Original Article

The Role of Musculoskeletal USG as Diagonostic Tool of CTS

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Abstract

Introduction: Over the years NCS has been used to diagnose and monitor the patients with CTS though USG has several advantages as diagnostic tool. This study has been done to find out the diagnostic accuracy of USG in CTS and to compare the efficacy of USG with standard NCS in CTS.

Prospective cross-sectional analytical study was conducted at Dept. of PM&R, IPGME&R, Kolkata from 1st March, 2012 to 31st August 2012 (6 months). Patient with clinical diagnosis of CTS of age >18 year of both sexes were included in this study and on the other hand patient with previous wrist surgery /injury, wrist deformity, diabetes mellitus, anatomical variants of median nerve on ultrasound were excluded from the study.

Methodology: After getting institutional ethical committee clearance, all patients who fulfil the above criteria were included in the study and further diagnostic conformation done by the standard diagnostic criteria of NCS. The same group of patients have been also screened by ultrasonography (USG).

Results: At the end of the study, data analysis showed that sensitivity and specificity were 92.3 and 70.0% respectively. Predictive value of +test, predictive value of -test were 88.9 and 77.8% respectively. Kappa value was 0.64 (between 0.5 and 0.7). It signifies that there is good correlation between NCS and USG as diagnostic tool of CTS. The comparison of the numerical values of median latency, amplitude and CSA USG within the groups with the help of ANOVA followed by Tukey's test showed that there was good correlation between latency and amplitude in mild, moderate, severe and profound CTS but unfortunately it was not correlated with the CSA measured by USG.

Conclusion: USG can be used for screening large population of patients as it is simple, easily available, non-invasive test and has relatively low cost and useful in evaluating and excluding local causes of nerve compression.

Key words: **Nerve conduction studies, ultrasound, carpal tunnel syndrome.**

Introduction:

Carpal tunnel syndrome (CTS) is the compressive neuropathy of the median nerve as it passes under the flexor retinaculum at the volar aspect of wrist [1]. It is characterised by numbness and pain in the lateral three digits. In advanced cases there may be wasting of thenar muscles[2,3]. There is an estimated 9% prevalence of carpal tunnel syndrome among adult women and 0.6% prevalence among adult men[4]. The diagnosis of CTS is usually made on a combination of clinical signs such as the Tinel sign and the Phalen sign and electrophysiological examination. Although nerve conduction studies (NCS) provide important information, it has 95% specificity and a sensitivity ranging from 49% to 86%[5]. Nevertheless, an electro-diagnostic study remains an expensive and technically demanding time-consuming procedure and is not easily accessible for many physicians. NCS indicate the level of the lesion but they do not provide spatial information about the nerve and its surroundings that could help in determining its aetiology. Not only that but also NCS cannot diagnose clinically mild cases of CTS [6]. In recent

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years the imaging techniques like MRI and ultrasound have been shown to be of value in the diagnosis of CTS. Both of these show the anatomy of the carpal tunnel and the morphology of the median nerve quite accurately, and therefore provide information about local causes of CTS, which cannot be gained by the NCS [3]. Advances in ultrasound technology have made it possible to achieve a good spatial resolution for clear evaluation of the peripheral nerves. Wide availability, lower cost, non-invasiveness and shorter examination time are the advantages of sonography for primary evaluation of CTS. Usefulness of USG in the diagnosis of carpal tunnel syndrome are already reported in different literatures[7].

Many authors believe that the electrophysiological study may be used as the gold standard for the confirmation of clinically diagnosed CTS[8]. Mohammadi *et al*[6] showed that a combination of clinical findings and the electrophysiological study may be used as the gold standard.

Ultrasound techniques using high frequency transducer of 7-15 MHz provide excellent display of carpal tunnel and superficially situated median nerve. Quantitative analysis may prove useful in the diagnosis of nerve entrapment at carpal tunnel. Studies carried out so far show that in CTS, the cross-sectional area of median nerve is increased more than 10mm^2 when measured at proximal boundary of carpal tunnel (as compared to 6mm^2 to 9mm^2 in asymptomatic individuals). There is anterior bowing of flexor retinaculum more than 2.5mm from a line drawn from tubercle of triquetrum to the hook of hamate bone and is flattening of the median nerve at tunnel outlet. The present study was carried out to find out the diagnostic accuracy of ultrasound in comparison with NCS, being cheap, easily available and quick to perform non-invasive test[3]. This study was also performed to determine whether sonography might be an alternative method to nerve conduction study in the diagnosis of carpal tunnel syndrome.

