

Can decrease in hand grip strength in carpal tunnel syndrome be explained by interosseous muscle and intermetacarpal space dimensions?

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ABSTRACT

Objectives. To investigate the correlation of the grip strength with sonographic measurement of interosseous muscle (IOM) and intermetacarpal space (IMS) of the hands in carpal tunnel syndrome (CTS) patients. **Methods.** A total of 96 hands of 48 female patients constituted the study group. Of those, 36 hands of 18 patients (mean age: 50.2 ± 9 years) had CTS confirmed by electro-diagnostic tests. Sixty hands of 30 healthy volunteers (mean age: 45.2 ± 9.7 years) constituted the control group. Grip strength was assessed by Jamar hand dynamometer. IOM and IMS dimensions for all hands were measured sonographically at three levels (2nd, 3rd and 4th intermetacarpal; palmar side for IMS, dorsal side for IOM) by the same radiologist. Spearman and Mann Whitney U tests were used for statistical analysis. **Results.** The median hand grip strength was determined as 11.3 kg (min-max = 7.2-18.1 kg) in the CTS group and 19.5 kg (min-max = 7.8-30.5 kg) in the control group, with a statistical difference between the two groups ($p < 0.03$). In both groups, there was a positive correlation between the IOM-IMS dimensions and grip strength ($p < 0.05$). Sonographically, IOM-IMS measurements in CTS group were significantly lower than control group ($p < 0.01$). **Conclusion.** To our knowledge, this is the first study evaluating the correlation of grip strength and the sonographic IOM-IMS measurements in CTS patients. The muscular atrophy, which is generally a finding of advanced disease, may be revealed by sonographical measurements earlier than the physical examination findings.

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Introduction

Carpal tunnel syndrome (CTS) is an entrapment neuropathy that causes impairment and decrease in hand grip strength as well as paresthesia, which is more frequent at nights, and malfunction in the hand

[1].

The thenar- hypothenar muscle groups and interosseous muscle (IOM) and lumbrical muscle groups together form the intrinsic muscles of the hand.

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IOM groups are divided into ventral and dorsal parts. There are 4 muscles on the dorsal side and 3 muscles on the ventral side. They originate from the adjacent metacarpal proximal head and attach to the base of the proximal phalanx. While dorsal IOMs abduct; ventral IOMs adduct [2, 3]. Dorsal IOMs are sonographically detectable through metacarpal interspaces from the dorsum of the hand. IOMs are observed between metacarpals as a smooth contour in a hypo-echoic structure [4]. It is known that CTS symptoms develop due to compression of the median nerve. In addition to sensory symptoms, as motor fibers are also affected, hand grip strength decreases. This is one of the most important symptoms of the disease and is associated with muscle weakness. Visible muscle atrophies are mostly located in the thenar part of the hand and are observed in advanced and severe pathology [5, 6]. Predicting muscle strength decrease with sonographically detectable parameters such as intermetacarpal space (IMS) and IOM is an important step for treatment planning in the early phase [7, 8].

Ultrasound is a useful imaging method in examining CTS. In fully developed cases, a classic triad of palmar bowing of the flexor retinaculum, distal flattening of the nerve, enlargement of the nerve proximal to the flexor retinaculum is seen. Enlargement of the nerve is stated as the most sensitive and specific criterion [9]. Hand muscle ultrasound, as being non-invasive and real-time, is a useful technique to visualize normal and pathological muscles. Neuromuscular disorders, like CTS, cause structural changes in muscles that can be visualized with ultrasound: atrophy can be objectified by measuring muscle thickness, while infiltration of fat and fibrous tissue increase muscle echo intensity [10]. The aim of this study was to examine whether decreased hand grip strength in CTS patients is associated with interosseous muscle thickness and intermetacarpal space dimensions.

Methods

The study protocol was approved by the Institutional Review Board of our hospital. The study is performed between January-August 2016. We excluded 3 patients' due to the surgery history in one hand, 2 patients are excluded because of left hand dominance and 12 patients are excluded secondarily to having diabetes mellitus.

Hence, 96 hands from 48 female participants were

included in the study. All the participants were right-hand dominant, and they did not have any systemic diseases.

The patient group consisted of 36 hands of 18 participants previously diagnosed with EMG as CTS. In the physical examination, none of the patients in the CTS group had thenar atrophy. The control group was formed of 60 hands of 30 healthy volunteers and 5 hands detected as normal on EMG from the CTS patient group. For each hand, hand grip strength was measured with a Jamar dynamometer (Lafayette instrument, USA, 2004) in kilograms. To standardize the results, the hand grip strength test was conducted in the same position for each patient (shoulder in full adduction and elbow at 90°) (Figure 1).



