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The diagnostic efficacy of clinical findings and electrophysiological studies in carpal tunnel syndrome

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ABSTRACT

Objectives. The aim of the study was to examine the relation between clinical findings, neurological examination and electrophysiological studies in diagnosing carpal tunnel syndrome (CTS) and share our institutional experience in patients with CTS. ***Methods.*** Patients presenting with complaints of pain, paresthesia, and weakness in hands who diagnosed CTS between 2014 and 2015 were examined retrospectively. Demographic characteristics, clinical and neurological examination findings and electrodiagnostic evaluations were analyzed. ***Results.*** A total of 348 patients were included to the study. Weight and height measurements were significantly higher in patients with CTS on the right side (p=0.05 and p=0.04, respectively). Right hand side was the most dominant lateralization in patients with CTS (p=0.001) but there was no significant correlation for left side (p>0.05). The score of visual analogue scale was positively correlated with the severity of CTS (p=0.001). Thenar atrophy, hypoesthesia, positivity of Tinel and Phalen tests were also related to bilateral CTS (p=0.001 for each). ***Conclusion.*** We agree that clinical features, neurological examination findings and electrophysiological studies are effective diagnostic means in patients with CTS.

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Keywords: Carpal tunnel syndrome, pain, paresthesia, weakness, electrophysiological study

Introduction

Carpal tunnel syndrome (CTS) is the most frequent mononeuropathy in human body. In general population the risk to develop CTS is about 10%. CTS is produced by the chronic compression of median nerve while passing through carpal canal. This syndrome mostly seen between 40-60 years is 3 times more frequent in women than men. Although symptoms are seen in dominant hand at first, later other hand is also effected. Nocturnal pain and paresthesia are the most important characteristics features of the syndrome. With the progression of the disease symptoms become evident in day time. After a while sensational complaints turn into sensational disturbances. As the disease progresses weakness and atrophy at thenar area can be seen [1].

In this study we aimed to investigate the association between clinical features, examination findings and electrodiagnostic studies in patients

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complaining about paresthesia in hands and diagnosed as CTS by electrodiagnostic studies.

Methods

Including and Excluding Criteria

A total of 348 patients over 18 years of age who had compliants of pain, paresthesia and weakness in their hands from our outpatient clinics between 2014 and 2015 were included to the study. Excluding criteria were polyneuropathy symptoms or findings, radicular pain and/or sensation loss, other neurological and neuromuscular diseases.

Clinical and Demographic Findings

For the diagnosis of CTS, American Academy of Neurology criteria were used [2]. These criteria include: 1) Pain and paresthesia in the symptomatic hand at nights, 2) Sensational complaints during flexion and extension movements of wrist, 3) Pain and paresthesia in the morning, 4) Phalen test positivity, 5) Sensation loss in median nerve innervation area, 6) Atrophy and weakness in median nerve innervated muscles. In the presence of at least one criteria the patient was accepted to have CTS. Gender, age, weight, height, dominant hand, marital status, education level and job were recorded. Sensation, muscle strength, Tinel and Phalen signs were identificated by detailed neurological examination. Pain, paresthesia, weakness, symptomatic hand, starting time of complaints, concomitant illnesses were recorded. To modify the severity of pain visual analogue scale (VAS) was used. According to this scale, 0 means no pain, 10 means severe pain. Additional to all these psychical activation like using computer, knitting, sewing, doing housework were recorded.

Electrophysiologic Test Procedure

Conventional electroneurographic study was done. Median and ulnar nerve conduction studies were done according to reference technics. Motor and sensorial onset latency, amplitude and nerve conduction velocity of median and ulnar nerves of both upper extremity were recorded. Motor nerve conduction studies were orthodromic where as sensorial nerve conduction studies were antidromic. Supra-maximal stimulation technique was performed with 0.1-1 msn duration time by using superficial electrode. For motor conduction studies low frequency filter (LFF) was determined as 2 Hz, high frequency filter (HFF) was determined as 10 Hz, sensitivity was determined as 2-5 Mv/division. For sensorial conduction studies LFF was determined as 20 Hz, HFF was determined as 2 Hz and sensitivity was determined as 10-20 µV/division.

Electrophysiological severity of CTS was classified as mild, moderate and severe according to following criteria. Mild CTS was determined as prolongation of distal latency and decrease in the amplitude of median sensorial nerve. Moderate CTS was determined as in addition to mild CTS criteria prolongation of distal latency of median motor nerve. Severe CTS was determined as no record of sensorial potential, prolongation of distal latency and decrease in the amplitude of median motor nerve [1]. Demographic characteristics, clinical features, comorbidity and hand using habituation were recorded.

