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Evaluation of Ultrasound in Diagnosis of Carpal Tunnel Syndrome: A Hospital Based Cross Sectional Study

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***Abstract*: *Background:* Nerve conduction study is considered as the gold standard for diagnosis of carpal tunnel syndrome (CTS). Ultrasonography provides a simple non-invasive means of visualizing peripheral nerve pathology. *Objective:* The objective of the study was to assess the role of ultrasonography in CTS and its correlation with the present-day gold standard of nerve conduction studies (NCS). *Materials and Methods*: A prospective cohort size of 50 subjects was calculated based on a hypothesized sensitivity of 85%. All 50 patients underwent nerve conduction studies and USG. Transverse images of the median nerve were obtained at two levels: proximal to the carpal tunnel inlet, at the carpal tunnel inlet. Statistical analysis was done to correlate the ultrasound findings at each level with nerve conduction studies and calculation of the positive and negative predictive values. The cut offs of the cross-sectional areas of the median nerve at the two anatomical levels on ultrasonography were taken at the best sensitivity and specificity. *Results:* We found that at any one anatomical level, the sensitivity of ultrasound to detect carpal tunnel syndrome by increase in the cross-sectional area of median nerve as compared to the nerve conduction studies is 85%. *Conclusions*: At 84% specificity, ultrasonography could be used as a non-invasive and easily available screening tool in carpal tunnel syndrome. Also, the best level to look for nerve compression is at the level of the carpal tunnel inlet.**

***Keywords*: Carpal tunnel syndrome, ultrasound, nerve conduction study, screening test.**

1. Introduction

Carpal tunnel syndrome is a common clinical condition which is defined as a spectrum of signs and symptoms involving the hand and wrist due to the compression of the Median nerve as it passes through the carpal tunnel. Although the condition was first noted in medical literature in the early 19th century, the first use of the term "carpal tunnel syndrome" was in 1938.The condition was identified by orthopedician, Dr. George S. Phalen, of the Cleveland Clinic Foundation, as a painful disorder that afflicts workers whose jobs include repetitive wrist movements in the 1940s. He also described the clinical sign "Phalen's manoeuvre", which is named after him, for carpal tunnel syndrome, in 1948, at a meeting of the American Surgery for the Hand. The history of carpal tunnel goes way back to 1854, when Sir James Paget, a British surgeon and pathologist, first reported median nerve compression at the wrist following a distal radius fracture. His first patient was a man who developed pain and impaired sensation in the hand from the trauma of a cord drawn tightly around his wrist. In a second case, tardy median nerve palsy was a consequence of a distal radius fracture; this patient improved with wrist immobilization and thus was also the first description of treatment with a neutral wrist splint, a method still in use today. Three decades later, James Putnam (1880) presented a clinical series of 37 patients with the skin, giving rise to what is popularly known as numbness recurring periodically, coming on especially at night, "….in some cases simply letting the arm hang out of the bed or shaking it about for some moments would drive the numbness way".

2. Aims and Objectives

1. To assess the specificity and sensitivity of Ultrasonography as a diagnostic tool for the diagnosis of Carpal tunnel syndrome and compare it to Nerve conduction study (gold standard for diagnosis of carpal tunnel syndrome).
2. To determine the use of Ultrasonography as an alternate investigational modality for diagnosis of Carpal tunnel syndrome.

3. Materials and Methods

The study was conducted in the Department of Physical Medicine and Rehabilitation, Rajah Muthiah medical college, Chidambaram. The subjects were patients with symptoms of Carpal Tunnel Syndrome, referred from the out-patient services of the departments of Orthopaedics and PMR, between November 2019 and October 2021. The total sample size of 50

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subjects was required to find a hypothesized sensitivity of 85%.

