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● *Original Contribution*

IDIOPATHIC CARPAL TUNNEL SYNDROME: EVALUATION OF THE DEPTH OF THE CARPAL TUNNEL BY ULTRASONOGRAPHY

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Abstract—The objective of the work described here was to evaluate the depth of the carpal tunnel (DCT) in patients with idiopathic carpal tunnel syndrome (CTS) and healthy volunteers by ultrasonography (US), through measurement of the distance from the flexor retinaculum to the surface of the capitate bone at the carpal tunnel outlet, and compare it with other ultrasonographic and electrophysiologic parameters in CTS. The study was conducted in 60 non-diabetic patients with idiopathic carpal tunnel syndrome (unilateral n = 37, bilateral n = 23) evidenced by electrophysiologic diagnosis according to the criteria of the American Association of Electrodiagnostic Medicine (AAEM). Furthermore, 40 hands from 20 healthy volunteers were examined. Median nerve cross-sectional area (CSA); flattening ratio (FR), the ratio of the length to the width of the median nerve; and DCT at the canal outlet were measured for all participants. The mean age was 35.6 ± 9.48 y. The female-to-male ratio was 47:13 in the CTS patients. The sensitivity and specificity were 82% and 95% for CSA, 75% and 60% for FR and 75% and 87.5% for DCT, respectively. Differences between patients and healthy controls were significant for all three parameters, greatest for DCT, followed by CSA and then FR. We conclude that DCT increased in CTS and this new parameter is comparable in sensitivity and specificity to CSA and FR. DCT increased independently of the cause of the CTS (decrease in size of canal or increase in contents). (E-mail: Sarah.ohrndorf@charite.de) © **2015 World Federation for Ultrasound in Medicine & Biology.**

Key Words: **Idiopathic carpal tunnel syndrome, Electrophysiology, Ultrasonography, Carpal tunnel depth.**

INTRODUCTION

Carpal tunnel syndrome (CTS) is the most common form of entrapment neuropathy. In Scandinavian countries, its prevalence ranges from 8% at ages 35–44 to 15.8% at ages 55–64 (Atroshi et al. 1999). It affects 3% to 6% of the adult general population (LeBlanc and Cestia 2011). Carpal tunnel syndrome is compression of the median nerve at the carpal tunnel and can result in sensory and motor disturbances in areas of the hand supplied by this nerve, leading to pain and loss of function (Werner and Andary 2002).

The exact pathophysiology of CTS is not fully understood. Two theories have been put forward to explain its etiology. According to the first theory, the increase in pressure on the median nerve leads to transient ischemic episodes linked to microvascular disorders without changing the size of the carpal tunnel or the volume of the nerve; according to the second theory, median nerve compression results in a reduction in tunnel volume or an increase in the volume of tunnel contents (Rossignol et al. 1998).

In this study our aim was to shed light on the second theory by measuring depth of the canal in non-diabetic individuals with CTS and its correlation to other ultrasonographic parameters in patients with electrophysiologically confirmed CTS (Visser et al. 2008). Evaluation of the dimensions of the carpal tunnel has been inadequately addressed in the literature on CTS, as most previous studies evaluated the dimensions of the carpal tunnel in normal individuals and not in CTS patients. These studies, which were performed on healthy patients or cadavers, employed either computed tomography (CT) or magnetic resonance imaging (MRI), or used a silicon cast to fill the carpal tunnel to measure these dimensions (Bower et al. 2006; Mani et al. 2011; Pacek et al. 2010; Widgerow et al. 1996).

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Ultrasonography is a useful non-invasive painless bedside test preferred by most patients. In many studies, it has been used to evaluate CTS through measurement of median nerve cross-sectional area (CSA) and calculation of the flattening ratio (FR) (Visser et al. 2008). Sonographic measures of CTS are usually obtained at the inlet level, as it is believed that measures at the outlet are technically more difficult and have less inter-rater reliability, though the sensitivity and specificity at both levels are comparable (Moghtaderi et al. 2012; Moran et al. 2009).

METHODS

All patients recruited into the study were informed about the methodology and goals and signed a written consent. The study protocol was approved by the local ethics committee of Sohag Faculty of Medicine, Egypt. Personal and medical information was kept confidential and was not made available to a third party. Patients clinically suspected of having CTS were recruited from the neurology and rheumatology outpatient clinics of Sohag University Hospital. They were then referred to the neurologist for clinical and neurophysiologic examinations and, then, to the rheumatologist for ultrasonographic examination. Only the rheumatologist was blinded to the patients' diagnosis.

A descriptive cross-sectional study was carried out on the hands of 60 non-diabetic patients (unilateral n = 37, bilateral n = 23) aged ≥20 y with uni- or bilateral carpal tunnel syndrome and 40 hands of 20 healthy volunteers in the same age group attending the rheumatology and neurology outpatient clinics of Sohag University Hospital from January to March 2014.

