Original Article

Diagnostic Accuracy of Ultrasonography (USG) in Diagnosing Carpal Tunnel Syndrome (CTS) Taking Nerve Conduction Studies (NCS) as Gold Standard

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ABSTRACT

Objective: To evaluate the diagnostic potential of ultrasound taking nerve conduction study as the gold standard in patients with clinical and electro diagnostic evidence of CTS.

Study Design: Analytical Validation Study

Place and Duration of Study: This study was conducted at the department of Neurology Sh Zayed Medical College/Hospital, Rahim Yar Khan for a period of six months from March to August 2021.

Materials and Methods: 80 patients were enrolled after fulfilling the selection criteria. A total of 160 hands were tested. USG and NCS studies were performed. Cross sectional area of the carpal tunnel was calculated and the results were analyzed for sensitivity and specificity, positive predictive value and negative predictive values and diagnostic accuracy.

Results: Of the 80 patients and 160 hands tested, 8 patients were male and 72 were females. On NCS, 142 hands (89%) were tested positive for CTS and 18 hands (11%) were tested negative. On ultrasonography, 128 hands (80%) had CSA of more than 8.5mm^2, and 32 hands (20%) less than 8.5mm^2. Sensitivity of USG was 91% with 90% specificity. Diagnostic accuracy was 88% for USG to diagnose CTS. The results were significant with a p-value 0.0005 (.05).

Conclusion: Ultrasound is comparable to NCS in diagnosing CTS. It is cheap, readily available and does not require much technical expertise and equipment.

Key Words: Carpal Tunnel Syndrome (CTS), Nerve conduction studies (NCS), Cross sectional area (CSA), Ultrasonography (USG)

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INTRODUCTION

Carpal tunnel syndrome (CTS) is the most common symptomatic compressive neuropathy at the wrist. Median nerve is entrapped at the carpal tunnel.[1]. It has a prevalence of 2.7 to 5.8% in the adult population[2] and is more common among adult women (9%) than men (0.6%)[3].

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Typical symptoms include numbness, tingling or pain in the lateral two-thirds of the hand in the distribution of the median nerve. Symptoms are more severe at night and often patients are awakened from sleep. Patients may experience radicular pain in the arm, forearm and hand. Weakness may be noted in hand grip and opposition of the thumb[4].

The abnormally high pressure or injury may cause CTS. Although, many cases are idiopathic but also associated with smoking, pregnancy, overuse of hands and wrist, wrist injury, obesity, hypothyroidism, diabetes, renal failure, rheumatoid arthritis and osteoarthritis, etc.[5] It was estimated that between 400,000 and 500,000 cases of CTS require operative treatment annually in the States.[6] Similarly, surgical decompression is done in UK for 43 to 74 per 100,000 per year[7]. Several clinical examination tests help in the diagnosis of CTS but none of these tests are diagnostic on their own. The tests commonly used are Tinel's test, Phalen's Test and reverse phalen test. Nerve conduction studies are considered the gold standard test. However, they are also associated with false positive and false negative

results[8]. Comparison of ultrasound and nerve conduction studies for the diagnosis of carpal tunnel requires a reference standard for the diagnosis of CTS. In a meta-analysis, similar diagnostic accuracy between USG and CTS was found. [9] Median nerve compression at the carpal tunnel results in nerve swelling proximal and distal to the tunnel. The CSA of the median nerve at the tunnel inlet is measured on ultrasound, cutoff values of CSA are used to determine whether the test is positive or negative [10]. The CSA of median nerve at the distal wrist crease varies among different reports [11]. It has ranged from 7.2 to 9.8 mm^2 in various reports. The median nerve CSA range for diagnosing CTS is from 9 to 15 mm^2. These values have a sensitivity and specificity from 70 to 88% and 57 to 97%, respectively[12,13].

In our region, as we have very limited resources, especially the electrophysiological test availability, affordability and expertise is the concern, we designed this study to look for better, cheaper, comparable and easily available alternatives for early diagnosis of carpal tunnel syndrome. Also, very little work is done on this topic in our region.

