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ORIGINAL ARTICLES

Carpal tunnel syndrome evaluation with ultrasound in rheumatoid arthritis patients

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ABSTRACT

Aim: In this study, our primary aim was to compare ultrasound (US) findings of the median nerve between rheumatoid arthritis (RA) with carpal tunnel syndrome (CTS) (RA(+)CTS), RA without CTS (RA(-)CTS) and healthy controls (HC) and to determine the optimal US parameters to detect the presence of CTS in RA patients.
Methods: 65 RA patients and 25 HC patients were included in this study. The diagnosis of CTS was made according to the clinical history and physical examination of the participants. Median nerve cross-sectional area (CSA) was measured at the carpal tunnel inlet (CTI), outlet (CTO), and forearm level by the US. In addition, anteroposterior (AP) and mediolateral (ML) diameters of the median nerve were measured. After the measurements, wrist-to-forearm ratio, wrist-to-forearm difference, and flattening ratio were calculated. The presence of tenosynovitis was investigated.
Results: CTS was detected in 26(40.0%) of 65 RA patients who participated in the study. CTS was detected in 43 (35.2%) of 122 wrists of 65 RA patients. CTI CSA, CTO CSA, forearm CSA, anteroposterior/mediolateral diameter, wrist-to-forearm ratio, wrist-to-forearm difference, and flattening ratio were significantly higher in RA (+) CTS than in RA (-) CTS and HC ($p<0.01$). In addition, CDAI and CTI CSA ($r=0.322$, $p<0.01$), CTO CSA ($r=0.301$, $p<0.01$), CTI-to-forearm ratio ($r=0.345$, $p<0.001$), CTI-to-forearm difference ($r=0.362$, $p<0.01$) and CTO-Forearm difference ($r=0.304$, $p<0.01$) moderate correlation was found between. The frequency of tenosynovitis was higher in wrists with CTS than in wrists without CTS ($p<0.05$).
Conclusion: While the presence of CTS in RA patients is sonographically evaluated, it may be useful to evaluate parameters such as CTI-to-forearm difference, ratio, and CTI ML diameter rather than just sticking to CTI CSA during diagnosis. Correlations of these parameters with disease activity can also be noted.

Keywords: Carpal tunnel syndrome; Median nerve; Rheumatoid arthritis; Ultrasound.

INTRODUCTION

Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy[1]. CTS occurs due to compression of the structures around the median nerve at the wrist level[2]. The diagnosis of CTS is currently based on the confirmation of clinical history and physical examination findings by electrophysiological examinations. Although electrophysiological tests are accepted as the gold standard in diagnosing CTS, they have a false-negative rate of 13-27%[2,3]. In addition, the fact that electrophysiological studies are uncomfortable and the morphological features of the median nerve cannot be evaluated are other disadvantages[4].

In recent years, ultrasound (US) has been widely used to diagnose CTS. Morphological and mechanical features of the median nerve can be evaluated with US[5]. When the median nerve is compressed within the carpal tunnel, it typically results in enlargement of the nerve just proximal to the point of compression at the tunnel inlet[6].

Rheumatoid arthritis (RA) is the most common inflammatory arthritis that can cause permanent disability with cartilage damage and bone erosion. CTS is one of RA's most common extraarticular manifestations[7]. Previous studies have shown that CTS in RA patients is mainly associated with the inflammatory process in the tendons, joints, and median nerve itself[8]. Complaints in the hands and fingers due to CTS in RA patients may make it difficult to assess the disease activity of RA. In these patients, differences in US findings of the median nerve may allow the cause of symptoms to be easily distinguished. In this study, our primary aim was to compare the US findings of the median nerve between RA with CTS, RA without CTS and healthy controls (HC) and to determine the optimal US parameters to determine the presence of CTS in RA patients. Our sec-

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ondary aim is to evaluate the relationship between US findings and disease activity.

