Original Article

Can we define severity of carpal tunnel syndrome by ultrasound?

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Abstract

Background: Carpal tunnel syndrome (CTS) is a common entrapment neuropathy. Diagnosis of CTS is usually based on a combination of clinical symptoms and electrodiagnostic study (EDS). Ultrasonography (US) also has been shown to be a useful diagnostic tool in CTS and is based on an increase in the median nerve cross-sectional area (CSA) at the level of the pisiform bone. In this study we assessed findings in US in correlation with severity of CTS.

Materials and Method: This was a cross-sectional case-control study, which was carried out on November 2012 to July 2013. Subjects were chosen from patients who referred to the Alzahra Hospital (Isfahan, Iran). Patients were classified as having mild, moderate, and severe CTS according to EDS and high-resolution US was performed for CSA measurement at the tunnel inlet.

Results: A total of 87 individuals screened and 52 subjects (81 hands) met all inclusion and no exclusion criteria. The mean ± SD of the CSA was 0.12 ± 0.03 cm^2 (range, 0.08–0.18) in mild, 0.15 ± 0.03 cm^2 (range, 0.08–0.19) in moderate, and 0.19 ± 0.06 cm^2 (range, 0.11–0.32) in severe CTS. We detected a significant correlation between MN CSA and the severity of CTS ($P < 0.001$).

Conclusion: In conclusion it is expected that sonography may serve as an additional or complementary method which is useful and reliable in assessing the severity of CTS.

Key Words: Carpal tunnel syndrome, cross-sectional area, median nerve, severity, ultrasonography

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INTRODUCTION

Carpal tunnel syndrome (CTS) is a common entrapment neuropathy due to the compression of the median nerve (MN) at the wrist.[1] The prevalence ranges from 1% to 5% among the general population and up to 14.5% among specific occupational groups.[2,3] Early diagnosis is essential in preventing permanent nerve damage and functional sequela.[4] Also, severity of disease is an important clinical factor that may affect the treatment course and prognostic evaluation and should be routinely recorded.[5,6] Diagnosis of CTS is usually based on a combination of clinical symptoms (burning pain, numbness, and nocturnal paresthesia in the distribution of the MN), and signs, such as Tinel sign (tapping over the MN producing dysesthesias) and Phalen sign (wrist flexion producing dysesthesias), and electrodiagnostic study (EDS) [electromyography-nerve conduction

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studies (EMG-NCS)] which have a sensitivity in the range of 56–85% and a specificity of 94% or higher.[4,7-9] However, EDS are time-consuming and expensive, may not be diagnostic in 10–25% of patients with clinical evidence of CTS depending on the severity of disease and the type of nerve conduction techniques used, and false negatives and false positives may occur, even when the most sensitive methods are used.[9-11]

Ultrasonography (US) has been shown to be a useful diagnostic tool in CTS and has been used increasingly to confirm a clinical diagnosis of CTS with sensitivity between 44% and 95% and specificity between 57% and 100%.[12,13] It is feasible, simple, relatively low-cost, rapid, accurate, and noninvasive.[14] US diagnosis of CTS is based on an increase in the MN cross-sectional area (CSA) at the level of the pisiform bone.[12]

In this study we survey our findings in US based on measurement of CSA and diameter of MN in mild to severe CTS.

MATERIALS AND METHODS

Subjects

Subjects were chosen from patients who referred to the Alzahra Hospital (Isfahan, Iran). All subjects met the following inclusion criteria: (1) 18-65 years aged; (2) diagnosed clinically with CTS defined according to the criteria of The American Academy of Neurology practice parameters[15,16] and confirmed by EDS (prolonged MN distal motor latencies >4.4 ms or prolonged MN distal sensory latencies >3.5 ms);[17] (3) written informed consent. Subjects also met none of the following exclusion criteria: (1) History of prior carpal tunnel release procedure; (2) history of trauma to the wrist or hand that included broken bones; (3) known history of other neurologic disorders such as polyneuropathy, proximal median or ulnar neuropathy, plexopathy, mononeuritis multiplex and cervical radiculopathy, or cervical spondylosis; (4) pregnancy or being within 3 months postpartum for women.

