Hospital, Physical Medicine and Rehabilitation Department, Aydin, Turkey

Correspondence Address
Yazışma Adresi

Gülnur TAŞÇI BOZBAŞ
Adnan Menderes Üniversitesi Tıp Fakültesi, Fiziksel Tıp ve Rehabilitasyon Anabilim Dalı, Aydın, Turkey
E-mail: gulnurtb@yahoo.com

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ABSTRACT

Objective: The purpose of this study was to assess the relationship between electrodiagnostic findings and hand functions, clinical severity and examination findings of carpal tunnel syndrome (CTS). In addition, we aimed to determine the diagnostic value of provocative tests such as tinel, phalen and reverse phalen tests in the diagnosis of CTS.

Material and Methods: We evaluated 79 wrists of 44 patients who were diagnosed as CTS on the basis of clinical history, physical examination and abnormalities of median nerve sensory and motor conduction velocities and 50 healthy volunteers. Physical evaluation included the tinel, phalen and reverse phalen tests. The clinical severity of CTS was scored in terms of a historic and objective scale and hand function was evaluated through the Boston carpal tunnel questionnaire and Duruoz Hand Index.

Results: It was determined that the severity of CTS and the electrophysiological assessment was correlated with the severity of symptoms, pain and hand strength whereas it was not correlated with functional status. Functional status is affected by hand and pinch grip strength. Sensitivities of the tinel, phalen and reverse phalen tests were 62%, 54.4%, and 57% respectively, whereas their specificities were 92%, 86%, and 88% respectively in our study group. There was no association between CTS severity and the positivity of provocative tests.

Conclusion: Electrophysiological evaluation is quite important for the diagnosis of CTS disease. However, this investigative method cannot be carried out everywhere and patient appointments to evaluate their condition are arranged for later times. In such situations, provocative tests, symptoms and functional status are important for the diagnosis.

Key Words: Carpal tunnel syndrome, Disease severity, Hand function, Provocative test

ÖZ

Amaç: Çalışmamızın amacı karpal tünel sendromunda elektrodiyagnostik bulgular ile el fonksiyonları, semptomlar ve muayene bulguları arasındaki ilişkiyi değerlendirmektir. Ayrıca KTS tanısında kullanılan tinel, phalen ve ters phalen gibi provakatif testlerin tanısal değerini de saptamayı amaçladık.

Gereç ve Yöntemler: Öykü, fizik muayene ve median sinir duysal ve motor ileti hızlarının değerlendirilmesi sonucunda KTS tanısı konan 44 hastanın 79 eli ve 50 sağlıklı gönüllü değerlendirildi. Fizik muayenede tinel, phalen ve ters phalen testleri kullanıldı. Semptomların şiddeti "semptom şiddet skalası" ve el fonksiyonları ise "Boston karpal tünel anketi" ve "Duruöz el indeksi" ile değerlendirildi.

Bulgular: Karpal tünel sendromunun elektrodiyagnostik şiddeti semptomların şiddeti, ağrı ve el kavrama güçleri ile korele bulunurken, el fonksiyonları ile korelasyon saptanmamıştır. Fonksiyonel durum, el ve başparmak kavrama gücünden etkilenmiştir. Tinel, phalen ve ters phalen testlerinin sensitiviteleri sırasıyla %62, %54.4 ve %57 bulunurken, spesifiteleri %92, %86 ve %88 olarak saptanmıştır. KTS'nin şiddeti ile provakatif testlerin pozitifliği arasında ise korelasyon saptanmamıştır.

Sonuç: KTS tanısında elektrofizyolojik değerlendirmeler çok önemlidir. Ancak bu inceleme her yerde yapılamamakta ve değerlendirme için uzun hasta randevuları oluşmaktadır. Böyle durumlarda provakatif testler, semptomlar ve fonksiyonel düzeyin değerlendirilmesi KTS tanısı koymada oldukça değerlidir.

Anahtar Sözcükler: Karpal tünel sendromu, Hastalık şiddeti, El fonksiyonları, Provakatif testler

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OBJECTIVE

Carpal Tunnel Syndrome (CTS) is the most common entrapment neuropathy in the upper extremity. Clinical symptoms as a result of median nerve entrapment in the wrist to palm segment include pain and paresthesia of the fingers, which are innervated by the median nerve, muscular atrophy and loss of strength (1-3). In chronic conditions, CTS is characterized by impaired hand function and disability (1).

