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ETIOLOGY OF CARPAL TUNNEL SYNDROME

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Abstract

Aim: Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy resulting from compression of the median nerve at the wrist level. Increased intercarpal canal pressure plays an important role in the etiology of CTS. Although most cases are idiopathic, there may also be some systemic or local causes. The aim of this study was to evaluate the demographic and etiological characteristics of patients with CTS who applied to our electroneuromyography (ENMG) laboratory within 3 months.

Material and Methods: One hundred forty-nine patients (=298 hands) who were sent to our ENMG laboratory for ENMG evaluation and diagnosed with CTS were included in our study. Cases with cervical vertebral root lesions, thoracic outlet syndrome, polyneuropathy, trauma such as nerve injury, and cases with tumors and secondary CTS to pregnancy were excluded from the study.

Results: One hundred six (71.1%) of the cases in our study were women and 43 (28.9%) were men. The average age of the patients was 54.27±13.10, and the body mass index (BMI) was 27.92±3.98. BMI ≥30 was found in 47 (31.5%) of the patients. In our study, we found that housewives were the occupational group with the highest risk in terms of CTS (n=94, 63.1%). In this study, we found bilateral hand involvement in 93 (62.4%) patients. The most common condition was idiopathic CTS (n=81, 54.6%).

Conclusion: CTS is more common in postmenopausal women who work as housewives and is usually seen in the dominant hand. It was concluded that this study would be useful for the diagnosis of CTS.

Keywords: Carpal tunnel syndrome, etiology, electroneuromyography, demographic characteristics

INTRODUCTION

Carpal tunnel syndrome (CTS) is the most common type of entrapment neuropathy that occurs as a result of compression of the median nerve at the wrist level (1). The carpal tunnel (canalis carpi) is a fibro-osseous tunnel at the wrist level, limited by fibrous elements on the palmar side and osseous elements on the dorsal side (Figure 1) (2). CTS accounts for approximately 90% of entrapment neuropathies (3). CTS is more common in women. Approximately 50% of the cases are bilateral (3). The prevalence rate was approximately 3% in women and 2% in men (4). Increased intercarpal canal pressure plays an important role in the etiology of CTS (3).

CTS is usually diagnosed by history and physical examination. Electroneuromyography (ENMG) and ultrasonography (US) support the diagnosis of CTS. The use of US for the diagnosis of CTS is increasing. US can evaluate structural changes in the nerve (hypoechoic swelling of the nerve, loss of fascicular pattern), as well as other pathologies that cannot be detected by electrophysiological examinations (muscle hypertrophy, anatomical variations, tenosynovitis, tumors, etc.) (5). The

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median nerve enlargement (cross-sectional area ≥10 mm^2 at the level of the pisiform bone or tunnel entrance) on US is used to establish the diagnosis of CTS (6).

The Etiology of CTS

Although most cases are idiopathic, systemic or local causes may also occur.

Repetitive Trauma

It may be accompanied by occupational or hobby-related trauma. These include repetitive movements of the hand and wrist (carpenters, typewriter-computer use), continuous and repetitive gripping or pinching of tools and objects, work requiring forceful wrist movements, work that creates direct pressure on the carpal tunnel, and the use of vibrating hand tools (Table 1) (7).

Systemic Causes

These include diabetes mellitus (DM), hypothyroidism, acromegaly, amyloidosis, carcinomatosis, polymyalgia rheumatica, rheumatoid arthritis (RA), obesity, local trauma, pregnancy (may reach 25%), and breastfeeding, mucopolysaccharidosis, menopause, pyridoxine insufficiency, toxic shock syndrome, hemodialysis, chondrocalcinosis, and athetoid-dystonic cerebral palsy. The most common of these conditions are DM, RA, and obesity (Table 1) (8).

Local Causes

These include anomalies of muscles and tendons, tenosynovitis, persistent median artery (thrombosis, aneurysm or arteriovenous malformation), palmar infections, bleeding, masses (neurofibroma, hemangioma, lipoma, ganglion cyst, xanthoma, gouty tophaceous), wrist burns, familial or idiopathic thickening of the transverse carpal ligament, callus or malunion resulting from carpal bone fractures and colles fracture, dislocation of the intercarpal joint or wrist, and plaster compression (9-12). CTS occurs more frequently in individuals with congenital small carpal tunnel (Table 1).

