The Best Cutoff Point for Median Nerve Cross Sectional Area at the Level of Carpal Tunnel Inlet

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Abstract- Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy. It accounts 90% of all entrapment neuropathies all over the world. Ultrasound is a non-invasive, cost effective and available para-clinical method which could be applied for CTS diagnosis. Cross-sectional area of the median nerve at the level of the inlet is considered as a diagnostic criterion in CTS cases. In this study, thirty-eight patients with electrophysiologically confirmed idiopathic CTS and 22 healthy controls were enrolled. Seventy-one affected nerves and 42 unaffected nerves were evaluated within 14 days after electrophysiological examination. The largest cross-sectional area (CSA) was measured at the level of the carpal tunnel inlet and the maximum nerve perimeter was also recorded by means of the software. Mean CSA and perimeter were 14.02 ± 4.5 mm^2 and 1.7±0.28m in all patients and 8.2±2.1 mm^2, 1.3±0.19 m in controls (P<0.001, P<0.001). Mean CSA and Perimeter were significantly different between patient's groups and control. The best cut off point for CSA of the tunnel inlet was 10.5 mm^2 with sensitivity and specificity of 80% and 76% (AUC (Area under the Curve) = 0.9, P<0.001). The best cut off point for inlet perimeter was 1.44 m with sensitivity and specificity of 85% and 77 % (AUC=0.87, P<0.001). Our findings showed that median nerve CSA at carpal tunnel inlet could be used as the diagnostic criteria for CTS.

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Keywords: Carpal tunnel syndrome; Ultrasound; Cross-sectional area; Diagnostic accuracy

Introduction

Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy. It accounts 90% of all entrapment neuropathies all over the world. Median nerve entrapment in the carpal tunnel is the cause of clinical symptoms such as pain, numbness, and tingling (1,2). Its prevalence reported between 0.6 and 5.8 % of the general population and is more common in women than men (3). CTS diagnosis is mostly based on clinical findings.

Although, physiologic information has been considered as the gold standard for CTS diagnosis, its sensitivity ranged from 49% to 86% and false negative ranged between 16 and 34% (4,5).

Ultrasound (US) is a non-invasive, cost effective and available para-clinical method which could be applied for CTS diagnosis. By means of US, different measurements can be possible for predicting severity of the disease. Cross- sectional area in different levels of median nerve pathway can be measured for disease diagnosis. Different studies demonstrated that cross-sectional areas of the median nerve at the level of inlet and outlet of the carpal tunnel are significantly greater in CTS patients in comparison with normal population.

In previous studies, cut off point of CSA at tunnel

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inlet in patients with CTS ranged from 6.5 to 15 mm^2 (6-8), although exact cut off point is not determined.

The goal of this study was to compare CSA and perimeter of the inlet in CTS patients and healthy controls and define the best cut off point of CSA for differentiating patients and controls.

Materials and Methods

In this study which conducted between January 2012 and January 2013 in imaging center of Imam Hospital, thirty-eight patients with electrophysiologically confirmed idiopathic CTS and 22 healthy controls were enrolled. Seventy-one affected nerves and 42 unaffected nerves were evaluated within 14 days after electrophysiological examination.

All EDTs were done before US evaluation by an expert neurologist. According to EDTs results, patients were divided into mild, moderate, and severe cases according to Paula *et al.,* scoring system (9).

Patients with underlying diseases such as wrist trauma or neuropathies due to diabetes mellitus, hypothyroidism, chronic renal failure, pregnancy, cervical radiculopathy, poly-neuropathy, and previous corticosteroid injection were excluded.All participants asked to fill informed consent form before study entrance.

An expert radiologist in the field of muscle-skeletal radiology (with 6 years experience) performed all US evaluations by means of a 5–13-MHz (MYLAB 70 XVG,Esaote Company,Jenoa, Italy) linear array transducer. She was blinded to clinical symptoms and EDTs results.

Patients were asked to lie on the bed while their fore-arms were extended, their wrists resting on a flat surface (in the supine position), and their fingers were semi-extended. The largest cross-sectional area (CSA) was measured at the level of the carpal tunnel inlet as described by Ziswiler *et al*., (10) at the beginning of the examination by performing gray scale examination.The maximum nerve perimeter was also recorded by means of the device software.

Data was analyzed by SPSS version 18 (SPSS Inc., Chicago, IL, USA), presented as mean ± SD. The Kruskal-Wallis test applied for comparing continuous variables. ROC curve was used to determine

Optimal cut-off values of the median nerve inlet CSA and perimeter. Area under the Curve (AUC) calculated. P-value < 0.05 was considered statistically significant.

Results

We assessed 71 median nerves of 38 confirmed CTS patients and forty-four nerves of healthy controls. Of the 71 nerves, 21 (29.5%) were mildly affected, 37 (52.1%) were moderately affected and 13 (18.3%) were severely affected. Mean age of patients was 47.1±10.9 years and mean duration of symptoms was 2.6± 4.1 years.

