

# Ultrasonographic Assessment of Thumb Muscle Thickness and Evaluation of Pinch and Grip Strength in First Carpometacarpal Joint Osteoarthritis: A Comparison of Early and Advanced Stages

Birinci Karpometakarpal Eklem Osteoartritinde Başparmak Kası Kalınlığı ile Parmak ve El Kavrama Kuvveti Değerlendirilmesi: Erken ve İlerlemiş Evrelerin Karşılaştırılması

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## Abstract

**Objective:** This study investigated the ultrasonographic thickness of the thenar muscles and assessed pinch and grip strength in patients with first carpometacarpal (CMC) osteoarthritis by comparing early and advanced stages of the disease.

**Method:** A total of 34 female patients aged 50-80 years with early- or advanced-stage first CMC osteoarthritis were included in this cross-sectional study. Patients were classified as early-stage (Eaton stages 1-2) or advanced-stage (Eaton stages 3-4). The thicknesses of the abductor pollicis brevis (APB), opponens pollicis (OPP), and first dorsal interosseous (FDI) muscles were measured by ultrasound on both the dominant and non-dominant hands. Grip and key pinch strengths were assessed with a hand dynamometer and a hydraulic pinch meter, respectively.

**Results:** Muscle thicknesses of APB, OPP, and the dominant-side FDI, as well as key pinch strength, were significantly higher in early-stage patients ( $p<0.05$ ). Grip strength did not differ significantly. Dominant OPP thickness was positively correlated with pinch strength ( $r=0.382$ ,  $p=0.026$ ), while APB thickness was negatively correlated with age and pain severity.

## Öz

**Amaç:** Bu çalışmanın amacı, birinci karpometakarpal (KMK) eklem osteoartriti olan hastalarda tenar kasların ultrasonografik kalınlığını incelemek ve erken ile ilerlemiş evreleri karşılaştırarak parmak ve el kavrama kuvvetini değerlendirmektir.

**Yöntem:** Bu kesitsel çalışmaya, erken veya ilerlemiş evre birinci KMK eklem osteoartriti tanısı konmuş, 50-80 yaş aralığında toplam 34 kadın hasta dahil edildi. Hastalar erken evre (Eaton evre 1-2) veya ilerlemiş evre (Eaton evre 3-4) olarak sınıflandırıldı. abduktör pollicis brevis (APB), opponens pollicis (OPP) ve birinci dorsal interosseöz (FDI) kaslarının kalınlıkları, hem dominant hem de non-dominant ellerde ultrason kullanılarak ölçüldü. El kavrama kuvveti el dinamometresiyle, parmak kavrama kuvveti ise hidrolik pinçmetre ölçer ile değerlendirildi.

**Bulgular:** APB, OPP ve dominant taraftaki FDI kas kalınlıkları ile parmak kavrama kuvveti erken evre hastalarda anlamlı olarak daha yüksekti ( $p<0,05$ ). El kavrama kuvvetinde ise anlamlı bir fark saptanmadı. Dominant OPP kalınlığı, parmak kavrama kuvveti ile pozitif korelasyon gösterirken ( $r=0,382$ ,  $p=0,026$ ), APB kalınlığı yaş ve ağrı şiddeti ile negatif ilişki içindeydi.

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## Abstract

**Conclusion:** In first CMC osteoarthritis, muscle thickness and pinch strength decrease as the disease progresses. Early ultrasound detection of thenar changes may help guide treatment to preserve thumb function.

**Keywords:** Carpometacarpal joints, osteoarthritis, pinch strength, ultrasonography

## Öz

**Sonuç:** Birinci KMK osteoartrisinde kas kalınlığı ve parmak kavrama kuvveti, hastalığın ilerlemesiyle birlikte azalmaktadır. Tenar kaslardaki değişikliklerin ultrasonografi ile erken tespiti, başparmak fonksiyonunu korumaya yönelik tedavi rehberliğine yardımcı olabilir.

**Anahtar kelimeler:** Karpometakarparal eklemler, osteoartrit, sıkma kuvveti, ultrasonografi

## Introduction

First carpometacarpal (CMC) joint osteoarthritis is a common degenerative condition that can lead to significant functional limitations in affected individuals. First CMC osteoarthritis, which predominantly affects postmenopausal women, has been reported in 17-33% of this population, while its prevalence among men of the same age group ranges from 5% and 11% (1-3).

The first CMC joint is a saddle-type joint, and its stabilization is primarily provided by ligaments rather than bony structures (2,4). Laxity in the supporting ligaments increases mechanical load on the joint and contributes to the development of osteoarthritis. This increase in load is particularly evident during pinch grip, and it has been shown that a 1 kg pinch force at the fingertip translates into a 13.42 kg load on the first CMC joint (5). A reduction in pinch strength in patients with first CMC joint osteoarthritis has been demonstrated (6). Grip strength, on the other hand, is a commonly used method in the literature to assess hand function in patients with thumb osteoarthritis (7).