Materials and Methods:

This cross-sectional analytical study was conducted in the Department of Physical Medicine and Rehabilitation of IPGME&R, Kolkata, India from 1st March, 2012 to 31st August 2012 (6 months). After getting institutional ethical committee clearance, patients of both sexes between 20 and 60 years of age, with symptoms of nerve compression at wrist were included in the study group according to following inclusion and exclusion criteria.

Inclusion criteria:

- Patient with clinical diagnosis of CTS
- Patient who give consent
- Age >18 years
- Both sexes

Exclusion criteria:

- Patient who did not give consent
- Age <18 years
- Patients with previous wrist surgery /injury, wrist deformity
- Diabetes mellitus
- Anatomical variants of median nerve on ultrasound.

Clinically confirmed cases of CTS are assessed based on phalen sign, tinel sign, tenderness and VAS was recorded and severity grading was done. Total 36 wrists were included, of which each wrist was considered separately in the clinical diagnosis. Thereafter all patients had undergone nerve conduction study and ultrasound study to confirm the diagnosis.

All patients had high resolution real time ultrasound (USG) of the wrist with a 12 MHz linear transducer. The patient was made to sit in a comfortable position on a stool facing the examiner. The forearm was resting on the table with palm in a supine neutral position and the fingers in a semi flexed position. The ultrasound examination was started at the proximal boundary of the carpal tunnel at the intersection of the distal transverse wrist crease with the longitudinal wrist crease. The carpal tunnel appears as a lentiform hypoechoic area at the anterior aspect of wrist bounded medially and laterally by strongly reflecting bones and anteriorly by flexor retinaculum which appears as an echogenic linear structure slightly convex anteriorly. The median nerve here was identified on the basis of its superficial position at the radial aspect of the carpal tunnel, its internal fascicular echotexture, isotropy and lack of motion in contrast to the moving tendons as the fingers were extended and flexed. After identification of the median nerve, it was imaged from approximately 4 cm proximal to the wrist crease to distally until the median nerve was no longer visible. The mobility of the median nerve was exhibited as slight rocking caused by the movement of adjacent tendons as the fingers were flexed and extended one by one. Next, the median nerve was imaged in a sagittal plane (Figs 1&2). The continuity of the median nerve, any area of constriction and irregularity of the outline were assessed. Thereafter the entire carpal tunnel was scanned from side to side.

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Fig 1- *Showing the Median Nerve*

Fig 2- *Showing the Median Nerve*

The median nerve cross sectional area (CSA) was measured in mm^2. This was done in a transverse plane and taken at the level of the proximal wrist crease. The pisiform bone was taken as a landmark. To ensure the consistent transverse images and that measurement of a true cross-sectional area the following precautions were taken.

(i) The ulnar artery was identified in cross-section just medial to the longitudinal wrist crease along the ulnar aspect.

(ii) The probe was kept perpendicular to the long axis of the nerve.

To take the measurements the cursor was placed at the echogenic rim around the nerve and the area was traced along that echogenic rim. The area was displayed only when the final trace was complete.

NCS measurements were done by included median nerve motor and sensory distal latencies and sensory conduction velocities of symptomatic wrists using RMS EMG EP MK II software. A sensory latency longer than 3.5 m/second and a motor latency longer than 4.4 m/second were considered abnormal. Normal ulnar nerve motor and sensory latencies with increased median nerve latencies were considered diagnostic of CTS.

Data Analysis and Results:

All the data collected were entered in computer programme statistical version 6 and analysed. The qualitative variables analysed were sex and history of present illness. The quantitative variables analysed were age and median nerve measurements i.e. cross sectional area and distal motor latency (DML). Sensitivity, specificity, diagnostic accuracy and predictive values were calculated.

In our study, there were total 28 patients of which 8 had bilateral involvement. Mostly female patients (n=24, 85.71%) had suffered from CTS, though there were 4 (14.29%) male patients in our study. We have tabulated the data (Table 1) taking NCS as the gold standard for the diagnosis of CTS.

Table 1: *Comparative Diagnostic Table Using NCS as Gold Standard*

Test result (USG)	Positive	Negative	Total
Positive	24	3	27
Negative	2	7	9
Total	26	10	36*

*8 had bilateral movement

From the above data calculated sensitivity and specificity were 92.3 and 70.0% respectively. Predictive value of +test, predictive value of –test were 88.9 and 77.8% respectively (Table 2).

