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18 CMC thumb & common CMC & interMC II–V: anatomy & pathology

Carpometacarpal (trapeziometacarpal) joint of the thumb • Carpometacarpal and intermetacarpal joints of the index to little fingers

18.1 Carpometacarpal (trapeziometacarpal) joint of the thumb

The trapeziometacarpal (TMC) joint, which enables the hand to gain a unique "grasping" function, is the most important joint of the hand, particularly for thumb opposition. Topographically, the alignment of the thumb is unique at rest position as it is located palmar to the coronal plane of the fingers II–V while simultaneously facing towards the ulnar side.[1]

18.1.1 Anatomy

The TMC joint is composed respectively of biconcave, reciprocating saddle-shaped facets on the trapezium bone and on the base of the first metacarpal.

18.1.1.1 Articular anatomy

The saddle-shaped TMC joint is different in structural alignment and anatomic configuration when compared to the carpometacarpal (CMC) joints II–V:[1, 2]

- The axis of the TMC joint is angled approximately 60° in palmar direction to the coronal plane and inclined proximally roughly 35° to the transaxial plane (Fig. 18.1).
- The articular joint of the trapezium is concave in radioulnar direction and convex in dorsopalmar direction (Fig. 18.2 a).
- Inversely, the articular surface of metacarpal base I, which is also saddle-shaped, is convex in radioulnar direction and concave in dorsopalmar direction (Fig. 18.2 b). The articular surface of metacarpal base I is significantly smaller than the corresponding surface of the trapezium.
- The articular surfaces of the TMC partners are only fully aligned during opposition of the thumb. In the so-called "resting position" (i. e. MRI positioning with the thumb adducted), metacarpal base I displaces considerably out of the trapezial center in dorsoradial direction. Radial subluxation up to 3.4 mm and dorsal subluxation up to 2.0 mm are considered normal findings.[3, 4]

In addition to its saddle-like facet for metacarpal base I, the trapezium exhibits several other characteristic features. Its palmar side is narrower than the dorsal side and has a rough and irregular surface: a ridge-like, longitudinal tubercle functions as the point of origin for several anatomical structures, namely the abductor pollicis brevis (APB) tendon, the opponens pollicis (OP) tendon, the flexor pollicis brevis (FPB) tendon, the flexor retinaculum, and the posterior oblique ligament (POL). A deep groove for the passage of the flexor carpi radialis (FCR) tendon is located directly ulnar of the tubercle.

The base of metacarpal I is also characterized by anatomic landmarks (Fig. 18.2 b). At its palmar aspect, a beak-like, prominent protrusion surrounds the TMC articular surface, the anterior oblique ligament ("beak ligament") insertion is just distal to it. On the radial side, a tubercle serves as the insertion of the abductor pollicis longus (APL) tendon. Finally, a flat tubercle on the ulnar side is the origin of interosseous muscle I.

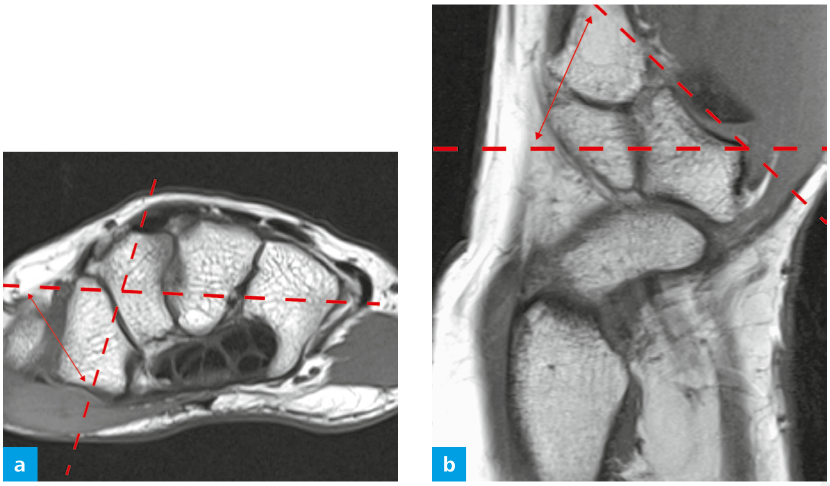

Fig. 18.1: *Alignment of the trapeziometacarpal (TMC) joint depicted in (a) transaxial and (b) sagittal T1-weighted FSE images. (a) The saddle facet of the trapezium is angled approximately 60° to the coronal plane of the palm. (b) The saddle facet of the trapezium is angled roughly 35° to the transaxial plane of the palm.*