In addition to ligamentous structures, the abductor pollicis brevis (APB) and opponens pollicis (OPP) muscles, located on the palmar surface of the hand, along with the first dorsal interosseous (FDI) muscle, contribute to stabilization of the CMC joint (8). It is known that pain and structural changes secondary to osteoarthritis can lead to muscle atrophy. This muscle loss can be evaluated indirectly through various muscle strength measurements or directly by measuring muscle thickness using imaging methods. Ultrasonography (USG) is a safe alternative for muscle assessment due to its rapid application, cost-effectiveness, and lack of radiation exposure (9). For the evaluation of intrinsic hand muscles, USG is recommended by many studies and has been shown to be valid (9-11). Test-retest reliability of ultrasonographic muscle thickness measurements has previously been reported for intrinsic hand muscles (e.g., dorsal interossei and lumbricals), with high intraclass correlation coefficients and low measurement error (10). In addition, ultrasonographic measurements of intrinsic

hand muscle size (cross-sectional area) have been shown to correlate strongly with muscle strength and to demonstrate excellent intra-rater and good inter-rater reliability (9). However, studies using USG to evaluate hand muscles in first CMC joint osteoarthritis are limited. Lai et al. (8) evaluated thumb muscles using USG in patients with early-stage first CMC osteoarthritis and found a weak association between OPP muscle thickness and presence of early-stage osteoarthritis.

To the best of our knowledge, no study has ultrasonographically evaluated muscle thickness in both early and advanced stages of first CMC joint osteoarthritis and compared the findings with grip and pinch strength. The present study aims to address this gap. We hypothesized that patients with advanced first CMC joint osteoarthritis would have significantly reduced muscle thickness, pinch strength, and grip strength compared with patients with early-stage osteoarthritis. The findings of this study may provide insights into muscle involvement across disease stages and support future research focusing on muscle-oriented assessment approaches, particularly in early disease stages.

## Materials and Methods

### Study Design and Participants

This cross-sectional study included patients who presented to the physical therapy and rehabilitation outpatient clinics at Beylikdüzü State Hospital between 10.12.2024 and 20.01.2025. Ethical approval for the study was obtained from the Ethics Committee of İstanbul Physical Therapy and Rehabilitation Training and Research Hospital with protocol number: 2024-73, date: 05.12.2024. Informed consent was obtained from all participants before the study, and the study was conducted in accordance with the Declaration of Helsinki.

Inclusion criteria were being between 50-80 years of age, having bilateral hand radiographs taken within the last three months, having a diagnosis of early or advanced stage first CMC osteoarthritis, and being female. Exclusion criteria were refusal to participate in the study,

use of medications that suppress osteoarthritis flare-ups, presence of rheumatologic diseases that may cause peripheral joint involvement, history of fracture or surgery in the first CMC joint, presence of cervical disc herniation, presence of entrapment neuropathies such as carpal tunnel syndrome that may cause muscle atrophy in the thenar region, presence of de Quervain's tenosynovitis or other tendon inflammations in the wrist area, psychiatric disorders, and cognitive impairments.

At the beginning of the study, the participants' socio-demographic, anthropometric, and clinical data—such as age, height, weight, marital status, and comorbidities—were recorded. Pain intensity was evaluated using the visual analog scale (VAS); patients rated their pain from 0 (no pain) to 100 (worst pain imaginable) (12). Hand radiographs were evaluated, and osteoarthritis severity was classified using the Eaton classification. According to this classification: Stage 1: The joint space is normal, but mild joint widening may be present due to ligament laxity and effusion. Stage 2: Joint space narrowing, osteophytes and debris smaller than 2 mm, and subluxation of more than one-third of the metacarpal bone are observed. Stage 3: Joint space narrowing is more pronounced, with osteophytes and debris larger than 2 mm present. Stage 4: The scaphotrapezoid joint is also involved (13,14). The Eaton classification was conducted by an experienced physical medicine and rehabilitation specialist, who was blinded to all ultrasonographic and clinical assessment results.

Patients classified as Stages 1 and 2 were considered early-stage, and those classified as Stages 3 and 4 were considered late-stage (15). Patients whose dominant

and non-dominant hands were at different stages were excluded from the study. Grip strength and pinch strength were measured and recorded separately for the dominant and non-dominant hands. Subsequently, APB, OPP, and FDI muscle thicknesses were measured by USG on both the dominant and non-dominant sides. Ultrasonographic evaluations were performed by a second examiner with expertise in musculoskeletal USG, who was blinded to the Eaton classification and functional assessment findings (ClinicalTrials.gov ID: NCT06730698).

