ORIGINAL RESEARCH

CARPAL TUNNEL SYNDROME: WHAT IS THE DIAGNOSTIC VALUE OF USG WITH HIGH RESOLUTION TRANSDUCERS?

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ABSTRACT

Objective: Carpal tunnel syndrome (CTS) is a common peripheral entrapment neuropathy, caused by the entrapment of the median nerve. Ultrasonography (USG) has been used as a cost-effective and comfortable technique in the examination of the carpal tunnel and the median nerve in the last decade.
Material and Methods: Thirty-five wrists of 21 patients with the signs, symptoms and electromyelography (EMG) confirmed diagnosis of CTS and 40 wrists of healthy adults were evaluated by ultrasonography (USG), performed with a 7.5-12 MHz transducer.
Results: All of the 35 wrists of 21 patients with CTS diagnosed by EMG and 40 wrists of 20 healthy adults were diagnosed accurately.
Conclusion: USG may be performed as a first step test in the diagnosis of suspected CTS.

Keywords: Carpal tunnel syndrome, EMG, High resolution USG

KARPAL TÜNEL SENDROMU: YÜKSEK REZOLÜSYONLU USG'NİN TANISAL DEĞERİ NEDİR?

ÖZET

Amaç: Karpal Tünel Sendromu (KTS), median sinir tuzağına bağlı sık görülen periferal tuzak nöropatidir. Ultrasonografi (USG), son yıllarda karpal tünel ve median sinirin değerlendirilmesinde kullanılan ucuz ve rahat uygulanabilen bir tekniktir.
Yöntem: KTS bulgusu, semptomları ve elektromyelografik tanısı olan 21 hastada 35 ve 20 sağlıklı olguda 40 el bileği 7.5-12 MHz prob kullanılarak USG eşliğinde değerlendirildi.
Bulgular: 21 KTS 'li olguda 35 el bileğinin tamamı ve sağlıklı 20 sağlıklı olguda 40 el bileği doğru olarak değerlendirildi.
Sonuç: Yüksek rezolüsyonlu USG, KTS tanısında tercih edilecek ilk basamak görüntüleme tekniği olabilir.

Anahtar Kelimeler: Karpal Tünel Sendromu, EMG, Yüksek rezolüsyonlu USG

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INTRODUCTION

Carpal tunnel syndrome (CTS) is a common peripheral entrapment neuropathy, including a group of signs and symptoms, caused by the entrapment of the median nerve as it passes through the carpal tunnel. The diagnosis of CTS is usually based on a combination of clinical signs and physical examination findings. Additional nerve conduction studies may be required for confirmation. The most reliable method for confirming a clinical diagnosis of CTS, is electrodiagnostic testing, but false negatives and false positives may occur, even when the most sensitive methods are used[1-3]. Although the electrodiagnostic studies are usually not comfortable and badly tolerated by the patients, they are still accepted as the gold standard in a CTS diagnosis. Magnetic resonance imaging and high resolution ultrasonography (USG) have been shown to be useful diagnostic tools in CTS providing information about the median nerve and surrounding structures[4,5]. Sonography has been used as a cost-effective and comfortable technique in the examination of the carpal tunnel and the median nerve in the last decade, with a sensitivity of 49-84% and spesificity of over 95%[6]. Our aim is to review the efficacy of high resolution USG in the diagnosis of CTS.

MATERIAL AND METHOD

Twenty-one patients diagnosed with CTS, confirmed by clinical signs, symptoms and electromyelography (EMG) were included in this study. All the patients were informed about the procedure and an informed consent from all the participants was obtained.

Patients with only idiopathic CTS were included in the patient group and 35 of the 21 patients' wrists were examined. Patients with a history of trauma, surgery or steroid injection and patients with systemic disease such as uncontrolled diabetes, gout, or renal insufficiency were also excluded. Three patients with wrists with a previous history of CTS on the contralateral right side were excluded. We also excluded a patient's left wrist diagnosed as bifid median nerve and persistant median artery, detected during our USG examination. Another patient with CTS symptoms on the right wrist was also excluded after a ganglion cyst was detected. In one patient, only the right wrist was examined, due to only right sided symptoms. The control group included the patients who had no known systemic disease, wrist trauma history or symptoms related to the wrist.

The sensory and motor nerve conduction studies and needle EMG examinations of the median and ulnar nerve in the patients' symptomatic wrists were applied using standard techniques. The prolongation of the 2nd finger sensory response latency, equal to or more than 1 millisecond compared to the 5th finger ulnar response latency, the pathologic decrease in the velocity of sensory transmission between the wrist and the 2nd finger, a sensory response amplitude of the 2nd finger below 10 microvolt, a median–ulnar sensory response latency difference over 0,4 millisecond in the 4th finger (the prolongation of median sensory response latency), a normal median nerve motor transmission velocity in the forearm segment but a pathological prolongation in the distal motor transmission period in between the tenar muscles and wrist were used as CTS criteria in the EMG examination.

