ORIGINAL ARTICLE

ASSESSMENT OF CARPAL TUNNEL SYNDROME WITH ULTRASONOGRAPHY

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Background: Carpal tunnel syndrome (CTS) is the most common nerve entrapment neuropathy caused by compression of median nerve at wrist as it passes through Osseo fibrous canal known as carpal tunnel. Epidemiological statistics shows one in every ten people develops the disease at any stage of life. CTS mostly affect females than males with mean age of 50. Clinical features are considered to be enough for establishing the diagnosis of carpal tunnel syndrome. However, nerve conduction studies give quantitative information regarding median nerve function therefore good at predicting outcome of intervention. Ultrasound being easily available, cost effective and real time is a promising modality for diagnosis and grading carpal tunnel syndrome. **Methods:** This correlational study was conducted in collaboration of Neurology and Radiology Department of Pakistan Institute of Medical Sciences, Islamabad from January 2018 to January 2019. Total 50 patients with 85 wrists involved were included in the study. All patients with positive nerve conduction study were included. Patient with history of wrist trauma were not included. Detailed history and clinical features were recorded. All patients with positive result on nerve conduction studies underwent ultrasound examinations. Fifty control wrists were also included to establish the normal median nerve cross sectional area value in our study population. Results were recorded. Data was analyzed and appropriate statistical tests were applied by using SPSS v20. **Results:** Mean cross sectional area of median nerve for controls was 6.34±1.23. Mean cross sectional area of median nerve for mild CTS was 8.05±1.72, moderate CTS was 11.15±2.32, severe was 17.49±4.93. Strong correlation was found between (r=0.76, *p*-value <0.0001) between increased cross-sectional area on Ultrasonography and severity of CTS on NCS. Other finding on Ultrasonography included flattening in 4 and fluid in 10 affected wrists. **Conclusion:** Increased cross-sectional area on Ultrasonography and severity of carpal tunnel syndrome on nerve conduction studies are very strongly correlated.

Keywords: Carpal Tunnel Syndrome; Ultrasonography; Median Nerve Caliber; Nerve Conduction Studies

Citation: Ahmed A, Malik G, Imtiaz H, Riaz R, Badshah M, Zameer S. Assessment of carpal tunnel syndrome with ultrasonography. J Ayub Med Coll Abbottabad 2022;34(2):295–9.

INTRODUCTION

Carpal tunnel syndrome (CTS) is the most common nerve entrapment neuropathy caused by compression of median nerve at wrist as it passes through Osseo fibrous canal known as carpal tunnel. Epidemiological statistics shows one in every ten people develops the disease at any stage of life. CTS mostly affect females than males with mean age of 50.[1] Risk factors of CTS include diabetes, hypertension, hypothyroidism, rheumatoid arthritis, obesity, smoking, pregnancy and fracture involving wrist. Obesity increases the risk of CTS by two times. Pregnancy increases the risk by combination of oedema and hormonal imbalance. Long term alcohol drinking increases the risk of peripheral neuropathies by causing axonal degeneration and demyleination. Although not significant but alcohol intake is now also considered to be a risk factor for developing CTS.[2]

Clinical examination is alone enough for diagnosing CTS. Pain, numbness, tingling and weakness are most common complaints by patients of CTS. Positive Tilen test and Phalen's test aids in diagnosis. Among electrodiagnosis of CTS, nerve conduction studies are the most useful in determining the severity of carpal tunnel syndrome. Electromyography is also used for establishing the diagnosis however less useful than nerve conduction studies (NCS). Both sensory and motor NCS are recorder for determining the severity of NCS.[3] Till now no radiological investigation is considered to be diagnostic for CTS. With advance protocols in MRI like tensor imaging, fractional anisotropy for diagnosing demyelination, studies are focused on their possible role in diagnosing CTS. Cross-sectional area measurement of median nerve on MRI and fractional anisotropy could aid in diagnosing CTS.[4]