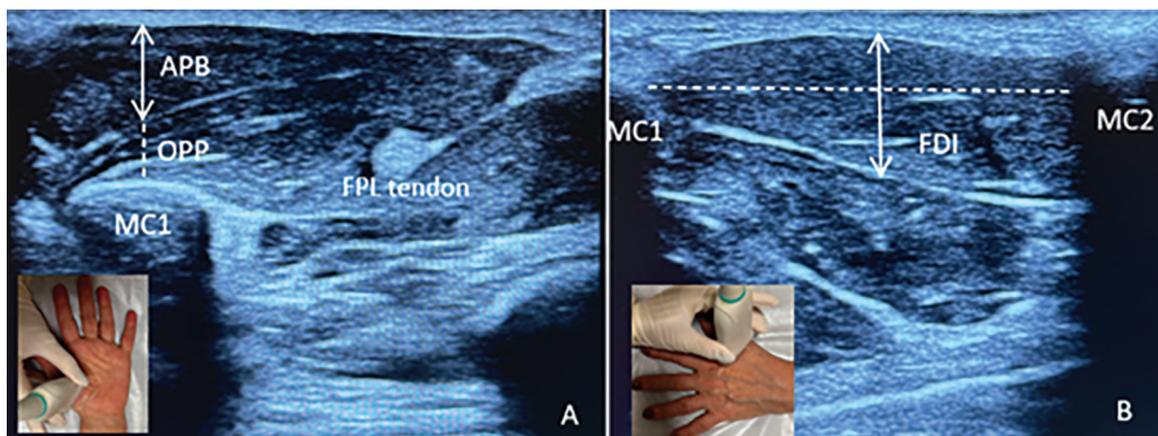
## Outcomes

### Handgrip Strength

We measured handgrip strength using a Jamar handgrip dynamometer. We had the patient sit upright in a chair with back support but no armrests, ensuring their feet were flat on the floor. The wrist was held in a neutral position, and the elbow was flexed 90 degrees. We instructed the patient to grasp the dynamometer and squeeze with maximum effort. We performed measurements separately for the dominant and non-dominant hands. Each measurement was repeated three times with 45-second rest intervals, and the highest value was recorded (16).

### Pinch Strength

Pinch strength was measured with a Jamar hydraulic pinch gauge. The patient maintained the same posture during the handgrip strength measurement. We placed the pinch gauge between the pulp of the thumb and the lateral surface of the index finger and instructed the patient to squeeze with maximal force (Figure 1A, B). Measurements were performed separately for each hand. We took three measurements at 45-second intervals and recorded the highest value (8).



**Figure 1.** (A) Grip strength assessment using a hand dynamometer. (B) Lateral pinch strength measurement using a pinch meter

FDI: First dorsal interosseous, APB: Abductor pollicis brevis, OPP: Opponens pollicis, MC: Metacarpal, FLP: Flexor pollicis longus

## Ultrasonographic Assessment

All muscle thickness measurements were performed using a high-frequency (3-11 MHz) linear ultrasound probe (Mindray DC-8 EXP). We positioned the patient facing the examiner. To ensure consistency, the same experienced examiner performed all measurements. We held the probe upright using ultrasound gel to avoid compression.

We imaged the APB, OPP, and FDI muscles in both the dominant and non-dominant hands. During the assessment of the APB and OPP muscles, the patient was positioned with the elbow in flexion and the forearm in full supination. The probe was placed in the short-axis of the thenar eminence, at the proximal one-third of the first metacarpal, ensuring visualization of the flexor pollicis longus tendon. Muscle thicknesses of the APB and OPP were measured perpendicular to the first metacarpal, which served as the reference point (Figure 2A). To image the FDI muscle, the probe was placed on the dorsal surface of the hand in the short-axis orientation, aligned with the proximal one-third of both the first and second metacarpals. Thickness was measured perpendicular to the muscle, at the midpoint between the two bones (Figure 2B). Each measurement was repeated three times, and the average was recorded.

## Statistical Analysis

Categorical variables were presented as numbers and percentages; numerical data as mean  $\pm$  standard deviation, median, and interquartile range. Normality was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests. Either an independent-samples t-test or the Mann-Whitney

U test was used, depending on the data distribution. Pearson or Spearman correlation tests were applied as appropriate. Analyses were conducted using SPSS 21.0.

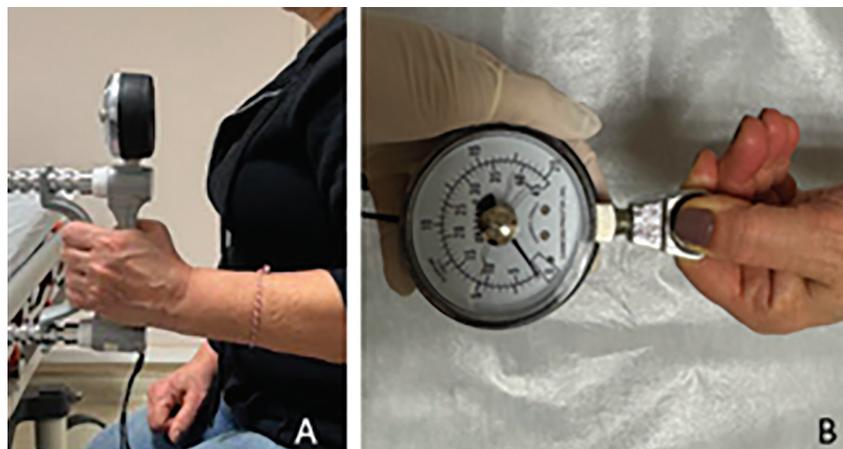
## Sample Size Calculation

Based on the referenced study, the effect size was calculated as 1.52 using the mean pinch-strength values (7). Assuming an alpha level of 0.05 and a power of 99%, the minimum required sample size per group was 17, resulting in a total of 34 patients.

