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ORIGINAL ARTICLE

Comparison of Ultrasonographic Assessment of Cross Sectional Area of the Median Nerve in the Diagnosis of Carpel Tunnel Syndrome with Nerve Conduction Studies

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ABSTRACT

Background: Carpal Tunnel Syndrome (CTS) is a common problem which interferes with the normal use of the hand. It has general population prevalence of 16%.

Objective: The objective of this study was to determine the validity of high-resolution ultrasound (US) in carpal tunnel syndrome in adult patients using nerve conduction studies (NCS) as gold standard.

Study design & Settings: Cross sectional validation study with purposive (non-probability) sampling conducted in the Department of Diagnostic Radiology, Federal Government Polyclinic Hospital, Islamabad in collaboration with outdoor departments of Neurology and Rheumatology of the same hospital.

Study duration: The study was conducted in Federal Government Polyclinic Hospital Islamabad for duration of one year, from November 2021 to November2022.

Methods : 152 patients were included in study group who underwent ultrasound by using 12 – 15MHz linear transducer. Later on their nerve conduction studies were performed & results were compared.

Results: There were 152 patients included in the study, with 47 (30.9%) males and 105 (69.1%) females and overall mean age of 33.74±11.58 years. The sensitivity of ultrasound to detect carpel tunnel syndrome was calculated to be 90.6% while specificity was found to be 82.52 %. The positive predictive value, negative predictive value and diagnostic accuracy of 86.5%, 87.3% and 86.8% was reported, respectively.

Conclusion: High resolution US is an accurate imaging study with diagnostic accuracy of 86.8% and gives results comparable to NCS. It can be used in patients unsuitable for the latter modality.

Keywords: Carpel tunnel syndrome (CTS), ultrasound (US), Nerve conduction studies (NCS).

INTRODUCTION

Carpal tunnel syndrome (CTS) is caused by compression of the median nerve within the carpal tunnel, is the most prevailing peripheral nerve entrapment disease.[1] Its prevalence varies world wide in the range of5% [2, 3] to 16.6% [4,5].Adult women between the ages of 40 and 60 have a two- to three-fold higher prevalence of the illness than men.[6] The risk factors that are most frequently associated with the development of CTS are post-menopausal status, pregnancy, high BMI, rheumatoid arthritis, diabetes mellitus, thyroid illnesses, and kind of profession.[7]

The history, physical exam, and electrophysiological testing (EP), if required, were traditionally used to determine the diagnosis of CTS. However, the more invasive nature and higher false-negative incidence of EP tests have prompted a search for alternative diagnostic modalities that are more suitable and minimally invasive. [8] Furthermore, as a diagnostic imaging modality for CTS, ultrasonography (US) is being employed increasingly frequently in routine clinical practice. Moreover, it can spot structural differences, changes in nerve form, and lesions that take up space, such tenosynovitis and ganglion cysts. [9] High-resolution US and the gold standard, NCS, have comparable sensitivity and specificity, which have been reported to be 82%-94% and 65%-97%, respectively.[10]

Due to its widespread accessibility, simplicity of use, mobility, noninvasiveness, and affordability, high frequency ultrasonography has been shown in numerous trials to be beneficial in the diagnosis of CTS. [11] For this reason, the cross-sectional area (CSA) of the median nerve at different locations can be assessed. For the diagnosis of CTS, several studies proposed various cut-off values, with cut-off points of CSA at tunnel inlet in CTS patients ranging from 6.5 to 15 mm^2. [12] Patients who underwent nerve conduction tests (NCS) for the diagnosis of CTS reported discomfort and anxiety.[13]The objective of this study is to determine the validity of US for the diagnosis of CTS in adult patients using NCS as gold standard. The results could help in prompt and early diagnosis of CTS as facility of US is easily available in health care facilities as compared to EP studies. Use of US will also reduce cost, anxiety and discomfort associated with NCS.

