Anatomy of the Upper Limb: Finger and Thumb Joints

None of us can imagine a life without fingers. We would no longer be able to use a computer, play an instrument or greet a friend or colleague with a friendly handshake. Hardly any other joint is as frequently affected by joint rheumatism as the finger joints. Countless metacarpophalangeal joints, like the second knuckles of people living in industrialized nations, are affected by chronic polyarthritis. Knowledge of the anatomy and pathology of the fingers and thumb is thus indispensable for every (aspiring) medical practitioner.

Surface Anatomy and Osteology: Phalanges

When finger joints are being discussed in human anatomy, the following sections must be differentiated:

- Metacarpophalangeales (MCP)
- Interphalangeales manus proximales (PIP)
- Interphalangeales manus distales (DIP)

People’s fine motor skills lie in the distinctive mobility of the finger joints, made possible by all three movement axes.

Art. metacarpophalangeales: The horizontal axis lies in the caput metacarpale and
runs in a radial-ulnar direction. This enables extension and flexion, although the degree of movement of extension is not equal for all fingers. The sagittal axis lies in the middle of the caput metacarpale and runs in a dorsal-palmar direction. This is what makes abduction and adduction possible. Rotation occurs through the longitudinal axis, which is equal to the long axis of the os metacarpale. The average active extents of mobility are:

- 90–100 degrees of flexion
- 0–40 degrees of extension
- 20–30 degrees of abduction
- 10–20 degrees of adduction

**Note:** Axial rotation is only passively possible and amounts to approx. 5 degrees for both inner and outer rotation.

**Art. interphalangeales manus proximales et distales:** The PIP and DIP joints merely move via the horizontal axis during flexion and extension. They lie in the convex caput phalangis of both the proximal and middle phalanx in a radial-ulnar direction. The average active extents of mobility are:

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<th>PIP</th>
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<td>• 110 degrees of flexion</td>
<td>• 70–80 degrees of flexion</td>
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<td>• 0 degrees of extension</td>
<td>• 5 degrees of extension</td>
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Translational gapping can be triggered in the joints by a mobilization impulse. However, these movements hold no major functional significance for active mobility in extension and flexion and thus need not be tested for purposes of the neutral-null method.

**Art. metacarpophalangeales**

The metacarpophalangeal joints are **ellipsoidal joints**.

**Artt. metacarpophalangeales: Osseous structures and joint surfaces**

Through the metacarpophalangeal joints, the **caput metacarpale** articulates with the **basis phalangis proximalis**.

**Caput metacarpale**

The caput metacarpale is convex. On the dorsopalmar side, the joint surface is coated in cartilage and is larger there than it is on the radioulnar side. The average thickness of the cartilage is about 0.8 millimeters and is especially distinctive in the index and middle finger.

**Basis phalangis proximalis**

The base of the proximal phalanx, contrary to the caput metacarpale, is concave and is much smaller. A fiber cartilage plate enlarges the joint surface in the distal area, which is fastened like a hinge at the palmar end and consists solely of fiber cartilage, as the name itself implies. Proximally, this turns into conjunctive tissue and can be considered a type of **labrum glenoidale**, although this term is only rarely used, as the nomenclature can be easily confused with the **joint surface of the scapula to the humerus in the shoulder joint**.

The contact surface of the cartilage plate where it rubs against the caput is greatest in the neutral-null position. It is reduced as flexion increases because of its proximal
translation. Ultimately, the cartilage plate provides insertion points for the lig. metacarpale profundum, which links together the cartilage plate and the caput, as well as a few fibers of the mm. interossei. The synovial tendon sheaths of the flexors are also attached to them by ring ligaments.

Artt. metacarpophalangeales: Joint capsule

The capsule surrounds the bone-cartilage threshold of the apex of the fiber cartilage plates. It completely envelops the joints and forms a dorsal and palmar recess. Additional smaller recesses are located radial and ulnar. The joint capsule is reinforced by the lig. palmare at the basis of the phalanx, and is dorsally infiltrated by several fibers of the dorsal aponeurosis.