## Results

All 34 patients with first CMC osteoarthritis included in the study were female. The mean age was  $65.82 \pm 8.6$  in the early-stage group and  $69.76 \pm 8.04$  in the late-stage group, with no significant difference. Body mass index (BMI) was significantly higher in the late-stage group ( $p=0.028$ ). Comorbidities did not differ significantly between groups. VAS scores were significantly lower in the early-stage group ( $p=0.012$ ). Pinch strength was higher in the early-stage group for both the dominant ( $p=0.026$ ) and non-dominant ( $p=0.021$ ) hands. However, no significant difference was found in handgrip strength ( $p>0.05$ ) (Table 1).

Ultrasonographic measurements of thumb muscle thickness are presented in Table 2. The thicknesses of the APB and OPP muscles were greater in the early-stage osteoarthritis group than in the advanced-stage group on both dominant and non-dominant sides ( $p<0.05$ ). The FDI muscle thickness was also greater in the dominant hand of the early-stage group ( $p=0.007$ ). Although the FDI thickness



**Figure 2.** Ultrasonographic assessment of thenar and first dorsal interosseous (FDI) muscle thickness. (A) Short-axis ultrasonographic image showing the abductor pollicis brevis (APB) and opponens pollicis (OPP) muscles overlying the first metacarpal (MC1). The flexor pollicis longus tendon is also visualized in the deeper layer. The vertical dashed line indicates the measurements of APB and OPP muscle thicknesses taken perpendicular to MC1. (B) Short-axis ultrasonographic image of the FDI muscle between the first (MC1) and second metacarpal (MC2) bones. The vertical arrow represents the muscle thickness measured from the midpoint between MC1 and MC2

in the non-dominant hand was also higher in the early-stage group, this difference was not statistically significant (p=0.158) (Table 2).

In our study, pinch strength on the dominant side was positively correlated with the OPP muscle thickness on the that side (r=0.382, p=0.026). No significant relationship was observed between pinch strength and the thickness of other muscles. Handgrip strength was not correlated with the thickness of the APB, OPP, or FDI muscles (p>0.05). A negative correlation was found between APB muscle thickness and age, whereas no such relationship was observed between age and the thicknesses of the other muscles. A significant negative correlation was observed between BMI and the thickness of the dominant OPP muscle (r=-0.487, p=0.003), the non-dominant OPP muscle (r=-0.518, p=0.002), and the dominant FDI muscle (r=-0.343, p=0.047). While handgrip strength significantly decreased with age (r=-0.470, p=0.005), pinch strength

was not significantly affected (p>0.05). No significant relationship was found between pain severity and either pinch strength or handgrip strength, but a negative correlation was observed only between pain severity and APB muscle thickness (Table 3).

## Discussion

In this study, the muscle thicknesses of APB, OPP, and FDI were evaluated using USG in patients with early- and advanced-stage first CMC osteoarthritis. It was found that in early-stage patients, the thicknesses of the APB and OPP muscles were greater on both the dominant and non-dominant sides than in advanced-stage patients. In early-stage osteoarthritis, the FDI muscle thickness was higher in the dominant hand, whereas no significant difference was found between the groups for the non-dominant hand. In addition, pinch strength was higher in patients with early-stage first CMC osteoarthritis compared to those

**Table 1. Descriptive statistics**

		Early stage (n=17)		Late stage (n=17)		p-value
		Mean ± SD/n (%)	Median (IQR)	Mean ± SD/n (%)	Median (IQR)	
Age(year)		65.82±8.6	67 (13)	69.76±8.04	72 (15)	0.178 <sup>t</sup>
BMI [kg (m <sup>2</sup> )]		27.72±4.51	28.19 (4.75)	30.87±3.40	31.22 (4.03)	<b>0.028<sup>t</sup></b>
Marital status	Married	11 (64.7%)		10 (58.8%)		1.000
	Single	6 (35.3%)		7 (41.2%)		
Hypertension		6 (35.3%)		10 (58.8%)		0.303 <sup>s</sup>
Diabetes mellitus		1 (5.9%)		5 (29.4%)		0.175 <sup>f</sup>
CAD		1 (5.9%)		5 (29.4%)		0.175 <sup>f</sup>
Hypothyroidism		7 (41.2%)		5 (29.4%)		0.720 <sup>s</sup>
VAS		49.71±20.95	50 (25)	70±20.31	70 (40)	<b>0.012<sup>m</sup></b>
Pinch dominant (lb)		10.71±2.95	10 (6)	8.47±3.28	8 (3)	<b>0.026<sup>m</sup></b>
Pinch non-dominant (lb)		9.35±3.06	9 (5)	7.06±2.41	7 (2)	<b>0.021<sup>t</sup></b>
Handgrip dominant (kg)		16.24±5.14	16 (5)	14.94±6.37	12 (8)	0.374 <sup>m</sup>
Handgrip non-dominant (kg)		15.29±4.58	16(6)	12.76±6.40	12 (8)	0.194 <sup>t</sup>

