Original Article

Diagnostic Value of Cross-Sectional Area of Median Nerve in Grading Severity of Carpal Tunnel Syndrome

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Abstract

Purpose: Carpal tunnel syndrome is a common peripheral entrapment neuropathy. The purpose of this study is to determine whether high resolution ultrasonography can be an alternative diagnostic method to nerve conduction study in grading the severity of carpal tunnel syndrome.

Methods: A total of 164 wrists of 82 patients, bilaterally, were enrolled in the study. The cross-sectional area of the median nerve at the carpal tunnel inlet and outlet was measured in all patients with electrophysiologically confirmed carpal tunnel syndrome. All patients had nerve conduction study performed one week before ultrasonography. Then, comparisons between ultrasonography and nerve conduction study were made. The grading severity according to nerve conduction study was used as a gold standard reference.

Results: The mean median nerve cross-sectional area at the tunnel inlet was11.4±1.7 mm^2 for the carpal tunnel syndrome affected wrist and 5.78±0.9 mm^2 for the normal wrist ($P<0.001$). The mean median nerve cross-sectional area at the tunnel outlet was 9.9±1.2 mm^2 for the affected wrist with carpal tunnel syndrome and 4.7±0.7 mm^2 for the normal wrist ($P<0.001$).The best cutoff value of cross-sectional area at the tunnel inlet and outlet was 8.5 mm^2.

The difference in cross-sectional area of the median nerve in mild, moderate and severe carpal tunnel syndrome was not statistically significant ($P=0.2$) neither in the carpal tunnel inlet nor outlet.

Conclusion: Based on this study, cross-sectional area of median nerve ultrasonography has a diagnostic value to confirm or exclude carpal tunnel syndrome, but could not be used for grading its severity.

Keywords: carpal tunnel syndrome, electrophysiology, ultrasonography

Introduction

Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy and one of the essential etiologies of hand morbidity.[1] CTS is more common among adult women (9%) than men (0.6%).[2] The diagnosis of CTS is usually based on a combination of both clinical signs and electrophysiologic studies.[2]

Although physiologic information is obtained based on nerve conduction studies (NCS); however, it has a specificity of 95% and a low sensitivity that ranges from 49% to 86%.[3]

According to previously published literature ultrasonography is a useful diagnostic modality with which to diagnose CTS.[4–8]

Recent advances in ultrasound (US) equipment have improved the quality of US images for clearer evaluation of soft tissue.

In comparison with NCS, ultrasonography has many

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advantages such as: availability, lower cost, noninvasiveness, and shorter examination time.

The aim of this study, therefore, is the comparison of diagnostic usefulness of high resolution ultrasonography with NCS in grading the severity of CTS by measuring the median nerve cross-sectional area (CSA).

Grading CTS as mild, moderate, and severe according to NCS (based on median nerve conduction velocity) was used as the gold standard reference in our study.

Patients and Methods

Between January and March 2008, 82 patients with electrophysiologically confirmed CTS were examined with high-resolution ultrasonography for the determination of median nerve CSA at the carpal tunnel inlet and outlet.

Eighty-two patients (74 women and 8 men) with 132 affected nerves (132 wrists) were examined within ten days following NCS.

Thirty-two patients had unilateral CTS (20 cases right hand and 12 cases left hand) and 50 patients were diagnosed with bilateral CTS. We assessed both the right and left hands of all 82 patients blinded to the electrophysiologic study.

From unilateral CTS, only those patients were enrolled in the study that had normal hands, which were both clinically and electrophysiologically negative for CTS. Patients with positive clinical symptoms of CTS and a negative NCS result were excluded. In our study, all patients with unilateral CTS had negative clinical and electrophysiological results in their normal hands.

Patients with coexistent neurological diseases such as polyneuropathy, proximal median neuropathy, and cervical radiculopathy, in addition to patients with diabetes mellitus, those with space occupying lesions of the wrist and previous wrist surgery were excluded from the study.

