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# Anatomy, Shoulder and Upper Limb, Hand Metacarpal Phalangeal Joint

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## Introduction

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The metacarpophalangeal (MP or MCP) joint, also known as “the knuckle,” is formed by the articulation of the metacarpal head and proximal phalanx. This multiaxial joint allows flexion and extension as well as abduction and adduction motions. The MP joint also dynamically coordinates with the interphalangeal (IP) joint to perform thumb opposition and composite finger flexion. The MP joint has implications in many congenital or acquired deformities, sports-related injuries, and degenerative conditions and sequelae.

## Structure and Function

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The MP joint is responsible for two planes of motion: flexion and extension, as well as abduction and adduction.[1]

### Thumb MP joint

The proximal convex surface of the first metacarpal bone is opposed by the elliptical cavity of the proximal phalanx. Additionally, two sesamoid bones embed in the palmar aspect of the joint capsule, which is secured by intersesamoid ligaments. The first MP joint provides additional flexion to the thumb in opposition, permitting the grasping and contouring objects to facilitate fine motor tasks.

### Finger MP joints

The finger MP joints have an oval convex metacarpal surface that articulates with a concave, more shallow proximal phalangeal surface.[1] Despite their structural similarities, these joints are much less restricted in motion compared to the first MP joint of the thumb. On the palmar side, the flexor digitorum superficialis, flexor digitorum profundus, lumbricals, interossei, flexor digiti minimi, flexor pollicis longus, and flexor pollicis brevis muscles support the joint.[2][3][4][5] Dorsally, the extensor digitorum, extensor indicis, extensor digiti minimi, extensor pollicis longus, and extensor pollicis brevis muscles reinforce the joint.[6]

Various ligamentous structures such as the volar plate, longitudinal fibers of the joint capsule, and (superficial and deep) transverse metacarpal ligaments provide additional stability to the joint.

From deep to superficial, the anatomic structures of the MP joint facilitate the overall dynamic function of the MP joint include[3]:

- Volar plate
- Joint capsule fibers
- Deep transverse metacarpal ligament

- Flexor digitorum profundus (FDP) tendon
- Flexor digitorum superficialis (FDS) tendon
- Digital tendon sheath
- A1 annular pulley

The volar plate is a short, transverse thickening of the joint capsule that functions to increase overall joint congruence.[7] The volar plate also prevents MP hyperextension.

The joint capsule is a thin, fibrous, and durable network, reinforced by the flexor pollicis brevis and adductor pollicis brevis muscles, the palmar plate, and various collateral ligament connections. The radial and ulnar collateral ligaments arise proximally from their respective sides on the metacarpal bone, spanning distal and volar to attach on the proximal phalanx.[8] Each collateral ligament has its own proper and accessory ligamentous structures.

The volar fan-shaped accessory ligament attaches from the middle of the metacarpal head to the palmar plate and deep transverse metacarpal ligament and tightens during finger extension. The dorsal, cord-shaped, proper ligament attaches from the metacarpal head to the proximal phalanx base, becoming taut at about 30 degrees of finger flexion. The natatory ligament, also known as the superficial transverse metacarpal ligament, originates distal to the MP joint and runs through the web space to insert on the proximal phalanx. It functions to resist abduction. The deep transverse metacarpal ligament connects the 2nd to 5th metacarpal heads together at the volar plate and provides soft tissue support. Dorsal to this ligament, are the ribbon-shaped sagittal bands that centralize the MP joint and stabilize the extensor tendons in motion.[1]

## Embryology

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The MP joint forms a cavity in mesenchyme between developing bones. The mesenchyme also gives rise to the joint capsule and other ligaments that stabilize the joint. The upper limb bud appears around the fourth week of gestation,[9] with the development of the MP joint occurring around 6 to 7 weeks gestation. The sesamoid bones of the first metacarpophalangeal joint do not appear until approximately 12 years of age.

## Blood Supply and Lymphatics

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The primary blood supply to the hand is through the radial and ulnar arteries. The ulnar artery gives rise to the superficial palmar arch, and the radial artery gives rise to the deep arch. Blood supply to the thumb MP joint may be directly the superficial arch or via a deep branch of the radial artery: the princeps pollicis artery.[10] The arterial supply to the MP joints of the fingers is by branches from adjacent digital arteries.

The axillary lymph nodes provide lymphatic drainage of the upper limb.