<sup>t</sup>: Independent sample t-test, <sup>m</sup>: Mann-Whitney U test, <sup>s</sup>: Chi-square test, <sup>f</sup>: Fisher's exact test, SD: Standard deviation, IQR: Interquartile range, BMI: Body mass index, CAD: Coronary artery disease, VAS: Visual analog scale

**Table 2. Comparison of muscle thickness measurements between early and late stage first carpometacarpal osteoarthritis**

	Early stage		Late stage		p-value	95% CI
	Mean ± SD	Median (IQR)	Mean ± SD	Median (IQR)		
APB dominant (cm)	0.49±0.05	0.5 (0.09)	0.41±0.09	0.40 (0.15)	<b>0.002</b>	0.032-0.130
APB non-dominant (cm)	0.48±0.05	0.49 (0.1)	0.39±0.08	0.40 (0.11)	<b>0.001</b>	0.035-0.132
OPP dominant (cm)	0.57±0.08	0.57 (0.14)	0.43±0.08	0.40 (0.12)	<b>0.000</b>	0.088-0.197
OPP non-dominant (cm)	0.52±0.07	0.52 (0.11)	0.42±0.09	0.42 (0.16)	<b>0.001</b>	0.046-0.158
FDI dominant (cm)	0.92±0.09	0.93 (0.16)	0.84±0.09	0.82 (0.12)	<b>0.007</b>	0.025-0.145
FDI non-dominant (cm)	0.82±0.09	0.81 (0.10)	0.77±0.12	0.80 (0.17)	0.158	-0.021-0.122

SD: Standard deviation, IQR: Interquartile range, CI: Confidence interval, APB: Abductor pollicis brevis, OPP: Opponens pollicis, FDI: First dorsal interosseous

**Table 3. Correlation between muscle thickness and grip/pinch strength, age, BMI, and pain severity (VAS)**

	Pinch dominant		Hangrip dominant		APB dominant		APB non-dominant		OPP dominant		OPP non-dominant		FDI dominant		FDI non-dominant	
	r	p	r	p	r	p	r	p	r	p	r	p	r	p	r	p
Age (year)	-0.113 <sup>s</sup>	0.523	-0.470 <sup>**s</sup>	<b>0.005</b>	-0.446 <sup>**</sup>	<b>0.008</b>	-0.488 <sup>**</sup>	<b>0.003</b>	-0.121	0.496	-0.119	0.503	-0.279	0.110	-0.181	0.307
BMI (kg/m <sup>2</sup> )	-0.280 <sup>s</sup>	0.109	-0.166 <sup>s</sup>	0.349	-0.026	0.885	-0.115	0.519	-0.487 <sup>**</sup>	<b>0.003</b>	-0.518 <sup>**</sup>	<b>0.002</b>	-0.343 <sup>*</sup>	<b>0.047</b>	-0.298	0.087
VAS	-0.142 <sup>s</sup>	0.424	-0.069	0.699	-0.346 <sup>**s</sup>	<b>0.045</b>	-0.381 <sup>s</sup>	<b>0.026</b>	-0.109 <sup>s</sup>	0.541	0.091	0.611	-0.156 <sup>s</sup>	0.377	-0.010 <sup>s</sup>	0.956
Pinch dominant (lb)	1.000 <sup>s</sup>		0.660 <sup>**s</sup>	<b>0.000</b>	0.208 <sup>s</sup>	0.237	0.188 <sup>s</sup>	0.288	0.382 <sup>s</sup>	<b>0.026</b>	0.257	0.142	0.037 <sup>s</sup>	0.837	0.075 <sup>s</sup>	0.673
Pinch non-dominant (lb)	0.793 <sup>**s</sup>	<b>0.000</b>	0.737 <sup>**s</sup>	<b>0.000</b>	0.240	0.171	0.201	0.254	0.240	0.172	0.170	0.336	0.154	0.384	0.131	0.460
Hangrip dominant (kg)	0.660 <sup>**s</sup>	<b>0.000</b>	1.000 <sup>s</sup>		0.053 <sup>s</sup>	0.765	0.096 <sup>s</sup>	0.588	0.122 <sup>s</sup>	0.492	0.087	0.625	0.206 <sup>s</sup>	0.242	0.178 <sup>s</sup>	0.313
Hangrip non-dominant (kg)	0.427 <sup>s</sup>	<b>0.012</b>	0.653 <sup>**s</sup>	<b>0.000</b>	0.179	0.310	0.270	0.122	0.260	0.138	0.156	0.377	0.133	0.452	0.168	0.343
APB dominant (cm)	0.208 <sup>s</sup>	0.237	0.053 <sup>s</sup>	0.765	1.000		0.842 <sup>**</sup>	<b>0.000</b>	0.271	0.122	0.329	0.057	0.215	0.222	0.053	0.765
APB non-dominant (cm)	0.188 <sup>s</sup>	0.288	0.096 <sup>s</sup>	0.588	0.842 <sup>**</sup>	<b>0.000</b>	1.000		0.407 <sup>*</sup>	<b>0.017</b>	0.463 <sup>**</sup>	<b>0.006</b>	0.360 <sup>*</sup>	<b>0.037</b>	0.159	0.368
OPP dominant (cm)	0.382 <sup>s</sup>	<b>0.026</b>	0.122 <sup>s</sup>	0.492	0.271	0.122	0.407 <sup>*</sup>	<b>0.017</b>	1.000		0.862 <sup>**</sup>	<b>0.000</b>	0.438 <sup>**</sup>	<b>0.009</b>	0.341 <sup>*</sup>	<b>0.048</b>
OPP non-dominant (cm)	0.257 <sup>s</sup>	0.142	0.087 <sup>s</sup>	0.625	0.329	0.057	0.463 <sup>**</sup>	<b>0.006</b>	0.862 <sup>**</sup>	<b>0.000</b>	1.000		0.453 <sup>**</sup>	<b>0.007</b>	0.288	0.099
FDI dominant (cm)	0.037 <sup>s</sup>	0.837	0.206 <sup>s</sup>	0.242	0.215	0.222	0.360 <sup>*</sup>	<b>0.037</b>	0.438 <sup>**</sup>	<b>0.009</b>	0.453 <sup>**</sup>	<b>0.007</b>	1.000		0.621 <sup>**</sup>	<b>0.000</b>
FDI non-dominant (cm)	0.075 <sup>s</sup>	0.673	0.178	0.313	0.053	0.765	0.159	0.368	0.341 <sup>*</sup>	<b>0.048</b>	0.288	<b>0.099</b>	0.621 <sup>**</sup>	<b>0.000</b>	1.000	