PATIENTS AND METHODS

The study protocol was approved by the …… …… (approval no: 2011-KAEK-50, Decision no:126 22.04.2022). A written informed consent was obtained from each patient. The study was conducted in accordance with the principles of the Declaration of Helsinki. www.clinicaltrials.gov registration number: *NCT06012630*

STUDY POPULATION

This study was conducted at a single center with RA patients who met the 2010 American College of Rheumatology/European League Against Rheumatism classification criteria and healthy controls (HC) who had no history of rheumatic diseases or CTS. Participants aged 18–65 years Exclusion criteria: history of hypothyroidism, gout, diabetes mellitus, CTS surgery, upper extremity plexopathy, polyneuropathy, uncontrollable fibromyalgia, steroid injection for CTS. For the HC group, the study did not include those with phalen or tinel detected in at least one wrist and those with bifid median nerve detected during US evaluation.

Sample size calculation: The sample size was calculated using NCSS, LLC.'s Power Analysis, and Sample Size Software 15 (2017) (Kaysville, UT, USA; www.ncss.com/software/pass). In this study, the sample size was calculated with 80% power according to the CSA values measured at the CTI level of the median nerve in RA patients with CTS, RA patients without CTS, and healthy controls in previous studies[8,9].

CLINICAL EXAMINATION

The age, gender, height, weight, and BMI of the patients who applied to our clinic and met the inclusion criteria were recorded. Then, C reactive protein (CRP), erythrocyte sedimentation rate (ESR), and rheumatoid factor (RF), anti-cyclic citrullinated peptide (CCP) values were recorded in the patient group. Disease duration, tender joint count, swollen joint count, patient global assessment visual analog scale (VAS 0–10 mm), Clinical Disease Activity Index (CDAI), Health assessment questionnaire disability index (HAQ-DI), and treatment were recorded. Phalen and Tinel tests were performed for each hand. Patients performed the Boston CTS questionnaire (BCTQ) with the functional scale (BQ-FSS) measuring 8 questions and the symptom severity scale (BQ-SSS) measuring 11 questions. Scores ranged from 1 point (mildest) to 5 points (most severe) [10]. The diagnosis of CTS was made according to the diagnostic criteria of the American Academy of Neurology based on clinical history and findings. 1) Paresthesia, discomfort, swelling, weakness, or clumsiness of the hand caused or exacerbated by sleep, prolonged hand or arm position, or repeated motion of the hand or wrist that is relieved by a change in posture or shaking of the hand; 2) sensory impairments in median nerve-innervated hand areas; 3) motor deficit or hypotrophy of median nerve-innervated thenar muscles; and 4) positive provocative clinical tests (positive Phalen's maneuver and/or Tinel's sign). The clinical diagnosis of CTS was made when criterion 1 and one or more of criteria 2–4 were fulfilled[11,12].

US EXAMINATION

The US examination was performed by the same physician (BTD) with a MyLab50 (Esaote Biomedica, Genova, Italy) brand US device. A 12-MHz linear transducer was used during the examination. During the US evaluation, the probe was not pressurised. The patient's arm was resting comfortably on the table with the elbow flexed, the forearm supinated, the wrist in the neutral position, and the fingers semiflexed. The US examination started by investigating the presence of tenosynovitis in the flexor tendons at the carpal tunnel level. Tenosynovitis was defined as abnormal anechoic and/or hypoechoic tendon sheath widening according to the Outcome Measures in Rheumatology (OMERACT) definition[13]. Then the echogenicity of the median nerve was evaluated. Echogenicity was evaluated as normal or decreased (hypoechogenicity). The median nerve at the forearm level was detected with the US probe held perpendicular to the 10 cm proximal section of the distal wrist line. The image of the median nerve was obtained clearly. Then, the probe was shifted distally, and the median nerve was visualised at the carpal tunnel inlet (CTI) at the scaphoid-pisiform levels. Then, the probe was shifted a little more distally, and the median nerve was visualised at the carpal tunnel outlet (CTO) at the hamat-trapezium level. Three images were taken from each level. After being saved, the images were later added to our database for research.

After the images of all participants were recorded, the arithmetic average of the data obtained from the three images was taken. The continuous tracing method was used for the CSA measurement. The line separating the hypoechoic nerve fascicles from the hyperechoic nerve sheath was referred to as the median nerve's

border[14]. The median nerve CSA was measured at the forearm, CTI, and CTO levels. In addition, the anteroposterior (AP) and mediolateral (ML) diameters of the median nerve were measured at the CTI level. After the measurements were completed, the flattening ratio (FR) was calculated as the ratio of ML diameter to AP diameter. The ratio of CTI CSA to CTO CSA was calculated. The ratio of CTI CSA and CTO CSA to forearm CSA was calculated separately (wrist-to-forearm ratio). The difference of CTI CSA from forearm CSA and CTO CSA from forearm CSA was calculated separately (CTI-to-forearm difference and CTO-to-forearm difference)[15].