Statistical Analysis

The description of parametric and non-parametric data was done by using kurtosis skewness test. The parametric data was given by mean ± standard deviation. For comparation of categorical variables between right and left CTS groups ki-kare test was used. We used Spielman correlation test for correlation of non-parametric variables with independent groups. We used one-way analysis of variance test for comparison of means of two independent groups. p value <0.05 was considered as statistically significant.

Results

There were 286 women and 62 men in the study. The mean age was 51.27±12.46. According to medical history, dominant hand was right in 334 (96%) patients, whereas in 14 (4%) patients it was left. There was no significant correlation between age, gender, marriage status, education level and electrodiagnostic CTS (p>0.05). Weight and height were both significantly higher in right handed CTS (p=0.05 and p=0.04, respectively) but there was no significantly correlation for left handed CTS (p>0.05). In the patients with right CTS mostly right hand was dominant (p=0.001) but there was no significant correlation for left side (p>0.05). Demographic characteristics and their correlations with electrodiagnostic CTS are summarized in Table 1.

Among 348 patients 292 (84%) had right CTS,

Table 1. Correlations of demographic datas due to electrophysiological findings

	Right CTS (n=292)			*p*	Left CTS (n=269)			*p*
	Mild	Intermediate	Severe		Mild	Intermediate	Severe	
Sex (F/M)	118/30	107/24	13/0	**0.06**	101/20	107/22	16/3	0.98
Age (years)	51.70±13	51.25±12	54.54±13	0.65	51.43±13	51.70±12	57.68±12	0.12
Weight (kg)	78±13	81±14	84±14	**0.05**	79±12	81±14	79±12	0.59
Height (cm)	163±8	161±6	158±5	**0.04**	162±7	161±7	161±8	0.32
Dominant hand (Right-Left)	145/3	129/2	12/1	**0.00**	112/9	126/3	17/2	0.09

Data are given as mean ± standard deviasyon or number. CTS=carpal tunnel syndrome, F=female, M=male

269 (77.2%) had left CTS and 214 (61.5%) had bilateral CTS. From the patients with right CTS 148 (42.5%) had mild CTS, 131 (37.6%) had moderate and 13 (3.7%) had severe CTS. From patients with left CTS, 121 (34.8%) had mild CTS, 129 (37.1%) had moderate and 79 (22.7%) had severe CTS. When we analyse patients with right CTS, we found out that 96 patients had symptoms only on the right hand and among this group 54 had mild, 36 had moderate, 6 had severe CTS. When we look at patients with left CTS, 66 had symptoms only on the left hand. Within this group 32 had mild, 27 had moderate and 7 had severe CTS. One hundred and seventy-seven (50.9%) patients had symptoms on both of the hands.

Symptomatic findings were summarized as follows; pain, paresthsia, weakness and sensation loss. VAS score was in positive correlation with CTS severity (p=0.001). While weakness was bilateral (p=0.001 for both left and right) correlated with increased CTS; sensation loss was correlated with increased CTS only on the right hand (p=0.05). The time of symptom starting was 0-6 months for 98 (28.2%) patients, 6-12 months for 123 (35.3%) patiens, 1-5 years for 105 (30.2%) patients, 5-10 years for 16 (4.6%) patients and more than 10 years for 6 (1.7%) patients. Thenar atrophy was correlated with CTS severity for both right and left hand (p=0.001). Weakness (p=0.001), hipoestesia (p=0.001), positivity of Tinel (p=0.001) and Phalen (p=0.001) tests were also correlated with CTS severity for both hands. The relation between clinical symptoms, neurological examinations and electrodiagnostic CTS is summarized in Table 2.

Psychical activation like using computer, knitting, sewing and doing housework was not significantly related with right and left CTS severity (p>0.05). We also investigated the effect of smoking and diseases like rheumatoid artritis, thyroide pathologies and diabetes mellitus and found out no significant relation between these status and CTS (p>0.05). The relation between risk factors and and electrodiagnostic CTS is summarized in Table 3. .