Pearson correlation test; <sup>s</sup>: Spearman correlation test, BMI: Body mass index, VAS: Visual analog scale, APB: Abductor pollicis brevis, OPP: Opponens pollicis, FDI: First dorsal interosseous, <sup>\*</sup>: Correlation is significant at the 0.05 level (2-tailed), <sup>\*\*</sup>: Correlation is significant at the 0.01 level (2-tailed)

with advanced-stage disease, while handgrip strength was found to be similar between the two groups.

Few studies focus on thumb muscles in first CMC osteoarthritis. In a previous study, OPP muscle thickness was greater in patients with early-stage first CMC osteoarthritis than in healthy controls. In multivariate analysis, only OPP muscle thickness was significantly associated with early-stage osteoarthritis, whereas no significant relationship with early-stage osteoarthritis was found for the APB and FDI muscles (8). In the study by Karademir et al. (17), a total of 24 patients with first CMC osteoarthritis (according to the Eaton classification: 7 stage-1, 9 stage-2, 6 stage-3, and 2 stage-4 patients) and 8 healthy controls were evaluated by water-bath USG to assess the thenar muscles. As a result, APB, OPP, and FDI muscle thicknesses on the dominant side did not differ between the two groups. On the non-dominant side, only APB muscle thickness was found to be higher in the control group (17). In this study, the lack of homogeneity in sample sizes across groups and the relatively small number of advanced-stage patients, among whom muscle atrophy would be more pronounced, may have prevented obtaining the expected results (17). In the present study, a comparison of early- and advanced-stage first CMC osteoarthritis revealed that the muscle thicknesses of APB, OPP, and FDI (FDI measured only on the dominant side) were significantly greater in the early-stage group. These findings suggest that thumb muscle thickness varies by disease stage and that muscle involvement is more pronounced in advanced stages of first CMC osteoarthritis.

In our study, no significant difference was observed in handgrip strength between patients with early-stage and advanced-stage osteoarthritis, whereas pinch strength was notably higher in the early-stage group. In the study by Lai et al. (8), pinch strength and cylindrical grip strength were found to be similar between patients with early-stage first CMC osteoarthritis and healthy controls. In another study evaluating patients with first CMC osteoarthritis, tip and tripod pinch strength measurements were significantly lower in the osteoarthritis group (7). In the study by McQuillan et al. (6), patients with early-stage first CMC osteoarthritis were compared with healthy controls; key pinch strength was significantly lower in the osteoarthritis group. Moreover, compared with tip and tripod pinch grips, the association between key pinch and osteoarthritis was more pronounced (6). In our study, as in that study, key pinch strength was assessed and found to be significantly lower. Previous studies have shown that the key-pinch position is associated with CMC joint instability, trapezium

translation (18), and increased mechanical load on the trapezium (19). In light of this information, it is reasonable to conclude that key pinch strength is more strongly affected by muscle weakness and functional loss associated with first CMC osteoarthritis (6).