4. Results

The study was conducted in the Department of Physical Medicine and Rehabilitation, Rajah Muthiah medical college, Chidambaram. The subjects were patients with symptoms of Carpal Tunnel Syndrome, referred from the out-patient services of the departments of Orthopaedics and PMR, between November 2019 and October 2021 for evaluation with Electrodiagnostic studies for CTS. The patients recruited for the study were those who were found to have carpal tunnel syndrome on NCV/EMG. They were also evaluated for any secondary cause for CTS (diabetes, hypothyroidism, fractures of the wrist). An informed consent was obtained from all the recruited patients. The mean age of study participants was 47.7 years (± 15.5), majority 56.0 % of participants were aged less than 50 or equal to 50 years, followed by 44% aged more than 50 years, minimum age of participants was 17 years and maximum age of study participants was 75 years. Among study participants, female with 50.0 % and followed by male participate with 50.0 %. Among 50 study participants, 72.0 % students were Right Hand and 28.0 % students were left hand. Among 50 study participants, majority 70 % belonged to little pain,18 % followed moderate pain, 12% with no pain and 12% with no weakness Phalen's test results, 80% were positive, 20% were negative. (Table 1)

Table 1
Distribution of study participant's gender category, age category, hand, motor weakness, Phalen's test.

Demographic characteristics and clinical findings		**Frequency (n)**	**Percent (%)**
Gender	Male	25	50.0
	Female	25	50.0
Age	≤ 50 years	28	56.0
	> 50 years	22	44.0
Hand	Right	36	72.0
	Left	14	28.0
Motor weakness	Little Pain	35	70.0
	Moderate weakness	9	18.0
	No weakness	6	12.0
Phalen's test	Positive	40	80.0
	Negative	10	20.0

The study participants of USG screening shows increased cross sectional area of median nerve were 68%, normal cross-sectional area was 32%. Nerve conduction study shows increased distal motor latency were 76 %, normal distal motor latency was 24%. (Table 2).

Table 2
Distribution of study participants according to USG screening and nerve conduction study results.

Investigation		**Frequency (n)**	**Percent (%)**
USG Screening	Increase cross-sectional area of median nerve (screening positive)	34	68.0
	Normal (Screening negative)	16	32.0
Nerve conduction study	Increased distal motor latency (Positive test)	38	76.0
	Normal distal motor latency (Negative test)	12	24.0

Table 3 shows comparison between USG screening and nerve conduction study of participants. Among 38 participants who had increased motor latency in nerve conduction study, 32 participants had increased cross-sectional area of median nerve while 6 participants did not have increased cross-sectional area of median nerve in USG screening study. Similarly, among 12 participants who had normal motor latency in nerve conduction study, 10 participants did not have increased cross-sectional area of median nerve in USG screening study. Kappa statistics was used to find out the level of agreement between the nerve conduction study and USG screening. The value of kappa was 0.606 which was statistically significant with P value of < 0.001. The sensitivity of USG screening was 84.21 %, specificity was 83.33 %, positive predictive value of the test was 94.12 % and accuracy of USG screening was found to be 84 %.

Table 3
Comparison between USG screening and nerve conduction study of study participants.

		Nerve conduction study		**Total**
		Positive	Negative	
USG Screening	Positive	32	2	34
	Negative	6	10	16
Total		38	12	50

5. Discussion

The diagnosis of carpal tunnel syndrome usually relies on typical signs, symptoms and outcomes of Electro diagnostic studies. Single signs and symptoms have shown to have limited diagnostic accuracy, while Electro diagnostic methods are time consuming, expensive and not widely available. Therefore, there has been a search for an alternative modality to confirm the diagnosis of CTS. Ultrasonographic detection of pathologic swelling of the median nerve by assessing its cross-sectional area has been in the recent times found to be most convenient and least expensive.

Ultrasonography is useful in CTS diagnosis, providing anatomic images of the median nerve, neighboring structures, and mass-occupying space in the carpal canal. The advantages of Ultrasonography are that it is low cost, takes short duration to perform the investigation compared to nerve conduction studies and commonly available, besides it is painless and non-invasive; and gives dynamic images. US is operator dependent, but shows high reproducibility after adequate training of the operators (1).

The US measurement used in CTS diagnosis is the cross-sectional area of the nerve at various levels of the carpal canal, the flattening ratio, the swelling ratio, and the increased palmer bowing of the flexor retinaculum. In some studies, cross sectional area was performed at a single level, mostly at the proximal carpal tunnel. In several studies cross sectional area was measured by ellipsoid formula (2,3,4), but a more accurate measure is obtained by using continuous boundary trace of the nerve, because the nerve does not always have a perfect ellipsoid shape. However, some studies demonstrated that similar results are obtained by both methods (5,6). The sensitivity and specificity of Ultrasonography measures vary

widely among studies. Many authors demonstrated that the increase in cross sectional area at the tunnel inlet had the highest sensitivity and specificity; moreover, the measurement at this level was easier to perform. Among the various studies available, there was also disagreement about the exact localization of tunnel inlet. Most authors considered the proximal edge of the flexor retinaculum, approximately at the level of the distal radio-ulnar joint, as the tunnel inlet, while others considered the pisiform bone as the landmarks (1). In this study, we have taken the distal radio-ulnar joint as the level proximal to the tunnel, the level of the pisiform as the level of the inlet. Studies have shown that ultrasound measurements have a good inter- and intra- observer reliability (7).