Table 2: *Diagnostic Value of USG versus NCS*

Variables	Percentage	95% CI
Sensitivity	92.3	74.9 -99.1
Specificity	70.0	34.8 – 93.3
Predictive value of +test	88.9	70.8 – 97.7
Predictive value of -test	77.8	40 – 97.2

Interestingly it was noted that the Kappa value was 0.64(between 0.5 and 0.7). It signifies that there is good correlation between NCS and USG as diagnostic tool of CTS. Then we have classified the hands in four groups as mild, moderate, severe and profound according to NCS criteria and have calculated the mean CSA of median nerve by USG. We have also calculated mean latency and mean amplitude of median nerve for all 4 groups.

Table 3: : *Correlation between Latency and Amplitude*

Varibles	Mild	Moderate	Severe	Profound
No of cases	11	12	7	6
Mean lat + SD	5.69 ± 1.890	7.02 ± 1.501	8.97 ± 1.873	15.00 ± 0.000
Mean amp + SD	10.91 ± 4.028	12.28 ± 3.976	4.99 ± 3.654	0.00 ± 0.000
Mean CSA USG + SD	9.44 ± 1.694	10.88 ± 2.066	10.54 ± 1.959	10.88 ± 1.118

The comparison of the numerical values of median latency, amplitude and CSA USG within the groups with the help of ANOVA followed by Tukey's test showed that there was good correlation between latency and amplitude in mild, moderate, severe and profound CTS but unfortunately it was not correlated with the CSA measured by USG (Tables 3&4).

Again Table 4 shows that there is good correlation between latency and amplitude in mild, moderate, severe and profound CTS as per different methods of standard calculation.

When we did the comparison between the groups with the help of Pearson's correlation coefficient it became obvious that there was good correlation between amplitude and latency parameter of NCS with severity of CTS (Table 5). The same analysis failed to show correlation between CSA and severity of CTS. The analysis was further strengthened by the plotted scattered diagrammes below (Figs 3&4).

Discussion:

This prospective study conducted in Department of PMR, IPGMER over six months time showed that females were common victims of CTS as per our diagnostic tools. As per the current literature ultrasonography is a reliable method for the diagnosis of CTS. In comparison with NCS, ultrasonography is not effective to assess the physiologic condition of the median nerve but clearly

Table 4: *Comparison of Numerical Variables between Groups - One way ANOVA followed by Tukey's Test*

	Variables	Sum of squares	df	Mean square	F	Significance
Lat	Between groups	366.887	3	122.296	48.000	.000
	Within groups	81.530	32	2.548		
	Total	448.417	35			
Amp	Between groups	755.175	3	251.725	19.354	.000
	Within groups	416.214	32	13.007		
	Total	1171.390	35			
CSA USG	Between groups	14.540	3	4.847	1.478	.239
	Within groups	104.928	32	3.279		
	Total	119.468	35			

Table 5: *Correlation between NCV Parameters and CSA by USG - Pearson's Correlation Coefficient*

	Variables	Lat	Amp	CSA USG
Lat	Pearson correlation	1	-.611**	0.164 (poor)
	Significance (2-tailed)		.000	.340
	No of cases	36	36	36
Amp	Pearson Correlation	-.611**	1	–0.130 (Poor)
	Significance (2-tailed)	.000		.450
	No of cases	36	36	36
CSA USG	Pearson Correlation	.164	-.130	1
	Significance (2-tailed)	.340	.450	
	No of cases	36	36	36