Design and procedures

This was a cross-sectional case-control study, which carried out from November 2012 to July 2013. The study followed the Declaration of Helsinki on Biomedical Research Involving Human Subjects and was approved by the Ethics Committee from the Isfahan University of Medical Sciences. All participants provided written informed consent. Demographic data included age, height, and sex. Patients were classified as having mild, moderate, and severe CTS according to these criteria[18]:

- Mild: Prolonged DSL and/or median mixed nerve latency (MNL); normal DML; amplitudes of all responses within normal range; no conduction block (CB) or mild CB; and no thenar EMG abnormalities (if tested)
- Moderate: Prolonged DSL, MNL, and DML (if all tested); Amplitudes of all tested responses may be diminished, typically a relative decrease (but not required); CB may be present; and minor thenar EMG abnormalities may be present (if tested)
- Severe: Unobtainable median sensory nerve action potentials (or low amplitude and prolonged DSL); low-amplitude or unobtainable median mixed nerve response and, if present, prolonged MNL; low-amplitude or unobtainable median compound muscle action potential and, if present, prolonged DML; CB may be present and pronounced (i.e. >70%); and thenar EMG abnormalities often present (if tested).

Assessments

High-resolution US were performed using a scanner with a 13-MHz linear array transducer for the carpal tunnel study and measuring of CSA (Sonosite machine). During the examination, the patient sat in a comfortable position facing the examiner, with the measured forearm resting on the table, the palm supine, and fingers semi-extended in the neutral position.[19] Since previous reports demonstrated that the CSA of the MN at the carpal tunnel inlet is the best discriminatory criterion with which to identify patients with CTS, so in the present study, the CSA measurement was obtained at the tunnel inlet (just before the proximal margin of the flexor retinaculum)[20] [Figure 1]. The MN was imaged in a longitudinal scan first, placing the US probe at the midline between the radius and ulna with the center of the probe at the distal wrist crease, to obtain an initial general overview of the MN which was then used to assist the examiner in order to obtain optimal axial (cross-sectional) images. Then a transverse scan, keeping the probe directly perpendicular to the long axis of the MN in order to ensure that the area measured indeed reflected a CSA, was performed to record the CSA (calculated by continual tracing of the nerve circumference, excluding the hyperechoic epineurial rim) and elliptical (the transverse and the anteroposterior) diameters (DMN).[21]

Statistical methods

Data were analyzed by SPSS version 16.0 (SPSS Inc., Chicago, IL, USA). A $P < 0.05$ was

considered significant. Continuous variables were expressed as mean ± SD. ANOVA and Pierson correlation were used for analysis.

RESULTS

A total of 87 individuals were screened and 52 subjects (81 hands) met all inclusion and no exclusion criteria and were divided into three subgroups according to severity of CTS [Figure 2]. Twenty-six hands (32.1%) were affected with mild CTS, 32 (39.5%) with moderate CTS, and 23 (38.4%) with severe disease. The demographic data of the 52 participants (81 hands) are shown in Table 1.

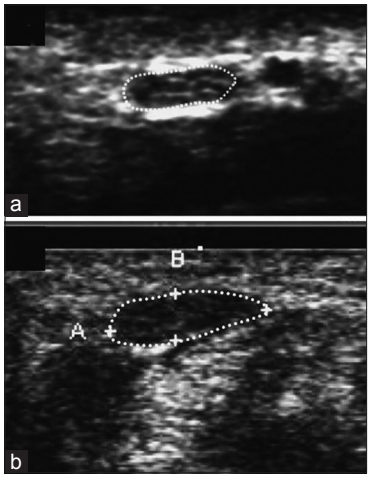

Figure 1: (a) Transverse view of sonogram of the median nerve at the carpal tunnel inlet in a healthy subject. The outer margin of the median nerve is surrounded by a dotted line. (b) Transverse view of sonogram of the median nerve at the carpal tunnel inlet in a subject with carpal tunnel syndrome. The nerve is relatively hypoechogenic

The mean ± SD of the CSA was 0.12 ± 0.03 cm^2 (range, 0.08–0.18) in mild, 0.15 ± 0.03 cm^2 (range, 0.08–0.19) in moderate, and 0.19 ± 0.06 cm^2 (range, 0.11–0.32) in severe CTS. We detected a significant correlation between MN CSA and the severity of CTS ($P < 0.001$) [Table 2].