USG examinations were performed by a radiologist experienced in musculoskeletal system sonography. During the examination, a 7.5-12-MHz linear array transducer (TOSHIBA Applio) was used and the patients were in supine -neutral position while the observer was on the right lateral side and the patient facing the examiner. The examination was supported by using a gel standoff pad. The median nerve in and proximal to the carpal tunnel was scanned in the transverse axial plane initially. The presence of ganglion cysts, anatomic variations, etc. and fluid accumulations in the tendons neighbouring the nerve (tendinitis-tenosynovitis) were investigated and patients with such findings were excluded. The course of the median nerve was followed through its trace from the

most distal palmar region to the distal 1/3 of forearm. The examination began with an evaluation of the nerve and the neighbouring anatomical structures and it was followed by the assesment of the structure, contour and internal echogenicity of the median nerve. The anteroposterior (AP) and transverse diameters of the median nerve were measured at the level of the radiocarpal joint and the proximal carpal bones. At the level of the proximal carpal bones, the flattening ratio (FR) was calculated using the diameter measurements of the mid- median nerve (FR=Transverse diameter/ AP diameter).

The cross-sectional area of the median nerve at the level of the radiocarpal joint proximal median nerve area (PMNA) and at the level of proximal carpal bones mid- median nerve area (MMNA) were also measured. The manual trace method in the USG equipment was used in the area measurements and the hyperechogenic rim was not included. In the overall measurements, ‘’millimetersquare’’ unit was used for area measurements and ‘’millimeter’’ unit was used for the length measurements. The final measurement was obtained following three trials, and by calculating the arithmetical mean. The measurement was carefully performed to demarcate the nerve to be in the transverse projection of the imaging plane.

Palmar displacement or volar bulging may be defined as the farthest distance between the flexor retinaculum and an imaginary line tangent to the trapezium and hamate at the level of the distal carpal bones. We also measured the palmar displacement at the level of the distal carpal bones.

The statistical analysis was evaluated by performing the “SPSS 10.0 for windows” programme, using Student’s t, q square, Fisher exact square and ROC Curve tests. A p value of less than 0.05 was considered statistically significant. All of the values were defined as percent with mean+/- standard deviation and n.

RESULTS

The patients were aged 32-74 years (mean age 48,00 +/-10,24). The patient group consisted of 1 male (4,8%) and 20 females (95,2%). The control group consisted of 17 females (85%) and 3 males (15%) aged 26-51 years (mean 37,45 +/- 8,99). The duration of the symptoms was at least 1 month and not more than 24 months. Of 21 patients, 15 were housewives, (71,4%), 4 were tailors (19.0%), 1 was a waiter (4,8%) and 1 was a butcher (4,8%).

We detected the typical reticular echo pattern in the control group. There was no significant difference between the diameters of the median nerve at the level of the radiocarpal joint and at the level of the proximal carpal bones. In all patients with CTS; the median nerve at the wrist region was hypoechogenic. We also detected the loss of thin reticular echogenicities which are formed by the epineurium layers surrounding the neural fascicles.

Mean PMNA at the level of the radiocarpal joint was 6,97±1,09 mm^2 and the mid level cross-sectional area of the MMNA at the level of the proximal carpal bones was 7,70±1,06 mm^2 in the control group. There was no significant increase in the values of MMNA compared to PMNA in the control group. Mean PMNA at the level of the radiocarpal joint was 12,71±5,2 mm^2 and MMNA at the level of proximal carpal bones was 16,02±6,65 mm^2 in the patient group. There was a significant increase in the values of both PMNA and MMNA compared to the control group($P<0.001$). There was no significant difference between PMNA and MMNA in the control group, whereas MMNA showed a significant increase compared to PMNA in the patient group (Table I).

The thickening ratio (TR) (TR = MMNA / PMNA) was 1,12±0,21 in the control group and 1,30±0,31 in the patient group. The TR ratios of the patient group was increased in the patient group and there was a significant difference compared to the control group ($p<0.05$) (Table II).

The FR of the control and patient groups were calculated using the dimension of the median nerve obtained at the level of the proximal

carpal bones (FR = Transverse diameter / PA diameter). The FR in the control group was calculated as 2,27±0,50 and the FR in the patient group was calculated as 2,86±0,61. The FR of the patient group was significantly increased compared to that of the control group ($p<0.05$) (Table III).