Carpal tunnel syndrome was diagnosed according to the criteria of the AAEM (Jablecki et al. 2002; You et al. 1999). These criteria included both clinical and electrophysiologic evidence of CTS. Clinical evidence of CTS included both major and minor criteria for CTS diagnosis. Major criteria include: (i) paresthesias of the hand in a median nerve, median nerve and ulnar nerve

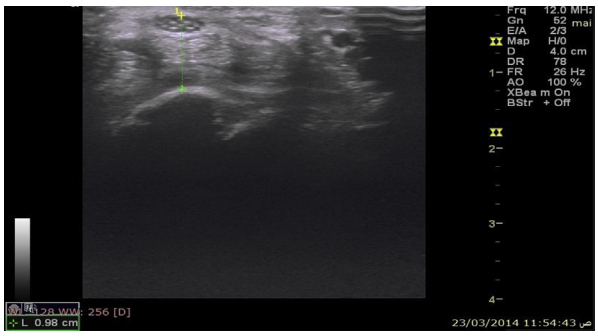

Fig. 1. Normal median nerve with fascicular pattern and transverse measurement of the depth of the carpal tunnel from the flexor retinaculum to the surface of the capitate bone.

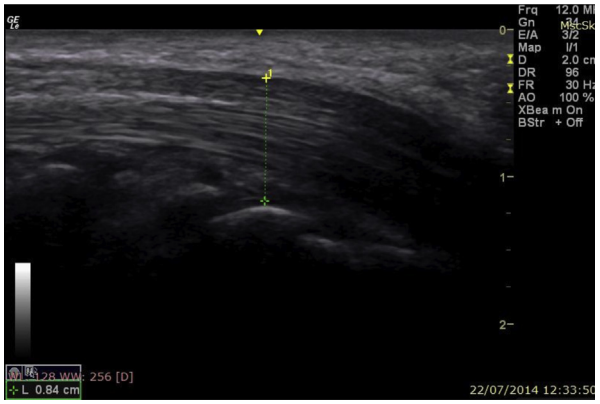

Fig. 2. Longitudinal measurement of the DCT from the surface of the median nerve perpendicularly to the capitate bone. DCT = depth of the carpal tunnel.

or glove distribution; (ii) paresthesias aggravated by activities such as driving, holding a book, holding a telephone and working with the hands raised; (iii) paresthesias and pain in the hand that awaken the patient from sleep; and (iv) paresthesias relieved by shaking the hand or holding it in a dependent position. The minor criteria for diagnosis of CTS were: (i) subjective weakness of the hand; (ii) clumsiness of the hand or dropping of objects; and (iii) positive Tinel or Phalen sign. The electrophysiologic evidence of slowing of distal median nerve conduction includes prolongation of distal sensory and/or motor latency of the median sensory nerve action potential (SNAP) and/or compound muscle action potential (CMAP) ± reduced SNAP/CMAP amplitude of the median nerve (Keith et al. 2009).

Patients with polyneuropathy were excluded from the study. Polyneuropathy was diagnosed according to the recommendation of the AAEM (England et al. 2005).

For motor nerve conduction, compound muscle action potential (CMAP) was recorded using (Ag/AgCl)

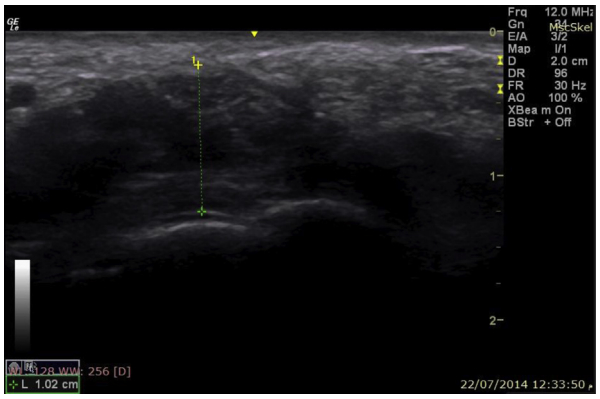

Fig. 3. Transverse measurement of the DCT from the flexor retinaculum perpendicularly to the capitate bone. DCT = depth of the carpal tunnel.

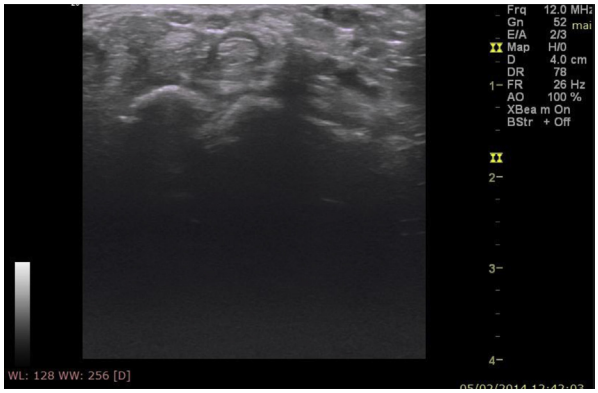

Fig. 4. Bifid median nerve with double-barrel appearance that was present only in patients with carpal tunnel syndrome.

electrodes (Nihon Koheden Co, Japan) placed over the motor points of abductor pollicus brevis and abductor digiti minimi muscles for median and ulnar nerve studies. The median nerve was stimulated at a distance of 8 cm from the active electrode, between the tendons of the flexor carpi radialis and palmaris longus muscles at the wrist and at the elbow. The ulnar nerve was stimulated at the wrist at a distance of 8 cm from the recording electrode and at the elbow. Distal motor latency, conduction velocity, and CMAP amplitude were calculated.