NCS were performed by an electrodiagnostician with ten years experience. Patients were classified as mild, moderate, and severe CTS according to a measurement of the median nerve conduction velocity (cm/s). When results of the NCS were positive, patients were classified as electrophysiologically confirmed CTS.

Sonographic examination was performed after NCS by a radiologist with six years experience in musculoskeletal sonography. All sonographic examinations were performed by one radiologist.

All examinations were performed with a high frequency (11 MHz) linear array transducer (Toshiba Nemio 30, Japan).

The radiologist and electrodiagnostician were blinded to the study results.

Additionally, all patients were examined by a hand surgeon and referred for ultrasonographic and electrophysiological examinations.

For the examination, subjects were seated facing the radiologist with arms extended, wrists resting on a hard, flat surface, forearms were supinated, and the fingers were semi-flexed.

Axial US of the median nerve were obtained at two anatomical levels and at each level the CSA of the median nerve were measured: 1) at the carpal tunnel inlet at the level of the pisiform and scaphoid bones (Figure 1) and 2) at the carpal tunnel outlet at the level of the hook of the hamate and trapezium bones.

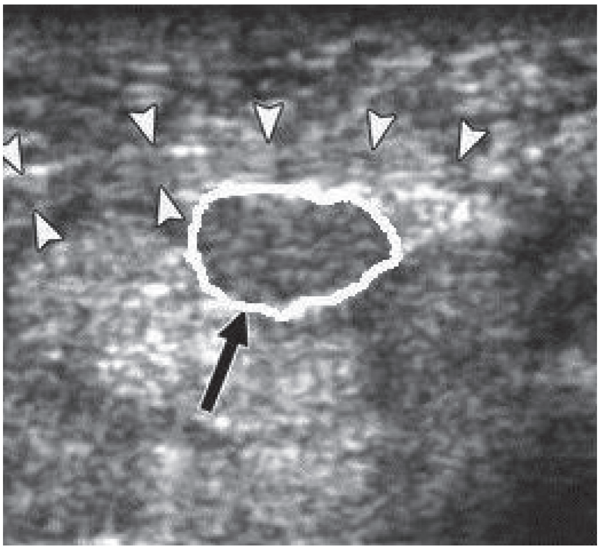

Figure 1. Axial sonogram of the median nerve cross-section at the carpal tunnel inlet. Arrowhead shows the flexor retinaculom and arrow shows the median nerve

Particular attention was paid to adequate probe orientation in order to keep the US beam perpendicular to the nerve and maintain the wrist in a supine position.