There is no gold standard for the diagnosis of CTS (4). Although nerve conduction studies are reported by many authors to be the definitive method for diagnosing CTS, other authors argue that clinical history with a physical examination is adequate for diagnosing CTS (5). Furthermore, treatment is often planned to diagnosed based on subjective symptoms and provocative tests without nerve conduction studies (4,6). In our study, we aimed to determine the relationship between electrophysiological findings and clinical severity of CTS as assessed by a validated clinical scale (historic and objective scale [Hi-Ob scale]), examination findings and hand functions (Boston carpal tunnel questionnaire [BCTQ], Duruöz hand index [DHI]). Another aim of this study was to assess the diagnostic value of commonly used provocative tests as the tinel, phalen and reverse phalen (rphalen) tests in the diagnosis of CTS.

MATERIAL and METHODS

We evaluated 79 wrists of 44 patients, mean age 51.84 ±11.8 years, who were diagnosed as CTS on the basis of the clinical history, physical examination and abnormalities of median nerve sensory and motor conduction velocities. The control group consisted of 50 subjects, mean age 50.56 ±12.88, with no complaints such as pain or parestesia on the median nerve tracing. These patients did not undergo additional electrodiagnostic examination. Patients with a history of wrist surgeries, carpal tunnel injuries/fractures, cervical radiculopathy and polyneuropathies were excluded from the study. The Institutional Ethics Committee approved the study, and all participants provided their written informed consent to participate in the study. The clinico-epidemiological characteristics such as age and sex, and the symptoms and signs were recorded

Physical evaluation included testing for the following signs: Tinel sign (paresthesia in the distribution of the median nerve after tapping over the nerve on distal wrist); Phalen sign (paresthesia in the distribution of the median nerve after complete wrist flexion for 60 seconds); and reverse Phalen sign (paresthesia in the distribution of the median nerve after complete wrist extension for 60 seconds)(7). Grip strength and pinch strength were measured with dynamometry at the position of elbow at 90-degree flexion, forearm midprone and wrist neutral (8). The average score of three successive measurements was recorded.

The clinical severity of CTS was scored based on a Hi-Ob scale (9). This scale is based on two measurements. The first section was evaluated on the basis of clinical history and objective findings. It includes the following: Grade 1 - nocturnal paresthesia only; grade 2 - nocturnal and diurnal paresthesia; grade 3 - sensory deficit; grade 4 - hypotrophy or motor deficit of the thenar muscle innervated by the median nerve; grade 5 - plegia of the thenar muscle innervated by median nerve. The second evaluates the presence or absence of pain as a dichotomous score obtained by the patient answers of yes or no. The Hi-Ob score was presented by the number 1-5 that was linked to the letter P (P:Pain) in patients who have pain. In addition, the intensity of the pain during the day was analyzed using the visual analog scale (VAS) (0-100 mm).

The Boston carpal tunnel questionnaire (BCTQ) and Duruöz Hand Index(DHI) were used for evaluation of the hand function. BCTQ is a specific questionnaire for CTS developed by Levine et al. (10). The questionnaire has shown reliability and sensitivity to change and the Turkish version has been validated by Sezgin et al. (11). BCTQ has two distinct scales, the Symptom Severity Scale (SSS) which has 11 questions and the Functional Status Scale (FSS) containing 8 items. Each question was scored in the range of 1 point (mildest) to 5 points (most severe) and each scale generated a final score as the sum of individual scores divided by the number of items (12). It has been shown that the BCTQ is a valid, reliable, responsive and acceptable instrument for functional evaluation in CTS (13). The DHI was used to assess hand-related activity limitations and functional performance (14). It contains 18 activities commonly performed by hand in the kitchen, or during activities of dressing, personal hygiene and office tasks, in addition to other general items. Ability is rated from 0 (no difficulty) to 5 (impossible to do). The maximum total score is 90, with higher scores indicating severe activity limitation or more difficulty (15).