In this study, we aimed to evaluate the demographic and etiological characteristics of patients with CTS who applied to our ENMG laboratory affiliated with University of Health Sciences Turkey, Elazığ Fethi Sekin City Hospital, Physical Therapy and Rehabilitation Clinic within 4 months.

MATERIALS AND METHODS

Before starting the study, approval was obtained from the Fırat University Non-Interventional Research Ethics Committee

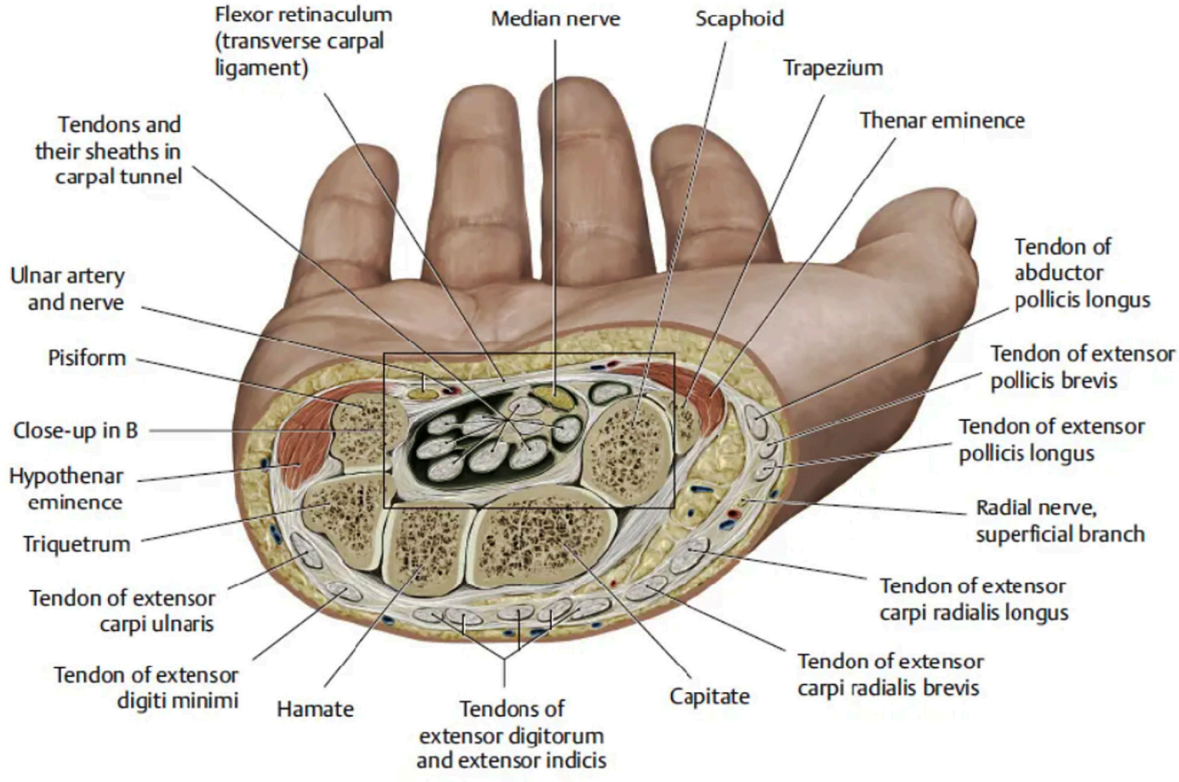

Figure 1. Cross-section of the right wrist at the level of the carpal tunnel

(approval number: 2024-23858, date: 25.04.2024) and the ability to work was confirmed. Written informed consent was obtained from the patients or their legal representatives.

