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Comparison of ultrasonography, electromyography, and clinical findings of patients with carpal tunnel syndrome

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Abstract

In the present study, we compared ultrasonography (USG), electromyography (EMG), and clinical outcomes of patients exhibiting clinical findings suspected of carpal tunnel syndrome (CTS). This comparison included individuals diagnosed with CTS through control examinations involving electrodiagnostic tests, as well as those who were not diagnosed with CTS. The study included 50 patients who applied to the Physical Medicine and Rehabilitation and Orthopedics and Traumatology outpatient clinics at Elazig Fethi Sekin City Hospital with complaints of hand numbness and pain, raising suspicion of CTS and were subsequently diagnosed with CTS through EMG between January 2022 and June 2022. In addition, the records of 50 control patients were reviewed; these individuals were also suspected of CTS and had undergone EMG, but their results were determined to be normal upon interpretation. All patients completed the Boston CTS questionnaire, while a radiologist with seven years of experience employed a linear probe within a 5-13 MHz frequency range to measure and record the cross-sectional area (CSA) of the wrist median nerve. The patient group comprised the evaluation of 87 wrists, whereas the control group included 79 wrists under assessment. The mean age for the patient group stood at 49.94±8.9 years, while the control group exhibited a mean age of 51.61±9 years. There was a significant correlation between the median nerve CSA measured by USG and the corresponding EMG data. In our study, we concluded that both EMG and USG are effective in the diagnosis of CTS, with USG exhibiting greater effectiveness compared to EMG.

Keywords: Boston CTS questionnaire, carpal tunnel syndrome, electromyography, ultrasonography

Introduction

Carpal tunnel syndrome (CTS) is the most common peripheral entrapment neuropathy that develops after the compression of the median nerve in the carpal tunnel, presenting with numbness, tingling, and pain in the hand. The condition is mostly seen in women [1,2].

The carpal tunnel is the anatomical space bounded by the carpal bones dorsally and the fibrous flexor retinaculum on the volar side; CTS develops with the compression of the median nerve within this space [3]. The transverse carpal ligament puts pressure on the carpal tunnel in flexion and extension of the wrist and causes compression in the tunnel. Surgical intervention often involves the release of the transverse carpal ligament [4].

Most cases of CTS are idiopathic. CTS symptoms are estimated to be bilateral in up to 73% of cases, although they may not occur simultaneously. The condition has been associated with pregnancy, overuse of the hand or wrist, trauma, obesity, hypothyroidism, kidney failure, diabetes mellitus, inflammatory arthropathies, and various other causes [1,5].

Many methods, including splinting, prednisolone administration, physical therapy exercises, therapeutic ultrasound, and surgical decompression, have been described in the treatment of CTS [6,7].

While pain, tingling, and numbness developing in the median

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nerve distribution constitute the clinical symptoms, it is essential to confirm these symptoms with electromyography (EMG).

Research indicates that clinical tests like the Tinel, Phalen, reverse Phalen, and carpal compression tests, employed in the clinical assessment of CTS, exhibit greater sensitivity in diagnosing tenosynovitis compared to diagnosing CTS [8].

There are instances where electrodiagnostic testing indicates carpal tunnel abnormalities, but clinical confirmation is lacking. As a matter of fact, the symptomatic prevalence was 3.8% in clinical examinations, while it was 4.9% in the electrodiagnostic study; meanwhile, the prevalence in which a definitive diagnosis of CTS was established through both clinical examination and electrodiagnostic tests was reported as 2.7% [2].

While CTS is often diagnosed with EMG clinically, ultrasonography (USG) has progressively emerged as a valuable diagnostic tool. USG is better tolerated, less expensive, offers insights into the condition's severity, and allows for the differentiation of anatomical variations [4,9].