To determine the landmarks during the evaluation of the median nerve and to standardize the measurements, two practice sessions were done prior to the pilot research, and the measurements were repeated and discussed with five participants. These participants were not included in the study.

STATISTICAL ANALYSIS

Statistical analysis was performed using the IBM SPSS version 22.0 software (IBM Corp., Armonk, IL, USA). Normal distribution was evaluated by Kolmogorov-Smirnov/Shapiro-Wilk test, kurtosis-skewness values, and histogram graphics. While descriptive analyses are presented, mean and standard deviation values or median and ınterquartile range values are given for quantitative variables. Between groups, the Mann Whitney U or Student t-test was used when comparing data. While presenting the categorical variables, the frequency and percentage values of the variables were used, and the analysis of the categorical variables was carried out with the Chi-square Test. Correlation analyses were performed with the Spearman or Pearson Test. ROC curve analysis was performed to determine the cut-off values. We considered r values < 0.3 to represent a weak association, 0.3–0.7 to represent a moderate association, and > 0.7 to express a strong association[16]. P-values below 0.05 were considered statistically significant results.

RESULTS

25 HC and 65 RA patients were included in this study. 22(33.8%) of the patients are receiving biological therapy. CTS (CTS(+)RA) was found in 26 (40%) of RA patients. The mean age for HC, CTS(-)RA, and CTS(+)RA is 53.0±11.6, 55.5±9.5, and 55.4±8.1 years, respectively. Other demographic data of the participants is given in Table I.

Clinical and laboratory findings of CTS(-)RA patients and CTS(+)RA patients were compared. Patient global assessment, HAQ-DI, CDAI, tender joint count, BQ-SSS, and BQ-FSS were significantly lower in CTS(-)RA patients than in CTS(+)RA patients. A comparison of other findings between patient groups is presented in Table II.

A total of 122 wrists of 65 RA patients were included in the study, and 8 wrists were excluded (previous surgery=1, corticosteroid injection=1, bifid median nerve=6). CTS (CTS(+)RA wrists) was detected in 43 (35.2%) of 122 RA wrists.

Clinical and sonographic findings were compared in HC wrists, CTS(+)RA wrists, and CTS(-)RA wrists. The phalen and tinel tests were positive in 12.7% and 13.9% of CTS(-)RA wrists, respectively; 62.8% and 53.5% of CTS(+)RA wrists, respectively ($p<0.01$). Tenosynovitis is present in 2% of HC wrists; it was present in 13.9% of CTS(-)RA wrists and 32.6% of CTS(+)RA wrists ($p<0.05$). Hypoechogenicity in the median nerve was present in 6% of HC wrists, 12.7% of CTS(-)RA wrists, and 39.5% of CTS(+)RA wrists ($p<0.05$). All sonographic measurements between the groups were

TABLE I. Demographic characteristics of healthy control (HC) and Rheumatoid arthritis (RA) patients

	HC (n:25)	RA with CTS(-) (n:39)	RA with CTS(+) (n:26)
Age, years	53.0±11.6	55.5±9.5	55.4±8.1
Height, cm	163.1±6.6	162.1±8.0	159.3±7.0
Weight, kg	75.9±14.7	73.6±11.4	76.4±13.7
BMI, kg/cm^2	28.6±5.7	28.0±4.1	30.1±5.4
Gender, n (% female)	21 (84.0%)	31 (79.5%)	23 (88.4%)
Treatment Biological, n (%) Non-Biological, n (%)	-	14 (35.8%) 25 (%34.2%)	8 (30.7%) 18 (59.3%)

CTS, Carpal tunnel syndrome; HC, Healthy controls; RA, Rheumatoid arthritis; BMI, Body mass index.
Mean + SD for continuous variables

TABLE II. Comparison of laboratory and clinical findings of RA with CTS(-) patients and RA with CTS(+) patients