The study protocol was approved by the Urmia Uni-

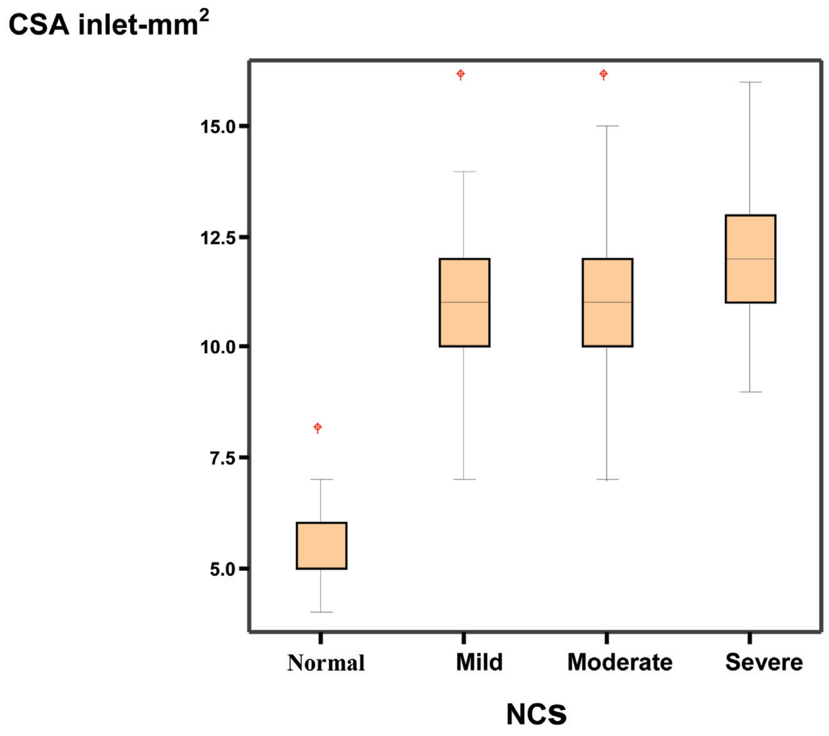

Figure 2. Graph shows the difference between mean cross-sectional area of normal and mild, moderate and severe forms of CTS at the carpal tunnel inlet. CSA=cross-sectional area; mm²

versity Research Ethics Committee and writhen informed consents were obtained from all patients.

Statistical analysis was carried out using the Student's *t*-test and one-way ANOVA. Mean value and standard deviation was determined. Correlation coefficient was calculated with Spearman's Rank Correlation Analysis. The level of confidence was taken at a *P* value of 0.05 or less. Roc curve was used to explore the relationship between the sensitivity and specificity of US in diagnosing CTS with different amounts of median nerve CSA and determination of the optimal cut-off value of the median nerve CSA in the diagnosis of CTS.

Results

We assessed 164 wrists, of which 132 were electrophysiologically confirmed as CTS affected wrists and 32 normal wrists in 82 patients (74 women and 8 men). All were examined bilaterally.

Of the 132 symptomatic wrists, 34 were mild, 53 moderate, and 45 had severe CTS.

From 132 affected wrists, 20 wrists were related to patients with right handed CTS and 12 wrists were related to patients with left handed CTS. A total of 50 patients had bilateral CTS.

The study group had a mean age of 43.6 ± 9 years.

Table 1. Results of median nerve cross-sectional area at the carpal tunnel inlet and outlet in patients with mild, moderate and severe CTS

Cases/NCS results	Number	CSA (inlet) mean±SD	CSA (outlet) mean±SD
Normal	32	5.9±0.6 mm²	4.5±0.8mm²
Cases			
Mild	34	10.8±1.9 mm²	9.7±0.9 mm²
Moderate	53	11.4±1.8 mm²	10.1±1.2 mm²
Severe	45	12.0±1.5 mm²	10.0±1.4 mm²
All cases	132	11.4±1.7 mm²	9.9±1.2 mm²
CSA=Cross-sectional area; mm²			