## Nerves

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The MP joint receives innervation from the articular branches of the dorsal and palmar digital nerves. The second to fifth MP joints receive innervation from a deep branch of the ulnar nerve that is superficial to the interosseous muscles, but deep and radial to the flexor tendon.[11]

## Muscles

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There are several muscles balancing the actions of the MP joint. The extrinsic and intrinsic muscles function in flexion and extension respectively. The intrinsic muscles acting on the MP

joint include the abductor pollicis brevis, adductor pollicis, dorsal interosseus, palmar interosseus, flexor digiti minimi, flexor pollicis brevis, and lumbrical muscles.[12] The flexor digitorum profundus, flexor digitorum superficialis, flexor pollicis longus, extensor digitorum communis, extensor indicis proprius, and extensor digiti minimi are the extrinsic muscles acting on the MP joint.[12][13]

The flexor digitorum superficialis and flexor digitorum profundus muscles are the flexors of the MP joint. The flexor digitorum superficialis muscle produces more torque at the metacarpophalangeal joint than flexor digitorum profundus muscle. The flexor digitorum superficialis muscle crosses fewer joints and is less likely to lose tension as it shortens over multiple joints. The flexor pollicis brevis flexes the thumb MP joint.[12] The flexor digiti minimi muscle flexes the MP joint of the little finger.[12]

The dorsal interosseous muscles function primarily in MP joint abduction. The abductor pollicis brevis and abductor digiti minimi muscles perform similar functions at the thumb and pinky respectively. The palmar interosseous muscles perform adduction of the MP joint to close spread fingers.[12] The lumbrical muscles are intrinsic muscles that are weak metacarpophalangeal flexors, regardless of the MP joint position.

Thumb extension at the MP joint is a function of the extensor pollicis brevis and extensor pollicis longus muscles. The extensor digitorum communis, extensor indicis, and extensor digiti minimi perform extension of the metacarpophalangeal joints of the fingers. The extensor digitorum communis muscle creates a tension of the sagittal bands and pulls them over the proximal phalanx, to create MP joint hyperextension.[12] Specifically, the extensor indicis and extensor digiti minimi muscles extend the MP joints at the index and little fingers respectively.

## Physiologic Variants

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The literature describes anatomic variation regarding the location of the sesamoid bones of the MP joint. In addition to the thumb MP joint, sesamoid bones are sometimes present at the metacarpal heads of the index and little fingers.[14]

## Surgical Considerations

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### MP joint arthritis

MP joint arthritis is a frequent topic in the literature discussing various conditions that ultimately result in mild to end-stage degenerative changes and deformity that can significantly impact a patient's ability to perform essential daily functions. In milder forms of acquired (e.g., post-traumatic) or degenerative arthritis and deformity, nonoperative measures are the standard, first-line treatment options:

- Rest, activity modification
- Oral or topic anti-inflammatory medications
- Cortisone injections
- Splinting

Additionally, the healthcare provider should consider the underlying etiology as this may indicate additional management options. For example, patients with underlying rheumatoid arthritis should obtain a referral to a rheumatologist for specialized medical management to consider starting the patient on disease-modifying antirheumatic drugs (DMARDs).

Persistent symptoms, synovitis, or swelling despite a 3- to 6-month course of nonoperative interventions warrants consultation with a hand specialist for possible surgical considerations.

[15] Considerations for surgery, especially in patients with RA, require a comprehensive evaluation of the patient's overall health and nutritional status, comorbidities, pharmacologic disease control, and infection risk. Additionally, the degree of bone deformity, which includes an assessment of total bone loss, will help to determine, which the most viable surgical options for the patient.

### **Metacarpophalangeal Joint Arthroscopy**

Metacarpophalangeal joint arthroscopy was first described in 1979,[16] although in general, its use remains limited.

### **Metacarpophalangeal Joint Arthroplasty**

MP joint arthroplasty remains a relatively reliable procedure in terms of its ability to restore function, reduce pain, and improve both function and range of motion[17]. This procedure essentially involves replacement of the deformed joint with a hinged silicon implant, or newer-generation, unconstrained implants designed with either pyrocarbon or metal on polyethylene (MoP), are thought to be most likely to produce good long-term results in patients with pre-existing soft-tissue stability. In patients with end-stage degenerative deformities including compromise of the surrounding soft tissue stabilizing structures, the silicone implants are the favored option. The pyrolytic carbon joint replacements appear to be preferable for patients with well-controlled osteoarthritis or early RA with no or minimal deformity.[15]

### **Metacarpophalangeal Joint Arthrodesis**

Metacarpophalangeal joint arthrodesis, also known as "MP joint fusion," is commonly used to correct MP joint arthritis in the thumb. This surgical technique usually involves a dorsal incision. The extensor interval is incised longitudinally, and the dorsal capsule is split to expose the joint. Following denuding of the diseased cartilage, fixation is possible through a variety of means, including screws, plates, and wires. Adjuvant allograft or autograft bone grafting is usable in cases of severe bone loss or deformity. The patient requires immobilization for 4 to 6 weeks or until radiographic union occurs.[15]

## **Clinical Significance**

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### **MP Joint Arthritis in patients with Rheumatoid Arthritis**

Rheumatoid arthritis is a common autoimmune disease associated with a progressive disability caused by synovial inflammation and hyperplasia that leads to the production of autoantibodies, rheumatoid factor, and anti-citrullinated protein antibodies which attack the MP joint and cause increasing degrees of swelling, pain, and underlying cartilage and osseous destruction.[18][19] Cardiopulmonary disease, psychological disorders, and musculoskeletal complications are also characteristic of this condition.