Artt. metacarpophalangeales: Ligaments

The metacarpophalangeal joints are very well equipped with ligaments. Along with the ligg. collaterale radiale et ulnare, the lig. collaterale accessorium and the lig. phalangeoglenoidal ensure sufficient protection of the osseous structures. These counteract palmar pulling forces during flexion, which primarily target the ligament bands.

Ligg. collaterale radiale et ulnare
Both the radial and the ulnar lateral ligament are powerfully equipped and possess the same direction and force of movement. They both emerge dorsally from the flexion and extension axis along the caput metacarpale and insert into the lateral base of the proximal phalanx. The radial lateral ligament has a more slanted course than the ulnar, due to the asymmetry of the joint surfaces. During flexion, the ligaments are strained, making passive gapping and active abduction and adduction in the artt. metacarpophalangeales impossible during this movement. These movements are possible in extension as the lateral ligaments are not under strain.

**Lig. collaterale accessorium**

This ligament inserts into the caput metacarpale proximal to the lateral ligament and connects with the radial and ulnar edge of the palmar cartilage plate. Consequently, this ligament connects to the respective lateral ligament and supports tension during flexion. Yet contrary to the ligg. collaterale radiale et ulnare, the lig. accessorium is also strained in extension, although it does not prevent lateral movements of the finger, showing that these do not have the same pulling force as the lateral ligaments.

**Lig. phalangoglenoidale**

This ligament is not commonly observed, although it provides lateral reinforcement of the joint capsule, and thus the joint itself, just like the lateral ligaments. It stems from the base of the proximal phalanx, runs in a proximal-palmar direction over the lateral ligament and inserts into the cartilage plate and into ring ligament A1 with its distal fibers.

**Artt. interphalangeales manus proximales et distales (PIP/DIP)**

Both the PIP and DIP joints are hinge joints.

**Artt. interphalangeales manus proximales et distales: Osseous structures and joint surfaces**

In the PIP and DIP joints the caput phalangis articulates with the basis phalangis.

**Caput phalangis**

The caput phalangis of the proximal and middle phalanx is made up of the proximal convex joint surfaces of the PIP and DIP joints. It is coated with a layer of cartilage with an average thickness of 0.5–1 millimeter.

**Basis phalangis**

The basis phalangis is the concave distal joint partner of the PIP and DIP joints. The layer of cartilage is much thinner in comparison to the caput, at 0.2–0.5 millimeters. Located at the palmar corner of the base of the middle phalanx is a fiber cartilage plate that is thicker in the PIP joint than in the DIP joint.

**Artt. interphalangeales manus proximales et distales:**
Joint capsule

The joint capsule inserts both into the bone-cartilage threshold and the tip of the fiber cartilage plate of the PIP and DIP joints. From the palm, the fiber cartilage plate is entirely inserted into the capsule. From the dorsal and palmar sides, it forms recesses in the proximal interphalangeal joints, whereby the recess in the dorsal DIP joint region is far more distinct than in the palmar DIP region.

Artt. interphalangeales manus proximales et distales:

Ligaments

The medical student on the way to their exam may be relieved to learn that the names of the ligament structures in the PIP and DIP joints are the same as those in the metacarpophalangeal joints. Nevertheless, they have different origins and beginnings, the respective localization of which must be remembered.

Ligg. collaterale ulnare et radiale
The ulnar and radial lateral ligaments emerge dorso-proximal from the caput phalangis and insert into the tuberculum laterale of the palmar basis of the middle and distal phalanx. They are taut during flexion and relaxed during extension.

Lig. collaterale accessorium
Both radial and ulnar this ligament have its origin in the caput of the proximal and middle phalanx. It inserts into the edge of the fiber cartilage plate, and along with some fibers enters into the ring ligament A3 (PIP) and ring ligament A5 (DIP). It is taut during flexion, while extension has no direct effect on it.

