

Diagnostic accuracy of Ultrasound and Carpal tunnel syndrome-6 scoring system for diagnosis of Carpal tunnel syndrome taking nerve conduction study as gold standard

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Abstract

Background & Objective: Comparative analysis of different diagnostic tools will help clinicians in choosing the appropriate test for the diagnosis of Carpal Tunnel Syndrome (CTS), is able to shorten the time of diagnosis and treatment. The purpose of this study was to assess the diagnostic accuracy of ultrasonography and the CTS-6 scoring system with reference to nerve conduction test as gold standard for the diagnosis of CTS. **Methods:** This cross-sectional study was conducted at neurology department of Federal Government Polyclinic, Islamabad for one year. All patients presenting with signs and symptoms of CTS, and fulfilling the eligibility criteria were enrolled in the study. Enrolled participants underwent the nerve conduction study, ultrasonography, and the CTS-6 score to diagnose CTS. The diagnosis established by nerve conduction study (NCS) was considered as a gold standard. **Results:** The sensitivity of CTS-6 scoring method was found to be 63.6%, and the specificity was found to be 78.3%, considering nerve conduction test as standard. On the other hand, the sensitivity of ultrasound technique was found to be 86.7%, specificity was found to be 70.3%, considering nerve conduction test as standard.

Conclusion: The sensitivity and specificity of ultrasound and CTS-6 scoring method was found to have moderate diagnostic accuracy in establishing diagnosis of CTS.

Keywords: Carpal tunnel syndrome, nerve conduction test, ultrasonography, CTS-6 score, diagnostic accuracy.

INTRODUCTION

Carpal tunnel syndrome (CTS) is recognized as the most common type of entrapment neuropathy, with an estimated global prevalence ranging between 4% and 5%.¹ The clinical presentation of CTS can vary widely among patients and is commonly classified into three categories based on severity: mild, moderate, and severe. The condition is typically characterized by symptoms such as pain, numbness, and tingling sensations in the hand and arm, predominantly affecting

the wrist associated with the median nerve. These symptoms are caused by the compression of the median nerve as it passes through the carpal tunnel, a narrow anatomical structure at the wrist. This nerve compression results in progressive dysfunction, including reduced grip strength and impaired manual dexterity, which may be further aggravated by pain during hand and wrist movements.² A variety of risk factors have been identified for CTS, many of which are associated with systemic or local

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conditions. These include metabolic disorders such as diabetes mellitus, lifestyle factors such as smoking and obesity, hormonal imbalances like hypothyroidism, mechanical issues such as wrist trauma or repetitive motion, and inflammatory conditions, particularly rheumatoid arthritis.³ The multifactorial etiology and variable presentation underscore the need for a nuanced approach to the diagnosis and management of CTS.

The diagnosis of CTS can be established through various methods, including clinical examination, clinical assessment tools, nerve conduction studies (NCS), and ultrasonographic measurement of the median nerve diameter.⁴ Among these, NCS is considered to be the gold standard test, which demonstrates a sensitivity of 73.4% and a specificity of 93.6%⁵, but the procedure is associated with significant discomfort, pain, and cost, making it less favorable for some patients.⁶ Ultrasonography has been reported to offer comparable sensitivity and specificity to NCS when clinical assessment is used as a reference standard.⁷⁻⁸ Furthermore, literature reports that the CTS-6 scoring system can also achieve diagnosis of CTS compared with gold standard with a sensitivity of 84% and a specificity of 91%.⁹

There is limited research reported in Pakistani population to assess the efficacy of these new diagnostic tests to establish diagnosis of CTS in comparison to nerve conduction test. By establishing comparative diagnostic efficacy of new, easy to use and quicker diagnostic tools, patients will get a chance to get diagnosed with choice of their test, and the clinicians would be able to diagnose CTS without the use of specialized tools that are not available in peripheries. Additionally, comparison of new diagnostic tools will help clinicians in choosing the appropriate one for the diagnosis and this will shorten the time for diagnosis and treatment. The present study aimed to assess the diagnostic accuracy of ultrasonography and the CTS-6 scoring system with reference to nerve conduction test as gold standard for the diagnosis of CTS.

METHODS

A cross-sectional study was conducted at Department of Neurology, Federal Government Polyclinic (PGMI), Islamabad in collaboration with department of Radiology from November 2023 to November 2024. The study sought ethical approval from Institutional Review Board of the hospital prior to start participant enrollment.