Electrodiagnostic studies were performed according to a protocol inspired by the recommendations of the American Association of Electrodiagnostic Medicine (16). The test was conducted by the same person in the same room and under similar temperature conditions. The person who conducted the electrophysiological examination was not given information about clinical findings. Motor and sensory nerve conduction study (NCS) of the median and ulnar nerves were performed in both hands. The severity of electrophysiological CTS impairment was assessed using a previously reported classification as follows: stage 1, abnormal segmental or comparative tests only; stage 2, abnormal digit/wrist sensory nerve conduction velocity

(SCNV) and normal distal motor latency (DML); stage 3, abnormal SCNV and abnormal DML; stage 4, absence of sensory response and abnormal DML; stage 5, absence of motor and sensory response (17).

For statistical analysis, we used version 18 of SPSS for Windows. Sensitivity was calculated as the number of true positive divided by the total number of persons with the disorder. Specificity was calculated as the number of true negatives divided by the total disease-free persons as the golden standard test. Nonparametric analysis of the correlation was carried out using Spearman's rank correlation coefficient, and comparisons among the groups were performed by using the Mann-Whitney U test and the chi-square test.

RESULTS

We evaluated 79 wrists of 44 patients who were diagnosed as CTS and 50 healthy controls. The dominant hand was affected in all cases and 75% were affected bilaterally. The hand grip strength, pinch strength and hand function were worse in CTS patients than in the control group (Tablo I). The frequency of positive test findings with the provocative tests was significantly higher in CTS patients than in control subjects (respectively CTS for tinel, phalen, and rphalen tests 49/4, 43/7, 45/6). The most commonly positive test in CTS patients was the Tinel sign. Sensitivities of the 3 tests (tinel, phalen and rphalen) were 62%, 54.4%, and 57% respectively, whereas their specificities were 92%, 86%, and 88% respectively. There was a correlation between the phalen test, rphalen test and tinel test and nerve conduction measurements (p:0.000).

Clinical and electrophysiological characteristics of CTS patients are reported in Table II. Eight hands (10.1%) had stage 1, 28 hands (35.4%) had stage 2, 31 hands (39.2%) had stage 3, 9 hands (11.4%) had stage 4 and 3 hands (3.8%) had stage 5 electrophysiological severity. Seven hands (8.9%) had stage 1, 56 hands (70.9%) had stage 2, 6 hands (7.6%) had stage 3 and 10 hands (12.7%) had stage 4 at clinical evaluation. Many of our patients were moderate CTS according to the clinical and electrophysiological evaluation. Provocative testing positivity was seen especially for patients who had more positive electrophysiological stage 2 and 3 (Table III). However, we found that the CTS severity did not significantly affect the positivity of provocative tests (p>0,05). All provocative tests were much more positive in patients with stage 3 according to symptom severity (Table III). We therefore decided that the phalen and rphalen tests had more significant value in patients with more severe symptoms.

The severity of symptoms as assessed by Hi-Ob and SSS was correlated with the severity of disease through the electrophysiological assessment (p<0.05), while functional

Table I: Clinical findings of patients with CTS and control group (BCTQ: Boston carpal tunnel questionnaire, DHI: Duruöz hand index).

	CTS group Mean±SD	Control group Mean±SD	p
Age	51.84 ±11.8	50.56 ±12.88	**
BCTQ	2.72 ±0.75	1.15 ±0.27	*
DHI	16.33 ±12.06	1.11 ±2.0	*
Pinch strength	9.77±4.48	12.24 ± 4.23	*
Hand grip strength	26.97±12.11	36.02±14.20	*

*: 0,05; **:0,05 (2-tailed).

Table II: Clinical and electrophysiological characteristics of patient with CTS.

Hi-Ob score	Electrophysiological score (frequencies, %)											
	Stage 1		Stage 2		Stage 3		Stage 4		Stage 5		All stages	
	n	%	n	%	n	%	n	%	n	%	n	%
Stage1	1	14.3	4	57.1	2	28.6	-	-	-	-	7	8.9
Stage2	5	8.9	22	39.3	23	41.1	4	7.1	2	3.6	56	70.9
Stage3	-	-	1	16.7	3	50	2	33.3	-	-	6	7.6
Stage4	2	20	1	10	3	30	3	30	1	10	10	12.7
All stages	8	10.1	28	35.4	31	39.2	9	11.4	3	3.8	79	100

status was not affected by the severity of CTS, correlated with hand and pinch grip strength (Table IV). The severity of pain in patients with CTS was correlated with the severity of symptoms and electrodiagnostic findings (p<0,01).

