Sonographic Evaluation of the Thenar Compartment Musculature

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The thenar region was studied with ultrasonography in 10 healthy volunteers. All thenar muscles could be identified and their course followed entirely. In addition, their function could be assessed by scanning during unresisted or resisted active movements. Standard approach, normal appearance, and dynamic tests for each muscle are described. Key words: Thumb, anatomy; Thenar muscles; Muscles, thenar.

Diagnostic evaluation includes conventional radiography to rule out bony abnormalities and MR imaging for diagnosing pathologic soft tissue conditions. Although MR imaging is an exquisite and elegant technique, high costs and limited availability restrict its daily clinical use. Consequently, ultrasonography has been gaining a role of growing importance in the evaluation of soft tissues of the limbs. While a number of studies deal with anatomy and various pathologic conditions in the human hand, none has concentrated on normal sonomorphology of the thenar muscles and on a standardized examination technique, including defined scan planes that guarantee complete sonomorphologic assessment of the thenar soft tissue.

Therefore, we established a standardized examination technique for sonomorphologic assessment of the thenar muscles and to describe their normal sonographic appearance. The thenar region comprises four muscles operating the carpometacarpal joint of the thumb: abductor pollicis brevis, flexor pollicis brevis, opponens pollicis, and adductor pollicis.

ABBREVIATIONS
MR, Magnetic resonance
PATIENTS AND METHODS

Sonographic evaluation of the thenar muscles of 10 healthy volunteers, 16 to 50 years of age, was performed using a 12 MHz linear array transducer (HDI 5000; ATL, Bothell, WA). Patients sat with their arms resting on a table in a relaxed position during the examination. A transducer with a small surface area was applied directly onto the skin using an acoustic coupling gel (Gerot, Vienna, Austria). Access was gained from the palmar surface of the hand (supination of the forearm, with the dorsal aspect of hand and forearm in broad contact with the examination table) for all patients, except for the evaluation of the first dorsal interosseous muscle. For that purpose, the forearm and the hand were in pronation, and the transducer was applied to the dorsal aspect of the first interdigital space. Sonomorphologic evaluation was done first in a static position and then in an additional functional step, with active and passive motions of the different muscles. Additionally, 10 cadaver specimens were assessed to determine the correct angles of transducer position.

RESULTS

Sonographically all thenar muscles could be identified reliably. The entire course of each muscle could be outlined by placing the transducer orthograde to the specific muscle group initially and angulating the transducer in all directions. Orthograde position means that the transducer is positioned parallel to the direction of the muscle fibers without building any oblique angle. All muscles showed typical echotexture (hypoechoic area surrounded by a hyperechoic fascia), although hyperechogenicity varied significantly depending on the position of the transducer in relation to the axial orientation of the muscle fibers to fascial planes.

The thenar region comprises four muscles operating the carpometacarpal joint of the thumb: abductor pollicis brevis, flexor pollicis brevis, opponens pollicis, and adductor pollicis (Fig. 1).

The flexor pollicis brevis muscle is composed of a superficial and a deep head, while the adductor muscle consists of an oblique and transverse head. The tendon of the flexor pollicis longus muscle divides these muscles into two groups. Lying to its radial side and forming the thenar eminence, the abductor pollicis brevis muscle, the opponens muscle, and the

Figure 1 A, Schematic drawing of the the thenar anatomy from a palmar view. B, Schematic drawing shows muscle and vascular anatomy from palmar view after removal of the abductor pollicis brevis muscle and the flexor pollicis brevis muscle (superficial head): M. add. poll. Caput transv., transverse head of adductor pollicis; M. add. poll. Caput obliq., oblique head of adductor pollicis; Fs, flexor pollicis brevis, superficial head; Fp, flexor pollicis brevis, deep head; M. abd. poll. brev., abductor pollicis brevis; FCR, flexor carpi radialis tendon; M. opponens poll., opponens pollicis; FPL, flexor pollicis longus tendon.
superficial head of the flexor pollicis brevis muscle can be observed; on the ulnar aspect the deep head of the flexor pollicis brevis muscle and the adductor pollicis muscle are localized.