One hundred forty-nine patients (=298 hands) who were sent to our ENMG laboratory for ENMG evaluation and diagnosed with CTS were included in our study. Patients who applied during a 4-month period between May 2024 and August 2024 were included in the study. Cases with cervical vertebra root lesions, thoracic outlet syndrome, polyneuropathy, trauma such as nerve injury, and cases with tumors and secondary CTS to pregnancy were excluded from the study. CTS diagnosis was made in patients who applied to our ENMG laboratory based on clinical findings, physical examination, and ENMG evaluation. During the examination, the results of the Tinnel and Phalen tests, which are auxiliary provocative tests, were evaluated as "positive" and "negative". For electroneuromyographic evaluation, a Medelek Synergy 2-channel ENMG device was used. After standardizing the extremity and ambient temperature, the median nerve peak sensory conduction velocity recorded from the 2nd finger was slower than 44 m/sec, and/or in the motor conduction study, when the distal motor latency (DML) was longer than 4.2 msec by stimulating the median nerve from the 5 cm wrist segment with recording from the abductor pollicis brevis muscle were evaluated as CTS (13). In median nerve sensory and mixed conduction studies, if the compound sensory action potential amplitude was normal and the conduction velocity was slowed, it was interpreted as mild CTS; if there was a prolongation of the median nerve DML in addition to these findings, it was interpreted as moderate CTS; if the compound sensory action potential could not be detected in sensory conduction studies and/or its amplitude was decreased and/or the compound muscle action potential amplitude was decreased in motor conduction studies, it was interpreted as severe CTS. All patients' age, gender, dominant and affected hand, height and weight, and presence of additional diseases that could cause entrapment neuropathy (DM hypo-hyperthyroidism, renal failure, and arthritis) were recorded. The height and weight of the subjects were measured and recorded, and body mass index (BMI) (kg/m^2) was calculated by dividing the individuals' weight by the square of their height.

Table 1. Etiology of carpal tunnel syndrome

A. Local causes **Inflammatory** • Tenosynovitis • Hypertrophic synovium **Trauma** • Colles fracture • Carpal bone dislocation **Tumors** • Hemangioma • Cyst • Ganglion • Lipoma • Neuroma **Anatomical abnormalities** • Thining of the transverse carpal ligament • Bone abnormalities • Accessory muscle • The persistent median artery	**C. Systemic causes** • Diabetes mellitus • Obesity • Hypothyroidism • Pregnancy • Menopause • Renal failure • Long-term hemodialysis • Alcoholism • Systemic lupus erythematous • Scleroderma • Dermatomyositis • Acromegaly • Multiple myeloma • Sarcoidosis • Leukemia • Hemophilia
B. Regional causes • Osteoarthritis • Rheumatoid arthritis • Amyloidosis • Gout	

Statistical Analysis

All statistical analyses were performed using the Statistical Packages for Social Sciences Version 22.0 for Microsoft Windows. Variables were presented in terms of mean ± standard deviation, and categorical variables were presented as number (n) and percentage (%).

RESULTS

In our study, 106 (71.1%) patients were female, and 43 (28.9%) were male. The average age of the patients was 54.27±13.10, and the BMI was 27.92±3.98. BMI ≥30 was found in 47 (31.5%) patients. Of the patients, 94 (63.1%) were housewives, 24 (16.1%) were civil servants, 13 (8.7%) were teachers, 10 (6.7%) were tradesmen, and 8 (5.4%) were farmers. While no additional disease was detected in 58 (38.9%) of the cases, hypertension was detected in 34 (22.8%), DM in 22 (14.7%), hypothyroidism in 13 (8.7%), asthma in 7 (4.7%), hyperlipidemia in 7 (4.7%), RA in 6 (4%) and chronic renal failure in 2 (1.3%). In total, 134 (89.9%) right-handed dominant cases were identified. Right hand involvement was found in 47 (31.5%) patients, left hand involvement in 9 (6%) patients, and bilateral hand involvement in 93 (62.4%) patients. The most common symptom in our patients was nocturnal hand paresthesia (124 patients-83%). Hypesthesia was detected in 35 (23.4%) patients, and thenar atrophy was detected in 14 (10%) patients on physical examination. The Tinnel test was performed in 97 (65.1%) patients and the Phalen-Phalen test in 82 (55%) patients. According to the ENMG results of the patients, 106 (71.1%) were mild CTS, 36 (24.2%) with moderate CTS, and 7 (4.7%) with severe CTS. The patient etiologies are presented in Table 2.