Thirty-one cases had bilateral CTS and 6 unilateral. Frequency of paresthesia, pain, numbing, motor weakness and muscle atrophy of thenar part were as follow: 60(53.1%), 57(50.4%), 61(54%), 46(40.7%) and 20 (17.7%). Mean CSA and perimeter were 14.02 ± 4.5mm^2 and 1.7±0.28m in all patients and 8.2±2.1 mm^2, 1.3±0.19m in controls (P<0.001, P<0.001).

Mean CSA and Perimeter were significantly different in 3 groups of patients and controls. There was no significant difference between CSA and perimeter of the right and left sides in study population (P=0.7)

In patients, there was no statistically significant difference between CSA and perimeter of the median nerve in men and women (CSA in women=13.7±4.4, CSA in men=15.2±5.3, p=0.3, perimeter in women=1.6±0.2, perimeter in men=1.8±0.3, P=0.2).

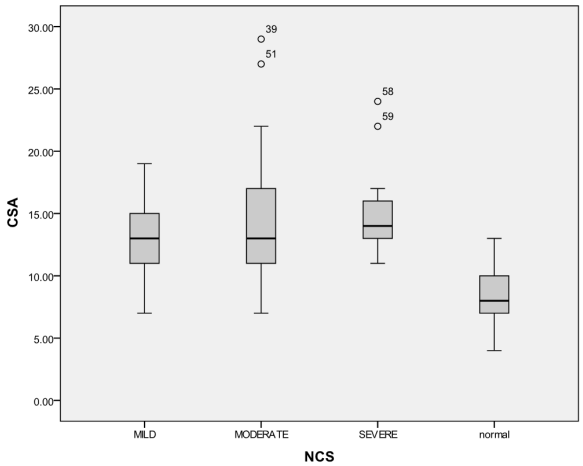

Figure 1. Boxplot showing inlet CSA in different groups of patients and controls

Table1. Mean CSA and Perimeter in 3 groups of patients and controls

	Normal	Mild	Moderate	Severe	P value
CSA(mm^2)	8.2±2.01	12.7±3.3	14.3±5.3	15.1±3.8	*P*<0.001
Perimeter(m)	1.3±0.19	1.6±0.2	1.7±0.32	1.8±0.23	*P*<0.001

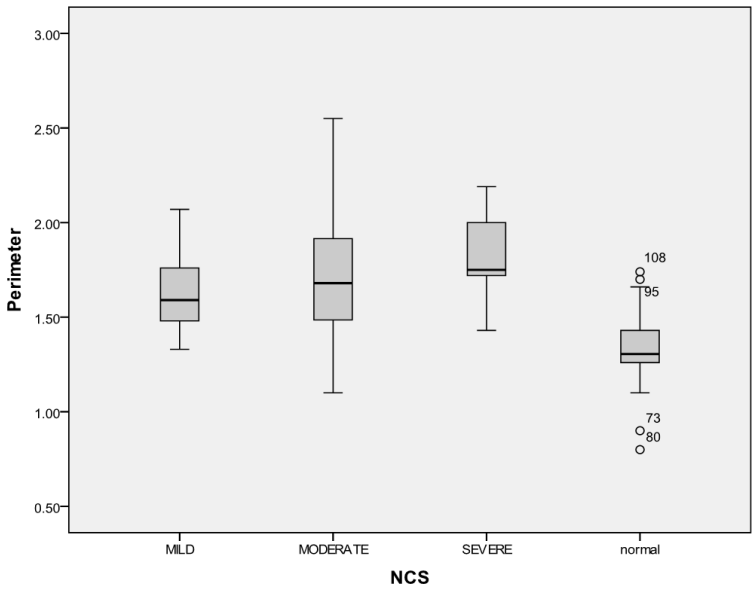

Figure 2. Boxplot is showing inlet Cperimeter in different groups of patients and controls