The mean ± SD of the diameter of MN (DMN) was 1.74 ± 0.3 (range, 1.19–2.51) in mild CTS, 1.83 ± 0.22 (range, 1.51–2.44) in moderate, and 2.14 ± 0.35 (range, 1.54–2.90) in severe CTS. We detected a significant correlation between DMN and the severity of CTS ($P < 0.001$).

Also Pierson correlation showed that there is a strait correlation between CAS and DMN ($r = 0.73$, $P < 0.001$).

DISCUSSION

Some authors consider that the role of US in diagnosis of CTS is yet to be proven[22] and other stated that US appears to be of little use in the diagnosis of CTS.[14] By contrast, Wong *et al.*[23] proposed an algorithm involving initial US examination of patients suspected of having CTS and secondary EDS performed only when US results were negative. Furthermore, one study stated that US could be used to grade the severity of CTS.[17] One meta-analysis was performed

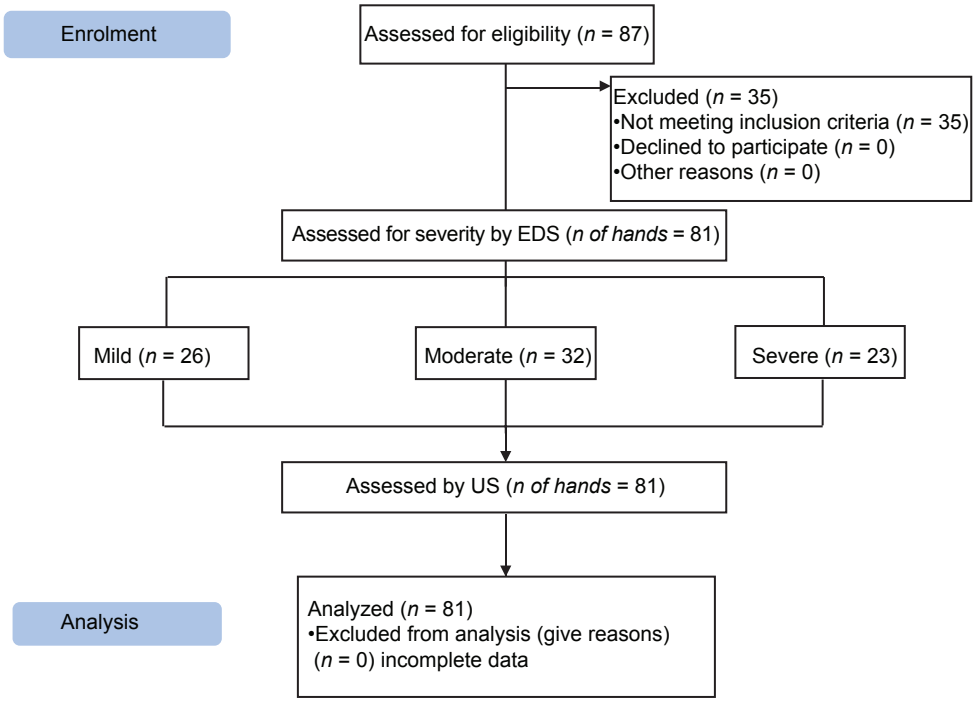

Figure 2: Study design flowchart

Table 1: Demographic data of the 52 participants (81 hands)

Characteristics	Total *N* (subjects)=52
Sex	
Male	7 (13.5)
Female	45 (86.5)
Age (years), mean (SD)	51.8±10.8
BH (cm), mean (SD)	158.8±7.7
Risk factors	
Diabetes mellitus	7 (13.5)
Hypothyroidism	4 (7.7)
Rheumatoid arthritis	41 (79)