Figure 1. Photograph showing hand grip strength measurement with Jamar dynamometer.

During the US examination, the patients were examined in a sitting position on the gurney with their hands on their knees. The fingers were spaced in the anatomical position and the dorsal and volar faces were scanned respectively (Figure 2). All patients were scanned by a radiologist with 25 years of muscle-bone sonography experience, using a B-mod US (SDU-2200; Shimadzu Corporation, Kyoto, Japan)

with an 8-10 MHz linear probe.



Figure 2. Photograph showing patients' position for ultrasound scan

With US, IOM groups were examined on the dorsal side in the 2nd, 3rd and 4th metacarpal spaces and the adjacent bone shaft (Figure 3). On the volar aspect, the IMSs were quantified in the 2nd, 3rd and 4th metacarpal spaces of the adjacent metacarpal distal head. On the obtained images of IMS measurements,

measurements were made on the radial aspect of the lumbrical muscle planes (Figure 4). For each region, 3 vertical measurements were taken in the anteroposterior and transverse planes and the mean values for each were recorded.

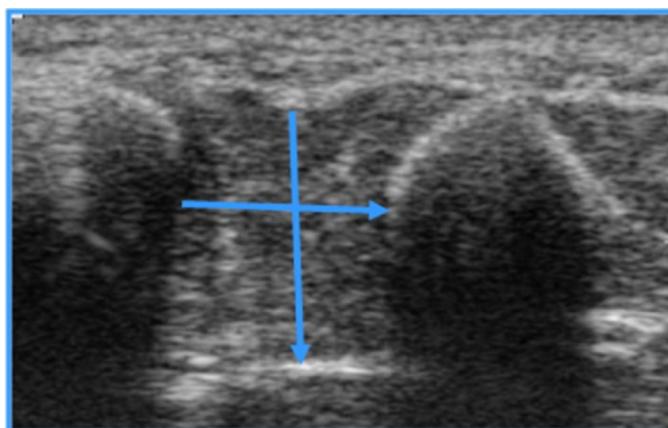


Figure 4. Intermetacarpal space, area between arrows.

To homogenize the sample, the groups were matched for age and gender, including patients with right hand dominance and excluding trauma/surgery history.

Statistical Analysis

Statistical analyses were performed using SPSS Statistics software (version 21.0; SPSS Inc., Chicago, Illinois, USA). The conformity of the data to normal distribution was evaluated with the Kolmogorov-Smirnov test. Numerical variables with normal

