

Hand anatomy

The hand contains many specialized structures which work in synchrony providing precise motor biomechanics and fine tactile senses. Our hands can be affected by a wide range of conditions, congenital and acquired. Even minor traumatic injuries can result in significant stiffness and loss of function. Management of these hand conditions requires a sound knowledge of anatomy.

Bones and joints

The hand consists of 27 bones, including eight carpal bones, five metacarpals and 14 phalanges (Figure 1). The metacarpal and phalangeal bones consist of a head, base and shaft. In the skeletally immature hand, the metacarpals have a single distal epiphyseal growth plate, with the exception of the thumb. The latter and the phalanges have a proximal epiphyseal growth plate.

The metacarpophalangeal joints and interphalangeal joints are both synovial joints. Metacarpophalangeal joints are condylar, which allow flexion, extension, abduction and adduction movements. Interphalangeal joints on the other hand are the hinge type, permitting flexion and extension movements only. Both metacarpophalangeal joints and interphalangeal joints have a fibrous layer of joint capsule that is strengthened by collateral ligaments, which limit lateral movements.

Injury to the thumb ulnar or radial collateral ligament can lead to instability of the first metacarpophalangeal joint. Gamekeeper's or skier's thumb refers to injury of the ulnar collateral ligament, which results in poor pincer grasp and opposition. The collateral ligaments also have an attachment to the volar plates.

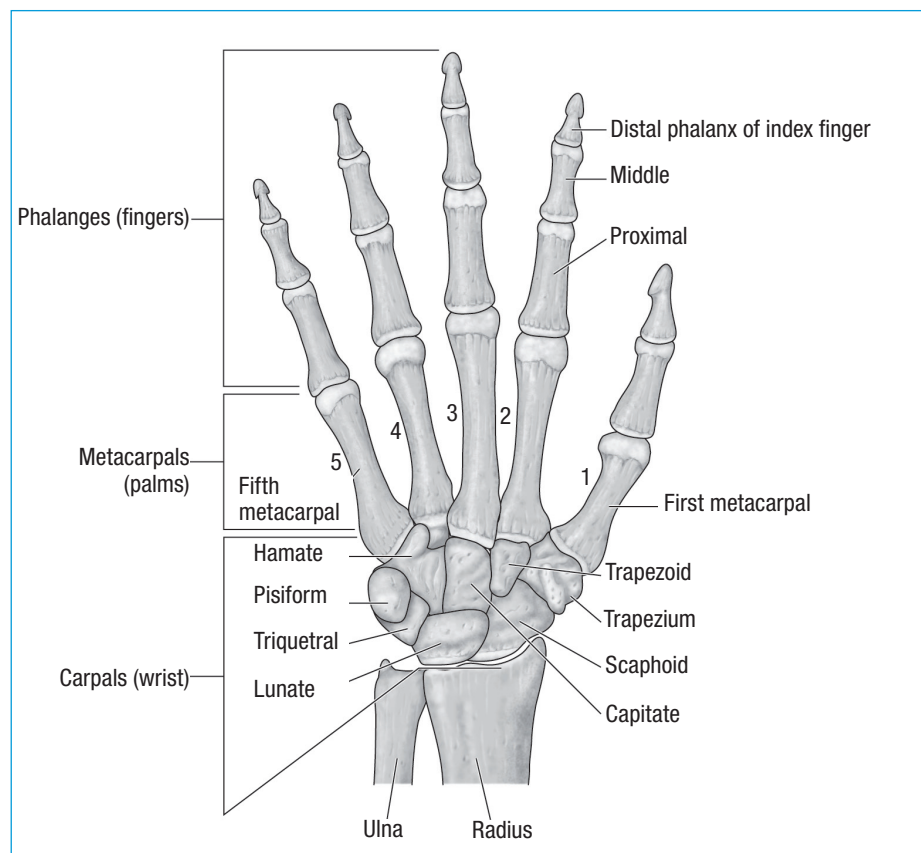
Volar plates are fibrous cartilaginous structures found at the metacarpophalangeal joints and interphalangeal joints (Figure 2). They reinforce the joint capsule enhancing stability. At the metacarpophalangeal joints they are only attached to the proximal phalanx allowing some hyperextension. In contrast, at the interphalangeal joints they are attached to the phalanges at each side of the joint to prevent hyperextension. The volar plates are also held together by the deep transverse metacarpal ligaments at the