Other studies have supported our findings, reporting that handgrip strength in patients with first CMC osteoarthritis is similar to that of the control group (8,20), whereas one study, contrary to our results, found lower handgrip strength in the osteoarthritis group (7). Handgrip strength is influenced not only by the intrinsic muscles of the hand but also by the extrinsic muscles forearm. In a study of older women and men, handgrip strength was correlated with forearm muscle thickness (21). These contradictory findings in the literature may be attributed to the more prominent compensatory effect of forearm muscles during handgrip than during pinch grip. Furthermore, because CMC joint osteoarthritis is more closely related to the thumb muscles, it may affect key pinch strength more than handgrip strength.

A study showed negative correlations between age and handgrip strength and between age and tip and tripod pinch strengths in patients with first CMC osteoarthritis. However, key pinch strength was not evaluated. In the control group, the negative relationship between age and muscle strength was found to be stronger than in the osteoarthritis group (7). Jansen et al. (22) found a negative association between age and grip and pinch strength in elderly women and men, independent of osteoarthritis. In our study, age showed a significant negative correlation with handgrip strength, but no such relationship was observed with key pinch strength. Because CMC osteoarthritis was present in our patient population, pinch strength may have decreased because of osteoarthritis rather than age, which may have led to the loss of correlation with age. Additionally, in our study, a negative correlation was observed between age and APB muscle thickness.

### Study Limitations

This study has strengths and limitations. To the best of our knowledge, no study has comparatively evaluated the thumb muscles in patients with early- and advanced-stage first CMC osteoarthritis using USG or investigated their relationship with handgrip and pinch strength. Our study is, to our knowledge, the first study of its kind. All USG measurements were performed by the same specialist experienced in the field, ensuring measurement standardization, which is one of our strengths. Participants

may compensate during daily activities by using the extremity with a lower stage of osteoarthritis, which may result in unpredictable changes in muscle thickness and strength independent of pathology. To minimize this issue, only patients whose dominant and non-dominant sides were classified in the same Eaton classification stage were included in the study.

Although the sample size was determined by power analysis, our sample remains relatively small. To ensure standardization of measurements and eliminate sex-related confounders, only female patients were included. The absence of a control group is another limitation; however, in this age group, it is extremely difficult to recruit patients without any signs of first CMC osteoarthritis, which limits the feasibility of establishing a truly “healthy” comparison group. The study was also conducted at a single-center. Additionally, due to the cross-sectional design of our study, it is difficult to establish causal relationships among the development of hand osteoarthritis, the loss of muscle strength, and the decrease in muscle thickness. Future multi-center studies with larger sample sizes, including both genders and appropriate control groups, may yield more generalizable results. Moreover, longitudinal follow-up studies may allow clearer conclusions to be drawn about the effects of hand osteoarthritis on muscle strength and thickness.

## Conclusion

In conclusion, examination of patients with first CMC osteoarthritis revealed that the USG-measured thicknesses of the APB, OPP, and FDI muscles, as well as pinch strength, were greater in patients in the early stage than in those in the advanced stage. These findings indicate that both muscle thickness and muscle strength significantly decrease as the disease progresses. The data obtained suggest that early identification of the functional effects of CMC osteoarthritis may be important for the timely implementation of interventions aimed at preserving muscle strength and structure. In this context, USG may be a useful assessment tool for evaluating muscle involvement and functional impairment in patients with first CMC osteoarthritis.

### Ethics

**Ethics Committee Approval:** This cross-sectional study included patients who presented to the physical therapy and rehabilitation outpatient clinics at Beylikdüzü State Hospital between 10.12.2024 and 20.01.2025. Ethical approval for the study was obtained from the Ethics

Committee of İstanbul Physical Therapy and Rehabilitation Training and Research Hospital with protocol number: 2024-73, date: 05.12.2024.

**Informed Consent:** Informed consent was obtained from all participants, and their confidentiality was strictly protected.

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### Footnotes

### Authorship Contributions

Concept: B.Ş.A., N.P., N.K., E.K., Design: B.Ş.A., N.P., N.K., E.K., Data Collection or Processing: B.Ş.A., N.K., Analysis or Interpretation: N.P., Literature Search: B.Ş.A., E.K., Writing: B.Ş.A., E.K.