Due to underlying pathophysiological mechanism involving CTS, median nerve compression results in

changes in its calibre. At site of maximum compression nerve gets flattened. And above it gets swollen due to Vaso congestion resulting in increased endoneural fluid and oedema. Measurement of cross-sectional area at this point could help in establishing the diagnosis and severity of disease.[5] Ultrasonography is real time, non-ionising and cost-effective technique for visualizing soft tissues. Measuring the median nerve cross sectional area on ultrasound is helpful in determining CTS and its severity.[6]

Currently, in Pakistan CTS is diagnosed on the basis of clinical features and nerve conduction studies. However, due to high cost of NCS and lack of availability in rural areas, disease is diagnosed only on clinical features. Ultrasound being cost effective and readily available will add in clinically establishing the severity of disease. Current study was conducted to find the relation of median nerve cross-sectional area measurement on ultrasound and disease severity on nerve conduction study and to establish baseline values of median nerve cross sectional area in controls and cases with increasing severity.

MATERIAL AND METHODS

This correlational study was conducted in collaboration of Neurology and Radiology Department of Pakistan Institute of Medical Sciences, Islamabad from January 2018 to January 2019. Total 50 patients with 85 wrists involved were included in the study. All patients with positive nerve conduction study were included. Patient with history of wrist trauma were not included. Detailed history and clinical features were recorded. To establish a reference range, 50 control wrists were also included in the study. Healthy individuals without any signs and symptoms of disease were taken as controls.

All patients were graded according to findings on NCS. NCS was performed with nicolet wiking quest EMG/NCS/EP system. Both motor and sensory nerve studies were performed. Motor NCS was performed by placing electrode over abductor pollicis and stimulating median nerve at wrist. For sensory NCS electrode was placed over nerve at wrist and fingers stimulated by ring electrodes. Grading of CTS was done on criterion defined by Losher *et al*.[7] Mild disease was considered in patients with abnormal segmental or comparative test only, moderate with abnormal digit/wrist sensory nerve conduction velocity & abnormal distal motor latency and severe disease in patients with absent sensory response with abnormal or absent distal motor latency.

Ultrasound was performed with state of art 14 MHz hockey stick transducer by Aplio500. Median nerve cross sectional area was measured at its maximum calibre, i.e., above carpal tunnel.

Data was analyzed with SPSS-20. Mean and standard deviations were calculated for quantitative data, i.e., cross-sectional area in control, mild, moderate and severe disease and to establish cut-off values. For establishing significance of cross-sectional area in controls versus mild disease, mild disease versus moderate disease and moderate disease versus severe, unpaired T-Test was applied. For checking correlation between NCS finding and ultrasonographic findings Pearson correlation coefficient was calculated. Correlation was considered significant at less than p-value<0.01.

RESULTS

Mean age of control was 43.03±15.3. Mean age of the patients was 41.03±13.6 years. Majority (n=40, 80%) of the patients were females. Among 50 patients, 34 patients had bilateral involvement, 11 had only right wrist affected and 6 had only left wrist affected. Most common (97.64%) complaint in the affected wrist was numbness followed by tingling (84.7%), pain (77.64%) and weakness (34.11%). Positive Tinel sign was present in 76% of the wrist while phalen's test was positive in 66% of the wrists. Most of the patients had intact vibration (86%) and proprioception (92%) (Figure-1).

Among history of positive risk factors, only 16% had positive history of diabetes, 4% were pregnant, 4% had rheumatoid, 2% had chronic kidney disease and 2% were hypothyroid.

Majority (n=46) of the wrist had mild CTS, 29 had moderate CTS and 10 had severe CTS on nerve conduction studies. Mean cross sectional area of median nerve for mild CTS was 8.05±1.72, moderate CTS was 11.15±2.32, severe was 17.49±4.93 (Table-1). Mean cross sectional area of median nerve for right wrist of control was 6.16±1.17 while for left wrist was 6.56±1.26. Overall mean cross-sectional area for controls was 6.34±1.23.

Significant difference (unpaired T=-5.3, p-value<0.0001) was found between mean cross sectional area of right median nerve between mild disease and control. Similarly significant difference (unpaired T=-3.2, p-value p-value<0.0001) was found between mean cross sectional area of right median nerve between mild disease and control.