Lig. phalangoglenoidale
This ligament emerges both radial and ulnar from the base of the middle phalanx and its roots are in the palmar cartilage plate. It is more common in the PIP joint than in the DIP joint. In some people, it is even missing entirely from the DIP joint.

The Thumb Joints: General Information

The thumb (pollex) is a functional peculiarity among the fingers. It contains the following joint segments:

- carpometacarpalis pollicis
- carpometaphalangealis pollicis
- interphalangealis pollicis

Art. carpometacarpalis pollicis
The horizontal axis runs through the distal portion of the os trapezium. Flexion and extension are made possible by this axis. Abduction and adduction are performed via the sagittal axis, which runs through the os metacarpale I. No rotation occurs in the art. carpometacarpalis pollicis. Instead, opposition and reduction are possible, with no actual axis described for these movements in biomechanics. The opposition is a combination of flexion, adduction and axial rotation. Reduction merely describes the return of the thumb from opposition into the neutral-null position. The average degrees of active movement are:
- 20 degrees of flexion
- 45 degrees of extension
- 45 degrees of abduction
- 0 degrees of adduction
- 20–30 degrees of opposition
- Reduction is not numbered in the literature used.

**Art. caropmetaphalengealis pollicis**

Flexion and extension run through the horizontal axis located in the caput metacarpale. The sagittal axis for abduction and adduction is also localized in the metacarpal head, whereby these movements are only passively possible. Rotation occurs on the longitudinal axis, which is equal to the beam axis of the proximal phalanx. The average degrees of active movement are:

- 50 degrees of flexion
- 5 degrees of extension
- Rotation is not numbered in the literature used.

**Art. interphalangealis pollicis**

Only flexion and extension on the horizontal axis are possible in this joint. It is located at the caput phalangis of the proximal phalanx. The average degrees of active movement are:

- 80 degrees of flexion
- 5–10 degrees of extension

**Art. carpometacarpalis pollicis**

The carpometacarpal joint I is defined as a saddle joint.

**Art. carpometacarpalis pollicis: Osseous structures and joint surfaces**

In the carpometacarpal joint I, the **basis metacarpalis I** articulate with the **os trapezium** of the distal carpal series.

**Basis metacarpalis I**
The basis metacarpalis I is radially convex and dorsally concave. This is important for oppositional motion, which entails a combination of flexion, adduction, and axial rotation.

**Os trapezium**
The joint surface of the os trapezium is curved opposite to that of the basis metacarpalis I. It is radially concave and dorsally convex. This metacarpal joint is thus a congruent joint.

**Art. carpometacarpalis pollicis: Joint capsule**
The joint capsule of the carpometacarpal joint I is wide and loose, which allows for large degrees of motion. The insertion points are located in the respective bone-cartilage thresholds of the aforementioned osseous structures. The capsule forms both dorsal and palmar recesses.
Art. carpometacarpalis pollicis: Ligaments

The ligamentary structures of this joint lie directly atop the joint capsule, and thus allow for optimal stabilization in every position of the thumb.

Ligg. carpometacarpalia palmaria

These are very thin ligaments. They stem from the os trapezium and the lig. carpi transversum, with their roots in the basis metacarpalis I. They are taut during extension and abduction.

Lig. carpometacarpale dorsale

This ligament links the os trapezium with the basis metacarpalis I and is connate with the joint capsule. It is taut during flexion and opposition.

Lig. carpometacarpale obliquum anterius

From the tuberculum ossis trapezii outward, the ligament runs to the radial side of the basis metacarpalis I. Like the ligg. carpometacarpalia palmaria, it is taut during extension and abduction.

Lig. carpometacarpale obliquum posterius

The posterior counterpart originates dorsal from the os trapezium and its roots are located on the palmar surface of the basis metacarpalis I. It is taut during flexion and abduction.

Art. metacarpophalangealis pollicis

The basal joint of the thumb is an ellipsoidal joint.