In palmar displacement (PD) measurements at the level of the trapezium-hamate, we observed a significant difference between the control group and the patient group. The PD values were calculated as 3,09±0,81 mm in thecontrol group and 4,98±0,69 mm in the patient group. The PD value of the patient group shows significant increase compared to the control group($p<0.05$) (Table IV). We determined the MMNA as the major criterion in CTS. In comparison of the patient and control groups, the sensitivity of USG was 91,40% and the spesificity was 92,50% in the diagnosis of CTS. The sensitivity of palmar displacement and flattening ratio which we used as minor criteria was 97,10% and 88,60% and the spesificity was 60,00% and 67,50% respectively.

Table I. The values of PMNA at the level of the radiocarpal joint and the values of MMNA at the level of proximal carpal bones

		Area (mm^2)			
		PMNA		MMNA	
Group	n	X±SD		X±SD	
Control	40	6,97±1,09		7,70±1,06	
Patient	35	12,71±5,2	P<0.001	16,02±6,65	P<0.001

Table II. The thickening ratio of the control and patient groups (TR = MMNA / PMNA)

		TR	
Group	n	X±SD	
Control	40	1,12±0,21	
Patient	35	1,30±0,31	P<0.05

Table III: The flattening ratio of the control and patient groups (FR)

		FR	
Group	n	X±SD	
Control	40	2,27±0,50	
Patient	35	2,86±0,61	P<0.05

Table IV. The palmar displacement values of the control and patient groups (PD)

		PD	
Group	n	X±SD	
Control	40	3,09±0,81	
Patient	35	4,98±0,69	P<0.05

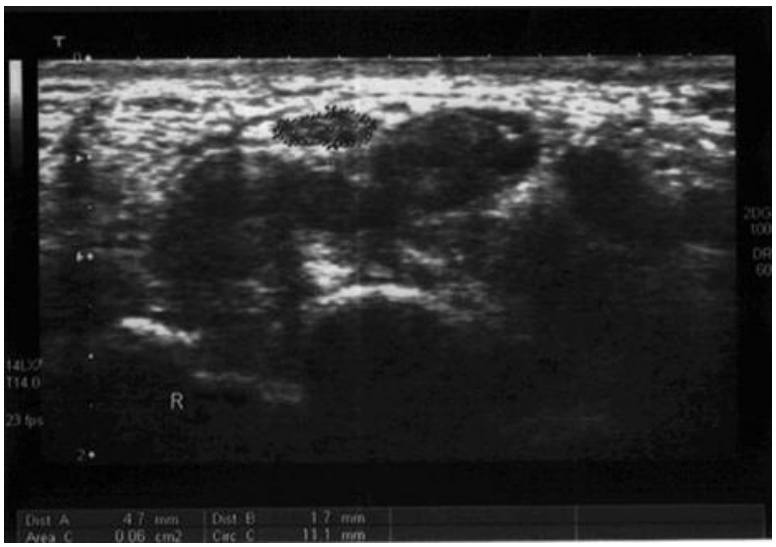

Fig 1: The USG image of a normal median nerve. The typical reticular pattern of the median nerve, formed by hypoechogenic areas surrounded by hyperechogenic bands.

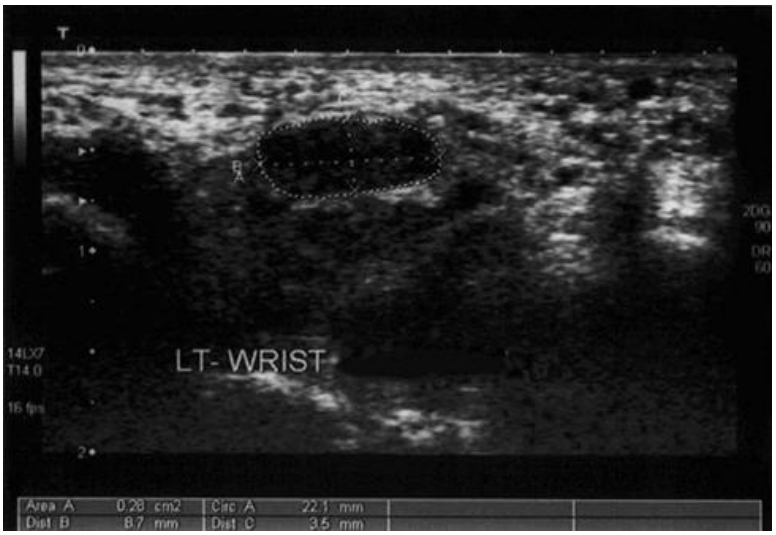

Fig 2: Extensive increase in the cross-sectional area of the median nerve and loss of reticular pattern in a patient with CTS

DISCUSSION

The diagnosis of CTS is made by history and physical examination in some patients, whereas in others some additional confirming studies are required.[7]. In the last few years, many reports have stated that US has high sensitivity and specificity in CTS diagnosis, but many of these studies considered EMG as the gold standard for inclusion criteria[8,9]. The conventional electrophysiological tests are expensive, time-consuming and are not well tolerated by the patients[9]. Technical factors such as filter adjustment or the voltage of the stimulator may effect the quality of the test. Though EMG can detect the presence and the extent of CTS, it cannot give information about the cause of the disease and the anatomical details of the median nerve and neighbouring structures.