The abductor pollicis brevis muscle takes origin from the flexor retinaculum and the tubercles of the scaphoid and trapezium. This broad and flat muscle runs parallel to the lateral border of the hand, inserting on the radial aspect of the proximal phalanx of the thumb and on the tendon of the extensor pollicis longus muscle. The opponens pollicis muscle lies deep to the abductor. It also arises from the tubercles of the scaphoid and the trapezium, runs in a more oblique direction, and attaches to the lateral margin of the first metacarpal bone.

The flexor pollicis brevis muscle lies medial to the abductor muscle. Its superficial head arises from the flexor retinaculum and adjacent trapezium and passes along the radial aspect of the long flexor tendon. The deep head arises from the trapezoid and capitate bones and crosses deep to the long flexor tendon to merge with the superficial head; the common distal tendon finally becomes attached to the proximal phalanx of the thumb via the radial sesamoid bone.

The oblique head of the adductor pollicis arises from the bases of the second and third metacarpal bones and the trapezoid and capitate bones. The transverse head arises from the entire length of the radial aspect of the third metacarpal bone. It crosses the first dorsal interosseous muscle anteriorly and attaches via the ulnar sesamoid bone to the base of the proximal phalanx of the thumb adjacent to the flexor pollicis brevis muscle.

The first dorsal interosseous muscle is bipennate, originates from the the first and second metacarpal bones, and attaches to the radial margin of the index finger. The radial artery crosses the first interosseous space between the two heads of the first interosseous muscle. The artery then courses underneath the oblique head of the adductor pollicis and emerges between the oblique and transverse heads or passes through the latter to form the deep palmar arch.

**Ultrasonographic Technique**

In principle, longitudinal, transverse, and oblique sections can be obtained by passing the transducer across the whole thenar region in a fan shaped manner. For assessment of each muscle individually, the transducer should be placed initially orthograde to the muscle and then should be angulated in all directions to view the muscle in its entire extent.

Compared to the cadaver investigation, the following transducer positions have proved to be the most efficient:

**Position 1: Opponens and Abductor Pollicis Brevis Muscles**

Hold the ultrasonographic transducer parallel to the lateral margin of the first metacarpal bone on the palmar aspect of the hand to visualize the opponens muscle. To show the abductor pollicis brevis muscle in total extension, the transducer must be positioned upon the radial sesamoid bone and pivoted to make a range of about 20 degrees (Fig. 2). The angle between the transducer and the midstline of the hand should be about 120 degrees (Fig. 2A).

**Position 2: Abductor Pollicis Brevis and Flexor Pollicis Brevis Muscles, Long Flexor Tendon**

Positioning the transducer on the palmar surface at a right angle to the first metacarpal bone demonstrates the abductor pollicis brevis and the flexor pollicis brevis muscles as well as the long flexor tendon in a transverse section (Fig. 3).

**Position 3: Abductor Pollicis and Flexor Pollicis Brevis Muscles (Superficial and Deep Heads)**

Positioning the transducer from the palmar surface between the first and second metacarpal bones displays the adductor pollicis muscle and the superficial and deep heads of the flexor pollicis brevis muscle in a transverse section (Fig. 4).

**Position 4: Adductor Pollicis Muscle (Transverse and Oblique Heads)**

To show both the transverse and oblique heads of the adductor pollicis in total extension, the transducer should be positioned upon the ulnar sesamoid bone and pivoted to make a range of about 60 to 70 degrees (Fig. 5A). The angle between transducer and midline of the hand should be about 65 degrees for the demonstration of the transverse head and about 50 to 55 degrees for the display of the oblique head (Fig. 5B, C).
Position 5: First Dorsal Interosseous and Adductor Pollicis Muscles

From the dorsum of the hand, position the transducer parallel to the second metacarpal bone to view the first interosseous space with the first dorsal interosseous muscle in longitudinal section; palmar to it, the adductor pollicis in a transverse oblique section for the transverse head and in an oblique section for the oblique head, respectively, can be visualized (Fig. 6).

Position 6: First Dorsal Interosseous and Adductor Muscles

Changing the transducer position about 90 degrees compared to position 5, the first dorsal interosseous and the adductor muscles in the first interosseous space can be observed in a transverse section (Fig. 7).