The cross-sectional area (CSA) of the median nerve measured by USG is strongly correlated with the symptoms and severity of CTS. In a particular study, the most significant finding on USG in CTS patients was identified as swelling in the median nerve. Furthermore, within the same study, a median nerve CSA over 9 mm^2 exhibited a sensitivity of 82% and a specificity of 97% [10].

Material and Methods

The study included 50 patients who applied to the Physical Medicine and Rehabilitation and Orthopedics and Traumatology outpatient clinics at Elazig Fethi Sekin City Hospital with complaints of numbness and pain in the hand, raising suspicion of CTS and were subsequently diagnosed with CTS through EMG between January 2022 and June 2022. In addition, the records of 50 control patients were reviewed; these individuals were also suspected of CTS and had undergone EMG, but their results were determined to be normal upon interpretation.

Patients younger than 18 years and older than 65 years, patients with systemic inflammatory rheumatic disease, patients with sociocultural communication difficulties, patients with acute or pre-existing clinically ambiguous conditions at the time of study (malignancy, thyroid, or endocrine disorders, etc.), and pregnant patients were not included in the study. The patients who met these criteria were reached by phone and the patients who agreed to participate in the study were invited to the hospital. All patients were asked to fill in the Boston CTS questionnaire, while a radiologist with seven years of experience employed a linear probe within a 5-13 MHz frequency range to measure and record the CSA of the wrist median nerve (Figures 1 and 2). Informed consent of the patients and ethics committee approval (date: March 18, 2021, no: 04-32) were obtained for the study.

In their study using the Boston CTS questionnaire, Ilhan et al. (2008) concluded that the Turkish version of the questionnaire is an effective tool for following patients in both clinical and scientific studies and that it can be used easily and safely [11].

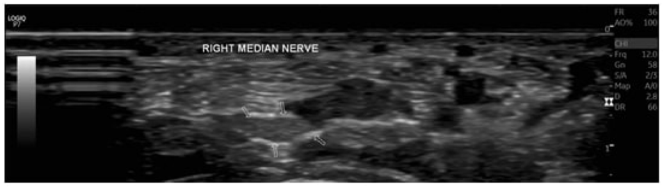

Figure 1. View of the right median nerve view using the linear probe in the 5-13 MHz frequency range

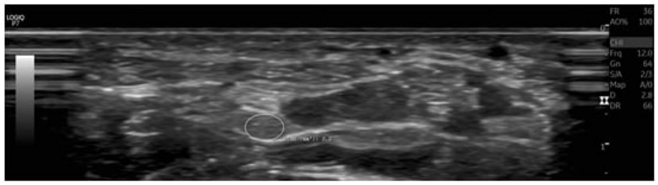

Figure 2. View of the right median nerve CSA measured using the linear probe in the 5-13 MHz frequency range

Statistical analysis

The SPSS 25.0 for Windows (IBM Corp., Armonk, NY, USA) software was used in statistical analyses. Descriptive statistics included standard deviation, mean, minimum, and maximum for numerical variables, while categorical variables were presented as numbers. The statistical significance level was set at $p<0.05$.

Results

Fifty patients diagnosed with CTS (46 women, 4 men) and 50 control patients (48 women, 2 men) whose EMG results were determined to be normal were included in our study. The patient group comprised the evaluation of 87 wrists, whereas the control group included 79 wrists under assessment.

The mean age for the patient group stood at 49.94±8.9 years, while the control group had a mean age of 51.61±9 years, exhibiting no significant difference. There was also no significant difference in terms of body mass index (BMI) between the two groups.

Findings related to the symptom severity scale (SSS) and the functional status scale (FSS) domains of the Boston CTS questionnaire, motor amplitude, sensory nerve conduction velocity, distal motor latency, and median nerve CSA were significantly higher in the patient group than in the control group (Table 1).

Upon analysis of the EMG and USG outcomes concerning the median nerve, a correlation between the clinical findings and the Boston symptom severity scale, sensory conduction velocity, median nerve CSA, and distal motor latency was observed. In addition, there was a significant correlation between the MN-CSA measurements obtained by USG and the EMG data (Table 2).