second through fifth metacarpophalangeal joints. Avulsion fractures of the volar plate are common injuries and usually involve the middle and ring fingers.

Sagittal bands originate from the metacarpophalangeal joint volar plate and intermetacarpal ligaments with insertion on the extensor mechanism. They play an important role in stabilizing the extensor tendon at the level of the metacarpal head. Sagittal band injuries are a common cause of extensor tendon subluxation secondary to inflammatory disease, attrition and trauma.

The wrist is a complex multiarticulated joint, composed of seven true carpal bones and one sesamoid bone, the pisiform (Figure 1). The proximal row includes the scaphoid, lunate, triquetrum and the pisiform. The distal row consists of the trapezium, trapezoid, capitate and hamate. These rows form the

Figure 1. The bones of the hand.



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radiocarpal, midcarpal and carpometacarpal joints, with intercarpal joints lying between the individual bones. As the carpus has no tendon or muscle attachments, the proximal carpal row represents an intercalated segment between the distal carpal row, radius and ulna bones. Carpal stability relies on ligaments and articular surface anatomy. Ligamentous injuries or carpal bone fractures can therefore lead to instability of the intercalated fragment. In the sagittal plane, two main patterns (Linscheid et al, 1972) of such injuries are dorsal intercalated segment instabilities and volar intercalated segment instabilities. In dorsal intercalated segment instabilities, the lunate appears abnormally extended relative to the radius and capitate. In volar intercalated segment instabilities, the lunate appears abnormally flexed. Carpal instability is a common cause of wrist pain and can lead to significant morbidity.

The carpometacarpal joint of the thumb has a saddle-shaped proximal end, which allows great movement, flexion, extension, abduction, adduction and circumduction. While the index and middle fingers carpometacarpal joint have relative stability, the fourth finger is slightly mobile and the fifth carpometacarpal joint allows cupping of the hand, flexing considerably in a tight grasp. The intercarpal joints are supported by intrinsic ligaments and there is very limited movement between the carpal bones. The scapholunate and lunotriquetral ligaments are of particular significance as disruption of either one can result in wrist instability.

The scaphoid is a biomechanically important carpal bone. It spans both proximal and distal carpal rows and therefore has a role in stabilizing the mid-carpal joint during wrist movement. Most of the blood supply to the scaphoid enters distally with no direct blood vessels to the proximal portion. As a result, scaphoid fractures can lead to complications such as avascular necrosis, non-union, scaphoid non-union advanced collapse and osteoarthritis of the carpus.

Skin

The skin on the dorsum of the hand is thin and pliable. The lymphatic and venous drainage runs through the loose areolar tissue, which attaches to the bones. Conversely, palmar skin is thicker, glabrous and less pliable. Oedema of the hand therefore normally presents in the dorsum. The skin is most firmly anchored to the deep

Figure 2. Oblique view of a finger showing annular (A) and cruciform (C) pulley system of the flexor tendon sheath. Note the volar plates found at the metacarpophalangeal and interphalangeal joints.