For sensory nerve conduction, sensory conduction velocity, SNAP amplitude and distal sensory latency were calculated from antidromically stimulated median and ulnar nerves using ring electrodes from the second, fourth and fifth digits for the median nerve and ulnar nerves. Both nerves were stimulated at the wrist 12 cm from the active electrodes. A minimum room temperature of 25°C and extremity distal skin temperature >32°C were maintained for all electrophysiologic studies. C-7, C-8 and T-1 radiculopathy was excluded by extensor indices and thenar and hypothenar electromyography.

Distal motor latency >4 ms, distal sensory peak latency >3.5 ms, sensory conduction velocity <45 m/s and a sensory latency difference of 0.4 ms between median and ulnar SNAPs in the fourth finger were taken as cutoff points for diagnosis of CTS according to our laboratory standards (Uncini et al. 1989). All electrodiagnostic examinations were performed by the same examiner.

Ultrasonography was performed with a 7- to 12-MHz (Logiq e, General Electric, China) linear probe. US examination was performed while the participant was sitting, with the elbow flexed and the wrist facing upward. We obtained longitudinal and transverse scans of the median nerve at the canal outlet, which was considered the distal edge of the flexor retinaculum (Wong et al. 2002). In the canal outlet area, the capitate bone has a characteristic capsule reflection that is easy to identify by US in both longitudinal and transverse scans, and because differentiation of the carpal bone is difficult, especially on a transverse scan, and to avoid faulty measurements, this level was used to measure DCT. On tracing the nerve distally on the transverse scan, the flexor retinaculum and the capitate capsule appear together at one point. Measurements were made at this point to ensure accuracy. Mani et al. (2011) used the same level to measure DCT. To make a logical comparison, CSA and FR were measured at the same level. The median nerve was identified by being the most superficial structure in the carpal tunnel under the flexor retinaculum, by its fascicular pattern and by the hyper-echoic

Table 1. Comparison of ultrasonographic and electrophysiologic measurements of patients and controls

Measure	Patients	Controls	*p* Value
Personal data			
Age (y)	35.6 ± 9.5	35.1 ± 6.04	0.812
Sex (male:female)	13:47	3:17	0.747
Body mass index (kg/m^2)	25.37 ± 2.35	24.04 ± 2.86	0.025
Dominant hand (yes:no)	51:32*	20:20	0.229
Electrophysiologic data			
Motor latency (ms)	5.2 (3.2–8.9)†	2.8 (2.1–3)*	<0.0001
Compound muscle action potential (mV)	6.07 (1.5–21.5)	6.2 ± 1.47	0.768
Motor conduction velocity (m/s)	59.6 (40–131.7)	45.3 (40–60)	0.001
Peak latency (ms)	4.69 (2.6–7.6)	2.47 ± 0.49	<0.0001
Sensory nerve action potential (μV)	13.03 (1.5–30.04)	25.76 ± 3.79	<0.0001
Sensory conduction velocity (m/s)	49.2 (28.7–68.4)	51.45 ± 6.59	0.027
Ultrasonographic data			
Cross-sectional area (cm^2)	1.66 ± 0.46	1.02 ± 0.13	<0.0001
Flattening ratio	3.6*	3.17 ± 0.51	<0.001
Carpal tunnel depth (cm)	1.02 ± 0.19	0.79 ± 0.1	<0.0001
Bifid nerve	5	0	0.424

* Test was performed on 83 hands from 60 patients; 37 had unilateral carpal tunnel syndrome (28 in the dominant hand and 9 in the non-dominant hand) and 23 had bilateral carpal tunnel syndrome, yielding 46 affected hands.

† Values are expressed as the median (range) instead of the mean ± standard deviation for non-normally distributed data.

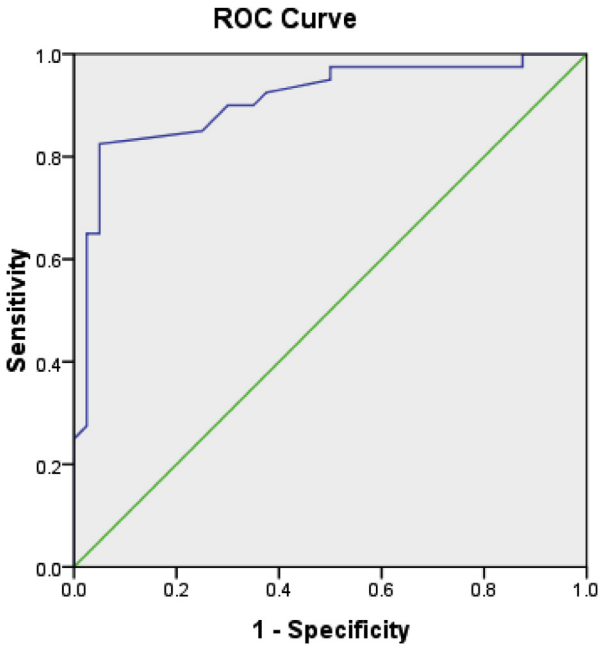

Fig. 5. Receiver operating characteristic curve for the cross-sectional area of the median nerve at the carpal tunnel outlet.