DISCUSSION

The most common entrapment neuropathy syndrome is CTS. In idiopathic cases, it is caused by microtrauma resulting from

Table 2. Etiology of CTS

Parameters (%)	CTS (n=149)
Idiopathic local causes	81 (54.6%)
Tenosynovitis	4 (2.7%)
Colles fracture	8 (5.3%)
Carpal bone dislocation	6 (4%)
Tumors (Ganglion cyst)	5 (3.3%)
Persistent median artery	1 (0.7%)
Thickening of the transverse carpal ligament	1 (0.7%)
Systemic causes	
Diabetes mellitus	22 (14.7%)
Hypothyroidism	13 (8.7%)
Rheumatoid arthritis	6 (4%)
Renal failure	2 (1.3%)

CTS: Carpal tunnel syndrome

chronic repetitive movements (3). The symptoms of CTS are burning, pain, and numbness in the hand (1st, 2nd, and 3rd fingers and the radial side of the 4th finger), which is consistent with the sensory distribution of the median nerve, and typically occur more frequently at night and during sleep. In late-stage cases, weakness develops in the thenar muscles, and thenar atrophy also develops secondary to denervation (14).

Maeda et al. (15) reported that CTS was seen at an average age of 49.3±8.6 years and the female/male ratio was 4/1. Yang et al. (16) conducted a population-based cohort study in Taiwan. They found that CTS was more common in women and in the 50-59 age group (16). The average age of the participants was 54 years, which is similar to the literature. The female/male ratio in CTS was 2/1-6/1 (17). Studies have reported that the frequency of estrogen receptors alpha and beta (ERα and ERβ) in the carpal tunnel is increased in women (18). These studies explain why CTS is higher in women. In our study, the female to male ratio was similar to that in the literature.

Bilateral involvement is common in CTS. The dominant hand is the most commonly used and the first affected hand in bilateral cases (3,8,14,19). This may be due to the more frequent use of the dominant hand and the smaller carpal tunnel diameter in the dominant hand. In our study, we found 134 (89.9%) patients who were right-handed dominantly, 47 (31.5%) of whom had right hand involvement, 9 (6%) had left hand involvement, and 93 (62.4%) had bilateral hand involvement. The hand-involvement results of our study were also consistent with the literature.

The most common symptom in our patients was nocturnal hand paresthesia (83%), which was found to be compatible with the literature (85%) (20). In a study conducted by Özgenel et al. (21), muscle atrophy and weakness were found in 8% of patients, and sensory loss was found in 24%. In our study, we detected thenar atrophy in 14 (10%) of our patients and hypesthesia in 35 (23.4%).

The Tinnel and Phalen provocative tests are widely used. However, conflicting results have been reported regarding the sensitivity and specificity of these two tests (22,23). In the literature, the sensitivity of the Tinnel test has been reported to be between 9% and 89% and that of the Phalen test between 10-74.5% (24-26). It has been stated that the reason for the variability in the results reported in the literature regarding the sensitivities of these tests may be due to differences in the application techniques (26). In our study, we found the sensitivity of the Tinnel test to be 65.1% and that of the Phalen test to be 55%. Our results indicate that the sensitivity of these two tests is not very high.

Electrophysiological examination is the most reliable method for diagnosing and determining CTS severity (3,14,26). The most commonly used parameters are median nerve sensory latency (SL) and DML. Some authors prefer peak sensory conduction velocity determined using peak SL, while others state that adding needle ENMG findings to nerve conduction velocity examinations is important in determining the severity of CTS (27). CTS is classified as mild, moderate, and severe using electrophysiological parameters to determine its severity (28). Sole (29) stated that ENMG provides the most reliable data for diagnosis, follow-up, and research purposes, but that the severity of patient symptoms should also be taken into consideration when planning treatment. According to the ENMG results, 106 (71.1%) patients presented with mild CTS, 36 (24.2%) with moderate CTS, and 7 (4.7%) with severe CTS.