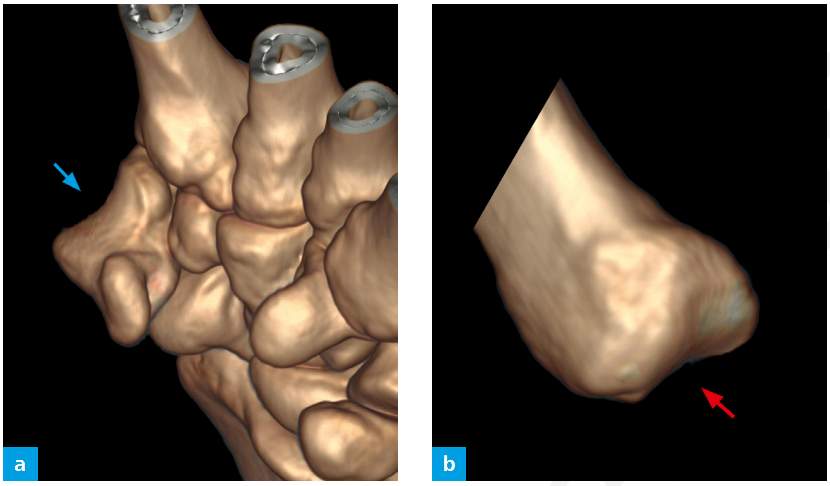

Fig. 18.2: *3D CT images (volume rendering technique) visualizing the anatomy of the TMC joint. (a) Saddle facet of the trapezium (arrow). Anterior oblique view of the palm after removal of the thumb. (b) Saddle facet of metacarpal base I (arrow). Inferior oblique view of the proximal metacarpal portion after removal of the wrist.*

18.1.1.2 Articular motion patterns

The TMC joint has little inherent stability and its dedicated configuration allows biaxial movements of the thumb in an extended range. When using anatomic terminology, the following motion patterns are possible:[1]

Motion patterns in a plane almost parallel to the palm:

- Extension: Metacarpal I (and the thumb) move(s) 0° to 20° in a radial direction away from metacarpal II with simultaneous lateral rotation (Fig. 18.3 a).
- Flexion: Metacarpal I (and the thumb) move(s) 0° to 20° in an ulnar direction towards metacarpal II with simultaneous medial rotation (Fig. 18.3 b).

Motion patterns in a plane perpendicular to the palm:

- Adduction: Metacarpal I (and the thumb) move(s) in sagittal direction towards the palmar plane, thereby flattening the carpal arch (Fig. 18.3 c).
- Abduction: Metacarpal I (and the thumb) move(s) 0° to 60° in a sagittal direction away from the palmar plane into a frontal position (Fig. 18.3 d).

Combined motion patterns:

- Opposition: This is the result of simultaneous abduction and rotation of the thumb with metacarpal I moving obliquely to the palm. Its head is located opposite the palm center; the pulp of the thumb is placed face to face with the other finger pulps.