Following a ROC analysis of our CTS patients and control group (Figure 3 and Table 3).

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1. We found the area under the ROC curve in USG measurement as 0.994 (95% confidence interval: 0.988-1), signifying its substantial significance in diagnosing CTS.
2. Motor latency was calculated as 0.987 in EMG evaluation, indicating its significant efficacy in identifying CTS.
3. In the control group, no EMG activity was observed except for sensory velocity.
4. We can assert that USG is more effective than EMG. Considering the limited number of patients in our study, we anticipate that a more comprehensive evaluation will be necessary.

Table 1. Comparison of the two groups by age, body mass index, median nerve cross-sectional area, and electrophysiological measurements

	Control group	Patient group	p
Age (years)	49.80±8.87	50.78±9	0.585
BMI (kg/m²)	28.60±4.52	27.40±4.60	0.192
Boston SSS	13.26±2.12	34.74±9	0.001
Boston FSS	10.26±2.12	24.86±7.12	0.001
MA	9.36±2.35	7.54±2.74	0.001
SNCV (ms)	58.48±2.39	40.68±4.16	0.001
DML (ms)	2.56±0.38	3.96±0.62	0.001
MN-CSA (mm²)	7.2±0.78	11.14±1.17	0.001

MN-CSA: median nerve cross-sectional area, SNCV: sensory nerve conduction velocity, DML: distal motor latency, MA: motor amplitude, SSS: symptom severity scale, FSS: functional status scale

Table 2. Correlation between EMG and USG results of the median nerve and clinical findings and the correlation between EMG and USG results

		MN-CSA (mm²)	MA	DML (ms)	SNCV (m/sn)
Boston FSS	r	0.302	-0.214	0.314	-0.493
	p	0.033	0.136	0.026	0.000
Boston SSS	r	0.456	-0.322	0.511	-0.547
	p	0.001	0.022	0.000	0.000
MN-CSA (mm²)	r	1	-0.407	0.762	0.762
	p		0.003	0.000	0.00

MN-CSA: median nerve cross-sectional area, SNCV: sensory nerve conduction velocity, DML: distal motor latency, MA: motor amplitude. SSS: symptom severity scale, FSS: functional status scale

Table 3. ROC analysis of the CTS patients

	USG		EMG	
	Area under the curve	95% confidence interval	Area under the curve	95% confidence interval
USG	0.994	0.988-1	0.005	0.00-0.012
MA	0.33	0.246-0.413	0.670	0.02-0.024
DML	0.987	0.976-0.998	0.013	0.362-0.5
SNCV	0.02	0.-0.006	0.998	0.994-1

SNCV: sensory nerve conduction velocity, DML: distal motor latency, MA: motor amplitude, USG: ultrasonography, EMG: electromyography

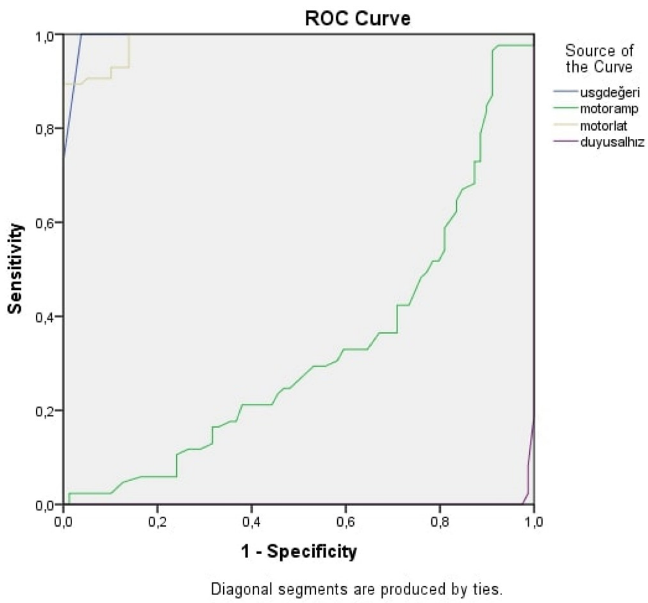

Figure 3. ROC analysis of the CTS patients

Discussion

CTS exhibits a common occurrence within the 40-60 age range, with its frequency escalating as individuals age [2,12]. In our study, both groups displayed a comparable mean age, with the patient group averaging 49.80±8.87 years and the control group averaging 50.78±9 years, thus achieving group homogeneity.