Muscle Function Tests

The following muscle function tests can be performed:

**Flexor Pollicis Longus Muscle**

While maintaining the metacarpophalangeal joint in full extension either with a splint or with a free finger of the examiner, lead the distal phalanx of the thumb through full flexion in the plane of the hand. Test active movement without or with pressure against the volar aspect of the distal phalanx.

**Flexor Pollicis Brevis Muscle**

After fixation of the first metacarpal bone, ask the patient to flex the thumb in the metacarpophalangeal joint while keeping the interphalangeal joint relaxed. This movement can be resisted by application of a force to the volar aspect of the proximal phalanx.
Abductor Pollicis Brevis Muscle

While the second to fifth metacarpal bones and the wrist joint are being immobilized, ask the patient to abduct the thumb at a right angle to the plane of the hand. Resistance can be applied to the lateral border of the proximal phalanx of the thumb.

Opponens Muscle

The patient approaches the volar surface of the distal phalanx of the thumb with the little finger. This movement is resisted by pressing onto the palmar aspect of the head of the first metacarpal bone.

First Interosseous Muscle

This muscle is examined from the dorsum of the hand, with the forearm in pronation. Abduction of the fingers in relation to the middle phalanx is performed after fixation of the metacarpal bones. Muscle power is tested by pressure onto the radial aspect of the index finger.
DISCUSSION

Evaluation of hand injuries and diseases can be a diagnostic challenge to the clinician because of the complicated anatomy of the hand with its multiple joints, muscles, tendons, fascial planes, and neurovascular pathways. In addition to the physical examination, MR imaging has been gaining an important role in the assessment of soft tissue structures. However, restricted availability and relatively high costs of this technique limit its routine clinical use. In addition, general anesthesia is often required in pediatric patients to avoid motion artifacts.

Numerous abnormalities and pathologic changes of the thenar region may require ultrasonographic imaging including atrophy of the thenar muscles in the case of carpal tunnel syndrome, foreign bodies, articular effusion of the carpometacarpal joint of the thumb, and fractures of the first metacarpal bone or tumors (e.g., ganglion cysts).

Supposedly ultrasonographic evaluation of the thenar region is of limited or no value in patients who have had surgery or injuries causing a certain degree of scarring so that an orthograde positioning of the transducer is not available.

With the introduction of high frequency transducers, ultrasonography has been established as an excellent diagnostic tool for superficial soft tissue assessment. As a relatively low cost and noninvasive technique, it offers the additional advantage of dynamic and functional muscle assessment. Over the past few years, numerous studies on acute and chronic affections of the hand have been published, dealing in particular with the carpal tunnel syndrome, infections, tumors, and posttraumatic entities. However, we found no paper focused specifically on the sonoanatomy of the thenar region, including a description of the scan planes necessary for individual muscle assessment. Detailed knowl-
edge about the normal anatomic appearance of the thenar region and particularly a standardized examination procedure, including functional assessment, are essential for recognition, interpretation, and topographic localization of pathologic entities in the thenar region.

However, the only aim of this study was to show the ability of ultrasonographic evaluation of all the components of the thenar compartment and to map out the origins and insertions of the specific muscles.
Figure 6: Ultrasonographic scan of the first interosseous space from dorsal position, approximately parallel to the second metatarsal bone. **A**, Schematic drawing shows the scan plane. **B**, Photograph shows the probe position in vivo. **C**, Scan shows the first dorsal interosseous muscle in a longitudinal direction and palmar adductor pollicis muscle in a more transverse oblique section. M. INTEROSS. DORS. I, First dorsal interosseous muscle; M. ADD. POLL., adductor pollicis muscle.

Figure 7: Ultrasonographic scan perpendicular to the scan plane used in Figure 6 from dorsal position. **A**, Schematic drawing shows the scan plane. **B**, Photograph shows the probe position in vivo. **C**, Scan shows the first dorsal interosseous muscle in a cross section between the first and second metacarpal bones and superficial to adductor pollicis muscle. Note distinct fascial planes (arrows). M. INTEROSS. DORS. I, First dorsal interosseous muscle; M. ADD. POLL., adductor pollicis muscle; MC I, first metacarpal bone; MC II, second metacarpal bone.
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