	RA with CTS(-) (n:39)	RA with CTS(+) (n:26)	p
ESR (mm/h)	17 (27)	17 (26.2)	0.931
CRP (mg/L)	2.74 (7.53)	5.35 (13.97)	0.069
RF, positivity (%)	28 (71.8%)	22 (84.6%)	0.367
CCP, positivity (%)	31 (79.4%)	22 (84.6%)	0.844
Patient Assesment VAS	4.0 (4.0)	7.0 (3.0)	0.006
HAQ-DI	0.3 (0.9)	0.6 (1.0)	0.028
CDAI	10.0 (12.0)	21.0 (9.2)	0.001
Tender joint count	2.0 (8.0)	7.0 (5.2)	0.011
Swollen joint count	0.0 (0.0)	1.0 (2.0)	0.931
Disease duration (months)	108.0 (140.0)	153.0 (111.0)	0.150
BQ-SSS	18.0 (19.0)	28.0 (7.2)	0.002
BQ-FSS	14.0 (12.0)	18.0 (8.0)	0.004

ESR, Erythrocyte sedimentation rate; CRP, C-reactive protein; RF, Rhumatoid factor, CCP; anti-cyclic citrullinated peptide, VAS; visual analogue scale, HAQ-DI; Health assessment questionnaire disability index, CDAI;Clinical Disease Activity Index, BQ-SSS;Boston questionnaire symptom severity scale, BQ-FSS; Boston questionnaire functional scale.

significantly lower in HC wrists and CTS(-)RA wrists than in CTS(+)RA wrists (p<0.01). Other measures "excluding CTI to CTO ratio, CTI AP diameter, forearm CSA and flattening ratio" were significantly lower in HCwrist than in CTS(-)RA wrists (p<0.01) (Table III).

ROC curve analysis was performed for optimal cut-off values of sonographic measurement values in order to differentiate CTS(+)RA wrists from CTS(-)RA wrists. The four measurements with the highest sensitivity and specificity are the CTI-forearm difference, CTI CSA and CTI ML diameter, and CTI-to-forearm ratio, respectively. The area under the curve (AUC 95%), sensitivity, specificity, and cut-off values for the three values are shown in Table IV.

Considering the correlation between clinical findings and sonographic findings was examined, a moderate correlation was found between CDAI and CTI CSA(r=0.322, p<0.01), CTO CSA(r=0.301, p<0.01), CTI-to-forearm ratio (r:0.345, p<0.001), CTI-to-forearm difference (r=0.362, p<0.01) and CTO-to-forearm difference (r=0.304, p<0.01). There was a moderate correlation between disease duration and CTI ML diameter (r=0.343, p<0.01), and CTI CSA(r:0.300, p<0.001). Other correlation findings between the variables are shown in Table V.

DISCUSSION

CTS is a set of signs and symptoms that can be explained by pathologic mechanisms leading to compression of the median nerve. Previous studies have explained that CTS in RA patients is due to inflammation in the tendons, joints, and the median nerve itself[8].

RF and anti-CCP positivity in RA patients have been associated with severe disease activity and multiple extraarticular manifestations[17]. Karadag *et al.*[18] reported RF and anti-CCP positivity in RA patients, respectively, as 71.0% and 69.0%. Mahmoud *et al.*[19] reported RF and anti-CCP positivity in RA patients, respectively, as 86.5% and 83.7%. On the other hand, Smerilli *et al.*[8] reported RF positivity of 71.4% in CTS(+)RA patients and 66.6% in CTS(-)RA patients, and anti-CCP positivity of 78.6% in CTS(+)RA patients and 66.6% in CTS(-)RA patients. In that study, the association of anti-CCP positivity with an increase in the prevalence of CTS in RA patients was reported[8]. In this study, although we found RF and CCP positivity higher in the CTS+RA patients, there was no significant difference.