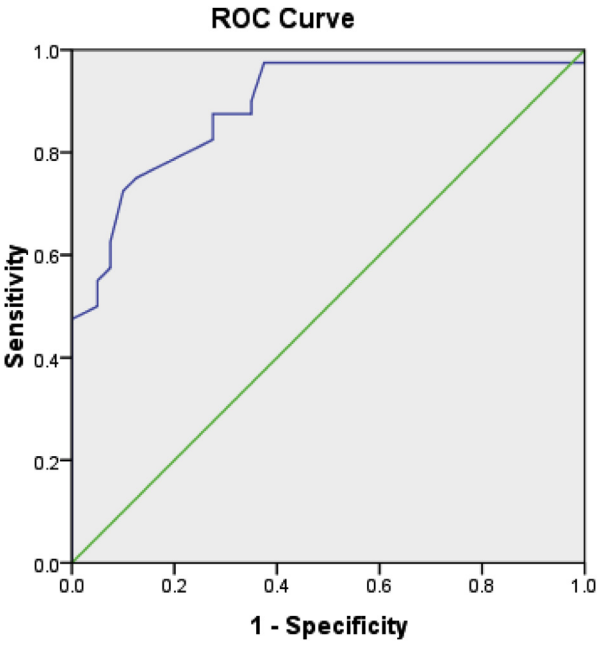

Fig. 7. Receiver operating characteristic curve for the depth of the carpal tunnel at the outlet.

sheath (El Miedany et al. 2004). CSA, FR and DCT (distance from the flexor retinaculum surface to the capitate bone surface's highest point) were measured in all participants. A CSA >1.33 cm^2 and FR > 3.2 were considered diagnostic of CTS (Wong et al. 2002). CSA was measured by following the nerve surface on the transverse section; the hyper-echoic epineural rim was thereby excluded (Tsai et al. 2013). FR was calculated as the ratio of the maximum length of the median on the transverse section to its maximum width (Tsai et al. 2013). CSA and FR were obtained twice, and if the values differed, the mean of the two measurements was considered. DCT was measured in two planes, longitudinal and transverse views, and the measurement was considered when it was the same in the longitudinal and transverse views; a difference up to 2 mm was accepted (Figs. 1–4). All ultrasonographic examinations were performed by the same examiner to avoid interobserver bias. During US measurements, the probe just touched the skin to avoid induction of artifacts (Jeong et al. 2011). A perpendicular angle of the probe was maintained in all examinations (Jeong et al. 2011).

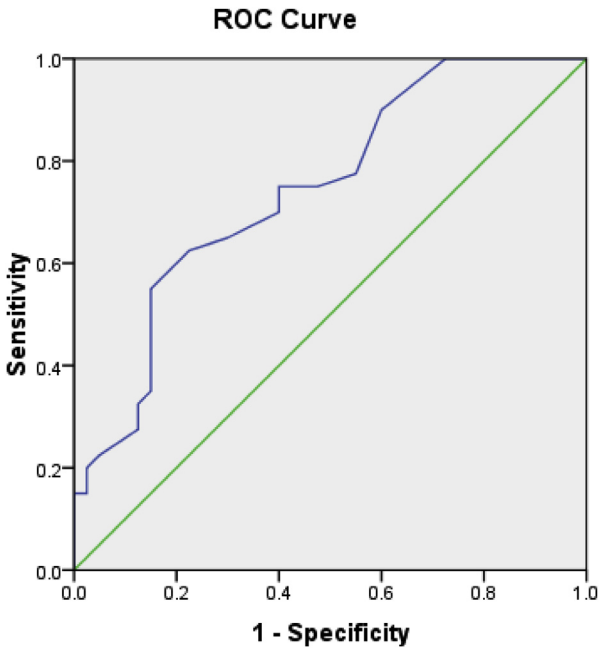

Fig. 6. Receiver operating characteristic curve for the flattening ratio of the median nerve.