The median nerve, its variations and the structures in the wrist region (ganglion cyst neighbouring median nerve, bifid median nerve accompanied by persistant median artery) can be accurately detected by USG. USG may also be helpful in determining the cause of the disease. The accuracy of the diagnosis is increased and the treatment protocol is accurately planned by USG. Additionally, USG has an important role in the treatment of entrapment neuropathies. It can be used as a guide during endoscopic surgery and in postoperative complication follow-up[9].

Decreased median nerve echogenicity and loss of reticular pattern in USG have been reported in most studies, though these findings are not diagnostic criteria for CTS[8,10,11]. The evaluation of nerve echogenicity is a subjective criterion which is observer dependent and even the variations in the angle of the transducer can effect the echogenicity of the nerve. The poor diagnostic value of the nerve echogenicity has also been stated by Wong et al.[12]. Although it was present in all our cases, decreased nerve echogenicity and loss of reticular pattern were not accepted as diagnostic criteria since we believe that they are subjective findings.

The diagnostic criterion in our study was the cross-sectional area of median nerve. The most sensitive measurements are obtained at the level of the pisiformis, because the increased diameter of the nerve due to edema is most remarkable at this plane[4]. We obtained the area measurements at the level of the radiocarpal joint and proximal carpal bones. In many studies, the critical cross-sectional area is stated as 9.0-14.0 mm^2 . We accepted the values over 9.5 mm^2 as pathologic. In some series, this value is found as high as 15.0 mm^2. In our study, we detected the mean cross-sectional area of median nerve as 16.02±6.65 mm^2 (sensitivity = 91.4% specifity = 92.5%). Wong et al. calculated the cross-sectional area of median nerve in left and right hands seperately in both the control and the patient Group[12]. In patient the group, it was calculated as 11.0±4.0 mm^2 in the right, 10.0±3.0 mm^2 in the left wrist and in the control group 8.0±2.0 mm^2 in the right 8.0±1.0 mm^2 in the left wrist. It was stated that the statistical results in the patients with a cross-sectional area of median nerve equal to or higher than 9.8 mm^2 at the entrance of the carpal tunnel are corresponding to the EMG findings. Lin-Yi Wang et al stated that the most useful diagnostic criterion in high resolution US was a 9.875 mm median nerve CSA of $\geq^2$ at the pisiform level[13].

Leonard et al. stated the mean values of area measurements in the patient group as 11.6 mm^2 and in the control group as 7.8 mm^2 at the level of the pisiformis[14]. In our study, we detected the mean cross-sectional area of the median nerve as 7,70±1,06 mm^2 at the level of the pisiformis in the control group and 16,02±6,65 mm^2 in the patient group. There was a significant difference in the values of the control and the patient group($p<0.05$). We observed that there was no significant increase in the cross-sectional area at the level of the pisiformis in the control group and in the patient group, there was a remarkable increase due to the edema of the median nerve. All these findings are concordant with the literature[11,12,14,15].

The FR and PD are also evaluated in the literature[8,10,11,16] but the diagnostic importance of these findings is controversial. In their study, Nakamichi and Tachibana stated that in the control group, the flattening ratios are increased at the level of the distal end of flexor retinaculum and hamate, whereas, in the patient group they are increased at wrist flection[16]. Wong at al. declared that the evaluation of the flattening ratio and palmar bowing is based on subjective interpretation, so these findings have poor diagnostic value[12]. In our study, we examined the significant increase in both values and we believe that these findings can be used as contributory minor criteria in the diagnosis of CTS. We detected that; 21 of 35 patients had wrists with CTS diagnosed by EMG, and 37 of 40 healthy patients' wrists were diagnosed accurately. According to this determination, USG has a sensitivity of 91.4% and spesificity of 92.5%. The statistical findings of our study, in which we accepted the critical value of cross-sectional area of the median nerve at the pisiformis level as 9.5 mm^2 is parallel to the literature[15,17].

In conclusion, USG is a modality of low cost, short duration, and availability. It is painless and noninvasive. Although it is operator dependent, it shows high reproducibility after adequate training of the operators. High-resolution USG, with measurement of the median nerve cross-sectional area at the proximal carpal tunnel inlet, can be used as a first step test in the diagnosis of suspected CTS, and EMG should be applied when the physical examination and USG findings are not sufficient.

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