The risk of CTS is increased in obese patients [1,5]. There was no significant difference between the groups in terms of the BMI measurements of our patients. Obesity did not affect the comparison of the two groups.

Numerous studies have concluded that manual tests for assessing patients' symptoms and clinical diagnosis are insufficient in CTS [2,4,8,9]. As a matter of fact, our control group was assembled from individuals whose symptoms and clinical presentation raised suspicion, yet their EMG outcomes did not suggest CTS. This underscores the necessity of additional diagnostic tests.

However, EMG findings consistent with CTS were observed in 70% of patients with clinically established CTS, 46% of patients with paresthesia in the median nerve trace, and even in 18% of patients with no discernible symptoms [2].

Electrodiagnostic studies may exclude other conditions such as polyneuropathy and radiculopathy, while also measuring the extent of CTS severity; however, it has been reported that a normal EMG does not rule out CTS. Electrodiagnostic studies have a sensitivity of 56-85% and a specificity of 94-99% for CTS [13]. In our study, the distal motor latency efficiency was significant in the EMG evaluation performed in the CTS group, while in the control group, only sensory velocity activity was observed.

A particular study measured median nerve enlargement in CTS

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cases, averaging 10.8 mm^2 via USG [12]. In a meta-analysis, a median nerve CSA measuring 9 mm^2 or more demonstrated 87.3% sensitivity and 83.3% specificity for CTS diagnosis [14].

In another study, when patients with and without EMG-confirmed CTS were compared, the mean median nerve CSA was found 15.58±3.83 mm^2 and 9.42±2.81 mm^2, respectively ($p<0.001$). When categorizing patients as exhibiting normal, mild, moderate, and severe CTS, the USG median nerve CSAs were measured at 9.4±2.8, 13.4±2.5, 15.8±3.8, 18.2±3.9, respectively, establishing a significant correlation between the severity of CTS and USG outcomes [15]. However, many studies still argue that the correlation between CTS severity and EMG findings is uncertain [8,16-18]. Our study did not incorporate CTS severity scaling.

There are also studies that use USG elastography in the diagnosis of CTS and argue that tissue stiffness and the level of stiffness hold significant implications for both the diagnosis and severity of CTS [19,20].

In a recent study, the highest sensitivity (87%) and specificity (91%) were recorded at the threshold of 11.5 mm^2, within a range of different cut-off values (8.5–12.5 mm^2) examined for the median nerve's CSA [21]. However, there are also studies asserting that there is presently inadequate evidence to advocate for the routine integration of USG [22].

A study; It has been shown that High Resolution Ultrasound-B measures intraneural vascularity better than Doppler Ultrasound and gives a better correlation than EMG [23]. With High Resolution USG, nerve shape, size, echogenicity and neural blood flow can be detected [24]. Shear wave elastography measures tissue stiffness and is more sensitive than strain elastography [25].

A meta-analysis reported that USG has satisfactory diagnostic accuracy in the diagnosis of CTS, the threshold value for median nerve width in the general population can be said to be 9-10.5 mm^2, and it can show the increase in median nerve stiffness and vascularity reflecting the severity of the disease. They also reported that EMG may miss the diagnosis of CTS in patients with classic symptoms and noticeable swelling at the tunnel entrance. However, they advocated performing EMG in patients with unclear symptoms and stated that EMG and USG are complementary to each other and that both should be applied at every stage of CTS [26].