Mahmoud *et al.*[19], in their study of RA patients, found CTS in 71 (95.9%) of 74 wrists. Smerilli *et al.*[8] found CTS in 23 (20.2%) of 112 wrists. Karadag *et al.*[18] found CTS in 30 (15%) of 200 wrists. In this study, we found CTS in 43 (35.2%) of 122 wrists. The difference

TABLE III. Comparisons of clinical and ultrasound findings in healthy controls wrists and RA with CTS(-) wrists and RA with CTS(+) wrists

	HC (n:50)	RA with CTS(-) (n:79)	RA with CTS(+) (n:43)	P value
Phalen n (%)	--	10 (12.7%)*	27 (62.8%)	<0.01
Tınnel n (%)	--	11 (13.9%)*	23 (53.5%)	<0.01
Tenosynovitis n (%)	1 (2%)+^	11 (13.9%)*	14 (32.6%)	<0.05
Hypoechogenicity n (%)	3 (6%)	10 (12.7%)*	17 (39.5%)	<0.05
CTI AP diameter	1.75 (0.42)^	1.8 (0.5)*	2.0 (0.6)	<0.01
CTI ML diameter	5.30 (1.10)+^	5.90 (1.20)*	7.50 (1.60)	<0.01
CTI CSA , mm^2	8.0 (2.0)+^	9.0 (2.0)*	13.0 (4.0)	<0.01
CTO CSA, mm^2	7.0 (1.2)+^	9.0 (2.0)*	12.0 (4.0)	<0.01
Forearm CSA, mm^2	4.0 (1.0)^	4.0 (1.0)*	5.0 (2.0)	<0.01
CTI to CTO ratio	1.00 (0.25)^	1.00 (0.09)*	1.16 (0.37)	<0.01
CTI to Forearm ratio	1.67 (0.50)+^	2.00 (0.40)*	2.60 (1.08)	<0.01
CTO to forearm ratio	1.75 (0.40)+^	2.00 (0.45)*	2.33 (0.80)	<0.01
CTI-Forearm difference, mm	3.00 (2.00)+^	4.00 (1.00)*	8.00 (4.00)	<0.01
CTO-Forearm difference mm	3.00 (2.00)+^	4.00 (2.00)*	7.00 (5.00)	<0.01
CTI-Flattening ratio	3.10 (0.88)^	3.25 (1.36)*	3.63 (0.98)	<0.01

AP; anterposterior, ML; mediolateral, CSA; cros-sectional area, CTI; carpal tunnel ınlet, CTO; carpal tunnel outlet
+ Statistically significant difference between HC and RA with CTS(-); ^ Statistically significant difference between HC and RA with CTS(+); * Significant difference between RA with CTS(-) and RA with CTS(+)

TABLE IV. Correlation analysis between clinical findings and sonographic findings

	CDAI	Disease Duration	BQ-SSS	BQ-FSS
CTI AP diameter	0,248*	0,122	0,021	0,065
CTI ML diameter	0,286**	0,343**	0,181*	0,109
CTI CSA	0,322**	0,300**	0,218*	0,180*
CTO CSA	0,301**	0,237**	0,208*	0,186*
Forearm CSA	0,079	0,249**	0,058	0,007
CTI to CTO ratio	0,082	0,227*	0,050	0,012
CTI to Forearm ratio	0,345**	0,195*	0,214*	0,225*
CTO to Forearm ratio	0,264**	0,099	0,166*	0,183*
CTI-Forearm difference	0,362**	0,295**	0,236**	0,220**
CTO-Forearm difference	0,304**	0,192*	0,213*	0,210*
CTI-Flattening ratio	0,012	0,127	0,103	0,003

AP; anterposterior, ML; mediolateral, CSA; cros-sectional area, CTI; carpal tunnel ınlet, CTO; carpal tunnel outlet, BQ-SSS;Boston questionnaire symptom severity scale, BQ-FSS; Boston questionnaire functional scale. **= p<0.01; *=p<0.05