MATERIAL AND METHODS

This is a validation cross-sectional study carried out in the department of Diagnostic Radiology in collaboration with outpatient departments of Neurology and Rheumatology at Federal Government Polyclinic Hospital, Islamabad from November 2021 to November 2022. The sample size of 152 was calculated for this study, by using the WHO sample size calculator. The parameters for sample size calculation included 16% prevalence of carpal tunnel syndrome in the general population,[4,5] 94% sensitivity of ultrasound to detect tunnel carpel syndrome with the specificity of 50%,[14]95% level of confidence, 80% study power, and 10% precision. Permission from the hospital ethical committee was sought before study commencement.

Clinically diagnosed cases of CTS of either gender with ages between 15 to 80 years and willing to participate in the study were included. Already diagnosed cases of CTS on basis of NCS, clinically suspected cases of brachial plexopathy, C6 radiculopathy, cervical disc syndromes, De Quervain tenosynovitis syndrome, interosseous syndrome, proximal median neuropathy, and patients with an open wound over wrist were excluded from the study. Verbal and written informed consent was obtained after explaining the procedure to the patients and they have explained clearly that it is a research study and their scans and NCS will be done free of cost without any harmful effects and radiation exposure during or after the procedure. Patients were scanned sonographically using high-frequency linear probe followed by NCS including recording of, distal motor latency, motor amplitude, distal sensory latency, sensory amplitude, and conduction velocities of motor and sensory nerves by a consultant neurologist, unaware of the US findings. Patients were labelled as true positive

having CTS on both US and NCS, true negative with no CTS on US and NCS, false positive as having CTS on ultrasound but not on NCS, false negative with no CTS on US but present on NCS.

Ultrasound Technique: Ultrasound scan was performed on a Toshiba Xario-100 ultrasound machine with a linear transducer of 12 to 15 MHz frequency, prior to nerve conduction studies. A consultant radiologist performed the ultrasound on all the patients, in a transverse plane, at distal wrist crease, keeping the focal zone, depth, gain, and frequency constant.[16] By using the default measurement software, the CSA of the median nerve was measured at the carpal tunnel inlet (level of the pisiform and scaphoid). [17,18] The separate CSAs of the two components were added to find out the CSA of bifid median nerve. At the level of carpal inlet, median nerve is seen as an oval shaped structure.

Sonographic features were recorded in the proforma and the patients were sent for nerve conduction studies which were subsequently taken as a gold standard. A comparison of the results of the ultrasound and nerve conduction study was done.

Data Analysis Procedure: Data was entered and analyzed using the data management software IBM Statistical Package for Social Sciences (version 23.0). Descriptive statistics were performed for quantitative variables as mean along with standard deviation. The 2x2 table was constructed to tabulate true positive, true negative, false positive and false negative cases based on which diagnostic accuracy in terms of sensitivity, specificity, positive predictive value, and negative predictive value was calculated. A p-value of ≤0.05 will be considered statistically significant.

RESULTS

In this study data from 152 patients was included in the analysis. The study group comprised mainly patients from the department of Neurology and Rheumatology department. Outdoor, indoor, and referred patients were considered, of which, however, outdoor patients were in majority. There were 47 (30.9%) males and 105 (69.1%) females with an overall mean age of 33.74±11.58 years (age range 15 to 80 years). The majority of the patients belonged to the age group of 36-55 years. Table 1 shows the baseline characteristics of the study population. It was found that the left wrist was involved in 56 patients (36.8%) and the right wrist was involved in 96 patients (63.1%) thus showing that the right wrist was more involved than the left wrist.

Table 1: Baseline demographic characteristics of study participants (n=152)

Characteristics	Frequency (n)	Percentage (%)
Age in years (mean±SD)	33.74±11.58 years	
Age range	15 – 80	
Age groups		
15-35 years	28	18.4%
36-55 years	63	41.4%
55-75 ears	51	33.5%
>76 years	10	6.5%
Wrist involvement		
Right	96	63.1%
Left	56	36.8%

Upon performing the ultrasound examination, it was observed that 89 (58.5%) cases were positive for CTS, while 63 (41.4%) were negative. Out of 89 positive cases, 77 (86.5%) cases were positive on NCS and thus regarded as true positive cases. On the other hand, 63 (41.4%) patients showed normal median nerve diameter on ultrasound examination. Out of 63, 55 (87.3%) were also normal on the gold standard NCS test, thus regarded as true negatives as shown in table 2.