The minimum required sample was calculated¹⁰ to be 158 wrists, considering 84.0% sensitivity and 91.0% specificity of CTS scoring method to diagnose CTS⁹, 5% prevalence of CTS in general population¹, 95% level of confidence, 20% precision, and 80% study power.

We used non-probability consecutive sampling technique to enroll participants in the study. All the consecutive patients presenting with signs and symptoms of CTS were considered for enrollment into the study. Adult patients of more than 16 years age, either gender, experiencing symptoms of compression of median nerve in the form of burning pain, paresthesias or numbness in the lateral three fingers were included in the study. Patients with no history or clinical picture not favoring the CTS for example in brachial plexopathy, C6 radiculopathy, cervical disk syndromes, de Quervain tenosynovitis syndrome, interosseous syndrome, or proximal median neuropathy; patients with open wound over the wrist, patients operated for CTS or having given local steroids injection were excluded from the study.

Informed consent was obtained from each participant after explaining the study procedure to the patient in detail including all diagnostic tests being performed free of cost, and risks associated with each type of diagnostic procedure. Patient were clinically examined after taking detail history in the outpatient department, and three tests including nerve conduction test, ultrasound, and CTS-6 score calculation by the Neurology resident under supervision of neurologist. Data was collected on predesigned questionnaire performa. The patients were confirmed for diagnosis using nerve conduction test, as well as severity of disease of measured for true positive cases. The nerve conduction study, as a gold standard test, was performed and interpreted by a consultant neurologist in the neurology department. All study participants presenting with signs and symptoms of carpal tunnel syndrome underwent nerve conduction study, and motor and sensory latencies were also performed for median and ulnar nerves. The temperature was maintained at 32°C during the procedure. For motor latencies, median nerve was stimulated 7cm proximal to active electrode at wrist and ulnar nerve was stimulated at 7cm proximal to active electrode. The sensory responses were recorded at digit II and digit V for median and ulnar nerves stimulating antidromically at 13cm and 11cm respectively. The normative values taken for median motor distal was <4.2ms and sensory

distal peak latency was <3.5ms. Grading of CTS-6 was done according to American Association of Electrodiagnostic Medicine (AAEM) criteria: mild CTS (prolonged distal sensory peak latency or decreased sensory amplitude; moderate CTS (abnormal sensory peak latencies with prolonged distal motor latency); severe CTS (prolonged motor and sensory distal peak latency with a low or absent SNAP or CMAP; and very severe CTS (absent thenar motor or sensory response either with a present or absent lumbrical response).

Subsequently, patients underwent ultrasonographic evaluation conducted by a radiologist using a high-frequency linear probe in the radiology department. The neurologist performing the NCS was blinded to the results of the ultrasonographic examination and the CTS-6 tool score, and similarly, the radiologist was blinded to the findings of the NCS and the CTS-6 tool score.

Findings of nerve conduction studies and ultrasonographic measurement were noted down in the data collection tool. Later on, following the NCS and ultrasonography, the CTS-6 score was calculated for all enrolled patients. The cut-off for CTS-6 score was taken as ≥ 12 for positive finding and < 12 for negative finding the diagnosis established by NCS was considered as a gold standard to compare the proposed diagnosis by ultrasonography and CTS-6 score methods. The individual sensitivities and specificities for both tests were calculated and reported.

The data was analyzed by using IBM SPSS

(version 23.0) software. The descriptive statistics were presented as mean and standard deviation for continuous variables, while frequencies and percentages were reported for categorical variables. Diagnostic accuracy in terms of sensitivity, specificity and predictive values was calculated and reported in percentages.

RESULTS

There were 158 wrists included in the analysis. The mean age was 40.2 ± 10.8 years, with age range of 17 to 67 years. There were 87 (55.1%) right wrists involved, while 71 (44.9%) were left wrists. Most of the participants, 135 (85.4%) of the participants were females, while 23 (14.6%) were male. There were 121 (76.6%) participants confirmed for diagnosis of CTS using the nerve conduction test. Out of 121, 51 (42.1%) were diagnosed with carpal tunnel syndrome less than 6 months ago, 24 (19.8%) were diagnosed within last 6 months to 1 year duration, 41 (33.9%) were diagnosed in past 1-5 years, while 5 (4.1%) were diagnosed over 5 years. Among 121 confirmed cases, the disease severity was mild in 18 (14.9%), moderate in 36 (29.8%) and severe in 67 (55.4%) patients. Table 1 gives summary of demographics among study participants.