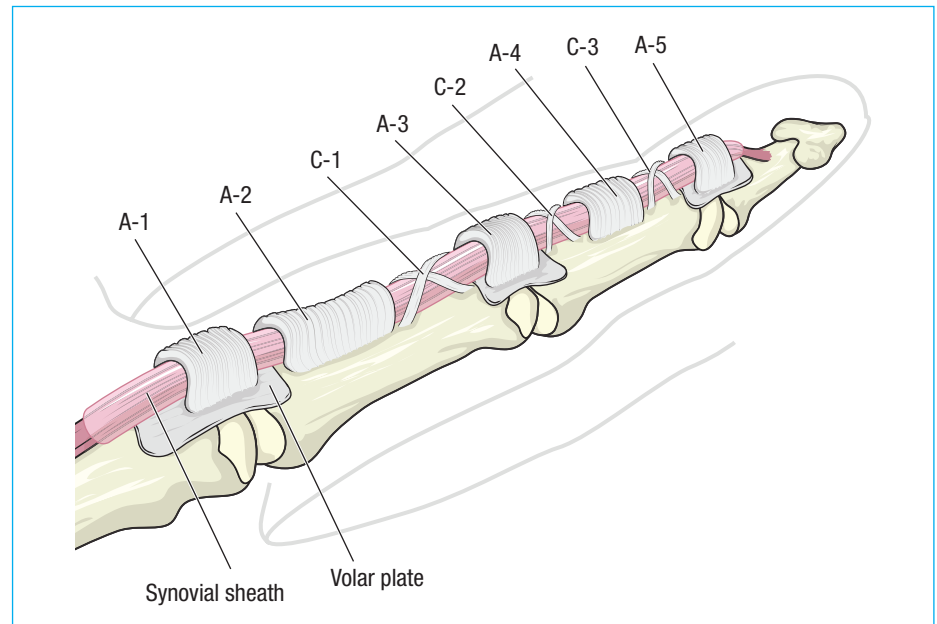


Figure 3. Surface anatomy of the hand.

1. Extensor retinaculum
2. Flexor retinaculum
3. Metacarpal heads
4. Ulnar artery
5. Radial artery
6. Deep palmar arch
7. Superficial palmar arch

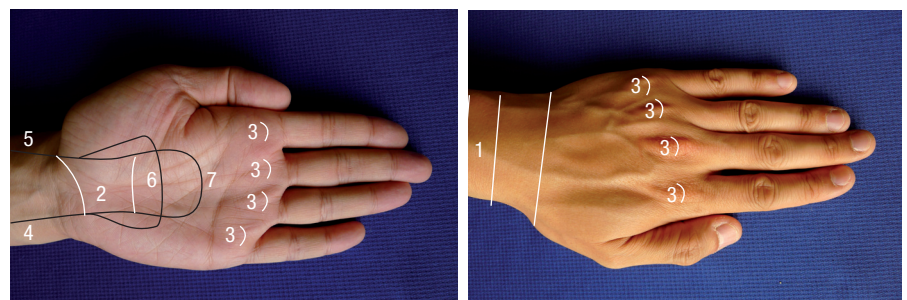
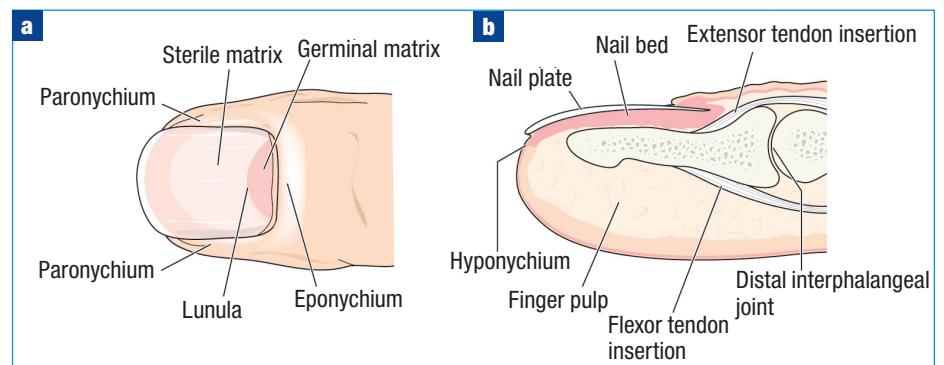


Figure 4. a. Gross anatomy of the fingertip with **(b)** emphasis on the nail bed.



structures at the palmar creases; this is of clinical importance when planning surgical incisions, to minimize skin contractures. *Figure 3* highlights some key surface anatomy landmarks.