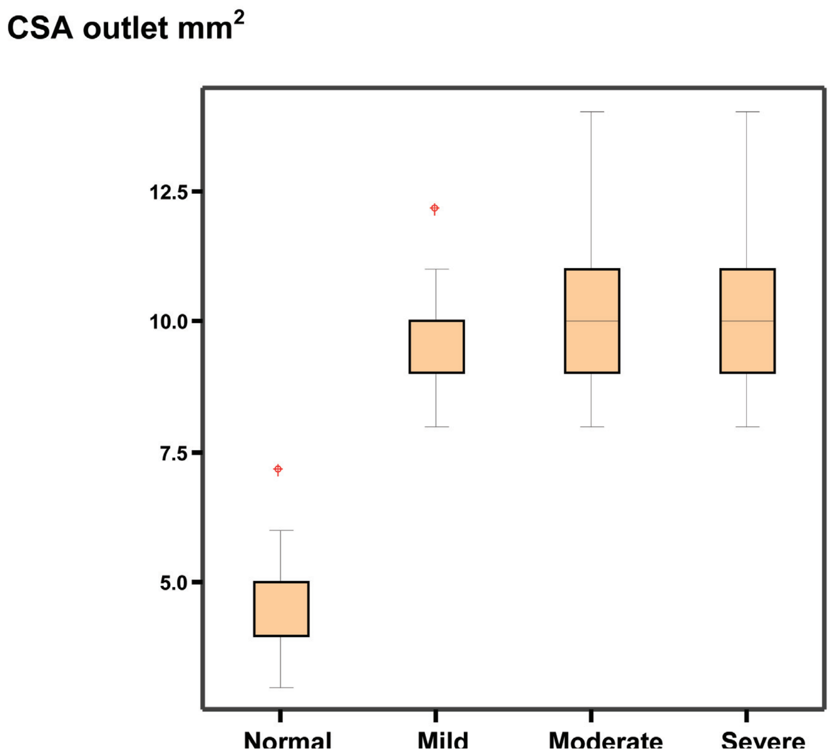

Figure 3. Graph shows the difference between mean cross-sectional area of normal and mild, moderate and severe forms of CTS at the carpal tunnel outlet. CSA=cross-sectional area; mm^2

The mean median nerve CSA at the tunnel inlet in all the affected wrists was 11.4±1.7 mm^2 (Table 1 and Figure 2).

There was no significant difference between the right and left hand in median nerve CSA at the carpal tunnel inlet or outlet in the study groups (P=0.1).

The mean median nerve CSA at the tunnel inlet was 10.8±1.93 mm^2 in patients with a mild form of CTS, 11.4±1.8 mm^2 in patients with moderate CTS and 12.0±1.5 mm^2 in patients with severe CTS, which was not statistically significant (P=0.2).

The mean median nerve CSA at the tunnel outlet was 9.9±1.2 mm^2 for the affected wrists.

The mean median nerve CSA at the tunnel outlet was 9.7±0.9 mm^2, 10.1±1.2 mm^2, and 10.00±1.4 mm^2 in the mild, moderate, and severe forms of CTS, respectively, which was not statistically significant (P=0.49) (Figure 3).

In our study, the cutoff value of 8.5 mm^2 at the carpal tunnel inlet had a sensitivity of 97% and specificity of 98% for the diagnosis of CTS.

Our study showed that a cutoff value of 8.5 mm^2 in median nerve CSA at the carpal tunnel outlet had a sensitivity and specificity of 100%.

For a cutoff of 8.5 mm^2 that yielded an approximately equal sensitivity and specificity, the negative and positive likelihood ratio were powered. A cutoff of 8.5 mm^2 had excellent power to rule out CTS; the fitted negative LR was 0.03 for CSA of less than 8.5 mm^2.

Conversely, a cutoff of 8.5 mm^2 had excellent power for diagnosing CTS with a fitted positive LR of 48.5 for an area greater than 8.5 mm^2 at the carpal tunnel inlet.

For a cutoff of 8.5 mm^2 at the tunnel outlet that had equal sensitivity and specificity (100%) for the diagnosis of CTS, the negative and positive likelihood ratios were excellent.

A cutoff of 8.5 mm^2 at the tunnel outlet had excellent power to rule out CTS; the fitted negative LR was 0.00 for CSA less than 8.5 mm^2 and had an excellent power to rule in CTS with a fitted positive LR of 100 for an area greater than 8.5 mm^2 at the carpal tunnel outlet.

Discussion

Our study showed that the mean median nerve CSA at the tunnel inlet in patients with CTS was 11.4±1.7 mm^2 and the mean median nerve CSA at the tunnel outlet in patients with CTS was 9.9±1.2 mm^2. We found that the difference in CSA of the median nerve in mild, moderate, and severe forms of CTS, was not statistically significant in either the tunnel inlet or outlet.

Accurate diagnosis of CTS and its differentiation from other causes of hand morbidity is essential, particularly if the patient is a candidate for surgery.

Magnetic resonance imaging (MRI) has excellent spatial resolution in showing carpal tunnel and median nerve anatomy.[9–11] However, MRI is not routinely used for screening patients with suspected CTS because it is time-consuming, expensive and may not be routinely available.