DISCUSSION

The diagnosis of CTS is based on the clinical diagnosis of specific signs and symptoms together with an electrodiagnostic examination (18,19). Electrodiagnostic evaluation is often used in the assessment of carpal tunnel syndrome. However, it is insufficient in the follow-up of the disease (19). Some authors have suggested that electrodiagnostic evaluation is unnecessary and a detailed physical examination and medical history are sufficient for diagnosis (5). We found significant relationships between symptom severity and CTS electrodiagnostic severity. Levine at al. (10) did not determine a significant correlation between these two parameters. However, the discrepancy between the results might have been caused by the fact that the electrophysiological severity evaluation scale had not

Table III: The prevalence of provocative tests according to severity of clinical and severity of electrophysiological findings.

Electrophysiological score	**Positive N(%)**		
	Tinel	**Phalen's**	**Reverse Phalen's**
Stage1	3 (%6.1)	6 (%14)	6 (%13.3)
Stage2	18 (%36.7)	16 (%37.2)	11(%24.4)
Stage3	18 (%36.7)	13 (%30.2)	19 (%42.2)
Stage4	7 (%14.3)	6(%14)	6 (%13.3)
Stage5	3 (%6.1)	2(%4.7)	3 (%6.7)
Hi-Ob			
Stage1	1(%2)	0(%0)	1(%2.2)
Stage2	1(%2)	2(%4.7)	0(%0)
Stage3	34(%69.4)	27(%62.8)	30(%66.7)
Stage4	5(%10.2)	6(%14)	6(%13.3)
Stage5	8(%16.3)	8(%18.6)	8(%17.8)

Table IV: Association severity of CTS between hand and pinch grip strength, symptom and pain severity, and functional status (SSS: Symptom Severity Scale, FSS: Functional Status Scale, BCTQ: Boston carpal tunnel questionnaire, DHI: Duruöz hand scala).

	Electrodiagnostic Severity of CTS	**Hand grip strength**	**Pinch grip strength**	**Pain**	**BCTQ**	**DHI**	**hiob**
Severity of CTS	1						
Hand grip strength	**-.239*** **.026**	1					
Pinch grip strength	**-.213*** **.049**	**.669**** **.000**	1				
Pain	**.349**** **.001**	-.191 .078	-.179 .115	1			
BCTQ	.125 .425	**-.455**** **.000**	**-.365**** **.001**	.169 .278	1		
DHI	.179 .251	**-.374**** **.001**	**-.314**** **.005**	.153 .328	**.892**** **.000**	1	
Hi-Ob	**.317**** **.003**	-.082 .452	-.084 .443	**.578**** **.000**	-.002 .990	.124 .428	1

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

been used in that study and each conduction study had been separately evaluated. Our result is similar to some previous studies (20,21). Electrodiagnostic examination is not available everywhere and there is a long list of appointments (4). Under these conditions, symptom severity can be used in the diagnosis and severity assessment of CTS

In our study, functional status was not affected from the severity of CTS as Mondelli (22) had also suggested. This situation may be similar to the inconsistency of the severity of MRI findings with the functional status in patients having disk problems (23). The reason for the functional status not being affected from the electrodiagnostic severity might have originated from compensation of the functional disorder by the healthy hand or upper extremity (24). Additionally, bilateral involvement, found in the majority of our patients, may be the cause of the inconsistency between functional status and severity of CTS. The results of de la Llave-Rinco et al. (25) were similar to ours and those authors have suggested that the reason for being unable to find any relationship between the seriousness of functional impairment in the hand and CTS severity was the variations in the innervation of muscle groups. Pinch and hand grip strength may be valuable for the assessment of hand disability. We determined that the functional status was affected by the grip strength in our patients. Besides, grip strengths of the hand were significantly impaired when compared to the control group in our study. While the severity of electrodiagnostic findings did not affect functional status, it affected the grip strengths of the hand and thumb, as in the result of Mondelli et al. (22). Szabo et al. (5), in contrast to our study, determined that grip strengths of the hand and pinch were not helpful in the diagnosis of CTS but valuable for patient follow-up. The reason for severity of the electrodiagnostic findings affects the hand strength, while does not affect the function. Functional loss may be compensated for through a healthy hand or upper extremity (24).

