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Is There A Correlation Between the Grip Strength and the Interosseous Muscles/Intermetacarpal Fat Pads of the Hand?: An Ultrasonographic Study

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ABSTRACT

Objective: To investigate the correlation of the grip strength with sonographic measurement of interosseous muscles (IM) and the intermetacarpal fat pads (IMFP) of the hand.

Material and Methods: A total of 40 healthy volunteers (mean age: 39±12 years, all female) were examined. Hand strength was assessed by the Jamar hand dynamometer. IM and IMFP thickness and width for both hands (n:80) were measured sonographically at four levels (1^{th}, 2^{nd}, 3^{rd} and 4^{th} intermetacarpal; palmar side for IM) and at three levels (2nd, 3rd and 4th intermetacarpal; dorsal side for IMFP).

Results: The mean grip strength was 40±12 pounds (range: 20-67). Mean values (thickness x width) for IM were 20.7±2.1×9.9±1.2 mm, 9.0±1×10.3±0.9 mm, 7.3±1.0×9.9±1.0 mm, 8.5±1×9.5±0.9 mm at four levels, respectively. Mean values (thickness x width) for IMFP were 9.9±1.2×5.3±0.7 mm, 8.5±0.9×5.4±0.7 mm and 9.0±1.2×4.7±0.7 mm at three levels, respectively. There was a positive correlation between the grip strength and the dimensions of IM and IMFP ($p<0.05$).

Conclusions: To our knowledge, this is the first study evaluating the correlation of grip strength and the sonographic IM-IMFP measurements. Further research in study groups affected by clinical situations involving the hand, is necessary to reveal the role of IM and IMFP studies in evaluating the pathologies.

Key Words: Hand, muscles, hand strength, adipose tissue, US

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Introduction

Gripping is a unique human ability and an extremely complicated action. The grip strength refers to the muscular power and force that is generated by the hands. Grip strength is directly correlated with upper extremity function, general strength, and biological growth (1, 2).

The interosseous muscles (IM) are one of the end-organs in gripping. Those muscles, together with the intermetacarpal fat pads (IMFP) are described as important in the function of gripping (3). IMFP fills in the intermetacarpal space and is assumed to have a mechanical role in participating in the load distribution during prehension (3). To the best of our knowledge, the relationship of the IM and IMFP dimensions with the grip strength has not been evaluated up to now.

The aim of this study is to investigate the correlation of sonographic evaluation of IM and the IMFP with the grip strength.

Materials and Methods

This prospective study had the approval of Institutional Review Board. A total of 40 healthy volunteers (mean age: 39 years±12 years, range: 25-65, all female) were included in this study. All subjects were in good physical health and had no previous hand injuries, disease or operation. Patients' height and weight were recorded for Body Mass Index (BMI) calculation. All patients were examined by a physiatrist to exclude any pathology of the hand. The grip strength was assessed by the Jamar hand dynamometer (Preston Jackson, Michigan 49203, USA) (Figure 1). The patients were seated comfortably in a chair and were requested to grasp the dynamometer with maximum force. The grip test was performed in the standard arm position as recommended by the American Society of Hand Therapists; the shoulder adducted, elbow at 90 degrees flexion, and forearm in neutral position (4). The patients were asked to squeeze the handle as hard as they could for 2 seconds. The test was repeated three times with an interval rest period of 2 minutes in-between. Then average grip strength was recorded.

After the evaluation of grip strength, the patients were examined by B-mode US (SDU-2200; Shimadzu Corporation, Kyoto, Japan) equipped with an 8- to-10 MHz linear transducer. The patient was in a seated position facing the radiologist, with the fingers in a neutral position, and the hands resting on her knees bilaterally.

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During the sonographic examination, the dorsal side of the hand was evaluated initially to assess the IM (Figure 2). Measurements were taken at the mid-metacarpal level at four locations (between the 1st-2nd, 2nd-3rd, 3rd-4th, and 4th-5th metacarpals) (Figure 3). In transverse sonographic scanning plane, the thickness (anteroposterior dimension) and the width (transverse dimension) were evaluated (Figure 4).