**Conflict of Interest:** No conflict of interest was declared by the authors.

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## References

1. Armstrong AL, Hunter JB, Davis TR. The prevalence of degenerative arthritis of the base of the thumb in post-menopausal women. *J Hand Surg Br.* 1994;19(3):340-341.
2. Ghavami A, Oishi SN. Thumb trapeziometacarpal arthritis: treatment with ligament reconstruction tendon interposition arthroplasty. *Plast Reconstr Surg.* 2006;117(6):116e-128e.
3. Gillis J, Calder K, Williams J. Review of thumb carpometacarpal arthritis classification, treatment and outcomes. *Can J Plast Surg.* 2011;19(4):134-138.
4. Eaton RG, Lane LB, Littler JW, Keyser JJ. Ligament reconstruction for the painful thumb carpometacarpal joint: a long-term assessment. *J Hand Surg Am.* 1984;9(5):692-699.
5. Katarincic JA. Thumb kinematics and their relevance to function. *Hand Clin.* 2001;17(2):169-174.
6. McQuillan TJ, Kenney D, Crisco JJ, Weiss AP, Ladd AL. Weaker functional pinch strength is associated with early thumb carpometacarpal osteoarthritis. *Clin Orthop Relat Res.* 2016;474(2):557-561.
7. Villafañe JH, Valdes K, Bertozzi L, Negrini S. Minimal clinically important difference of grip and pinch strength in women with thumb carpometacarpal osteoarthritis when compared to healthy subjects. *Rehabil Nurs.* 2017;42(3):139-145.
8. Lai C, Kenney D, Kerkhof F, Finlay A, Ladd A, Roh E. Ultrasound of thumb muscles and grasp strength in early thumb carpometacarpal osteoarthritis. *J Hand Surg Am.* 2022;47(9):898.e1-898.e8.
9. Mohseny B, Nijhuis TH, Hundepool CA, Janssen WG, Selles RW, Coert JH. Ultrasonographic quantification of intrinsic hand muscle cross-sectional area; reliability and validity for predicting muscle strength. *Arch Phys Med Rehabil.* 2015;96(5):845-853.
10. Abe T, Counts BR, Barnett BE, Dankel SJ, Lee K, Loenneke JP. Associations between handgrip strength and ultrasound-measured muscle thickness of the hand and forearm in young men and women. *Ultrasound Med Biol.* 2015;41(8):2125-2130.
11. Infantolino BW, Challis JH. Estimating the volume of the first dorsal interosseous using ultrasound. *Med Eng Phys.* 2011;33(3):391-394.
12. Klimek L, Bergmann KC, Biedermann T, Bousquet J, Hellings P, Jung K, et al. Visual analogue scales (VAS): Measuring instruments for the documentation of symptoms and therapy monitoring in cases of allergic rhinitis in everyday health care: Position Paper of the German Society of Allergology (AeDA) and the German Society of Allergy and Clinical Immunology (DGAKI), ENT Section, in collaboration with the working group on Clinical Immunology, Allergology and Environmental Medicine of the German Society of Otorhinolaryngology, Head and Neck Surgery (DGHNOKHC). *Allergo J Int.* 2017;26(1):16-24.
13. Eaton RG, Glickel SZ. Trapeziometacarpal osteoarthritis. staging as a rationale for treatment. *Hand Clin.* 1987;3(4):455-471.
14. Kennedy CD, Manske MC, Huang JI. Classifications in brief: the eaton-littler classification of thumb carpometacarpal joint arthrosis. *Clin Orthop Relat Res.* 2016;474(12):2729-2733.
15. Ordonez Diaz T, Vasilopoulos T, Wright TW, Cruz-Almeida Y, Nichols JA. A multi-modal evaluation of experimental pain and psychological function in women with carpometacarpal osteoarthritis. *Osteoarthr Cartil Open.* 2024;6(4):100515.
16. Shi Y, Fu K, Oo WM, Deveza LA, Wang X, Duong V, et al. Associations between radiographic features, clinical features and ultrasound of thumb-base osteoarthritis: a secondary analysis of the COMBO study. *Int J Rheum Dis.* 2022;25(1):38-46.
17. Karademir F, Ayhan Kuru C, Arın G, Soylu R. Morphometry of thenar muscles by water bath ultrasonography in trapeziometacarpal osteoarthritis: intra- and inter-rater reliability. *J Hand Surg Eur Vol.* 2023;48(2):115-122.
18. Halilaj E, Rainbow MJ, Got C, Schwartz JB, Moore DC, Weiss AP, et al. In vivo kinematics of the thumb carpometacarpal joint during three isometric functional tasks. *Clin Orthop Relat Res.* 2014;472(4):1114-1122.
19. Kovler M, Lundon K, McKee N, Agur A. The human first carpometacarpal joint: osteoarthritic degeneration and 3-dimensional modeling. *J Hand Ther.* 2004;17(4):393-400.
20. Coughlan MJ, Bourdillon A, Crisco JJ, Kenney D, Weiss AP, Ladd AL. Reduction in cylindrical grasp strength is associated with early thumb carpometacarpal osteoarthritis. *Clin Orthop Relat Res.* 2017;475(2):522-528.
21. Abe T, Thiebaud RS, Loenneke JP, Ogawa M, Mitsukawa N. Association between forearm muscle thickness and age-related loss of skeletal muscle mass, handgrip and knee extension strength and walking performance in old men and women: a pilot study. *Ultrasound Med Biol.* 2014;40(9):2069-2075.
22. Jansen CW, Niebuhr BR, Coussirat DJ, Hawthorne D, Moreno L, Phillip M. Hand force of men and women over 65 years of age as measured by maximum pinch and grip force. *J Aging Phys Act.* 2008;16(1):24-41.