Discussion

CTS which is usually seen between 60-70 years is 3 times more frequent in women than men. Right hand is more affected than left hand as accepted [1]. Similar to literature the mean age of patients in this study was 51.27. Although CTS was seen more frequent in women, we found no significant correlation between

Table 2. Correlations of electrophysiological CTS findings with clinical symptoms and examination findings

	Right CTS (n=292)			*p*	Left CTS (n=269)			*p*
Positive	**Mild**	**Intermediate**	**Severe**		**Mild**	**Intermediate**	**Severe**	
Pain	137 (49)	127 (46)	12 (4)	0.24	112 (41)	124(48)	18 (7)	0.46
VAS score	6±2	7±2	8±2	**0.001**	6±2	7±2	8±2	**0.001**
Numbness	144 (50)	129 (45)	13 (5)	0.60	118 (44)	127 (48)	19 (8)	0.61
Sensorial deficit	119 (48)	117 (47)	13 (5)	**0.05**	98 (44)	110 (49)	17 (7)	0.54
Motor deficit	65 (41)	81 (51)	11 (8)	**0.001**	51 (34)	79 (54)	18 (12)	**0.001**
Thenar hypoestesia	18 (21)	56 (68)	9 (11)	**0.001**	17 (22)	46 (62)	12 (16)	**0.001**
Thenar atrophy	6 (10)	38 (67)	13 (23)	**0.001**	10 (17)	34 (58)	15 (25)	**0.001**
Tinel test positivity	97 (44)	112 (51)	11 (5)	**0.001**	82 (40)	108 (52)	17 (8)	**0.001**
Phalen test positivity	61 (34)	106 (60)	12 (6)	**0.001**	47 (29)	98 (60)	17 (11)	**0.001**

Data are given as mean ± standard deviasyon or number (%). CTS=carpal tunnel syndrome, VAS=visual analogue scale

Table 3. Correlation of risk factors with electrophysiological findings

	Right CTS (n=292)			*p*	Left CTS (n=269)			*p*
Positive	**Mild**	**Intermediate**	**Severe**		**Mild**	**Intermediate**	**Severe**	
DM	40 (52)	34 (44)	3 (4)	0.94	29 (42)	37 (53)	3 (4)	0.39
Cleaning labour	104 (52)	85 (42)	12 (6)	0.07	85 (46)	88 (47)	14 (7)	0.86
Knitting	79 (50)	69 (44)	8 (5)	0.82	63 (45)	64 (46)	12 (9)	0.53
Sewing	74 (51)	69 (46)	5 (4)	0.60	65 (44)	71 (51)	7 (5)	0.30
Computer/mouse occupation	15 (50)	13 (43)	2 (7)	0.84	8 (28)	18 (62)	3 (10)	0.12
Smoking	22 (48)	24 (52)	0	0.07	14 (39)	20 (55)	2 (5)	0.61
Hypothyroidism	13 (54)	9 (37)	2 (8)	0.57	10 (43)	12 (52)	1 (4)	0.81
Arthritis	1 (25)	2 (50)	1 (25)	0.28	3 (60)	2 (40)	0	0.60

Data are given as number (%). CTS=carpal tunnel syndrome, DM=diabetes mellitus

CTS and gender in this study. In patients with right CTS right hand was dominant but there was no correlation like this for the left side. If we look up the literature investigating the relation between obesity and CTS, it is mentioned that obesity is a risk factor for CTS in most of the studies [3, 4, 5]. De Azevedo *et al.* [6] investigated the profile of patients on sick leave with CTS and reported obesity with a ratio of 44% among these patients [6]. Similar to these studies in this study we recorded that weight and height was significantly higher for patients with right CTS. But there was no significant relation for the left side statistically.

As Tinel and Phalen tests are easily applicable, they are usually preferred in polyclinic practice. In spite of common use of them there are different results abought the sensitivity and specificity of these tests. This calls the question of 'what is the reliability of these tests?' to mind. In a study investigating the the prevalence of CTS in women in Iran the most common findings in physical exam were Tinel sign (58.9%) and Phalen sign (50.9%) [7]. Again in Iran in another study Phalen and Tinel signs were positive in 82.2% and 71.1% of patients, respectively [8]. A study investigating the correlation between physical examinations and clinical severity along with the electrodiagnostic findings by subjects with CTS both hand elevation test and Phalen test were correlated well with the severity of CTS where the correlation of Phalen was higher than that of hand elevation test [9]. In 2012, Ma and Kim [10] compared Phalen's test, Tinel's test, and carpal compression test with hand elevation test. Phalen's test had 86.7% specificity and 84.4% sensitivity. Tinel's test had 88.9% specificity and 82.2% sensitivity. Comparisons of specificity and sensitivity between Phalen's test, Tinel's test, hand elevation test and carpal compression test had no statistically significant differences [10]. As mentioned above the positivity of these tests are variable. In our study Tinel and Phalen test positivity were correlated with CTS in both right and left hand.