Many authors have reported the diagnostic ultrasonographic criteria of CTS[4–8,12–16] and several studies have shown the diagnostic usefulness of the median nerve CSA in establishing a diagnosis of CTS.[6,11,13] In comparison with NCS, ultrasonography does not evaluated the physiologic condition of the median nerve but may show swallowing and flattening of the median nerve.[13]

Currently, ultrasonography is a reliable method for the diagnosis of CTS.[2–15]

Many authors believe that ultrasonography can be an alternative method in comparison with NCS for the primary evaluation of CTS in daily practice.[4–8]

Most previous studies have shown that an increase in the CSA of the median nerve at the carpal tunnel inlet is a reliable finding, yielding sensitivities that range from 67% to 94%, with specificities of 57% to 97%, and a cutoff value that varies from 8.5 and 15 mm^2 according to different reports.[4–6,12,14]

Other authors, however, have shown the measurement of the median nerve CSA at the carpal tunnel outlet to be more sensitive with a sensitivity ranging from 57% to 75% and specificity of 51% to 92%, with cutoff values from 11 to 13 mm^2.[16]

Our results showed no concordance of high resolution ultrasonography with NCS in diagnosing the severity of CTS.

The majority of previous studies have shown the concordance of ultrasonographic findings with NCS findings in differentiating a normal hand from those with CTS.[2–10] There are only a few studies that have focused on the determination of concordance between ultrasonography and NCS in defining CTS severity. Karadağ et al.[17] have shown a high concordance of ultrasonography and NCS in grading CTS severity. They determined that the use of ultrasonography may reduce the number of NCS in patients with CTS. Padua et al.[6] found a significant correlation between alterations in physiologic function of the median nerve in CTS and alterations of the median nerve CSA with ultrasonographic examination.

Moran et al. have shown that ultrasonography cannot differentiate between mild, moderate, and severe forms of CTS as well as NCS.[1]

Lee et al. showed that an ultrasonographic finding of the median nerve CSA at the carpal tunnel inlet has good correlation with NCS findings in various forms of CTS.[18]

According to Mondelli et al., mild CTS could be detected neither by ultrasonography nor by NCS in 23.5% of cases[5] and Ahn et al. determined that CTP was not correlated with neurophysiologic severity and nerve CSA.[19]

We determined that according to US, CTS could be classified into normal and abnormal finding; however, there is no significant difference between the CSA of median nerve at the tunnel inlet or outlet in the different grades of CTS according to NCS data.

In our study a cutoff value of 8.5 mm^2 at the tunnel inlet yielded a sensitivity of 97% and a specificity of 98% for the diagnosis of CTS.

Our cutoff point of 8.5 mm^2 was less than most previous studies,[4–6,12–15] because other studies were performed in patients who initially presented with symptoms severe enough to be candidates for surgery and most patients suffered from a severe form of CTS, as seen by NCS in the previous study. However, in our study, patients with mild, moderate, or severe symptoms were enrolled and thus there was no selection bias.

Moran et al. showed that a CSA of less or equal than 9.8 mm^2 was accurate enough to exclude CTS and a CSA greater than 12.3 mm^2 was diagnostic for CTS.[1]

In conclusion, high-frequency US examination of the median nerve and measurement of its CSA may be considered as a new diagnostic modality for the primary evaluation of CTS.

Ultrasonographic findings show high correlation with the present standard NCS in confirming or establishing a diagnosis of CTS. But ultrasonography can not be a complete alternate modality in evaluation of patients with CTS since it could not differentiate between mild, moderate, and severe forms of CTS. NCS may be necessary in those patients with more than 8.5 mm^2 CSA of the median nerve as seen in ultrasonography in order to confirm the diagnosis and make a surgical decision. According to our study, however, we recommend in patients suspected of having CTS, when the CSA of the median nerve is less than 8.5 mm^2 NCS may not be necessary for diagnostic confirmation of CTS.

Ultrasonography does not have diagnostic value in grading the severity of CTS.

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