Previous studies have stated that electrodiagnostic evaluation is an effective method for diagnosing CTS (4). However, there is no gold standard at this point. Clinical evaluation is also very important for diagnosis. Several provocative tests are utilized during the diagnosis of various disorders. The diagnostic values of these tests depend on their specificities and sensitivities (18). The sensitivities and specificities of provocative tests used in the diagnosis of carpal tunnel syndrome vary among studies. The sensitivity of the Phalen test was 0.1-1 and its specificity was 0.33-0.91; the sensitivity of the tinel test was 0.23-1.0 and its specificity was 0.25-0.87; the sensitivity of the reverse Phalen test was 0.1-1 and its specificity was 0.33-0.91. (27) In our study, the sensitivities and specificities of provocative tests were found to be quite high. The differences among the results of the studies may have originated from the differences of the methods. For example, during the tests, elevation of the shoulder and flexion of the elbow should be avoided, since these positions affect the result of the test adversely. Additionally, variations of the physical conditions in which the electrodiagnostic tests are performed and the clinical evaluations and tests being performed by different persons may also change the results. Furthermore, different threshold values in electrodiagnostic evaluation for the diagnosis of CTS alter the results as well (6). In our study, we used the reference values suggested by the American Association of Electrodiagnostic Medicine (16). According to our findings, the diagnosis of CTS can be excluded in cases in whom tinel, Phalen and rPhalen tests have revealed negative results. In cases having positive results, electrodiagnostic investigations should be performed in order to determine the severity of the disease. The sensitivities and specificities of combinations of these tests were not evaluated and this was a drawback of our study.

The most powerful provocative test for using the diagnosis of CTS was the tinel test according to MacDermid et al. (18) and phalen test according to Wiesman et al. (28), similar to our study (17,18). Despite the positivity of tests being more common in cases that showed moderate severity in electrodiagnostic tests, this difference was not statistically significant in our study. We determined that the incidences of provocative tests were not affected from the severity of CTS, as in the results of Ghavanini and Haghighat (29). Homan et al.(30) reported a weak correlation (29). They suggested that the test positivity might be reduced due to the axonal damage, which was caused by continuous compression of the nerve (17). The results may show differences due to structural intracarpal volume changes in patients. During provocative tests, positivity occurs as a result of increased intracarpal pressure, which enhances the compression. Therefore, the tests may not be affected from the severity of the disease. In cases with severe symptoms, we suggested that the positivity, found to be more in the Phalen and rPhalen tests, which reduce the volume of the canal, and these pressure increases may be important for formation of symptoms in our study. The most valuable test in advanced stages of the disease was the tinel test according to Novak et al. (31), and Phalen test according to Priganca (4).

Current electrophysiological evaluations may not fully evaluate the nerve functions, particularly in advanced stages of peripheral entrapment neuropathies (23). Therefore, studies have focused on advanced investigative methods such as ultrasonography and magnetic resonance imaging today (32,33). However, the roles of these methods in the diagnosis have not been certainly identified yet. Therefore, in our study, the diagnosis was made according to the

electrodiagnostic findings. A limitation of our study was that a needle-EMG study was not performed for abductor pollicis brevis other innervated muscles. However, losses in hand and pinch grip strengths were determined by comparing them with the control group.

CONCLUSION

The grip strength and severity of CTS symptoms are affected in electrophysiological severity at CTS patients. Additionally, the functional status is valuable for the diagnosis of CTS, although not affected by the severity of disease. Electrophysiological evaluation is quite important for the diagnosis of this disease. However, this investigative method is not available everywhere or patient appointments for investigation are made for far later times. In such situations, provocative tests, symptoms and functional status are important for diagnosis.

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