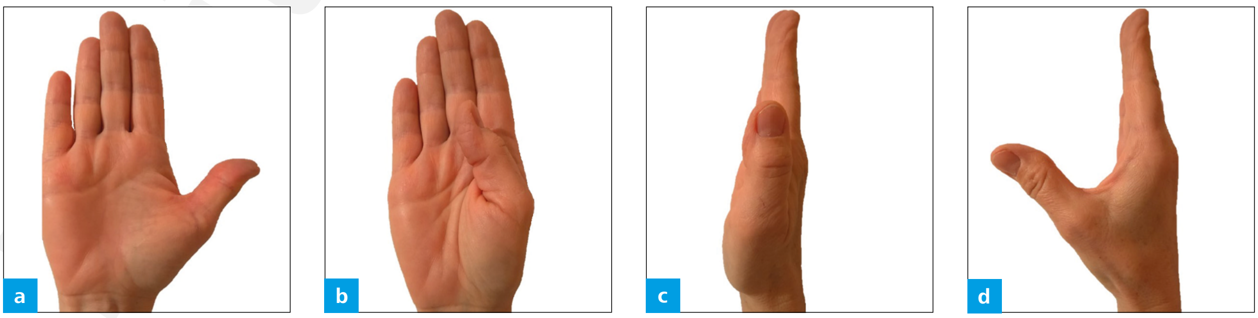

Fig. 18.3: *Photographs of the right hand to illustrate the motion patterns of the thumb. (a) Extension of the TMC joint: the thumb moves away from the index finger. (b) Flexion of the TMC joint: the thumb moves towards the index finger. (c) Abduction of the TMC joint: the thumb moves towards the palmar plane. (d) Adduction of the TMC joint: the thumb moves away from the palmar plane.*

- Circumduction: This term describes the full range of motion in the TMC joint with the thumb moving from extension to abduction and finally to entire opposition. Circumduction ends with the pulp of the thumb contacting the palmar side of the metacarpophalangeal V joint.

Caution: Differences between anatomical and surgical terminology may lead to misunderstandings!

18.1.1.3 Ligament anatomy

The TMC capsule is thick but loose, thus allowing joint distraction up to 3 mm. The capsule covers the palmar beak of the metacarpal base, which is free of ligament and tendon insertions. Five ligaments reinforce the capsule and contribute to TMC stability (Fig. 18.4 a, b), but only four of them are visible on MRI.[1, 4–8]

Two ligaments are discernible at the palmar site of the TMC joint: the anterior oblique and the extracapsular ulnar collateral ligaments.

The anterior oblique ligament (AOL, beak ligament) is strong, with a total thickness of about 1.5 mm (Fig. 18.4 c). It serves as the most important stabilizer of the TMC joint, mainly preventing palmar subluxation of the thumb metacarpal. The common trunk of the AOL originates from the ridge of the trapezium before dividing into two fascicles:

- The superficial AOL is the extracapsular fascicle which passes obliquely over the palmar beak of the thumb metacarpal to insert 2 mm distal from it. The superficial AOL tightens with adduction and extension of the thumb. Its "curtain-like" appearance creates a recess over the palmar base of metacarpal I.
- The deep AOL is the intracapsular fascicle of the beak ligament. Its insertion is located proximally to the superficial AOL at the thumb's metacarpal base. The deep AOL tightens with abduction and extension, thus preventing ulnodorsal translation of metacarpal I. The AOL may show increased signal intensity on MRI.[4] Differentiation of the superficial and deep AOL is not possible in plain MRI because of limited spatial and contrast resolution. As opposed to this, MR arthrography allows depiction of these ligamentous fascicles mainly due to volume-based distension and improved contrast resolution.[6]

The thin, extracapsular ulnar collateral ligament (UCL) courses from the distal-radial edge of the flexor retinaculum to the ulnopalmar base of metacarpal I, partially overlapping with the superficial AOL. The small UCL is invisible on standard MRI.[4]