Strong correlation was found between (r=0.77, p-value <0.0001) was found between increased cross-sectional area on Ultrasonography and severity of CTS on NCS (Table-2). Significant difference (unpaired T=-2.6, p-value p-value<0.01) was found between mean cross sectional area of right median nerve between mild disease and moderate disease. Significant difference (unpaired T=-3.4, p-

value *p*-value<0.0001) was found between mean cross sectional area of left median nerve between mild disease and moderate disease. Significant difference (unpaired T=-4.06, *p*-value *p*-value<0.0001) was found between mean cross sectional area of right median nerve between moderate disease and severe disease. Significant difference (unpaired T=-5.3, *p*-value *p*-value<0.0001) was found between mean cross sectional area of left median nerve between moderate disease and severe disease.

Among 46, patient with mild CTS, majority of patients did not have any associated finding. However, among patients with moderate and severe CTS on NCS, ultrasound showed additional features of free fluid and flattening. (Figure-2).

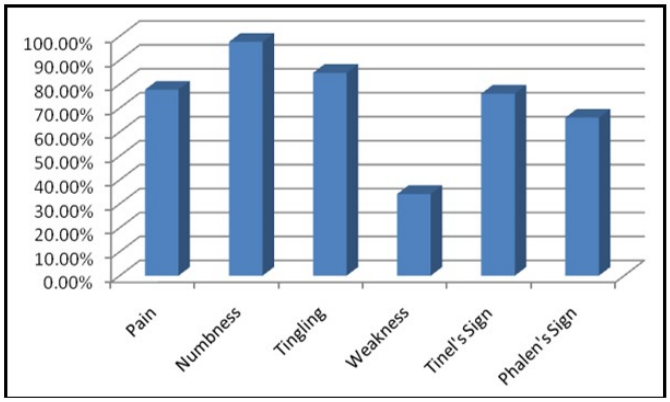

Figure-1: Clinical Feature of the patients of CTS

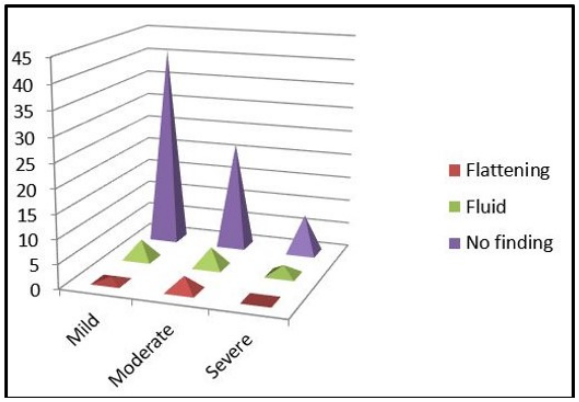

Figure-2: Associated ultrasound findings in CTS patients

Table-1a: One-Sample Statistics

	n	Mean	Std. Deviation	Std. Error Mean
Controls	50	6.3469	1.23408	.17630
Mild	46	8.0587	1.52630	.22504
Moderate	29	11.1538	2.32452	.45588
Severe	10	17.4900	4.93524	1.56066

Table-1b: One-Sample Test

	Test Value = 0					
	T	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Control	36.001	48	0.0001	6.3469	5.9924	6.7014
Mild	35.810	45	.00001	8.0587	7.4378	8.4622
Moderate	24.467	28	.00001	11.15385	10.2150	12.0927
Severe	11.207	9	.00001	17.49000	13.9595	21.0205

Table-2: Correlation between CTS & CSA

		CTS	CSA
CTS	Pearson Correlation	1	.772**
	Sig. (2-tailed)		.000
CSA	Pearson Correlation	.772**	1
	Sig. (2-tailed)	.000	
**Correlation is significant at the 0.01 level (2-tailed).			