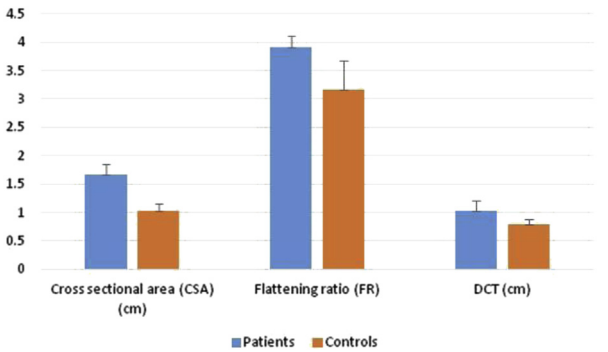

Fig. 8. Comparison of mean ultrasonographic measures of cases and controls. DCT = depth of the carpal tunnel.

Table 2. Spearman correlations (r) between ultrasonographic and electrophysiologic measurements

	Circumference		Flattening ratio		Depth	
	r	p	r	p	r	p
	0.729	<0.001	0.659	<0.001	0.583	<0.001
Compound muscle action potential AMP	−0.116	0.306	−0.134	0.237	−0.110	0.330
Motor conduction velocity	0.270	0.015	0.269	0.016	0.243	0.030
Onset latency	−0.003	0.983	−0.129	0.429	0.116	0.476
Peak latency N	0.669	<0.001	0.573	<0.001	0.582	<0.001
Sensory nerve action potential AMP	−0.596	<0.001	−0.509	<0.001	−0.537	<0.001
Sensory conduction velocity	−0.251	0.025	−0.201	0.073	−0.261	0.019
Flattening ratio mod	0.935	<0.001	0.987	<0.001	0.511	<0.001
CR mod	0.964	<0.001	0.956	<0.001	0.552	<0.001
Flattening ratio mod1	0.806	<0.001	0.893	<0.001	0.351	0.001

AMP = amplitude.

Data are expressed as the arithmetical mean ± standard deviation or median (range) depending on normality as determined with the Kolmogorov–Smirnov test. Student's t-test and the Mann–Whitney test were used for normally and non-normally distributed variables, respectively. Comparisons of percentages in qualitative data were tested using the χ^2 test or Fisher's exact test. The correlation between two quantitative values was determined using Spearman's correlation test. The sensitivity and specificity of US measurements in CTS patients were obtained by determining the cutoff point using receiver operating characteristic (ROC) curve analysis. Statistical Package for the Social Sciences (SPSS) software (Version 11.0, SPSS, Chicago, IL, USA) was used in all statistical analyses. A p value < 0.05 was considered to indicate significance.

In the patient group, motor latency, CMAP, motor conduction velocity (MCV), peak latency, SNAP, sensory conduction velocity (SCV) and FR were not normally distributed and thus expressed as the median (range), whereas age and CSA were normally distributed and expressed as the mean ± standard deviation.

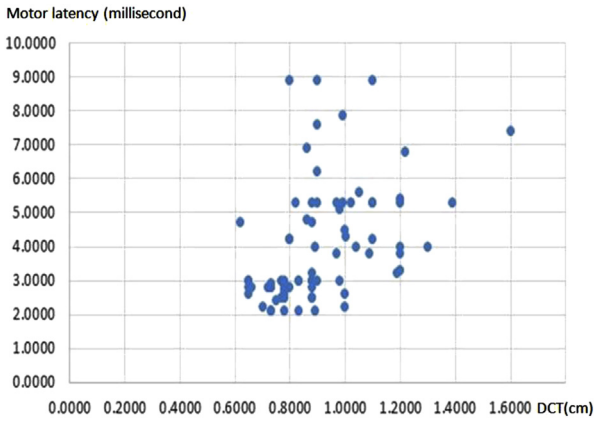

Fig. 9. Correlation between DCT and motor latency. DCT = depth of the carpal tunnel.

In the control group, motor latency and MCV were not normally distributed and the remaining parameters were normally distributed.

Ultrasonographic and electrodiagnostic measurements were made on all participants, patients and healthy volunteers.

RESULTS

The mean age ± standard deviation of the patients with CTS was 35.6 ± 9.5 y, and for the healthy controls, 35.1 ± 6.04 y; thus, the two groups were comparable with respect to age. Among the patients, 78.4% were female, and among the healthy volunteers, 85% were female (Table 1).

Electrophysiology

For the patient group, median motor latency was 5.2 ms (range: 3.2–8.9 ms), CMAP was 6.07 mV (1.5–21.5 mV) and MCV was 59.6 m/s (40–131.7 m/s). There were two patients with a Martin–Gruber anastomosis who had spuriously fast median conduction velocities: peak latency was 4.69 ms (2.6–7.6 ms), SNAP was 13.03 μV (1.5–30.04 μV) and SCV was 49.2 m/s (28.7–68.4 m/s).

For the control group, motor latency was 2.8 ms (2.1–3 ms), CMAP 6.2 ± 1.47 mV, MCV 45.3 m/s (40–60) m/s, peak latency 2.47 ± 0.49 ms, SNAP 25.76 ± 3.79 μV and SCV 51.45 ± 6.59 m/s.

The difference in motor latency between the two groups was highly significant with a p-value < 0.0001. The difference in CMAP was not significant ($p = 0.768$). The differences in MCV ($p = 0.001$) and peak latency ($p < 0.0001$) were significant. The difference in SNAP was highly significant ($p < 0.0001$).