Nails

Nails are specialized skin appendages derived from the epidermis (*Figure 4*). The nail bed consists of the germinal and sterile matrix, responsible for 90% and 10% of nail growth

Figure 5. Compartments of the digit showing Grayson's and Cleland's ligaments.

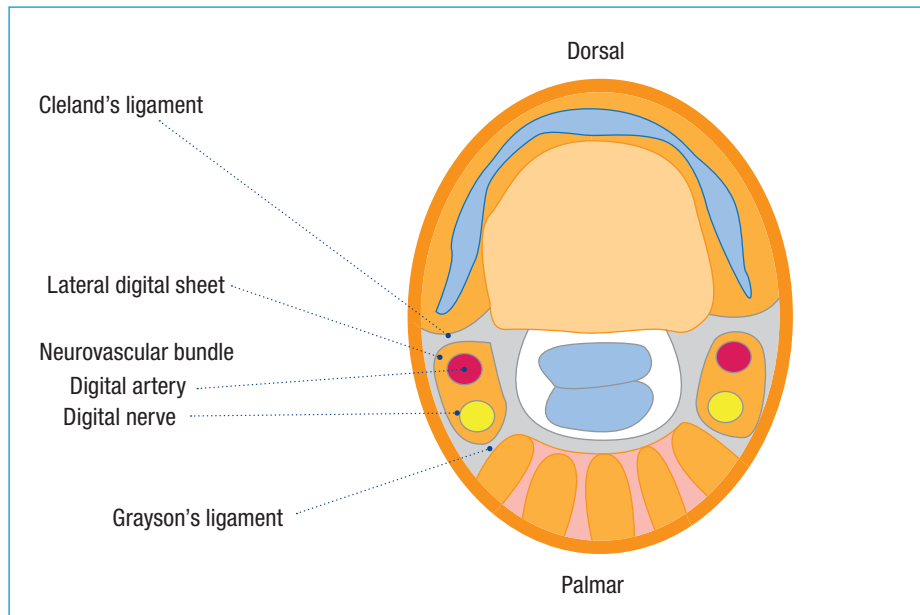
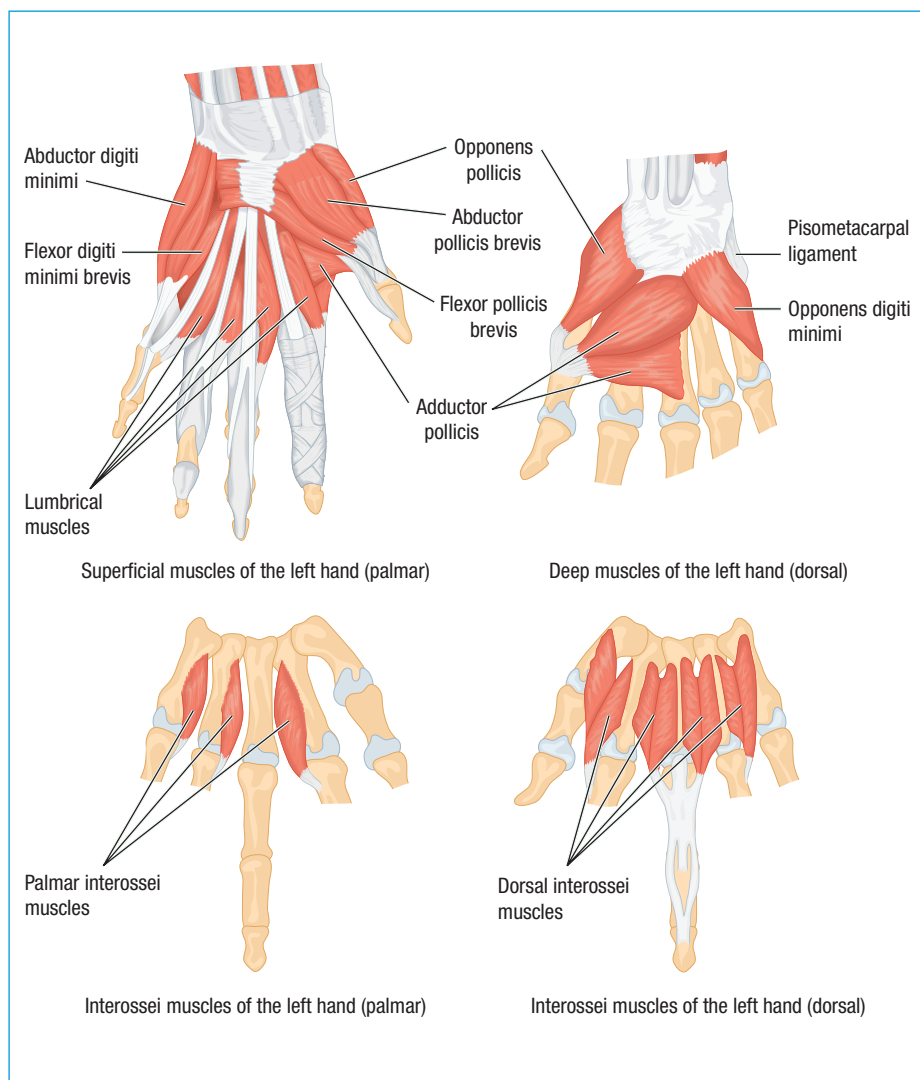