MATERIALS AND METHODS

Study Design: It is a cross sectional diagnostic study conducted at Sheikh Zayed Hospital, Rahim Yar Khan. The study duration was six months. The sample size was 80 patients, with a total 160 hands tested. The sampling technique used was non-probability purposive sampling.

Selection Criteria: Inclusion criteria: Patients with a CTS-6 score of ≥12 points (Appendix 1). Patients from both genders and all ages and those who agree to participate in this study

Exclusion criteria:

· All patients with history of trauma

· All patients with a history of wrist surgery, wrist trauma or congenital deformity.

. All pregnant females.

· All patients with history of post stroke contractures

· All patients who received steroid injections.

. All patients diagnosed with polyneuropathy, radiculopathy or mononeuritis.

Data Collection: Permission taken from the ethical review committee and informed consent taken from all the participants. High probability cases or the suspected cases were defined by using CTS-6 criteria. The CTS-6 is a clinical model that estimates the clinical diagnostic possibility of CTS. A total of six criteria are used for the clinical diagnosis using CTS-6 score. A score of ≥ 12 is considered for labelling patients with high probability of having CTS. We tested our hypothesis that "Ultrasonography is comparable to nerve conduction studies in diagnosing carpal tunnel syndrome".

Demographic details of the patients like age, gender, duration of symptoms, CTS 6 score were recorded using questionnaires. All patients underwent standard USG and NCS procedures for diagnosis of CTS. The data analysis was done using SPSS.

Ultrasound: All USG examinations were performed by the radiologist expert in musculoskeletal US, at Sheikh Zayed medical college/hospital, Rahim Yar Khan, on the same equipment, with high resolution and broadband linear transducers. The US examination was done on both hands with the forearm in a supine position, keeping the wrists in neutral position. The cross-sectional area (CSA) at the proximal "in let"of the carpal tunnel is directly measured. A cutoff value ≥8.5 mm^2 at the carpal tunnel inlet, considered to confirm diagnosis of CTS using USG.

Nerve Conduction Studies: For electro diagnostic study (EDX) we used the Neuropack EMG-EP measuring device. Device model is MEB-9200K, 2003; Nihon Kohden Corporation, Tokyo, Japan. Reference values of Dumitru and Zawarts were used[14]. The EDX studies were performed by only one neurologist with 12 years of experience. The skin and room temperatures were maintained around 32°C and at 25°C, respectively. Both the hands were tested, whether symptomatic or not. The nerve conduction studies were done by recording median and ulnar sensory peak latencies, median nerve conduction velocities, and median distal motor latencies (DML) in both hands. Standard parameters of median and ulnar nerve stimulation and surface recordings were used. The EDX parameters considered for diagnosing CTS were: a) more than 0.4 ms difference between the median and ulnar sensory peak latencies. b) a median distal motor latency (DML) of more than 4.0 ms.[15]

Data Analysis: Data analysis done using Statistical Package for Social Sciences (SPSS) version 25. For numeric data, mean and standard deviation were calculated. For categorical data, frequency and percentage were measured. Sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of Ultrasonography (USG) was determined. Keeping NCS taken as the gold standard, the two by two tables used for the USG findings to find the sensitivity and specificity, positive predictive value, negative predictive value, and diagnostic accuracy of ultrasonography in accurately diagnosing CTS. Chi square test done to find the significance of USG findings. The level of significance was 0.05. The ROC curve is drawn for true positives and true negatives. Area under the curve (AUC) depicts the diagnostic accuracy of USG in diagnosing carpal tunnel syndrome**.**

RESULTS

Of the 80 patients and 160 hands tested, 8 patients were male and 72 were females. Mean age of the patients was 37.6 ± 9.1 years (24–55 years) and the gender ratio

was 1:9 [M:F]. On NCS, 142 hands (89%) were tested positive for CTS and 18 hands (11%) were tested negative. (Table 1). On ultrasonography, 128 hands (80%) had CSA of more than 8.5mm^2, and 32 hands (20%) less than 8.5mm^2.(Table 2). Sensitivity of USG was 91% with 90% specificity. Diagnostic accuracy was 88% for USG to diagnose CTS. Chi square test for significance was done for the same samples undergoing the two tests. (Table 3). The results were significant with a p-value 0.0005 (.05). Of the female patients, 91.5% have positive nerve conduction studies and 75.6% females have positive results on USG. 75% of males have positive nerve conduction studies and 44% have positive USG. The ROC curve drawn for sensitivity and 1-specificity, shows that more than 80% of patients were successfully detected as having CTS on USG. It indicates that the test is a good test to diagnose CTS.