Ultrasonography

The mean CSA for CTS patients was 1.66 ± 0.46 cm^2, and that for healthy volunteers, 1.02 ± 0.13 cm^2. There was a significant difference in

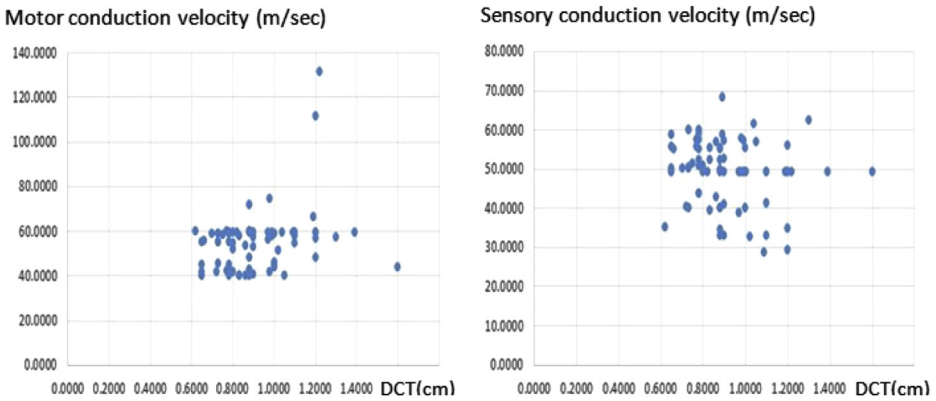

Fig. 10. Correlation between DCT and both motor conduction velocity and sensory conduction velocity. DCT = depth of the carpal tunnel.

the CSA at the canal outlet between the patient and healthy control groups ($p < 0.0001$). A cutoff value of 1.33 cm^2 yielded a sensitivity of 80% and a specificity of 95% (Fig. 5).

With respect to FR, the median for patients was 3.6 (range: 2.8–6.8), and that for healthy volunteers, 3.17 ± 0.51, the difference being significant ($p < 0.001$). There was a positive correlation between FR and distal sensory latency, with a cutoff value for FR of 3.2 yielding a sensitivity of 75% and a specificity of 60% (Fig. 6).

In the patient group, DCT was 1.02 ± 0.19 cm, and in the healthy controls, 0.79 ± 0.1 cm, the difference between the two groups being significant ($p < 0.0001$). The cutoff value was found to be 0.88 cm, which yielded a sensitivity of 75% and specificity of 87.5% (Fig. 7).

A bifid median nerve was found in 12.5% of CTS hands and was not found in the healthy controls (Fig. 4).

Table 1 summarizes sonographic and electrophysiologic results, and Figure 8 summarizes sonographic results of our cases.

Using the Spearman correlation test to study the concordance between the electrophysiologic and sonographic results of our patients, we found that motor latency, MCV, peak latency, FR mod and CR mod were positively and significantly correlated with the three sonographic parameters (CSA, FR and DCT). SNAP amplitude and SCV were negatively and significantly correlated with sonographic parameters, exception for the correlation between SCV and FR, which turned out to be not significant. CMAP amplitude and onset latency did not significantly differ from any of the sonographic findings. Table 2 summarizes these correlations, and Figures 9–12 illustrate the correlations between DCT and motor latency, motor and sensory conduction velocity, age and body mass index.

We also found that DCT was significantly related to age and male sex and negatively related to body mass index in controls, but positively related in patients (Table 3, Fig. 13). DCT was negatively correlated to handedness in controls, but positively related in patients (Table 3,

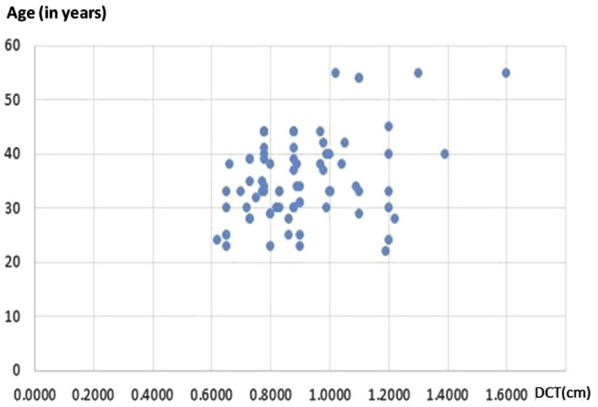

Fig. 11. Correlation between DCT and patient age. DCT = depth of the carpal tunnel.