Figure 6. The intrinsic muscles of the hand.



respectively. The nail grows at a rate of about 0.1 mm per day. The nail functions as a protective barrier and aids in two-point discrimination via counter pressure on the pulp.

Fascia and palmar spaces

The antebrachial fascia of the forearm is continuous with the fascia of the hand. Palmar fascia lies thinly over the thenar and hypothenar eminences becoming thickened centrally where it forms the fibrous palmar aponeurosis, which is continuous with the palmaris longus tendon. The latter is absent in up to 15% of the population varying with gender and ethnicity (Soltani et al, 2012). At the distal end of the forearm, the antebrachial fascia thickens to form the extensor retinaculum posteriorly and the palmar carpal ligament anteriorly. The flexor retinaculum is also continuous with the antebrachial fascia and lies just distal and deep to the palmar carpal ligament.

The fibrous digital sheaths are ligamentous tubes that enclose the synovial flexor digital sheaths and tendons. The synovial sheath allows smooth tendon glide by lining both the fibrous tunnel and the tendon. This fold of synovial membrane transports blood vessels and nerves to the tendons and is called the mesotendon. The paratenon is the fatty areolar tissue filling the interstices of the fascial compartment in which a tendon is situated.

The synovial sheaths are strengthened by five annular and three cruciform ligamentous pulleys (Figure 2). In the fingers, the A2 and A4 are critical to prevent bowstringing.

Grayson's and Cleland's ligaments are important fascial bands (Figure 5) found palmar and dorsal to the neurovascular bundle of each digit respectively. They tether skin to bone and deep fascial layers, preventing excessive skin mobility and improving grip. This assists stabilization of the digital neurovascular bundle in finger flexion and extension.

Within the fascial compartments of the hand and deep to the flexor tendons are two potential spaces, the thenar and midpalmar spaces. They are bounded by the medial and lateral fibrous septa connecting the palmar aponeurosis to the metacarpal bones. Distally these spaces extend into the lumbrical canals, which are potential spaces around the lumbricals. Unlike the thenar

space, the midpalmar space is continuous proximally with the anterior compartment of the forearm via the carpal tunnel. The potential spaces are clinically important as they can become infected and accumulate pus.