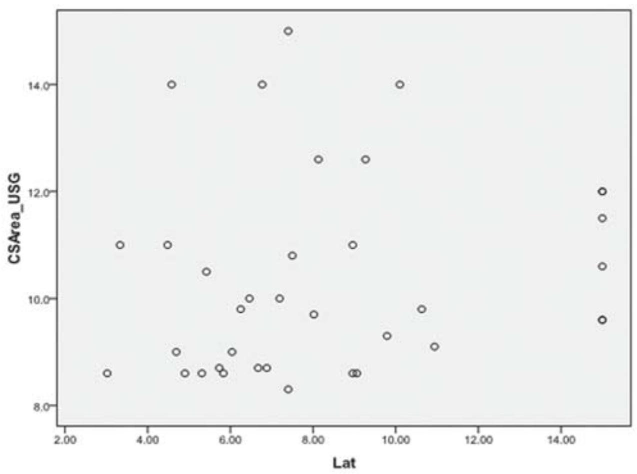

Fig 3- *Scattered Diagramme Showing Poor Relationship between CSA USG and Lat*

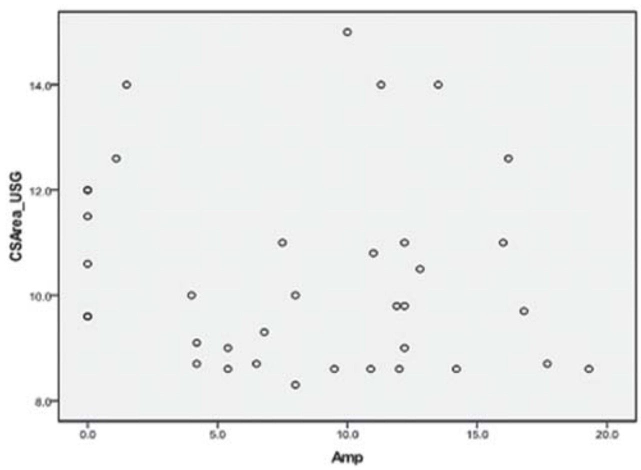

Fig 4- *Scattered Diagramme Showing Poor Relationship between CSA USG and Amp*

frame the swelling and tenting of the median nerve in CTS. The different measurement criteria of USG technique in diagnoses of CTS has been carried out in various studies. The most persistent criteria followed in different studies i.e. increased cross-sectional area of median nerve just proximal to the flexor retinoculum i.e. at pisiform bone has been followed up in this study. Most likely cause of taking this level is proximal swelling as a result of distal compression as the median nerve dips posteriorly under the flexor retinaculum[3,7].

To calculate the sensitivity and specificity of ultrasound as a diagnostic test the NCS results were taken as gold standard. A cut off point of 9mm^2 or higher for the median nerve cross sectional area on ultrasound and a value of >4.4 m/second for median nerve DML on NCS was used in our study. As per our statistical calculation it was found that ultrasound had 92.3% sensitivity. Out of 26 cases of confirmed CTS by nerve conduction studies, ultrasound correctly diagnosed 24 cases but failed to pick up two cases. Specificity of ultrasound was found to be 70% because ultrasound correctly identified 7 non CTS cases out of 10 who were diagnosed negative for CTS by NCS. The sensitivity of our study was corroborated well by the study done by Weisler *et al*[7] (91% sensitivity) though they used different cut off point of 11mm^2. The specificity in Weisler's study was 94% which was quite high because it was calculated from data of 43 asymptomatic individuals (72 of 86 wrists). In another study Lee *et al*[9] found 88 % sensitivity possibly due to higher cut off point (15mm^2) for area measurement. The specificity in their study was calculated as 96% and diagnostic accuracy was 92%. In different evidences sensitivity of USG were reported as 73% by Sarria *et al*[10] and 70% by Swen *et al*[11]. But Sarria *et al*[10] used a cut off point of 11mm^2 for the cross sectional area and a value >4.2 m/second for the DML of median nerve thereby reducing the sensitivity as well as specificity (57%) (as compared to the present study). In a study by Swen *et al*[11] the cut off point of 10 mm^2 was used with a cut off value of >4.3 m/second for the DML thereby further lowering the sensitivity (70%) but increasing the specificity (63%) which is equal to the present study. Here we want to measure not only the parameters but also the diagnostic criteria of CTS used by Swen *et al*[11] were also different. The positive and negative predictive values of our study population were 88.9% and 77.8% respectively.

The diagnostic accuracy in the present study is almost equal to 88% diagnostic accuracy given by Duncan *et al*[12]. In other studies the diagnostic accuracy of studies was reported as 68% (by Sarria *et al*[10] and by Swen *et al*[11]). As mentioned earlier, different diagnostic criteria and cut off values were used in those studies[3].

Magnetic resonance imaging (MRI) has excellent spatial resolution in showing carpal tunnel and median nerve anatomy. However, MRI is not routinely used for screening patients with suspected CTS because it is time-consuming, expensive and may not be routinely available. Several studies have shown the diagnostic usefulness of the median nerve CSA in establishing a diagnosis of CTS. Interestingly we found that the difference in CSA of the median nerve in mild, moderate, and severe forms of CTS was not statistically significant in the tunnel inlet[13]. Hence USG measurement of CSA of median nerve was not at all correlated with disease severity.

Conclusion:

Sonography is an accurate technique for the evaluation of median nerve in patients of CTS with high sensitivity but low specificity. Therefore it can be used for screening large population of patients as it is simple, easily available, non-invasive test and has relatively low cost. Not only that but also ultrasound is useful in evaluating and excluding local causes of nerve compression like tenosinovitis, cyst. It is also good in identifying the anatomic variations in carpal tunnel. To establish the diagnostic accuracy of ultrasound in CTS, more studies are needed taking asymptomatic individuals as controls. Last but not the least sonography should be compared to NCS using a strictly defined gold standard clinical parameters and standardised examination techniques.

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