The most important property in CTS diagnosis is pain that awakes the patient from sleep and paresthesia. After a while these complaints spread to fore arm and shoulder. In order to decrease the severity of these complaints, the patients flail and shy the hands and these movements are distinctive for the disease. Waking up at nights with pain in the hands, decreasing or losing the symptoms with flexion and extension movements of hands is helpful in diagnosing the disease with a ratio of 93%. As the disease grow up paresthesia in the hands in day time start [1]. In a study comparing physical examination, ultrasonography and electroneuromyography in diagnosing CTS, pain was reported by 74% of the patients while paresthesia was reported by 50% [11]. When comparing to other symptoms pain is more frequently positive in diagnosing CTS. In this study we found out that VAS score was positively correlated with CTS severity.

Sensation examination is normal in thenar area in CTS patients. The reason of this is accepted that the palmary branch of median nerve leaves the nerve before carpal tunnel. Sensation loss is marked in second and third fingers front part. The most frequent and early symptom is hyposthesia in the third finger. The sensation examination in fourth and fifth fingers on the ulnar side is normal. Sensation examination in CTS patients may be normal with a ratio of 20-50% [1]. As we discussed in Tinel and Phalen tests above this finding have variable positivity ratios. In our study we found out that sensation loss is positively related with CTS.

There are only limited studies assessing the power of hands and fingers in CTS patients. In Turkey Ozdolap *et al.* [12] found out no relation between coupling power and electrodiagnostic findings. Their result suggests the idea that hand coupling powers are not heplful in diagnosing CTS. But in our study weakness was related to CTS both in right and left hands.

As the disease progresses thenar atrophy and breakdown can be seen. Abduction and opposition in the first finger can not be done [1]. Ozdolap *et al.* [12] found out no relation between thenar atrophy and electrodiagnostic findings. In their study they mentioned that the reason for this result may be the low number of hands with thenar atrophy [12]. In our study we found out that thenar atrophy was related to CTS severity for both right and the left hand.

Electrodiagnostic studies are done to definite CTS diagnosis and also to fix the level and severity of the disease. Although electrodiagnostic studies are very sensitive in CTS, there is no accordance between sensational complaints and sensory studies. The reason for this is most probably nocturnal pain and paresthesia, which occurs according to ischemia in the median nerve, are not related to focal demyelinization in the carpal tunnel. Prolong distal motor latency and loss in motor amplitude is related to thenar atrophy and paresis [1]. Although we usually expect abnormalities only in the sensory studies in early stages of CTS; Vahdatpour *et al.* [13] reported a contrary result in their study. According to their study the most sensitive electrophysiological finding in CTS patients was median nevre terminal latency index (TLI) (82%), but the most specific one was distal motor latency (98%) [13]. In 2015, Kanikannan *et al.* [14] compared the diagnostic accuracy of high-resolution ultrasonography with electrodiagnostic testing in patients with CTS. As a result of this study electrodiagnostic testing has been found to be more sensitive and specific in mild CTS [14]. As we see in clinical and examination findings there are different results about the reliability of electrodiagnostic studies.

Hobbies and jobs which lead to extension and flexion movements of the wrist may increase complaints about CTS [1]. In this study we found no significant effect of hobbies like knitting, sewing, doing house work and using computer on the severity of CTS for both the right and the left hand. In Turkey, Ciftdemir *et al.* [15] investigated the prevalence of CTS related to manuel tea harvesting and reported that manuel tea harvesting might be a risk factor for work related CTS. And also we found no significant effect of smoking, diabetes mellitus, thyroid disease and rheumatoid arthritis on the severity of CTS. In a study investigating the prevalence of CTS in rheumatoid arthritis, CTS was more frequent in these group patients [16].

Conclusions

We suggest that these data may be helpful for clinicians in order to decide which tests and clinical findings should be used in CTS diagnosis in daily practice. As a result we found out significant relations between clinical findings, examination evidence and electrodiagnostic studies. Although above we discussed may studies dealing with the negative correlations for CTS we still suggest these clinical findings and electrodiagnostic tests can be used in daily practice.

Conflict of interest

The authors disclosed no conflict of interest during the preparation or publication of this manuscript.

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