Intrinsic muscles

Intrinsic muscles of the hand consist of interossei, lumbricals, thenar and hypothenar muscles (*Figure 6*). The seven interossei are divided into three palmar single-headed muscles and four dorsal double-headed muscles. The palmar and dorsal interossei adduct and abduct the digits respectively. A mnemonic aid is PAD (Palmar interossei ADduct) and DAB (Dorsal interossei ABduct). Interossei have a secondary function in aiding the action of the lumbricals.

The four lumbricals are unique as their origin and insertion are both tendons, namely the extensor digitorum communis and flexor digitorum profundus. They are responsible for flexion at the metacarpophalangeal joint while simultaneously extending the interphalangeal joint on the radial side of their respective flexor digitorum profundus.

Extrinsic muscles

Extrinsic muscles of the hand mainly originate in the forearm. The median nerve innervates all the extrinsic muscles within the flexor compartment except for the flexor carpi ulnaris and ulnar half of the flexor digitorum profundus muscles, which are supplied by the ulnar nerve. The radial nerve innervates all the extrinsic muscles of the hand within the extensor compartment.

The flexor digitorum superficialis, flexor digitorum profundus and flexor pollicis longus tendons enter the hand via the carpal tunnel (*Figure 7*). In the palm the flexor digitorum superficialis tendon is volar to the flexor digitorum profundus tendon. It splits at the level of the proximal phalanx (Camper's chiasm) and reunites dorsal to the flexor digitorum profundus tendon to insert onto the middle phalanx. The flexor digitorum profundus tendon continues distally to insert onto the distal phalanx.

Extensor tendons enter the hand via the extensor retinaculum (*Figure 8*). As the extensor digitorum communis tendons pass over the metacarpophalangeal joints, they are held in position by the sagittal bands. Just proximal to the

Figure 7. The carpal tunnel in cross section.