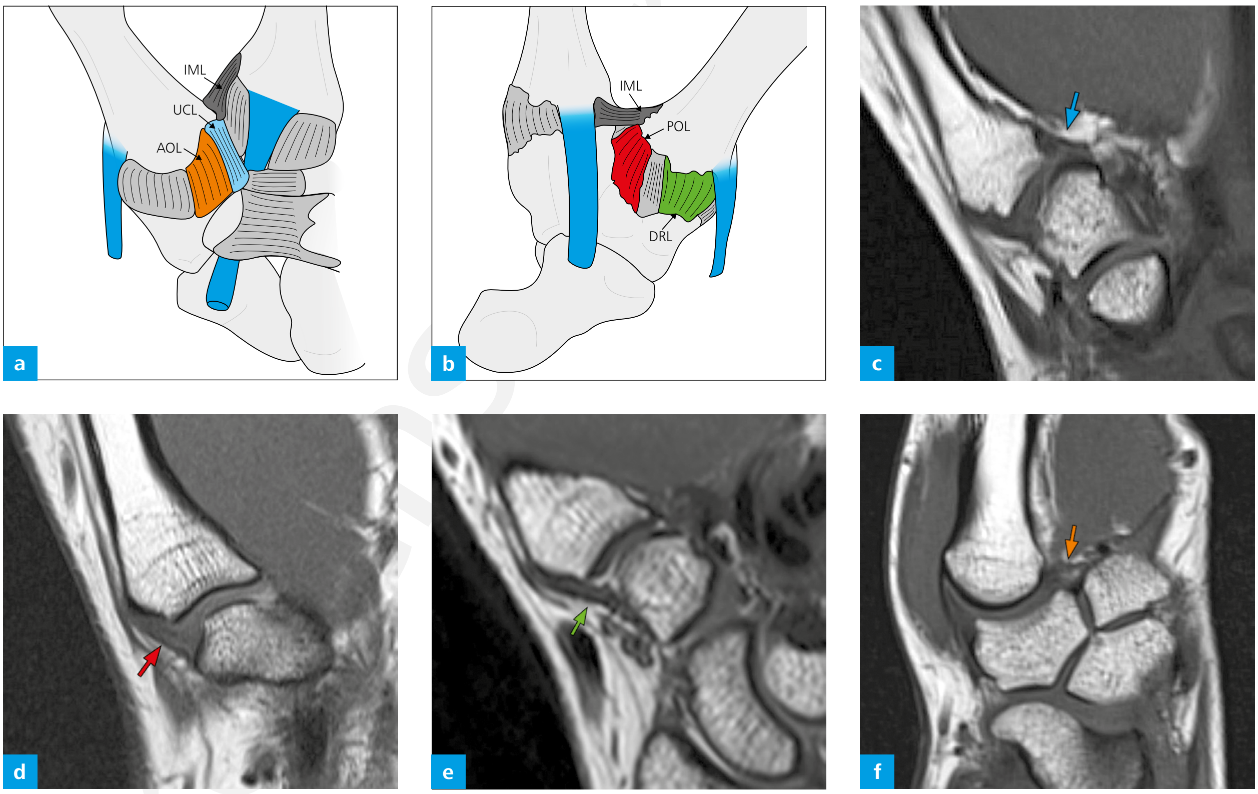

Fig. 18.4: The ligaments of the TMC joint. (a) Schematic drawing taken from a palmar view. The abductor pollicis longus and flexor carpi radialis tendons are also depicted (blue). AOL: anterior oblique ligament (orange), IML: intermetacarpal ligament (dark), UCL: ulnar collateral ligament (light blue). (b) Schematic drawing taken from a dorsal view. The abductor pollicis longus and extensor carpi radialis longus tendons are also depicted (blue). DRL: dorsoradial ligament (green), IML: intermetacarpal ligament (dark), POL: posterior oblique ligament (red). (c) Anterior oblique ligament (arrow) seen on sagittal T1-weighted FSE. (d) Posterior oblique ligament (arrow) depicted on sagittal T1-weighted FSE. (e) Dorsoradial ligament (arrow) coronally reconstructed from T1-weighted 3D SPACE. (f) Intermetacarpal ligament (arrow) depicted on coronal T1-weighted FSE.

The dorsal part of the TMC joint capsule consists of two ligaments:

- The posterior oblique ligament (POL) originates from the dorsoulnar side of the trapezium and takes an oblique course to the dorsoulnar aspect of metacarpal base I (Fig. 18.4 d). The intracapsular POL inhibits dorsoulnar translation of the thumb. The extensor pollicis longus (EPL) tendon crosses over the POL superficially.
- The dorsoradial ligament (DRL) is an extracapsular stabilizer with a thickness of about 1.5 mm. It arises from a dorsoulnar prominence of the trapezium and attaches – together with the POL – to the dorsoradial edge of metacarpal base I (Fig. 18.4 e). Despite its small caliber, the DRL offers the strongest resistance against dorsoradial subluxation of the thumb.

Finally, the bases of metacarpals I and II are connected by an extracapsular, horizontally aligned ligament:

- The intermetacarpal ligament (IML) courses from an ulnopalmar tubercle of metacarpal I to the dorsoradial base of metacarpal II next to the insertion of the extensor carpi radialis longus (ECRL) tendon (Fig. 18.4 f). The IML is the thickest TMC ligament with 3 mm and has a striated appearance on MRI. It counteracts excessive abduction and radial translation of the thumb. At its ulnopalmar aspect, it merges with the UCL and at its ulnodorsal aspect with the POL. Adjacent, the radial artery traverses a fibrous arch between the IML and the interosseous muscles.