Figure 1. The Jamar hand dynamometer used for evaluating the grip strength

Figure 2. The patient position during the sonographic examination of IM

As a second step of the US examination, the palmar side of the hand was evaluated to assess the IMFP (Figure 5). IMFP are well-defined adipose structures located between the heads of the second, third, fourth and fifth metacarpal bones. They are located in intermetacarpal spaces defined by the palmar fascia and its deep expansions (3). Sonographically, this space is bounded by the flexor digitorum tendons at the level of two adjacent distal heads of the metacarpal bones on both sides; the anterior and posterior boundaries are the superficial transverse metacarpal ligaments and the deep transverse metacarpal fascia (Figure 6). As there are 3 IMFP (namely, the spaces between the 2nd-3rd, 3rd-4th, and 4th-5th metacarpals), measurements were performed at these levels (Figure 7). In the transverse scanning plane, the thickness (anteroposterior dimension) and the width (transverse dimension) were measured (Figure 8).

All measurements were made three times by the same radiologist, and the average values were recorded.

The correlation of the grip strength with the BMI, height/width of the hand and the IM-IMFP dimensions were evaluated by Pearson's correlation test.

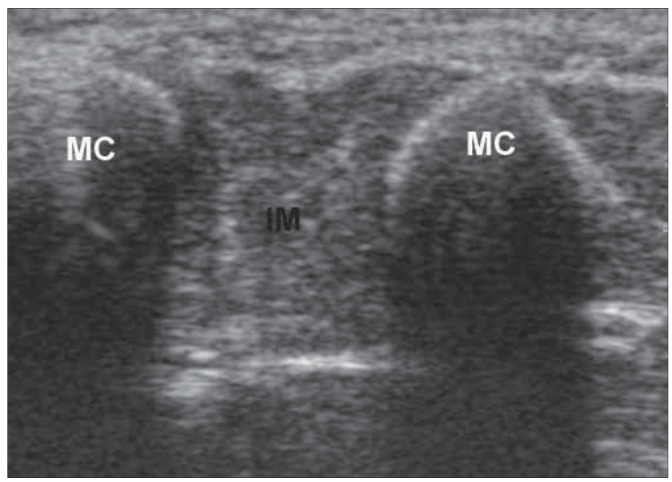

Figure 3. The transverse sonographic scanning plane of the IM (MC: metacarpals, IM: interosseous muscles)

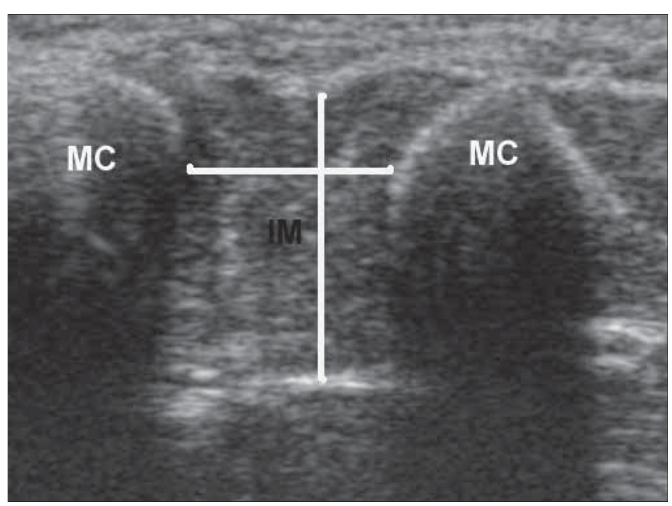

Figure 4. The measurements of the thickness and width of the IM (MC: metacarpals, IM: interosseous muscles)

Figure 5. The patient position during the sonographic examination of IMFP

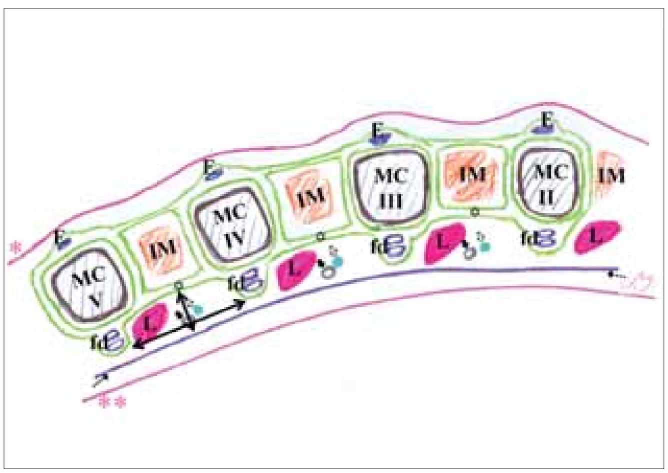

Figure 6. The schematic representation of the configuration of an IMFP (between thick black arrows) MC: metacarpals, fd: flexor digitorum tendons, E: extensor tendons, IM: interosseous muscle, L: lumbrical muscle, small white arrow: palmar digital nerve, small black arrow: palmar digital artery, dotted arrows: superficial transverse metacarpal ligament, stars: deep metacarpal fascia, asterix: dorsal skin, double asterix: volar skin)