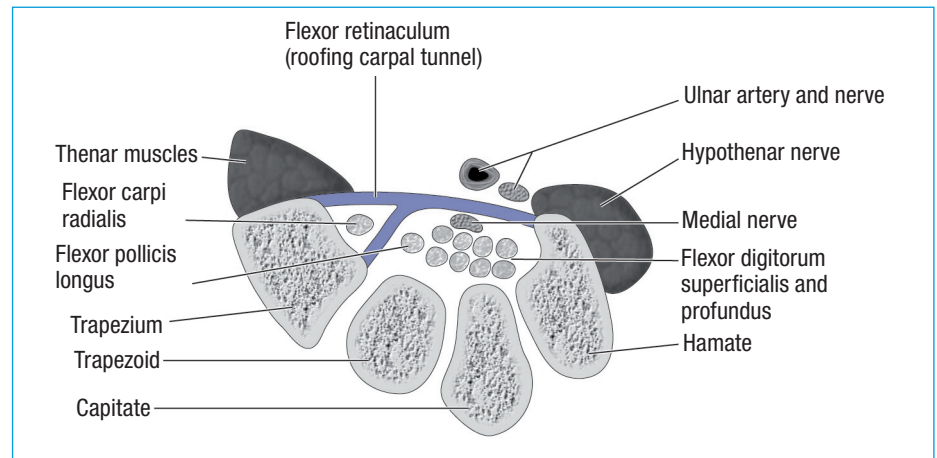
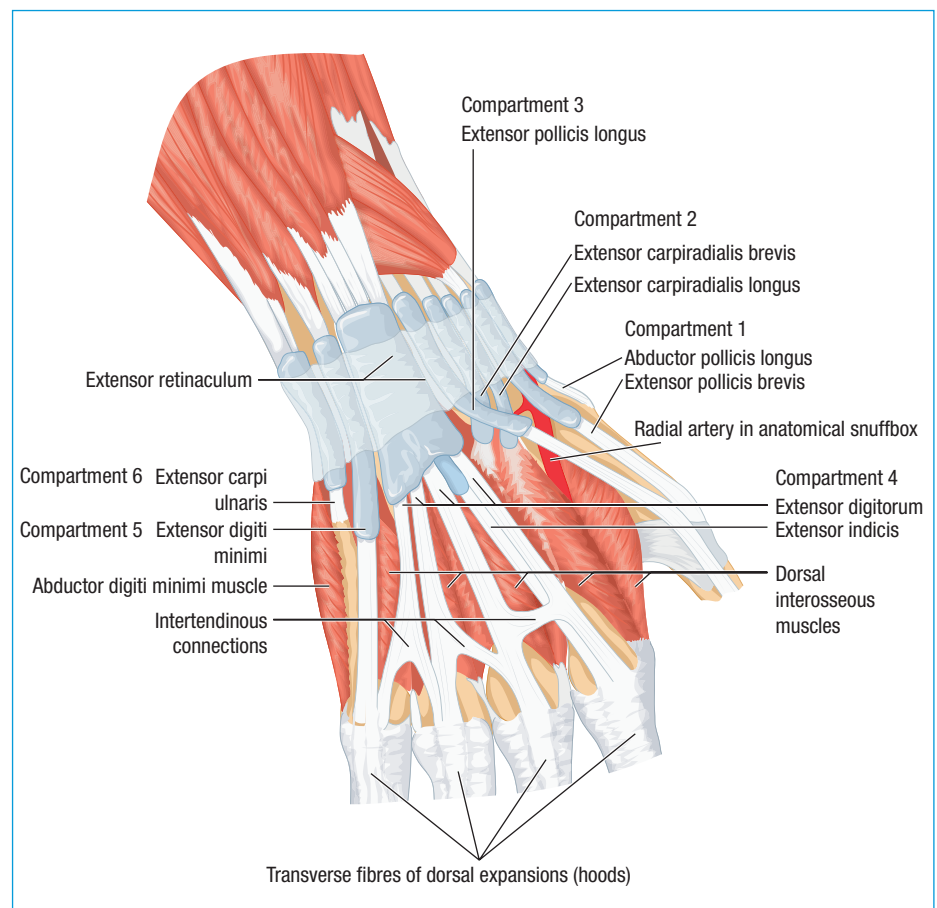


Figure 8. The six compartments of the extensor retinaculum.



metacarpophalangeal joints, juncturae tendinum provide fibrous connections between the extensor tendons. They aid coordinated extension, stabilization of the metacarpophalangeal joints and spacing of extensor digitorum communis tendons. Distal to the metacarpophalangeal joint the extensor digitorum communis trifurcates. The central slip inserts onto the base of the middle phalanx. The lateral slips of

the extensor tendon pass on either side of the proximal interphalangeal joint. They join with the lateral bands of the intrinsic muscles to form the conjoined lateral bands, which unite distally as the terminal tendon inserting onto the distal phalanx.

Arteries and veins

The blood supply to the hand is via the ulnar and radial arteries. The ulnar artery

KEY POINTS

- The hand contains many specialized structures, which work in synchrony providing precise motor biomechanics and fine tactile senses.
- A sound knowledge of hand anatomy is essential for assessing congenital and acquired hand conditions.
- Even minor traumatic injuries can result in significant stiffness and loss of function.

enters the hand via Guyon's canal between the pisiform and the hook of the hamate. It continues as the superficial palmar arch, which gives rise to the common palmar digital arteries. The latter bifurcate at the web spaces to form the proper palmar digital arteries. The deep palmar arch is a continuation of the radial artery, which gives rise to the palmar metacarpal arteries. The latter form anastomoses with the common palmar digital arteries.