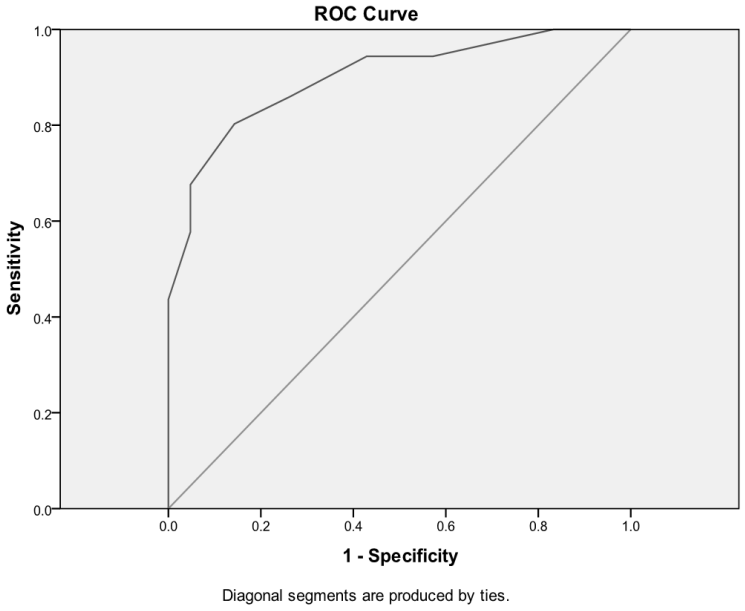

Figure 3. Receiver operating characteristic (ROC) curve of inlet CSA

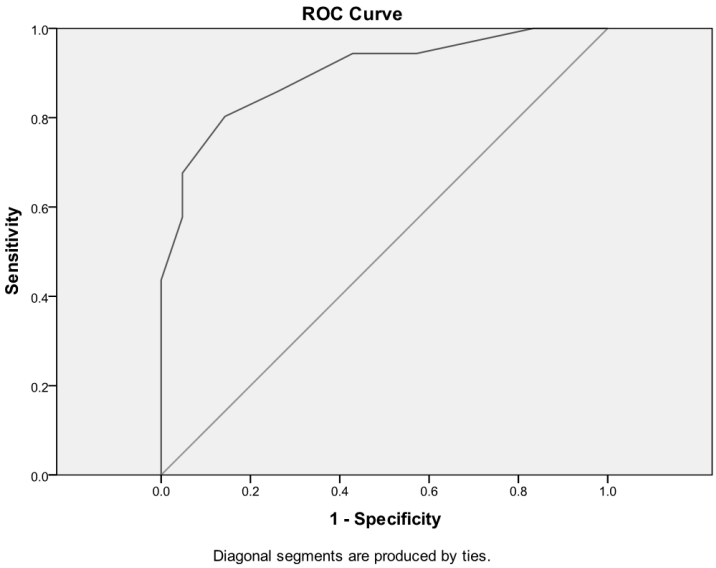

Figure 4. Receiver operating characteristic (ROC) curve of inlet perimeter

The best cut off point for tunnel inlet CSA was 10.5 mm^2 with sensitivity and specificity of 80% and 76% for CTS diagnosis. (AUC=0.9, P<0.001). The fitted positive and negative LRs (Likelihood ratios) for this cut off point were 3.3 and 3.8.

The best cut off point for inlet perimeter was 1.44 m with sensitivity and specificity of 85% and 77%. (AUC=0.87, P<0.001). The fitted positive and negative LRs (Likelihood ratios) for this cut off point were 3.6 and 5.1.

Discussion

We found that mean CSA and perimeter level of the median nerve at tunnel inlet in patients significantly differed with CSA and perimeter level of healthy controls, and the best cut off points for CSA and perimeter for distinguishing patients from healthy controls were 10.5 mm^2 and 1.44m.

Electrodiagnostic studies (EDS) provided good information about median nerve conduction and prolonged sensory and motor latencies and reduced both sensory and motor velocities in CTS patients are indicative.

Although, physiologic information has been considered as the gold standard for CTS diagnosis, its sensitivity ranged from 49% to 86% and false negative ranged from 16 to 34% (4,5).

By introducing the ultrasound as a diagnostic modality for carpal tunnel syndrome diagnosis, it has been applied in a suspected case of CTS.

In comparison with EDS, Ultrasound is cost effective, available, non-invasive and comfortable. Thickening of the median nerve, flattening of the nerve in the tunnel and bowing of flexor retinaculum are common findings of the median nerve in cases with CTS.

Diagnostic accuracy of ultrasound for CTS diagnosis has been evaluated in different studies previously, and different cutoff points have been reported for CSA of the tunnel inlet in different studies (Table 2).

Table 2. different cutoff points for CSA of the tunnel inlet in several studies

Author	Cut off point (mm)	sensitivity	Specificity
Wong (11)	9.8	89 %	83 %
Ziswiler(10)	9	86 %	70 %
Yesildag(12)	10.5	89 %	94 %
Naranjo (13)	9.7	63.6 %	78.3 %
Dalili (14)	9.45	78.9 %	82.8 %
Ashraf (15)	9.3	80 %	77 %
Kwon (16)	10.7	63 %	66 %
Kang (17)	9.5	96.4 %	92.1 %
Yazdchi (18)	12.5	71.4 %	59.1 %
Mohammadi (7)	8.5	97 %	98 %
Padua(19)	10	70%	Not determined
Visser (20)	10	78%	91%
El Miedany (21)	10	97%	100%
Moran (22)	12.3	62%	95%
Kele (23)	11	74%	98%

This difference in the cut-off point values of the tunnel inlet could be due to heterogeneity of study designs, different sample sizes, patient's characteristics and operator experience.

In most previous studies, concordance of findings of ultrasound and NCS in defining CTS severity has been shown (7,24).

For instance, Karadag *et al*., reported high

concordance of NCS and US findings in grading CTS severity (25).

Lee *et al*., investigated that carpal tunnel inlet CSA has good correlation with NCS findings in patients with different CTS grades (26).

On the other hand, Moran *et al*., found that ultrasonography cannot differentiate between different grades of CTS as well as NCS (22).

Our results showed that ultrasound findings are in concordance with EDTs findings in patients with CTS.

Magnetic resonance imaging (MRI) is another diagnostic modality which could show the carpal tunnel anatomy and median nerve condition well. But it is not recommended for CTS diagnosis in routine practice as it is costly, time consuming, and not available in most settings (27).

Median nerve CSA of the carpal tunnel inlet could be used as the diagnostic criteria for CTS.

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