In addition to the above-mentioned ligaments, the TMC joint is reinforced by muscular and tendinous structures:

- Three thenar muscles (abductor pollicis brevis, opponens pollicis, and flexor pollicis brevis) overlay the palmar aspect of the TMC joint.
- The extensor pollicis longus (EPL) tendon and the extensor pollicis brevis (EPB) tendon cover the dorsal aspect of the TMC joint, in which the EPL tendon is located ulnar to the EPB tendon.
- The abductor pollicis longus (APL) runs radial to the TMC and inserts nearby the joint into a radial tubercle of metacarpal I base.
- The dorsal interosseous I muscle is located on the ulnar side of the TMC joint.

18.1.2 MR imaging

Some technical prerequisites should be considered to achieve sufficient MRI quality at the TMC joint:[6–8]

- In 2D MRI, the scan planes must be individually aligned corresponding to the anatomic orientation of the thumb and TMC joint, i. e. the coronal plane must be angled about 60° in the palmar direction from the palm. In 3D MRI, multiplanar reconstructions (MPR) should be performed using the same orientation.
- Slice thickness in 2D MRI of either 2.0 mm or 1.5 mm without gaps is recommended in order to obtain the spatial resolution necessary for depicting the small ligaments.
- In standard MRI, a fat-saturated PD sequence with TE of 40 ms to 45 ms is best suited for obtaining optimized contrast between ligaments, articular cartilage and a potential joint effusion. Notably, inhomogeneous signal intensity and irregularities may be present in asymptomatic people.[4]
- MR arthrography provides optimal depiction of torn TMC ligaments in post-arthrographic T1-weighted sequences.[6] However, a specific clinical indication is required prior to performing arthrography.

The AOL, POL and DRL are preferably evaluated in the sagittal plane, while the IML (and the DRL) should be assessed in the coronal plane. The UCL is not depictable in MRI. Signal intensity of the TMC ligaments can vary. Particularly the AOL may appear hyperintense, while a striated pattern of the IML has been reported.[4]

18.1.3 Pathology

The TMC joint is a frequent site of hand trauma. Depending on impact and direction of the force vector, ligamentous lesions with varying degrees of severity may result, ranging from minor sprains and partial tears to complete tears, leading to dynamic TMC instability or permanent dislocation.

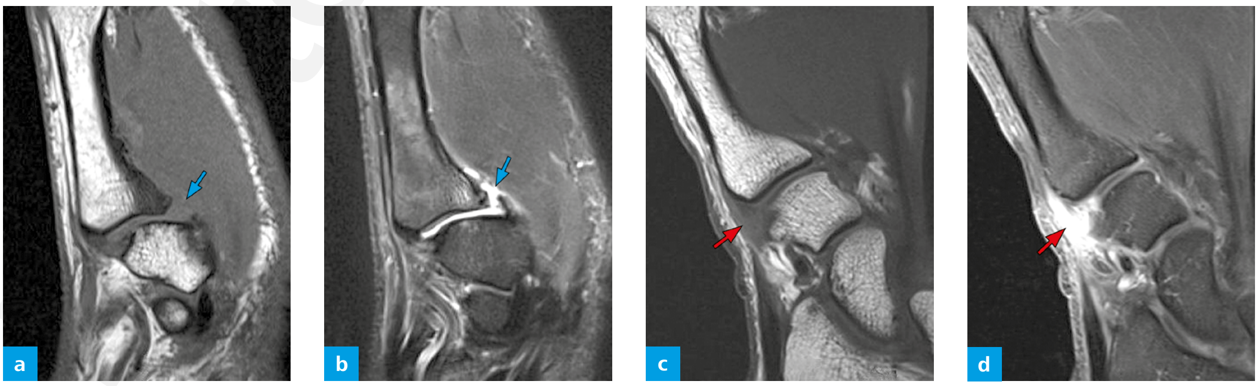

Fig. 18.5: *Tears of the TMC ligaments. (a, c) Sagittal T1-weighted FSE and (b, d) sagittal T1-weighted, fat-saturated FSE. (a, b) Distal tear of the anterior oblique ligament (arrows) displayed (a) before and (b) after intravenous gadolinium application. (c, d) Proximal tear of the dorsoradial ligament (arrows) shown (c) before and (d) after intravenous gadolinium application.*