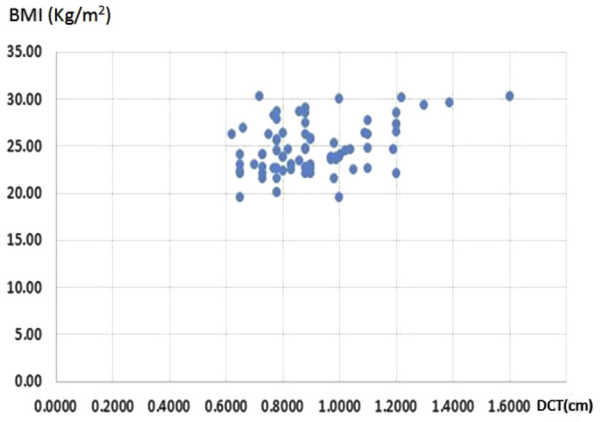

Fig. 12. Correlation between DCT and patient BMI. DCT = depth of the carpal tunnel; BMI = body mass index.

Table 3. Effect of age, gender, body mass index and bifid nerve on the ultrasonographic findings for both patients and controls

	Cross-sectional area (cm^2)		Flattening ratio		Depth of carpal tunnel (cm)	
Measure	Cases	Controls	Cases	Controls	Cases	Controls
Age (y)						
Spearman *r*	−0.017	−0.024	0.059	−0.030	0.416	0.357
p Value	0.919	0.885	0.716	0.852	0.008	0.024
Sex						
Male	1.53 ± 0.18	0.95 ± 0.22	3.53 ± 0.40	2.37 ± 0.67	1.29 ± 0.32	0.89 ± 0.08
Female	1.67 ± 0.47	0.92 ± 0.08	3.95 ± 1.24	2.37 ± 0.46	1 ± 0.16	0.76 ± 0.07
p Value	0.626	0.486	0.568	0.994	0.008	<0.001
Bifid nerve						
Yes	2.32 ± 0.52	—	5.34 ± 1.25	—	1.08 ± 0.14	—
No	1.57 ± 0.37	—	3.72 ± 1.06	—	1.01 ± 0.19	—
p Value	<0.001	—	0.003	—	0.451	—
Dominant hand						
Yes	1.68 ± 0.48	0.96 ± 0.15	4.02 ± 1.31	2.46 ± 0.63	1.07 ± 0.2	0.78 ± 0.1
No	1.63 ± 0.43	0.9 ± 0.09	3.73 ± 0.97	2.28 ± 0.34	0.94 ± 0.13	0.8 ± 0.08
p Value	0.742	0.128	0.476	0.276	0.028	0.500
Body mass index						
Spearman *r*	0.275	0.012	0.203	0.017	0.375	0.032
p Value	0.085	0.943	0.210	0.918	0.017	0.847

Fig. 14). The patients with bifid nerves had non-significantly higher DCT values than patients with non-bifid nerves (Table 3, Fig. 15).

DISCUSSION

The gold standard for CTS diagnosis is electrophysiologic examination. It has some advantages in early diagnosis and in mild cases, but in severe cases and severe peripheral polyneuropathy, it provides no information. In addition, it is a painful invasive technique and has limited ability to detect a bifid median nerve (AAEM et al. 2002).

Ultrasonography is a relatively new and complementary imaging method for the diagnosis of CTS. It is a painless, non-invasive technique that gives a direct view of the carpal tunnel and the cause of the nerve compression; furthermore, it is able to detect congenital anomalies of the median nerve. Nevertheless, US examination is dependent on the operator and requires that examiners be trained before conducting a study (Beekman and Visser 2003).

In our study, CSA, FR and DCT were measured at the canal outlet (although measurement of CSA and FR is more difficult here). At the canal outlet, the capitate bone has a characteristic capsule reflection that is easy to identify and provides an ideal measurement of DCT. For the measurement at the canal inlet, there is no fixed agreement: some consider the canal inlet at the pisiform level, and others, at the level of the distal radioulnar joint or the proximal edge of the flexor retinaculum (Hammer et al. 2006). Many studies maintain that the canal outlet measurements of CSA and FR are comparable to and also (sometimes) more sensitive than inlet measurements, but other studies maintain that measurements proximal to the inlet yield the best results. Nevertheless, ethnicity, whether the patient is diabetic or not, age and body mass index play a role in deciding which level of

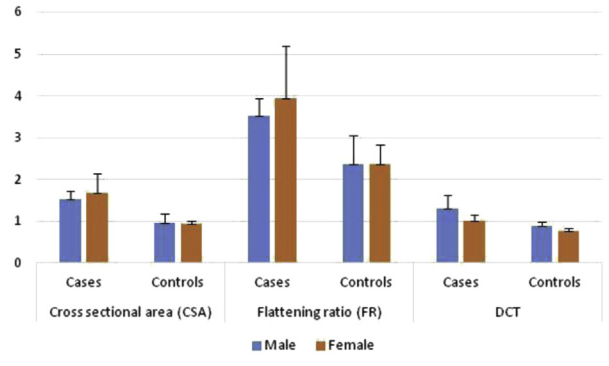

Fig. 13. Sex differences in ultrasonographic measures. DCT = depth of the carpal tunnel.