The sensitivity of the cross-sectional areas ranged from 48% to 89% (5,6) and the CSA cut off at which the value was considered abnormal varied from 9 mm2 (5,6) to 15 mm2 (8). In our study, the cut off for an abnormal nerve was taken as 0.09 cm2 at the level proximal to the inlet, 0.10 cm2 at the inlet. In our study, the sensitivity and specificity of the flattening ratio was not calculated as it did not show any significant co-relation with the presence of the disease. The discrepancies in the varied range of outcome result from many factors: selection criteria of patients and controls, gold standard for diagnosis of CTS, Electrodiagnostic methods, levels of CSA measurement, and US cut off values. In almost all studies the gold standard of CTS diagnosis was based on clinical and abnormal Electrodiagnostic tests, and sometimes the most sensitive tests, such as short segment study or comparative test of median-ulnar distal sensory latency, were not performed. In contrast, only a few studies used clinical findings only as the gold standard. (9, 10, 11) Only this type of study is able to compare US specificity and sensitivity with those of the Electro diagnostic tests. The few literature data reported different results on NCV specificity. (10, 11, 12). In the literature, only the study by Altinok et al (13) took into account mild-moderate cases. These authors defined mild cases as wrists with normal NCV and moderate cases as wrists with abnormal NCV, and demonstrated that abnormal US findings were present in 30% of 20 mild cases and in 100% of 20 moderate cases. Moreover, Koyuncuoglu et al (9) studied 59 wrists with negative Electro diagnostic tests and showed that CSA-I was abnormal (10.5 mm2) in 30.5% of wrists with clinically diagnosed CTS. In accordance with AAEM Electro diagnostic protocol, when standard methods did not show any conduction anomalies of the median nerve, comparative tests (ulnar/ median distal SCV comparison) or short segment conduction velocity was used. These tests have high sensitivity and high specificity. However, some authors consider NCV an “unnecessary luxury” and for others NCV causes discomfort and is considered expensive and time consuming. (15) We disagree that NCV is time consuming and uncomfortable, because an experienced electromyography can perform NCV for CTS according to AAEM protocol in 20 minutes, using surface electrodes and small current intensity. Needle electromyography is rarely necessary. Thus, laboratories can use their own normal reference values, making this scale a valuable tool for comparing electrophysiological results from different laboratories that use different techniques and reference values. This scale was also used by other authors in US studies (16, 17). In our study, we have used our normal reference standards based on the controls done in the lab and also the guidelines by Kimura (1986) and Kalita and Misra. (18)

6. Limitations

This study is done in Chidambaram, Tamil Nadu among patients attending daily outpatient department and convenient sampling technique was followed. Therefore, generalizability of the study result is to be carried out with care.

7. Conclusion

1. The cut offs of the cross-sectional areas of the median nerve at the two anatomical levels on Ultrasonography were taken at the best sensitivity and specificity, at the level proximal to the carpal tunnel inlet and at the level of carpal tunnel inlet (at the pisiform level). The best level to look for the compression of the nerve by increase in the cross-sectional area is at the level of the carpal tunnel inlet.
2. In this study, the sensitivity of ultrasound to detect carpal tunnel syndrome by the increase in the cross-sectional area of the median nerve as compared to the nerve conduction studies is 85% with the US value may be positive at any one anatomical level. The specificity for this is 84%. Hence Ultrasonography is a good screening investigation.
3. Ultrasonography has been found to be more widely available as compared to nerve conduction studies. It is also less time consuming (average time 15 minutes) and cost effective as compared to the nerve conduction studies. Along with this, Ultrasonography has also the advantage of giving information about the morphology of the nerve and its surrounding structures. Therefore, Ultrasonography can be used as an alternative diagnostic investigation for Carpal tunnel syndrome.

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Nil.

9. Conflicts of Interest

There are no conflicts of interest.

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