Art. metacarpophalangealis pollicis: Osseous structures and joint surfaces

The basal joint of the thumb is formed by the caput metacarpale I and basis phalangis.

Caput metacarpale I

The caput metacarpale I forms the proximal convex joint partner in the basal joint of the thumb. The cartilage layer is about 1 millimeter thick where both a radial and ulnar sesamoid bones are located on the palmar side. This serves as a starting point for, among others, the lig. collaterale accessorium and the 2nd fiber segment of the ligg. collaterale radiale et ulnare pollicis.

Basis phalangis

The base of the proximal phalanx is the distal concave joint partner in the basal joint of the thumb. At approx. 0.5 millimeters the cartilage layer is much thinner than that of the caput metacarpale I and has a proximal fiber cartilage plate in its palmar corner.

Art. metacarpophalangealis pollicis: Joint capsule

The joint capsule of the basal joint of the thumb inserts into the caput metacarpale I along with the bone-cartilage threshold with both membranes. It forms small dorsal and palmar recesses and is laterally braced by the collateral ligaments. In addition, the m.
extensor pollicis brevis is connate with the dorsal capsule. The membrana fibrosa has a palmar connection with the ring ligaments that fasten the m. flexor pollicis longus to the cartilage plate.

**Art. carpometacarpalis pollicis: Ligaments**

Again, the ligament structures bear the same names as those of the artt. interphalangeales manus proximales et distales and artt. metacarpophalangeales. They merely carry an additional “pollicis” for the lateral ligaments, and the lig. collaterale accessorium is a fiber segment of the same in the thumb.

**Ligg. collaterale radiale et ulnare pollicis**

The lateral ligaments of the thumb are divided into two fiber segments. The 1st fiber segment is called the *lig. collaterale proprium*. It originates from the *caput metacarpale I* and inserts into the *base of the proximal phalanx*. The 2nd fiber segment is called the *lig. collaterale accessorium*, originates next to the 1st fiber segment but inserts into the *radial and ulnar sesamoid bone*.

**Lig. phalangoglenoidale**

This ligament is localized on the surface, originates from the radial and ulnar side of the basis phalangis, and its roots are in the respective sesamoid bone.

**Art. interphalangealis pollicis**

The interphalangeal joint of the thumb is a hinge joint.

**Art. interphalangealis pollicis: Osseous structures and joint surfaces**

The interphalangeal joint of the thumb consists of the *caput phalangis proximalis* and the *basis phalangis distalis*.

**Caput phalangis proximalis**

The caput phalangis proximalis is the proximal convex joint partner of the art. interphalangealis pollicis.

**Basis phalangis distalis**

The basis phalangis distalis is the distal concave joint partner of the interphalangeal joint of the thumb. A fiber cartilage plate is located in the palmar corner of the basis of the middle phalanx.

**Art. interphalangealis pollicis: Joint capsule**

Both membranes insert into the bone-cartilage threshold of the fiber cartilage plate of the basis phalangis distalis. The joint capsule forms small dorsal and palmar recesses and largely consists of fatty and synovial tissue.

**Art. interphalangealis pollicis: Ligaments**

This “simple naming” continues into the interphalangeal joint of the thumb. However,
there is no lig. phalangoglenoidale here.

**Ligg. collaterale ulnare et radiale**

The lateral ligaments arise both ulnar and radial from the dorsal side of the caput phalangis proximalis and insert into the palmar base of the end phalanx. They are taut during flexion and loose during extension.

**Lig. collaterale accessorium**

This ligament stems from both the radial and ulnar side of the caput phalangis, proximal-palmar to the lateral ligaments. Its roots are located in both the radial and ulnar edge of the fiber cartilage plate of the basis phalangis distalis. They are taut during flexion, while their state of tension in extension is not further explained in the available literature.

**Examples of Diseases of the Finger and Thumb Joints**

Due to the wide variety of pathologies in the aforementioned structures, we will focus on the most important diseases with a high incidence rate.