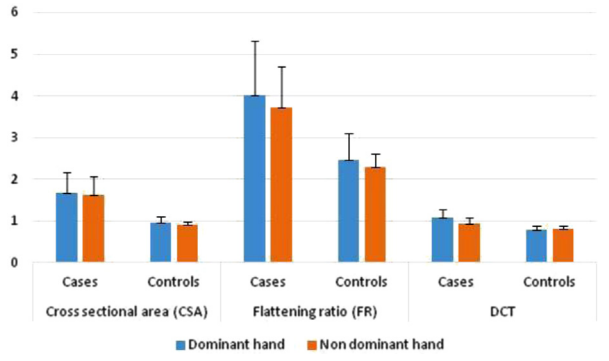

Fig. 14. Differences in ultrasonographic measures between the dominant hand and non-dominant hand. DCT = depth of the carpal tunnel.

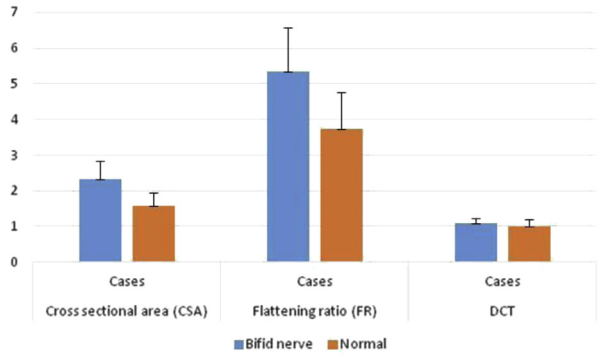

Fig. 15. Effect of the bifid nerve on ultrasonographic findings.

measurement is more sensitive (Ahmad 2011, Coraci et al. 2014; Mondelli et al. 2008; Paliwal et al. 2014; Tsai et al. 2013).

Cross-sectional area sensitivity varies widely among studies, from 48% to 89% (Beekman and Visser 2003; Duncan et al. 1999; El Miedany et al. 2004; Yesildag et al. 2004), and specificity varies from 62% to 100% (Ajeena 2013; Dejaco et al. 2013; Picerno et al. 2013). The CSA cutoff varies from 0.9 to 1.5 cm (Ahn et al. 2009; Keles et al. 2005; Wiesler et al. 2006). In our study, sensitivity was 80% and specificity was 95% at a cutoff value of 1.33 cm.

Flattening ratio sensitivity ranged from 37% to 100% in previous studies (Buchberger et al. 1991; Yesildag et al; 2004), FR specificity was between 50% and 75%; cutoff values ranged from 3.0 to 4.2 cm (Ahmad 2011; Kim et al. 2014). In our study, sensitivity was 75% and specificity was 60% at a cutoff value of 3.2 cm.

Most previously used ultrasonographic parameters involved measurement of the nerve itself; however, DCT is an evaluation of canal dimensions. The results of our study indicate that depth increases in most patients (non-diabetic) with CTS in comparison to healthy volunteers. This parameter has a sensitivity and specificity comparable to those of CSA and FR, although CSA is more sensitive and specific, but the difference between diseased and healthy individuals was highest for DCT. In a study on cadavers (Pacek et al. 2010), the depth of the carpal tunnel was 0.83 ± 0.09 cm, whereas the DCT in our study was 1.02 ± 0.19 cm in CTS patients and 0.79 ± 0.1 cm in healthy controls. The small difference between the two studies may be explained by the difference in ethnicity between the two groups and also by the use of cadavers in the study by Pacek et al. (2010). Another study obtained a mean DCT of 1.4 cm in an asymptomatic population, but had not performed electrophysiologic studies confirm that those volunteers did not have CTS; this also could explain the difference between the two studies (Mani et al. 2011). It appears counterintuitive to find that DCT is greater in diseased than in healthy individuals; however, even if the cause of CTS is a small canal, the increased pressure inside the canal results in an increase in canal dimensions. These results were also obtained in one previous study (Sernik et al. 2008).

With respect to handedness and sex, our results agree with those of Mani et al. (2011), but we should also take in consideration that their study did not include patients. Also, regarding the relation of DCT with body mass index, our results are in agreement with those of Hlebš et al. (2014), and as for DCT and age, our results agree with those of Pierre-Jerome et al. (1997).

Most of the previous studies used electrodiagnostic measures as a gold standard reference. However, this may be problematic because of their false-negative rate, which can be as high as 20% and, thus, would increase the false-positive rate of sonographic measures when electrodiagnostic measures are used as the gold standard (Roll et al. 2011). To avoid this high proportion of false-negative results, we used the criteria of the AAEM, which include both clinical and electrophysiologic evidence of CTS. Sonographic and electrodiagnostic measures should be made on the same day to obtain valid results. Controls should be age and sex matched (Roll et al. 2011), as in our study. Studies performed without standardization of room and skin temperature yield biased electrodiagnostic measures (Roll et al. 2011). In our study, skin and room temperature was standardized.

In conclusion, measurement of DCT is a new promising method for the detection of CTS. Much more work is needed to compare DCT values of different ethnic groups or body mass index groups and to improve the methodology of measurement.

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