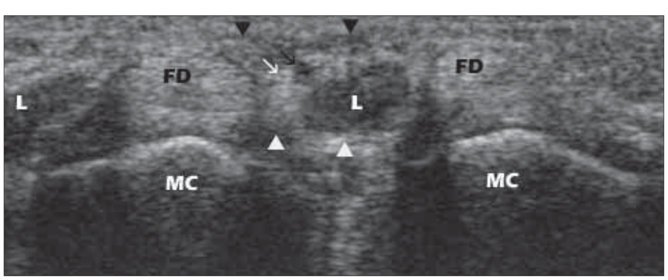

Figure 7. The transverse sonographic scanning plane of the IMFP (MC: metacarpals, fd: flexor digitorum tendons, L: lumbrical muscle, white arrow: palmar digital nerve, black arrow: palmar digital artery, black arrowheads: superficial transverse metacarpal ligament, white arrowheads: deep metacarpal fascia)

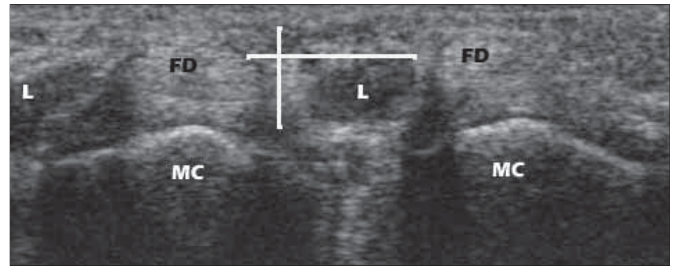

Figure 8. The measurements of the thickness and width of the IMFP (MC: metacarpals, FD: flexor digitorum tendons, L: lumbrical muscle

Results

A total of 80 hands were evaluated. Patients' characteristics are summarized in Table 1. In all patients, the dominant hand was the right hand.

Sonographically, the IM were seen as hypoechoic structures filling the space between the metacarpal bones (Figure 3). There were 4 dorsal and 3 palmar muscles between the 1^{st}-2^{nd}, 2^{nd}-3^{rd}, 3^{rd}-4^{th} and 4^{th}-5^{th} metacarpals. The sonographic visualization of these muscles was performed more easily while depicting them from the adjacent muscles with the dynamic abduction/adduction of the fingers. Mean values for the dimensions of IM are shown in Table 2.

The sonographic boundaries of IMFP were evaluated between two flexor digitorum tendons at the level of two adjacent distal heads of the metacarpal bones at both sides. The anterior boundary was formed by the superficial transverse metacarpal ligament which was sonographically seen easily as a thin hypoechoic linear structure, whereas the posterior boundary formed by the deep transverse metacarpal fascia was seen as a hyperechoic line (Figure 7). This pyramid-shaped IMFP was seen as a hyperechoic structure including the digital arteries and nerves. The posterolateral boundary of IMFP was formed by the lumbrical muscles arising from flexor digitorum profundus and was hypoechoic on ultrasound. There are 3 IMFP (namely the spaces between the 2^{nd}-3^{rd}, 3^{rd}-4^{th} and 4^{th}-5^{th} metacarpals).

The mean values of IM and IMFP dimensions are shown in Table 2. In the statistical analysis, there was a positive and significant correlation between the grip strength and the thickness/width of IM and IMFP ($r=0.4$-0.5, $p<0.05$). However, no correlation was found between the grip strength and the BMI, and also between IM-IMFP areas and the BMI ($p>0.05$).

Conclusion

Gripping is performed by the synchronous movement of internal and external hand muscles. External muscles which originate above the level of the wrist contribute to the movements of both the fingers and the wrist. However, intrinsic muscles like IM and lumbrical muscles originate below the level of the wrist, and function by moving the fingers.