DISCUSSION

Carpal tunnel syndrome affects 10 million people yearly and is among the most expensive musculoskeletal disorder resulting in cost burden on health care services.[8] Its prevalence is estimated to be 2.7–5.8% with lifetime incidence of 10–15%.[9]

Till now clinical features are considered to be enough for establishing the diagnosis of CTS. Among signs of CTS, sensitivity and specificity of tinel test in diagnosing CTS is 61% and 91 % while that for phalen's test is 33% and 93%.[10] NCS is also not 100% sensitive and specific, false positive and false negative studies do occur but NCS gives quantitative information regarding median nerve function therefore good at predicting outcome of intervention. Majority of guidelines recommend both clinical features and NCS to be considered in planning intervention.[11] In current study, 76% of the diagnosed patients had positive tinel test while 66% had positive phalen's test.

Musculoskeletal imaging is becoming increasingly used for assessment of carpal tunnel syndrome. MRI and ultrasound are the most studied

modalities. Ultrasound being easily available, cost effective and real time is a promising modality for diagnosis and grading carpal tunnel syndrome. In most of the studies increased cross-sectional area of median nerve on ultrasound has been found to be associated with carpal tunnel syndrome. However still some major concerns remain pervasive. Firstly, different studies had reported considerable variability in sensitivity and specificity of ultrasound in diagnosing CTS varying 78–97%.[8,12] Secondly most of the studies have taken cross-sectional median nerve value area of 9–11 mm as cut off for diagnosing CTS. However, this threshold has been proven too high or too low by other studies. As there is lack of large scale studies on normal median nerve cross-sectional area in different populations and age group. Therefore, till now no standard value has been set.[7] A study by Mani B *et al*., to establish normal range of median nerve found CSA of median nerve to be 5.2–9.6 mm on sonography.[13] Study by Ghasemi *et al*., find out normal median nerve calibre to be 7.7±1.1 in 124 normal wrists. However, both studies are limited by small sample size.[14] Also there is debate on exact site of measurement, however most of the studies recommend to measure at maximum nerve calibre just above the carpal tunnel.[8] In current study median nerve cross sectional area was found to be between 5–7 mm among controls with mean of 6.34 mm. According to study by Klauser, a 2 mm^2 difference in nerve cross-section area between the level of the pronator quadratus and the carpal tunnel has 99% sensitivity and 100% specificity for diagnosing carpal tunnel syndrome.[15] According to results of current study cut-off value of 8 mm can be safely used for diagnosing disease, 8–9 mm for mild disease, 10–12 mm for moderate disease and above 13mm for severe disease.

Despite of these limitations' ultrasound is considered to be an accurate modality in grading CTS. Miedany recommended median nerve calibre cut off for grading CTS to be 10–13 for mild, 13–15 for moderate and >15 for severe CTS.[16] In another study mild CTS was found to be 10.2±4.6mm, moderate CTS to be 11.6±2.6 and severe to be 17.1±7.5mm.[17] In our study, mean cross sectional area of median nerve for mild CTS was found to be 8.05±1.72, moderate CTS was 11.15±2.32, severe was 17.49±4.93. Our results were in concord with above mentioned studies.

When correlated with NCS, we found strong relation (r=0.76, *p*-value <0.0001) between increased cross-sectional area on Ultrasonography and severity of CTS on NCS. Among other related finding we found flattening and fluid in CTS patients, this was also in concord with studies in other countries of world.[5] Our results indicate that Ultrasonography can be used for grading CTS. In our study mean cross-sectional area of control was 6.34 mm with range of 5–7 mm, which shows that cut-off value of 8 mm can be safely used in diagnosing CTS in our study population.

CONCLUSION

Increased cross-sectional area on Ultrasonography and severity of carpal tunnel syndrome on nerve conduction studies are very strongly correlated. Therefore, Ultrasonography can be used in grading severity of carpal tunnel syndrome. Being cost effective and readily available it will be good alternative where nerve conduction studies are not available. Cut-off value of 8 mm can be used safely in our study population.

AUTHORS' CONTRIBUTION

AA: All ultrasound done, data collected, writing article. GM: *Proforma* filling and collected feed back. HI: Did all nerve conduction studies and feed back. RR: All statistical and test application. helped in writing the article. MB: Gave topic of research and supervised nerve conduction studies. SZ: Approved study and supervised median nerve ultrasounds

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Submitted: July 25, 2021	*Revised: --*	*Accepted: August 8, 2021*

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