The CTS was idiopathic in nature among 92 (58.2%) of the participants. Other reasons for carpal tunnel syndrome among study participants are summarized in Figure 1. There were 8 (5.1%) smokers in the study group. Around 13 (8.2%)

Table 1: Summary of baseline characteristics (n=158)

Characteristics	Frequency (n)	Percentage (%)
Mean age	40.2±10.8 years	
Age range	17 - 67	
Gender		
• Male	23	14.6%
• Female	135	85.4%
Confirmed diagnosis of CTS		
• Yes	121	76.6%
• No	37	23.4%
Duration of disease (n=121)		
• <6 months	51	42.1%
• 6 months – 1 year	24	19.8%
• 1 – 5 years	41	33.9%
• >5 years	5	4.1%
Disease severity (n=121)		
• Mild	18	14.9%
• Moderate	36	29.8%
• Severe	67	55.4%

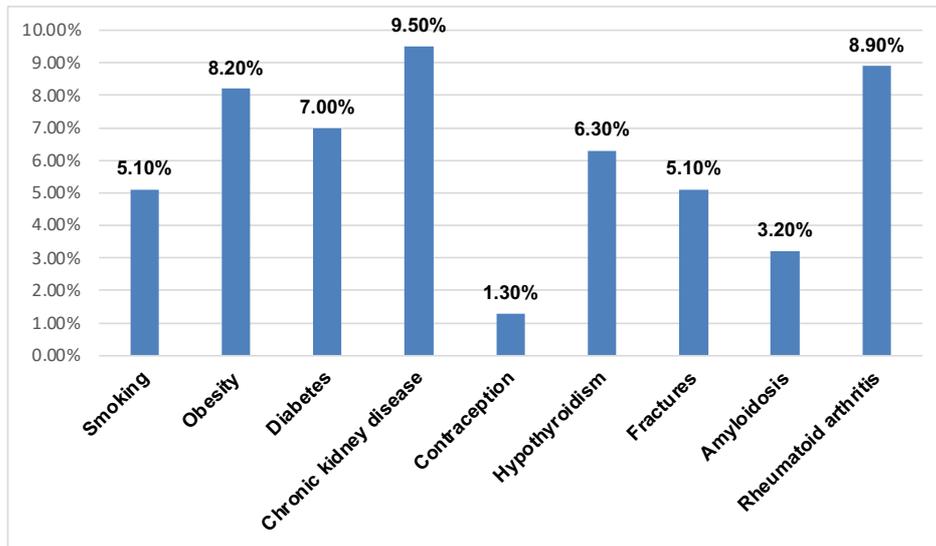


Figure 1. Percentage of various reasons of carpal tunnel syndrome reported among study participants (n=158)

participants were obese. There were only 2 (1.3%) participants who reported to be using oral contraceptives. Regarding comorbidities, diabetes was present in 11 (7.0%) participants, 14 (8.9%) reported to have rheumatoid arthritis while 10 (6.3%) had hypothyroidism, followed by 5 (3.2%) having amyloidosis. There were 8 (5.1%) participants who reported past history of fractures.

All the participants underwent three diagnostic tests including nerve conduction test as a gold standard, followed by CTS-6 scoring method and ultrasonography test. Considering the nerve conduction test as standard, the distribution of true positives, true negatives, false positive, false negatives for both CTS-6 score and ultrasonography technique were compared as given in Table 2.

The sensitivity of CTS-6 scoring method was found to be 63.6%, and the specificity was found to be 78.3%, considering nerve conduction test as standard. On the other hand, the sensitivity of ultrasound technique was found to be 86.7%, specificity was found to be 70.3%, considering nerve conduction test as standard as given in Table 3.

The CTS-6 score successfully confirmed the diagnosis of 7 (38.9%) mild, 13 (36.1%) moderate and 55 (82.1%) severe cases, while ultrasound technique successfully confirmed the diagnosis of 7 (38.9%) mild, 32 (88.9%) and 66 (95.5%) severe cases of CT.