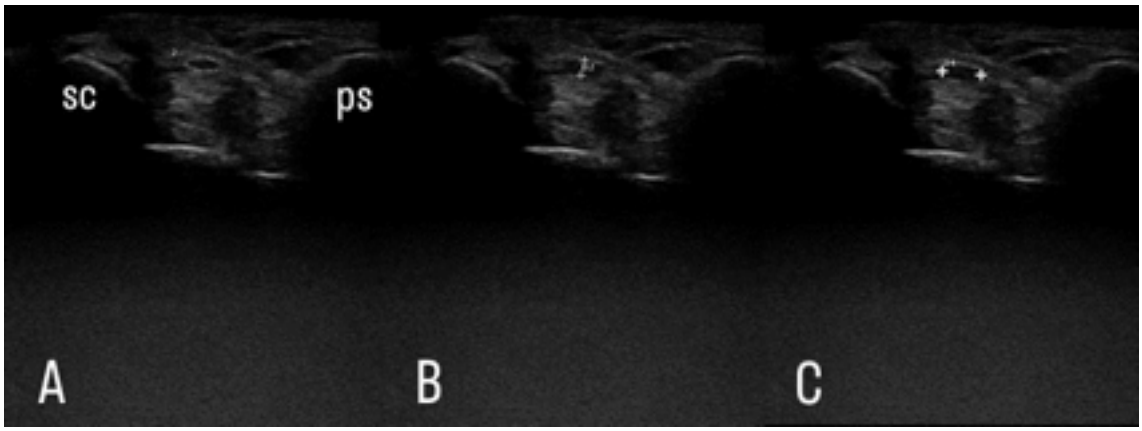

Figure 1. Sonographic measurements of the median nerve - Figure Legends: (A), Measurement of cross-sectional area of the median nerve, sc(scaphoid bone), ps(pisiform bone); (B), Measurement of the anteroposterior diameter of the median nerve; (C), Measurement of mediolateral diameter of the median nerve

in the prevalence of CTS between studies may be due to the method used in diagnosis.

Smerilli *et al.*[8] measured the median nerve CSA at the CTI in CTS(+)RA and CTS(-)RA patients, respectively, as 10.6±4.2 and 8.6±2.1. Karadag *et al.*[18] measured the median nerve CSA at the CTI in CTS(+)RA and CTS(-)RA patients, respectively, as 13.0 (9.0–15.3), 9 (6.0–12.0). Mahmoud et al.[19] found median nerve CSA higher in CTS(+)RA patients than in CTS(-)RA. They also stated in their study that there is a relationship between CSA and the severity of CTS. In this study, we obtained similar results between CTS(-)RA and CTS(+)RA for CSA at the CTI level of the median nerve.

When we look at the literature, we see that the cut-off values for CSA in the US diagnosis of CTS vary[2]. However, determining a single cut-off value for CSA, which can be affected by factors such as the individual's age, BMI, and gender, may cause the CTS diagnosis to be missed. Previous studies have indicated the relationship between the severity of the median nerve CSA and CTS severity (CSA 7.0–10.0 mm^2: normal; 10.0–13.0 mm^2: mild; 13.0–15.0 mm^2: moderate; >15.0 mm^2: severe CTS)[20]. It has previously been shown that this algorithm can be used in RA patients[21]. Karadag *et al.*[18] have used this algorithm in their studies. In this study, we made the diagnosis of CTS according to clinical symptoms and signs. If we had evaluated based on this algorithm, 7(16.2%) of CTS(+)RA wrists would have been overlooked (CTI CSA<10.0mm^2). CTI CSA was ≥10mm2 in 33(41.7%) of CTS(-)RA wrists, and CTI CSA was ≥10mm2 in 5(10.0%) of HCwrists. These findings were similar to those in the study of Yagci I *et al.*[9]. Kaya Subasi P *et al.* [22] found the optimal cut of CSA value for CTS to be 10.5 mm^2 in their study in psoriatic arthritis and RA patients. In our study, we also found the optimal cutoff value of CSA that can be used to detect CTS to be 10.5 mm^2. However, unlike them, we conducted our study only on RA patients. If we wanted to make a diagnosis based only on the CTI CSA value, 12 (15.1%) of CTS(-)RA wrists would have been diagnosed as false positive CTS. In contrast, 7 (16.2%) of CTS(+)RA wrists would have been missed. Currently, electrodiagnostic methods have similar false negative rates in the diagnosis of CTS. For this purpose, we aimed to evaluate different US parameters in the diagnosis of CTS in RA patients.

In previous studies, parameters such as CTO CSA, forearm CSA, CTI-to-CTO ratio, wrist-to-forearm ratio, wrist-to-forearm difference, as well as median nerve CTI CSA in CTS patients, were found to be significantly different from the control group[2,23-26]. In this study, we found these parameters to be significantly different in CTS(+)RA patients than in CTS(-)RA patients and HC. Forearm CSA was evaluated in only two studies[9,19] and wrist-to-forearm ratio was evaluated in only one study[19]. Mahmoud *et al.*[19] found that forearm CSA was higher in CTS(+)RA patients than in CTS(-)RA patients. This may indicate that pronator teres syndrome may also be a component of double crush syndrome[19,27]. They found no relationship between wrist-to-forearm ratio and CTS severity[19]. Yagci *et al.*[9] measured the median nerve CSA at the level of the pisiform, hamatum, and forearm in CTS(-)RA patients and a control group. Although they found median nerve CSA higher at the level of the pisiform and hamatum in their studies than in the control group, they found no difference at the level of the forearm. Similar to this study, we found that the median nerve CSA was higher at CTI and CTO levels in CTS(-)RA patients; however, we did not find any significant difference at the level of the forearm.