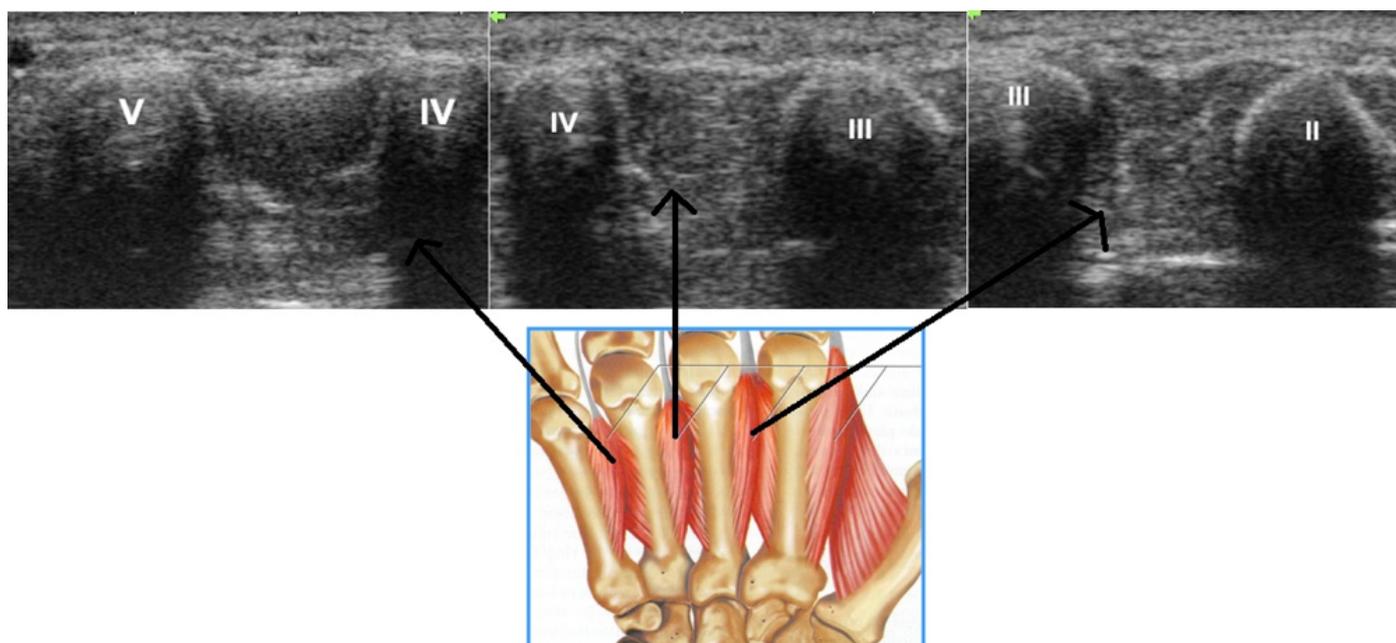


Figure 3. Sonographic pictures indicating interosseous muscle thickness measurement technique.

distribution were stated as mean ± standard deviation (SD) and those not with normal distribution were stated as median values (min.-max.). Categorical variables were shown as number (n) and percentage (%). In both groups, the relationship between hand grip and US measurements was examined with Spearman correlation analysis. To compare the CTS and control groups in terms of hand grip strength and US measurements, the Mann Whitney-U test was applied.

Results

The mean age of control group was 50.2 ± 9 years and the mean age of CTS group was 45.2 ± 9.7 years. The median hand grip strength was determined as 11.3 kg (min-max = 7.2-18.1 kg) in the CTS group, and 19.5 kg (min-max = 7.8-30.5 kg) in the control group. The IMS and IOM values for both groups are presented in Tables 1 and 2. There was a significant difference between the CTS group and the control group in terms of hand grip strength (28,103 vs. 41,005; *p* < 0.01).

In this study, the normal values for the dimensions of IMS in the anteroposterior and transverse axes were obtained. There was determined to be a correlation between these values and hand grip strength (*p*<0.01).

The IOM and IMS values of the CTS group were significantly lower than those of the control group (*p*<0.01). There was a statistically significant relationship between hand grip strength and IOM /MS values (*r* = 0.255-0.479, *p* < 0.01) in the control group. No such relationship was detected in the CTS group (Tables 1 and 2).

Discussion

CTS is the most frequent neuropathy of the upper limb caused by compression of the median nerve in the wrist [9]. Especially following long-term functional hand use, numbness, tingling and burning sensations are experienced in the thumb, index finger, middle finger, and radial half of the ring finger Motor symptoms such as weakness in the strength of the fingers, clumsiness and difficulty in daily life activities cause an impairment in life quality. Typically, the

Table 1. Intermetacarpal space (IMS) measurements of carpal tunnel syndrome (CTS) and control groups

IMS WIDTH	Control	CTS	<i>p</i> value
1 IMS			
Transvers	10.17 ± 1.10	10.12 ± 1.16	<i>p</i> < 0.01
Longitudinal	5.50 ± 0.70	5.45 ± 0.81	<i>p</i> < 0.01
2 IMS			
Transvers	8.62 ± 0.84	8.55 ± 1.04	<i>p</i> < 0.01
Longitudinal	5.58 ± 0.72	6.00 ± 0.92	<i>p</i> < 0.01
3 IMS			
Transvers	9.15 ± 1.16	9.05 ± 1.11	<i>p</i> < 0.01
Longitudinal	4.77 ± 0.76	4.66 ± 0.71	<i>p</i> < 0.01

Data are shown as mean ± stansard deviation. CTS = carpal tunnel syndrome, IMS = intermetacarpal spaces

Table 2. Interosseous muscles thicknesses of carpal tunnel syndrome and control groups

IOM WIDTH	Control	CTS	<i>p</i> value
2 IOM			
Transvers	9.07 ± 1.04	9.00 ± 1.06	<i>p</i> < 0.01
Longitudinal	10.28 ± 9.25	9.33 ± 1.14	<i>p</i> < 0.01
3 IOM			
Transvers	7.41 ± 0.92	7.28 ± 0.86	<i>p</i> < 0.01
Longitudinal	9.67 ± 1.51	8.95 ± 1.02	<i>p</i> < 0.01
4 IOM			
Transvers	8.37 ± 0.90	8.35 ± 0.95	<i>p</i> < 0.01
Longitudinal	9.40 ± 0.96	7.92 ± 0.84	<i>p</i> < 0.01