It is known that repetitive microtraumas of the wrist, which are predicted to be the most common cause of idiopathic disease, are closely related to occupation. One of the known facts about CTS is that CTS is also defined among occupational diseases (14,30). The occupational distribution of 149 patients in our study included 94 housewives (63.1%), 24 civil servants (16.1%), 13 teachers (8.7%), 10 tradesmen (6.7%), and 8 farmers (5.4%). It seems reasonable to conclude that all patients in our study may have been exposed to repetitive movements and microtraumas during occupational practice. In their study examining the clinical effects of occupation and gender on idiopathic CTS, Mathew and John (31) found that the incidence of CTS was higher in housewives than in other occupations, and that the neurophysiological severity was higher. Among the patient groups included in our study, housewives were the most notable occupational group (n=94, 63.1%). The findings show that housewives are the most at-risk occupational group members in terms of CTS.

It has been suggested in the literature that the hydrostatic pressure resulting from the increase in fat tissue around the nerve in obesity causes a slowdown in median nerve sensory transmission. In the study conducted by Adebayo et al. (32) on the frequency and severity of obesity in CTS, the frequency of obesity (BMI >30 kg/m^2) and overweight (25.0-29.9 kg/m^2) was determined in patients with CTS. Similarly, in the study conducted by Moghtaderi et al. (33), BMI was found to be 30.6±5.8. Age, sex, and obesity have been found to be independent risk factors for CTS. In our study, we found the BMI to be 27.92±3.98 and 31.5% of our patients were obese. It was found to be compatible with the literature.

CTS is frequently observed in diseases such as DM, thyroid dysfunction, RA, osteoarthritis, connective tissue diseases, amyloidosis, various infectious and inflammatory diseases such as Lyme and sarcoidosis, and chronic renal failure (34). Studies have reported rates of DM at 15-33%, hypohyperthyroidism at 2-5%, and arthritis at 1-2.1% (35,36). In our study, we found DM at 14.7%, thyroid dysfunction at 8.7%, and arthritis at 4%.

Bony anomalies in the carpal canal narrow the canal diameter. Traumas such as Colles fractures, carpal fractures, and dislocations of the carpal bones and distal radius fractures can also lead to acute CTS (37). Altissimi et al. (38) found that CTS was observed in 31% of cases after Colles fractures. Tumors such as giant cell tumor of the tendon sheath, lipoma, lipofibromatous hamartoma, hemangioma, ganglioma, and osteoid osteoma have also been reported to cause CTS (37). In our study, we detected colles fractures in 8 (5.3%) patients, carpal bone dislocations in 6 (4%), and tumors (ganglion cyst) in 5 (3.3%). We thought that the reason why we detected fewer patients with colles fractures than in the study conducted by Altissimi et al. (38) might be related to the small number of patients in our study.

CONCLUSION

CTS is the most common and well-known compression neuropathy of the upper extremities. It is known that etiology-based treatment of CTS is of great importance in preventing the development of late-stage neurological deficits. In this study, our experiences with CTS regarding age, sex, predisposing factors, and accompanying diseases, symptoms, and physical examination findings are presented. It was concluded that the findings of this study would be useful in evaluating the diagnosis of CTS cases.

Ethics

Ethics Committee Approval: The study, approval was obtained from the Fırat University Non-Interventional Research Ethics Committee (approval number: 2024-23858, date: 25.04.2024).

Informed Consent: Written informed consent was obtained from the patients or their legal representatives.

Footnotes

Authorship Contributions

Concept: N.Y., Design: M.Ş.E., N.Y., Data Collection or Processing: M.Ş.E., N.Y., M.K., Analysis or Interpretation: M.Ş.E., N.Y., M.K., Literature Search: N.Y., M.K., Writing: N.Y., M.K.

Conflict of Interest: The authors have no conflicts of interest to declare.

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