Table 2: 2x2 table with true positive, true negative, false positive, false negative cases

	Evidence of CTS by NCT	No evidence of CTS by NCT	
Positive CTS on USG	77	12	89
Negative CTS on USG	8	55	63
	85	67	152

There were 12/89 (13.4%) false positive cases, in which ultrasound findings were suggestive of carpel tunnel syndrome but NCS results proved otherwise. Similarly, 8/63 (12.6%) cases were false negative, in which ultrasound examination failed to highlight the disease which was proved otherwise by NCS test result.

This study revealed a sensitivity of 90.6 % (77/85), specificity of 82.1% (55/63), the positive predictive value of 86.5% (77/89), the negative predictive value of 87.3% (55/63), and diagnostic accuracy of 86.8 % (132/152).

DISCUSSION

Most studies support equivalent sensitivity and specificity when tak ing intoaccount both NCS and US, and ultrasound has lately gaine d respect as a helpful technique for the proper diagnosis of carpal t unnel syndrome.[19]

Our study demonstrated higher sensitivity of 90.6% (77/85), specificity of 82.1% (55/63), positive predictive value of 86.5% (77/89), negative predictive value of 87.3% (55/63), and diagnostic accuracy of 86.8% (132/152). These findings were consistent with a case series of 85 patients conducted by Fowler JR. et al.[20] that showed sensitivity and specificity to be 89% and 90%, respectively. Compared to electro diagnostic testing, ultrasonography has an 82% higher negative predictive value. In contrast to electro diagnostic testing, which had a diagnostic accuracy of 86%, ultrasound had an accuracy of 89% (p = 0.5).It was also demonstrated that when the clinical diagnosis was employed as the reference standard, ultrasonography (US) exhibited comparable sensitivity and specificity to NCS. Moreover, a meta-analysis conducted in 2011 found that ultrasound has sensitivity and specificity of 77.6% (95% confidence interval (CI) 71.6-83.6%) and 86.8% (95% CI 78.9-94.8%), respectively, for the diagnosis of CTS.[21]

In contrast to our findings, Wang L. et al. 22 evaluated five different clinical diagnostic modalities and discovered that the NCS had the best sensitivity (94%) and highest NPV (87%), but that its specificity (50%) was lower. As opposed to this, a case-control study by Azami A. et al.[23] revealed a substantial difference in the cross-sectional area (CSA) of the median nerve in mild, moderate, and severe CTS. Nonetheless, our study's sensitivity and specificity (99.2% and 88.3%, respectively) were comparable to those of the US.

When using a threshold CSA value of 1.0 mm^2, Monika Singhla et al. [24] discovered that the sensitivity and specificity of ultrasonography were 100% and 88%, respectively. In addition to disease severity, nerve size related to height, sex, weight, age, race, and visual quality also influences diagnostic accuracy and cutoff values.[25]

Our study obtained results show that the US is a useful screening tool in clinically suspected cases of CTS before undergoing NCS. It was observed when US diagnosis showed a normal median nerve diameter NCS was almost always normal in these cases (86.9%). It signifies that if the US used as a screening tool diagnoses a median nerve as normal, NCS can reliably be omitted. But on the other hand, if a median nerve diameter is increased as detected in the US, NCS should be planned to confirm the findings. Thus unnecessary NCS can be avoided by using US as our first line screening tool which is readily available, inexpensive, comfortable for the patient, and reliable.

CONCLUSION

High resolution ultrasound (US) is an accurate imaging study with diagnostic accuracy of 86.8% and gives results comparable to NCS. It can be used in patients unsuitable for the latter modality.

The diagnostic potential of high resolution US for median nerve diameter is good and comparable with thatof NCS in regard for diagnosing the carpal tunnel syndrome.

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