Data are shown as mean ± stansard deviation. CTS = carpal tunnel syndrome, IOM = interosseous muscles.

dominant hand is affected [11, 12]. Anatomical variations (narrow tunnel, persistent median artery), nerve compression susceptibility (diabetes mellitus, systemic neuropathy), systemic and endocrine diseases (pregnancy, amyloidosis, hypothyroidism) or space-occupying lesions in the tunnel are some of the predisposing factors [5].

No gross anatomical abnormality is observed in the median nerve in the early phases of CTS, but within the process, demyelization and fibro sclerosis develop. In the chronic period permanent, sensory and motor function losses occur. Atrophy is typically located in the thenar muscles ("ape hand" deformity). Although not innervated by the median nerve, atrophy also occurs in IOM muscles innervated by the ulnar nerve [13, 14].

In the literature, it is stated that atrophy and structural changes of hand muscles can be detected successfully by US [10, 15]. However, we cannot find a comprehensive study about the possible relationships between sonographic IOM/IMS measurements and hand grip strength. Seeing this gap in the literature; we primarily intend to detect possible relationships between hand grip strength and IOM/IMS measurements.

In this study, an examination was made of the alterations in the dimensions of the intrinsic muscles of hand that are not innervated by the median nerve before a visible thenar atrophy emerged. It was also aimed to determine the association between changes in dimension and loss of hand grip strength. In a review of literature review, no study was found which examined IOM dimensions sonographically and related them with loss of muscle strength. In the control group, there was a statistically significant relationship between IOM dimensions and muscle strength; as IOM dimensions increased, hand grip strength also increased. In the CTS patients, the IOM dimensions were significantly reduced but there was no significant relationship between the decrease in muscle strength and IOM dimensions. This is an unexpected finding. The small sample size of CTS patients can cause this result, but it is also possible that the decrease in hand grip strength becomes detectable after the muscle atrophy comes to some certain degree. Further prospective studies are needed to ensure this hypothesis.

In the literature review, no study was found which evaluated IMS sonographically, and investigated the normal dimensions of IMS and the relationship between these dimensions and grip. The current study can be considered to contribute to literature in these

respects.

In the control group, a significant relationship was observed between IMS dimensions and grip strength and in CTS patients, the IMS dimensions were found to be significantly reduced compared to the control group. However, no significant relationship was determined between muscle strength decrease and IMS dimensions in the CTS patients. The small sample size of CTS patients might be the explanation for this result, but we think that it is also possible that the decrease in hand grip strength becomes detectable after the muscle atrophy comes to some certain degree. Further prospective studies are needed to ensure this hypothesis.

Detecting a significant difference between CTS and control groups in sonographically detected IMS and IOM values revealed that these parameters can/should be used for detecting the atrophy and loss of hand grip strength in CTS patients. Even though the muscle strength decrease in the CTS patients was not directly associated with the IOM and IMS dimension decrease in this study, we strongly believe that, this could be attributed to the small sample size. Likewise, the millimetric measurement values and closeness of quantitative measurements may also have resulted in an inability to detect an existing statistically significant relationship. And also, we think that further prospective studies following the change in IOM/IMS measurements with repetitive examinations can show the relationship in some stage of CTS.

The Limitations of the Study

This study has some limitations. The limited number of patients obscured statistical evaluation and relational determination in the CTS group. As all measurements were conducted by the same radiologist, inter-rater variability was not applicable. The results may have differed if conducted by a less experienced researcher, as the radiologist who took a leading role in the present study had 25 years of experience in the field. As the study sample was homogenized for age and gender, a very limited population data was analyzed.

Conclusions

In conclusion, IOM and IMS values are found to be related with hand grip strength and this relationship can be easily detected using proper sonographic methods. This can definitely help clinicians to plan or

direct treatment. Further studies investigating IOM and IMS on different pathologies affecting hand grip strength and hand muscles and investigations on larger samples will enrich the information about these parameters and would provide more evidence to support the current results.

Authorship declaration

All authors listed meet the authorship criteria according to the latest guidelines of the International Committee of Medical Journal Editors, and all authors are in agreement with the manuscript.

Conflict of interest

The authors disclosed no conflict of interest during the preparation or publication of this manuscript.

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