Table No.1: Nerve Conduction Studies Results n=160

	Positive	Negative
Male	12	4
Female	130	14
Sub Total	142	18
Total	160	

Table No.2: Wrist Ultrasonography Results N=160

	Positive (CSA >8.5)	Negative (CSA <8.5)
Male	7	9
Female	121	23
Sub Total	128	32
Total	160	

Table No.3: Outcome parameters of USG

Sensitivity	91%
Specificity	90.00%
PPV	98.40%
NPV	60%
Accuracy	88%

DISCUSSION

The diagnosis of CTS is based primarily on typical clinical signs and symptoms and confirmed by nerve conduction studies. Median nerve ultrasonography has been considered a potential diagnostic tool in diagnosing CTS[8]. The CSA measurement at the carpal tunnel inlet is most frequently used for the diagnosis of CTS by ultrasound[16]. In our study, we used inlet CSA of the median nerve of symptomatic high probability cases of CTS.

In our study, of the 80 patients and 160 hands tested, 8 patients were male and 72 were females. Mean age of the patients was 37.6 ± 9.1 years (24–55 years) and the gender ratio was 1:9 [M:F]. On NCS, 142 hands (89%) were tested positive for CTS and 18 hands (11%) were tested negative. On ultrasonography, 128 hands (80%) had CSA of more than 8.5mm^2, and 32 hands (20%) less than 8.5mm^2. Sensitivity of USG was 91% with 90% specificity. Diagnostic accuracy was 88% for USG to diagnose CTS. The results were significant with a p-value 0.0005 (.05). In our study women were much higher in number than men. The factors underlying increased incidence include hormonal factors, higher frequency of musculoskeletal problems. CTS in women causes swelling and increased pressure on the median nerve. Similar to other studies, the women in the middle age group are frequently affected [17]. Most of the study participants were household women, who are engaged in daily chores like washing clothes and other cleaning tasks. All these increase the risk of developing CTS by causing frictional inflammation and tendon pressure[18].

Although electrodiagnostic studies are more accurate in diagnosis of CTS, USG can identify the underlying pathology causing CTS, anatomical variants or space occupying pathology[19].

Median nerve CSA values were 11.64 mm^2 for mild, 13.74 mm^2 for moderate, and 16.80 mm^2 for severe CTS in a meta-analysis of 16 studies[20]. In compression neuropathies, peripheral nerve CSA is an important USG finding.

Our study clearly shows that USG is comparable to NCS in the diagnosis of CTS. Inlet CSA is a valuable measurement, can be done at low cost and with less technical expertise. Women, due to their physiological make up, are more likely to develop CTS. Routine household activities are important contributory factors.

Our study has certain limitations, it uses a cut-off value of ≤ 8.5 and also uses single criteria to confirm CTS diagnosis. It does not take into account the severity or grading of CTS and compare it with the CSA values. This can help in further classifying the USG values for higher and severer grades of CTS on USG. Also the sample size can be increased and a case control study can be done to compare the asymptomatic control group to sampled group for comparison of CSA values in symptomatic and asymptomatic groups.

CONCLUSION

Ultrasonography is comparable to nerve conduction studies for the early diagnosis of CTS. It can effectively exclude the secondary causes of CTS. It is cheap, readily available and does not require much technical expertise and equipment.

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Author's Contribution:

Concept & Design of Study:	Muhammad Wazir Ali Khan
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Conflict of Interest: The study has no conflict of interest to declare by any author.

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