Another meta-analysis found that ultrasound has good sensitivity and is comparable to EMG; however, it has shown to have slightly higher specificity than EMG. Therefore, he stated that it can be used as an alternative to electrodiagnostic testing as a confirmatory test for CTS. USG is useful for the diagnosis of CTS because it is cost-effective, rapid diagnosis and painless, but it cannot be said to replace electrodiagnostic tests. Additionally, no literature has been able to correlate ultrasound measurements with the severity of CTS; therefore, further research is needed to investigate these correlations [27].

Another study is; found that the simple correlation between symptomatic and electrophysiological severity was comparable to previous studies, but that this relationship was stronger than previously reported and strong enough to be clinically useful [28].

In our study, the mean median nerve CSAs measured by USG were 11.14±1.17 mm^2 and 7.2±0.78 mm^2 for our patient and control groups, respectively ($p<0.001$). The area under the ROC curve in USG measurement was 0.994 (95% confidence interval 0.988-1), signifying its significant effectiveness in diagnosing CTS. We can assert that USG is more effective than EMG.

Conclusion

Upon examining the EMG and USG outcomes concerning the median nerve, we observed a clear correlation between the clinical findings and the Boston SSS, median nerve CSA, sensory nerve conduction velocity, and distal motor latency. In addition, there was a significant correlation between the MN-CSA measured by USG and the corresponding EMG data.

Both USG and EMG have significant efficacy in diagnosing CTS. No EMG activity was observed in the control group, except for sensory velocity. Accompanied by all these findings, we can conclude that USG is more effective than EMG in diagnosing CTS.

Conflict of Interests

The authors declare that there is no conflict of interest in the study.

Financial Disclosure

The authors declare that they have received no financial support for the study.

Ethical Approval

Ethics committee approval was obtained from the ethics committee of Fırat University, dated 18.03.2021 and numbered 04-32.

References

5. de Krom MC, Kester AD, Knipschild PG, Spaans F. Risk factors for carpal tunnel syndrome. Am J Epidemiol. 1990;132:1102-10.

6. Atroshi I, Gummesson C, Johnsson R, et al. Prevalence of carpal tunnel syndrome in a general population. JAMA. 1999;282:153-8.

7. Ghasemi-Rad M, Nosair E, Vegh A, et al. A handy review of carpal tunnel syndrome: From anatomy to diagnosis and treatment. World J Radiol. 2014;6:284-300.

8. Richman JA, Gelberman RH, Rydevik BL, et al. Carpal tunnel syndrome: morphologic changes after release of the transverse carpal ligament. J Hand Surg Am. 1989;14:852-7.

9. Middleton SD, Anakwe RE. Carpal tunnel syndrome. BMJ. 2014;349:g6437.

10. Wipperman J, Goerl K. Carpal tunnel syndrome: diagnosis and management. Am Fam Physician. 2016;94:993-9.

11. Page MJ, O'Connor DA, Pitt V, Massy-Westropp N. Reporting of allocation method and statistical analyses that deal with bilaterally affected wrists in clinical trials for carpal tunnel syndrome. Am J Phys Med Rehabil. 2013;92:1012-9.

12. El Miedany Y, Ashour S, Youssef S, et al. Clinical diagnosis of carpal tunnel syndrome: old tests-new concepts. Joint Bone Spine. 2008;75:451-7.

13. Petrover D, Richette P. Treatment of carpal tunnel syndrome: from ultrasonography to ultrasound guided carpal tunnel release. Joint Bone Spine. 2018;85:545-52.

14. Duncan I, Sullivan P, Lomas F. Sonography in the diagnosis of carpal tunnel syndrome. AJR Am J Roentgenol. 1999;173:681-4.

15. İlhan D, Toker S, Kilincioglu V, Gulcan E. Assessment of the Boston questionnaire in diagnosis of idiopathic carpal tunnel syndrome: comparing scores with clinical and neurophysiological findings. Duzce Medical Journal. 2008;10:4-9.