In a review, it was stated that the diagnostic value of CSA at the psiform level, wrist-to-forearm ratio,

and wrist-to-forearm difference was high[2,28]. Consistent with this review, we found the sensitivity and specificity of these parameters to be high. In addition to these parameters, CTI ML diameter had high sensitivity and specificity. In none of the CTS-RA wrists were these four parameters higher than the cut-off value at the same time. This result may make the study important at this point.

According to Mahmoud *et al.*[19], the US tenosynovitis score was associated with the severity of CTS. Smerilli *et al.*[8] found that the frequency of flexor tenosynovitis was higher in CTS(+)RA wrists than in CTS(-)RA wrists. Similar to these studies, we found that the frequency of tenosynovitis was higher in CTS(+)RA wrists than in CTS(-)RA wrists and HC. In fact, it has been stated that CTS in RA patients develops secondary to inflammation, unlike idiopathic CTS[8]. The frequency of hypoechogenicity of the median nerve was higher in CTS patients than in the control group[1]. In this study, we found that the frequency of hypoechogenicity in CTS(+)RA wrists was higher than in CTS(-)RA wrists and HC wrists. So much so that hypoechogenicity has been indicated to be indicative of an edematous lesion[29].

Karadag *et al.*[18] found no significant differences between CTS(+)RA and CTS(-)RA patients in terms of DAS28. However, they found a significant difference between the two groups in terms of HAQ-DI. Smerilli *et al.*[8], similar to our study, found a significant difference between CTS(+)RA and CTS(-)RA patients in terms of CDAI. In addition, we found a correlation between CDAI and sonographic findings in our study, but Mahmoud *et al.*[19] found no correlation between DAS28 and median nerve CSA. This may have been due to the difference in the scales assessing disease activity in the two studies. This is because CDAI may be better than DAS28 at assessing disease activity[30].

Smerilli *et al.*[8] did not find a significant difference between CTS(+)RA and CTS(-)RA in terms of disease duration. Karadag *et al.*[18] found disease duration to be higher in CTS(+)RA patients than in CTS(-)RA. In this study, we didn't find a significant difference between CTS(+)RA patients and CTS(-)RA patients, even though CTS(+)RA patients had a longer disease duration than CTS(-)RA patients. We did, however, find a moderate correlation between disease duration and median nerve CTI ML diameter and CTI CSA. Mahmoud *et al.*[19] found no correlation between disease duration and median nerve CSA. However, in the literature, it has been stated that there is a relationship between disease duration and CTS in patients with RA[18,31].

In conclusion, in this study, we evaluated parameters such as CTO CSA, forearm CSA, CTI to CTO ratio, wrist-to-forearm ratio, wrist-to-forearm difference, CTI AP diameter, CTI ML diameter, and FR in RA patients as well as CTI CSA. The cross-sectional area of peripheral nerves in CTS(-)RA patients was found to be wider than in the control group[9]. Considering the prevalence of CTS in RA patients, sonographic optimal cut-off values were needed to determine CTS in RA patients. For this purpose, we aimed to determine the optimal cut-off values of the four parameters with the highest sensitivity and specificity. In this respect, it was the first study in the literature.

Power Doppler has been reported to be a good sonographic parameter to detect the presence of CTS[32]. The limitations of this study are: firstly, the presence of power Doppler activity in the median nerve was not assessed; secondly, the presence of synovitis at the wrist level was not assessed; and thirdly, there was no patient follow-up.

CONCLUSION

When sonographically evaluating CTS in RA patients, it may be useful to evaluate parameters such as CTI-to-forearm difference, CTI-to-forearm ratio, and CTI ML diameter rather than relying only on CTI CSA. Attention can also be paid to the correlation of these parameters with disease activity.

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