The IM are of fundamental importance in the gripping function. Those muscles are located between the metacarpal bones and play a major role in the execution of fine finger movements. They are arranged in two layers of three palmar and four dorsal muscles. Dorsal IM arise from the adjacent

Table 1. Patient characteristics in the study group consisting of 40 healthy volunteers

Total number of patients/hands	40 patients/80 hands
Sex	All female
Age	mean age:39±12 years, range: 25-65
BMI	40±6 (range: 22-50)
Hand dominance	All right-handed
Grip strength	40±12 pounds (range: 20-67 pounds)

Table 2. The thickness and width of IM at four levels and IMFP at three levels

		Thickness (mm) Mean±SD	Width (mm) Mean±SD
IM	1st	20.7±2.1	9.9±1.2
	2nd	9.0±1.0	10.3±0.9
	3rd	7.3±1.0	9.9±1.0
	4th	8.5±1.0	9.5±0.9
IMFP	1st	9.9 ±1.2	5.3 ±0.7
	2nd	8.5±0.9	5.4±0.7
	3rd	9.0±1.2	4.7±0.7

dorsal sides of two metacarpal bones, whereas palmar IM originate from the palmar surface of the metacarpals. Both insert on the base of the proximal phalanges and on the extensor tendon. The dorsal IM are abductors, while the palmar ones are adductors of the fingers. Although the anatomy and function of these muscles are well-known, there is no report concerning their sonographic evaluation. We evaluated the normal sonographic appearance of IM and defined the normal thickness and width values for the muscle in normal subjects. Moreover, we have shown that IM thickness and width had significant positive correlation with the grip strength.

The gliding structures of the hand have a functional importance in the gripping; the evaluation of the intermetacarpal space containing the IMFP, lumbrical muscle and the neurovascular bundle are important in this context. The morphological description of this space has been defined in detail by the cadaveric study of Clavert et al. (3). There were three intermetacarpal spaces with a similar morphology (3). This pyramid-shaped fatty space has a distal base and a proximal apex, and neither IMFP nor intermetacarpal spaces communicate with adjacent IMFP and spaces. The boundaries of this intermetacarpal space is; metacarpal heads and flexor tendons on both sides, superficial transverse metacarpal ligament on the palmar (transverse fibers of the palmar fascia), and the deep transverse metacarpal fascia palmar (vertical fibers of the palmar fascia) on the dorsal side. The base of the pyramid continues with the subcutaneous tissue, whereas the apex is formed by the lumbrical muscles (3).

All three spaces were filled by IMFP and like the other fat pads in the body, the structure of IMFP is different from the subcutaneous fat, and has two important roles. First, they support and protect the vessels and the nerves passing between rigid osseous structures (5, 6). This is performed via its gliding function and changing shape, also preventing the torsion of neurovascular bundle during each finger movement (3). It is a well-known phenomenon that, in case of trauma or inflammatory processes, the reduction or loss of that function due to scar formation may be responsible for neurological symptoms such as paresthesia by compression of the palmar digital nerve. The second function of IMFP is maintaining the contact surface while an object is grasped; this is achieved by the deformation of fat pad to fill up spaces between metacarpal heads and fingers bases, decreasing the load applied on each tendinous and neurovascular structures (3). Although the structure of IMFP has been shown in cadaveric studies and CT, dimensional measurements have not been reported. To the best of our knowledge, this is the first study performed by US evaluating the normal sonographic appearance of IMFP and defining the normal thickness and width values for the IMFP in healthy subjects. Moreover, we have shown that the IMFP dimensions had significant positive correlation with the grip strength, implying their role in the maintenance of the gripping power.

It has been described that, similar to the other fat pads in the body (7), the fat pad remains unchanged even in cachectic patients (3). The results in our study also support the evidence that IMFP dimensions have no correlation with BMI. This is an important finding of our study.

To our knowledge, this is the first study evaluating the correlation of the sonographic IM-IMFP measurements and the grip strength. Our study group comprising healthy, right handed and adult female subjects has contributed to the relevance of the absolute effect of the IM and the IMFP in the generation of grip strength. This may be of major concern in the diagnosis and follow-up of a variety of clinical conditions. Further research in study groups affected by clinical situations involving the hand, is necessary to reveal the role of IM and IMFP studies in evaluating the pathologies.

Conflict of Interest

No conflict of interest was declared by the authors.

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