All variables are number (%) unless otherwise indicate. BH=Body height

Table 2: Between group ANOVA analysis of CSA and DMD in different severity subgroups

Variable	Mean±SD			*P*
	Mild	Moderate	Severe	
DMD	1.74±0.3	1.83±0.22	2.14±0.35	<0.001
CSA	0.12±0.03	0.15±0.03	0.19±0.06	<0.001

DMD=Diameter of median nerve distal; CSA=Cross sectional area, Unit of CSA=cm^2, Unit of DMD=mm^2

to determine the sensitivity and specificity of ultrasound in the diagnosis of CTS and the authors concluded that although ultrasound may not replace electrodiagnostic testing, it may be a feasible alternative to electrodiagnostic testing as a first-line confirmatory test.[5] Another recent meta-analysis confirmed that US, using cross-sectional area of the MN, could give complementary results for diagnosis of CTS.[24] Some authors showed that as neurophysiologic severity of CTS increases, there is increasing US abnormality and US can also be helpful in advanced CTS with severe abductor pollicis brevis muscle atrophy where NCS shows no more response.[25,26]

This study assessed the correlation between MN CSA and the severity of CTS. The results provide preliminary evidence that MN CSA was correlated with the severity of CTS based on the nerve conduction velocity studies and with increasing the sevierity of CTS, CSA would be enlarged. This finding is consistent with Miwa *et al*. and Ajeena *et al*. studies which confirmed that the MN CSA is enlarged in patients with CTS and it correlated with the severity of CTS.[14,20] Karadag *et al*. stated that the US was useful in grading the severity of CTS. They concluded that US measurement of CSA could give information about severity of MN involvement and they set US cut-off points that discriminate between different grades of CTS severity as follows: 10.0–13.0 mm^2 for mild, 13.0–15.0 mm^2 for moderate, and >15.0 mm^2 for severe symptoms.[27] In our study these ranges were nearly similar: 12 ± 3 mm^2 for mild, 15 ± 3 mm^2 for moderate and 19 ± 6 mm^2 for sever CTS. In the other hand, Moran *et al*., reported that the CSA of the MN at the tunnel inlet were 10.8 ± 1.9 mm^2, 11.4 ± 1.8 mm^2, and 12 ± 1.5 mm^2 in patients with mild, moderate, and severe CTS, respectively. They reported that their clinical groups differed significantly from their control group (5.8 ± 0.9 mm^2), but they found no differences between the patient groups.[28] This is in against with our findings. And Mohammadi *et al*. also asserted that US cannot be used to grade the severity of CTS.[29] But, El Miedany *et al*. and Lee *et al*. found that one can be confident of determining the level of severity of CTS based on US measurement of CSA of the MNs. In their work, they reported that US measurements of greater than 15 mm^2 correlate with NCS findings of moderate to severe disease and noted that these figures differ significantly from those patients with mild to moderate disease.[30,31]

In our study there was also a strait correlation between MN DMN and the severity of CTS. All these findings suggest that CTS can be objectively stratified in terms of disease severity and such stratification may lead clinical decisions in terms of treatment and prognosis and also be consistent with previous reports that demonstrated the utility of US measurement of MN CSA at the tunnel inlet as a good alternative to NCS for the initial diagnosis of CTS.[17,18]

It is interesting that many studies showed the lack of interreader reliability of the CSA measurements obtained at the tunnel outlet, because MN may be difficult to be seen at outlet in persons with thick palmar skin and it has a wide variation as it usually splits into digital branches here.[17,23] That is why the current study used measurements of the CSA of the MN at the tunnel inlet despite the findings of Mohammadi *et al*., in 2009, about the usefulness of measuring CSA of the MN at the tunnel outlet.[29]

In conclusion it is expected that sonography may serve as an additional or complementary method for investigation of CTS. But EDX findings are more accurate in comparison to ultrasound, which is more dependent on examiner experience. The MN is easily visualized and measuring its CSA at the level of pisiform bone is a useful noninvasive method that is reliable in assessing the severity of CTS and might reveal some of its possible causes as space-occupying lesion or anatomical variation of the MN.

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