16. Buchberger W, Judmaier W, Birbamer G, et al. The role of sonography and MR tomography in the diagnosis and therapeutic control of the carpal tunnel syndrome. Rofo. 1993;159:138-43.

17. Jablecki CK, Andary MT, Floeter MK, et al. Practice parameter: Electrodiagnostic studies in carpal tunnel syndrome. Report of the American Association of Electrodiagnostic Medicine, American Academy of Neurology, and the American Academy of Physical Medicine and Rehabilitation. Neurology. 2002;58:1589-92.

18. Tai TW, Wu CY, Su FC, et al. Ultrasonography for diagnosing carpal tunnel syndrome: a meta-analysis of diagnostic test accuracy. Ultrasound Med Biol. 2012;38:1121-8.

19. Ting BL, Blazar PE, Collins JE, et al. Median nerve ultrasonography measurements correlate with electrodiagnostic carpal tunnel syndrome severity. J Am Acad Orthop Surg. 2019;27:17-23.

20. Moran L, Perez M, Esteban A, et al. Sonographic measurement of cross-sectional area of the median nerve in the diagnosis of carpal tunnel syndrome: correlation with nerve conduction studies. J Clin Ultrasound. 2009;37:125-31.

21. Mhoon JT, Juel VC, Hobson-Webb LD. Median nerve ultrasound as a screening tool in carpal tunnel syndrome: correlation of cross-sectional area measures with electrodiagnostic abnormality. Muscle Nerve. 2012;46:871-8.

22. Padua L, Coraci D, Erra C, et al. Carpal tunnel syndrome: czakiical features, diagnosis, and management. Lancet Neurol. 2016;15:1273-84.

23. Lin CP, Chen IJ, Chang KV, et al. Utility of ultrasound elastography in evaluation of carpal tunnel syndrome: a systematic review and meta-analysis. Ultrasound Med Biol. 2019;45:2855-65.

24. Sernik RA, Pereira RFB, Cerri GG, et al. Shear wave elastography is a valuable tool for diagnosing and grading carpal tunnel syndrome. Skeletal Radiol. 2023;52:67-72.

25. Ratasvuori M, Sormaala M, Kinnunen A, Lindfors N. Ultrasonography for the diagnosis of carpal tunnel syndrome: correlation of clinical symptoms, cross-sectional areas and electroneuromyography. J Hand Surg Eur Vol. 2022;47:369-74.

26. Erickson M, Lawrence M, Lucado A. The role of diagnostic ultrasound in the examination of carpal tunnel syndrome: an update and systematic review. J Hand Ther. 2022;35:215-25.

27. Gitto S, Messina C, Chianca V, et al. Superb microvascular imaging (SMI) in the evaluation of musculoskeletal disorders: a systematic review. Radiol Med. 2020;125:481-90.

28. Hobson-Webb LD, Padua L. Ultrasound of focal neuropathies. J Clin Neurophysiol. 2016;33:94-102.

29. Park EJ, Hahn S, Yi J, et al. Comparison of the diagnostic performance of strain elastography and shear wave elastography for the diagnosis of carpal tunnel syndrome. J Ultrasound Med. 2021;40:1011-21.

30. Lin TY, Chang KV, Wu WT, Özçakar L. Ultrasonography for the diagnosis of carpal tunnel syndrome: an umbrella review. J Neurol. 2022;269:4663-75.

31. Zaki HA, Shaban E, Salem W, et al. A comparative analysis between ultrasound and electromyographic and nerve conduction studies in diagnosing carpal tunnel syndrome (CTS): a systematic review and meta-analysis. Cureus. 2022;14:e30476.

32. Fargaly SN, Bland JDP. Do nerve conduction studies or ultrasound imaging correlate more closely with subjective symptom severity in carpal tunnel syndrome?. Muscle Nerve. 2023;68:264-8.