**Rheumatoid arthritis**

As described above, a majority of rheumatoid diseases affect the hand and finger joints. The synovial proliferation results in skeleton erosion, destruction of the capsular ligamentary structures and lesions in the tendon tissue. This results in malpositions of the hand and fingers. In the metacarpophalangeal joints it is called the ulnar deviation; in the thumb, it is referred to as buttonhole deformity (90-90 deformity, Z-deformity) or swan-neck deformity (M-deformity).
Subluxation of the basal joints

The progressive inflammatory processes in the joints and the resulting destruction of bone and cartilage tissue result in malposition of the ulnar hand joint toward the palm. The radial extensors pull the hand in radial abduction via the direction of movement forming in supination.

The fingers position themselves in **ulnar deviation** as a way to compensate, which may lead to subluxations or complete dislocations of the osseous structures. Normal movements of the fingers are no longer possible in this state, and patients report incredible pain.

**Heberden’s mode**

Heberden’s node often forms in the distal finger joints as a result of arthritic incidents, with women being more commonly affected than men. These are **mucoid cysts** that form along the side of the edge of the extensor tendons, and they are filled with synovial fluid and emerge from the capsule of the DIP joint like a hernia.

If the node is not treated effectively, the result is compensatory malflexion with subsequent contractures that are very painful for the patient. Conservative treatment with inflammation-inhibiting medication and radiation, as well as physical therapy and ergotherapy, is recommended.

**Rhizarthritis**

The arthritic change of the carpometacarpal joint of the thumb is referred to as rhizarthritis. Progressive instability of the joint results in both dorsal and radial subluxation of the thumb, which advances into pain and cartilage decay. The restriction of movement brought on by the pain results in the phenomenon of the **pollex adductus**, a malposition of the basal joint of the thumb in flexion and adduction in combination with a palm position.

All encumbering movements, especially the opposition, are described as very painful by
those affected. Patients also complain of increasing loss of strength, which impairs the performance of ADLs. Rhizarthritis is usually treated conservatively with medication, physical therapy, and ergotherapy. If the arthritis is very advanced, a replacement prosthetic with an arthrodesis is surgically implanted in flexion position.

Skier’s thumb

Upon suffering a fall with reflexive, abrupt leaning on the ski pole, the result is the so-called skier’s thumb syndrome. The ulnar lateral ligament is overextended or (partially) ruptured due to the traumatic abduction and extension of the metacarpophalangeal joint. In especially severe cases, there may also be osseous avulsion with luxation of the basal joint of the thumb.

When the end of the tendon of the m. adductor pollicis strikes against the joint, this is called a Stener lesion. Overextensions and partial ruptures are usually treated conservatively, while total ruptures with skeletal involvement and the Stener lesion must be treated surgically.

Review Questions

The answers are below the references.

1. What is the extent of active rotation in the art. metacarpohalangeales?
   A. 5 degrees
   B. 10 degrees
   C. 15 degrees
   D. 20 degrees
   E. Active rotation is not possible in these joints.

2. What movements make up the opposition of the thumb?
   A. Extension, abduction, and axial rotation
   B. Extension, adduction, and axial rotation
   C. Flexion, abduction, and axial rotation
   D. Flexion, adduction, and axial rotation
   E. The opposition is an independent movement, not a combination thereof.

3. What is the pollex adductus, which can arise as a result of rhizarthritis of the carpometacarpal joint of the thumb?
   A. A malposition of the basal joint of the thumb in flexion and adduction with palm position.
   B. A malposition of the basal joint of the thumb in extension and adduction with palm position.
   C. A malposition of the basal joint of the thumb in flexion and abduction with palm position.
   D. A malposition of the basal joint of the thumb in extension and adduction with palm position.
   E. A malposition of the carpometacarpal joint of the thumb in flexion and adduction with palm position.
References


**Correct answers:** 1E, 2D, 3A

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