DISCUSSION

CTS is a type of neuropathy, characterized by

Table 2: Distribution of positive and negative cases for CTS-6 score and ultrasonography technique with respect to nerve conduction study

		Nerve Conduction Study		Total
		Positive	Negative	
CTS-6 score	Positive	77 ^a	08 ^b	85
	Negative	44 ^c	29 ^d	73
	Total	121	37	
Ultrasound technique	Positive	105 ^a	11 ^b	116
	Negative	16 ^c	26 ^d	42
	Total	121	37	

^a True positive, ^b False positive ^c False negative, ^d True negative

Table 3: Ultrasound and CTS-6 score method diagnostic parameters

	Sensitivity	Specificity	Positive Predictive value	Negative Predictive Value	Diagnostic accuracy
CTS-6	63.6%	78.3%	90.5%	39.7%	67.0%
Ultrasound	86.7%	70.3%	90.5%	61.9%	82.9%

pain, numbness or tingling sensations in the arms, hand or fingers with varied severity spectrum of mild, moderate and severe. There can be a range of risk factors contributing towards this condition which include but are not limited to edema due to any cause, lifestyle related conditions like obesity, smoking or posture, and chronic conditions such as diabetes or kidney diseases.^{1,3} The gold standard test to diagnose this condition rests with nerve conduction test, the diagnostic power of which is not up to the mark but highest amongst yet established diagnostic techniques. There are some new techniques used to establish diagnosis of CTS including ultrasonographic and CTS-6 scoring based techniques. These techniques are less invasive, quicker and more acceptable by patients.⁴ This study was conducted to compare the diagnostic power of these techniques as per gold standard. The ultrasound technique was found to have higher sensitivity as compared to CTS-6 scoring method i.e. 86.7% vs 63.6%, whereas in terms of specificity, CTS-6 scoring method was found to have higher specificity as compared to ultrasound i.e., 78.3% vs 70.3%. The diagnostic power has not found to be very impressive but in healthcare setups where nerve conduction studies cannot be conducted due to unavailability of equipment or trained staff etc., then these techniques can be used to establish the diagnosis of CTS.

Several studies have evaluated the diagnostic accuracy of high-frequency ultrasound for confirming CTS and compared its performance with the nerve conduction test. Singla *et al.*¹¹ reported a strong correlation between ultrasound and NCS test results, with ultrasound demonstrating 100% sensitivity and 88% specificity. Similarly, Drakopoulos *et al.*¹² found a positive correlation between both diagnostic methods, with slightly lower but still high accuracy (97% sensitivity, 89% specificity). Haddani *et al.*¹³ also concluded that ultrasonography offers diagnostic accuracy comparable to NCS test, reporting 92.2% sensitivity and 88.9% specificity, supporting its potential as an alternative diagnostic tool. El-Shintenawy *et al.*¹⁴ included CTS patients and matched controls, observing 91.3% sensitivity

and 100% specificity for ultrasound, indicating excellent diagnostic performance. Overall, these studies consistently demonstrate that ultrasound shows high sensitivity and specificity comparable to the nerve conduction test for CTS diagnosis, though variations in results may stem from differences in sample size, study design, and diagnostic parameters used.

Ferraguti *et al.*¹⁵, conducted a study to explore the efficiency of CTS-6 scoring method to rate severity of CTS disease and to confirm diagnosis of CTS. The authors reported that CTS-6 score is an acceptable method to measure the functionality and severity of CTS but might not be up to the mark to diagnose the condition. Chen *et al.*¹⁶, reported a study to evaluate the utility of CTS-6 scoring based method to diagnose the CTS condition, the authors reported sensitivity of this method to be 76% and specificity of 51%. The authors concluded that these values are not significant enough to say that this method can be solely used to confirm CTS condition, but keeping in view the scenarios where availability of nerve conduction tests is limited then scoring method can be used. These values are very much in line with the results reported in current study where the sensitivity specificity values are lower for CTS-6 scoring method. Kimura *et al.*¹⁷, recommended using CTS-6 score-based ultrasonography technique to diagnose idiopathic CTS patients which comprise of almost half of such cases. The author emphasized that this technique can be used as a first-line confirmatory test that can complement more sophisticated tests if needed.

The limitation of current study includes using NCS as gold standard, keeping in view that this technique has moderate sensitivity, this might have affected the results of current study. In most of the reference studies, the signs and symptoms of CTS were used as a gold standard to compare other diagnostic tests including ultrasound and NCS. It is recommended to infer the results with caution.

In conclusion, the sensitivity and specificity of ultrasound and CTS-6 scoring method was found to have moderate diagnostic accuracy in establishing diagnosis of CTS. It can be used as a

first-line confirmatory test specially at healthcare centers where nerve conduction diagnostic test facilities are not available.

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