MP joint arthritis is a distinguishing feature of rheumatoid arthritis. In RA, destruction of the MP joint connective tissue leads to an imbalance of the active and passive forces, leading to joint instability, pain, and deformity.[20] A typical early finding of the condition is swelling of the MP joints. Pain with passive motion or squeezing of the MP joints is a sensitive test for the joint inflammation that frequently presents with this condition. MP joint dislocation is common and classically presents in the endstage as flexion and ulnar deviation, with dislocation of the joint. Surgical intervention is a patient-centered decision to consider when the deformity severely limits function.[21]

## MP Joint Dislocation

Metacarpophalangeal (MP) joint injuries and dislocations of the fingers and thumb commonly occur secondary to direct trauma and/or falls.

A patient with an MP joint dislocation will typically present with a swollen, bruised, and obviously deformed finger. The patient will be focally tender to palpation over the joint itself in addition to the limited ability to move the finger.

Dislocations are described concerning the distal osseous fragment or bone's position relative to the proximal osseous element. Dorsal dislocations are the most common presentation pattern. In addition, dislocations are further classified as simple versus complex. The former implies a successful closed reduction is achieved by applying axial traction and splinting, while the latter indicates the MP joint dislocation is irreducible by closed means.

The classic description of complex dorsal MP dislocations are:

- Proximal phalanx hyperextension
- Volar plate rupture and avulses off of the proximal metacarpal head
- Volar plate subsequently interposes and impedes closed reduction as it lies on the dorsum of the metacarpal head
- Flexor tendons show ulnar displacement; metacarpal head displaces in both radial and volar directions
- Metacarpal head "button-holes" between 4 structures:
  - Lumbrical
  - Flexor tendon (the flexor tendon is on the ulnar side of the dislocated digit)
  - Transverse bands of the natatory ligaments (distal)
  - Superficial transverse ligament (proximal)

Complex MP dislocations, by definition, require open reduction to remove the interposing structures impeding reduction.

For the thumb MP joint, anatomical structures that may become trapped include the volar plate, sesamoid bones, bony fracture fragments or the flexor pollicis longus tendon.[22]

## Thumb Collateral Ligament Injury

Thumb collateral ligaments include injuries to the radial collateral ligament (rare) or ulnar collateral ligament (UCL). Thumb UCL injuries can also be described based on existing eponyms in the literature:

- Chronic thumb UCL injuries: gamekeeper's thumb
- Acute thumb UCL injury: skier's thumb
- Stener lesion:
  - By definition, implies complete UCL avulsion and displacement above the adductor aponeurosis; the latter interposes the UCL from its attachment site and prevents healing

- Stener lesions can include thumb UCL avulsion with or without an avulsed osseous attachment

Patients will typically present with a swollen, discolored thumb, with pain that is exacerbated by movement in any direction. Patients may also present significant weakness of grasp, at the base of the thumb in the first web space, and wrist pain.

Failure to repair a Stener lesion inevitably results in chronic pain, instability, deformity, weakness, and arthritis.

Milder injuries and ligamentous sprains (without instability) are amenable to nonoperative management. A thumb spica splint may be utilized until symptoms resolve.

### Sagittal Band Rupture

Sagittal band rupture is known as “boxer’s knuckle,” for its tendency to commonly affect members of the pugilist profession. This injury involves traumatic extensor tendon rupture on the dorsal aspect of the MP joint. Sagittal band rupture often goes unrecognized because the extensor tendon can remain in its normal midline position following the injury.[23] Symptoms range from MP joint pain and edema, due to extensor tendon dislocation. Associated injuries include capsular injury, collateral ligament sprains, and osteochondral fractures. Many acute injuries can be managed nonsurgically using extension splints. Optimal management of chronic or subacute injuries remains unclear. Surgical management involves repair or reconstruction of the radial sagittal band.[23]

### Questions

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**Figure**

Metacarpophalangeal articulation, articulations of digit, Ulnar aspect, Metacarpal, Collateral ligament, Phalanx,.  
Contributed by Gray's Anatomy Plates

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