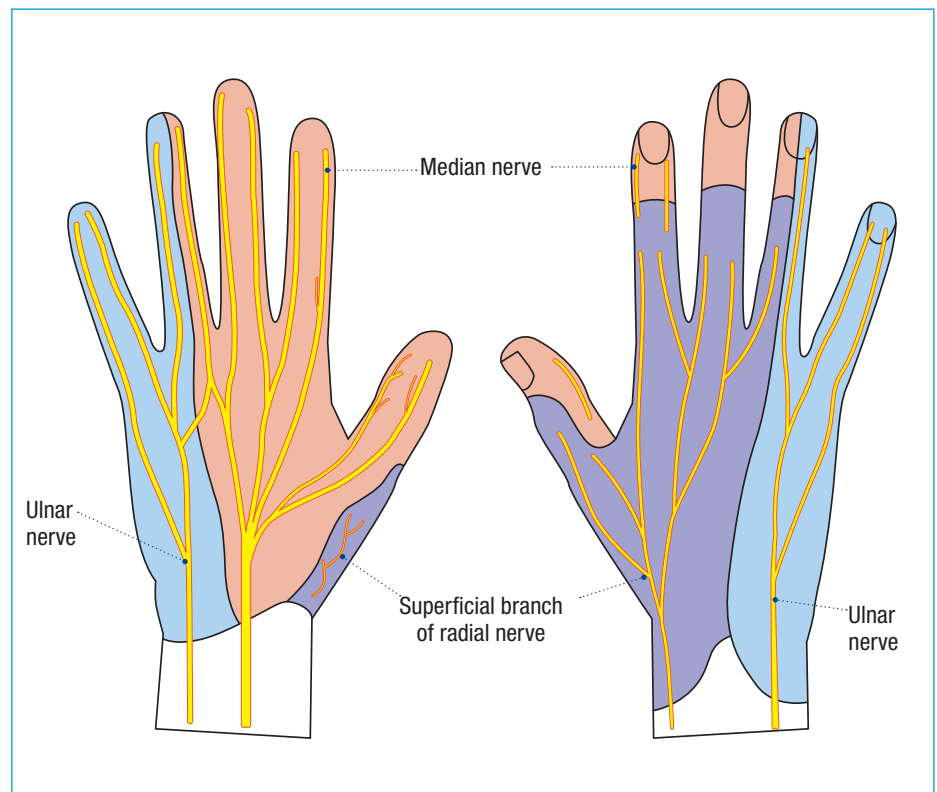
Blood supply to the dorsum of the hand typically originates from the posterior and anterior interosseous arteries. The latter arise from the ulnar artery and are not major sources of blood supply to the hand. The dorsum of each finger distal to the proximal interphalangeal joint is vascularized by dorsal branches of the proper digital arteries. On the other hand, the thumb is unique in having a dedicated dorsal vascular supply from the first dorsal metacarpal artery, which typically arises from the radial artery. The first dorsal metacarpal artery is the basis of a versatile flap (Holevich, 1963; Foucher and Braun, 1979) for covering distal thumb defects.

The superficial and deep palmar arches are accompanied by corresponding venous arches. The dorsal digital veins unite to form a dorsal venous network in the superficial fascia of the hand, which drains proximally into the lateral cephalic vein and medial basilic vein.

Nerves

Sensory and motor function of the hand is supplied by median, ulnar and radial nerves (Figure 9). The median nerve enters the hand via the carpal tunnel (Figure 7) supplying motor fibres to the three thenar muscles via its recurrent branch and the two radial lumbricals via its deep palmar branch. The median nerve innervates the LOAF muscles

Figure 9. Typical sensory nerve distribution of the hand.



(Lateral 2 lumbricals, Opponens pollicis, Abductor pollicis brevis and Flexor pollicis brevis). Sensory fibres of the superficial palmar branch supply the palmar skin and dorsal nail beds of the thumb, index, middle and radial half of the ring finger. A palmar cutaneous branch given off in the forearm proximal to the carpal tunnel supplies the lateral palm. There are variations to this pattern in a high percentage of hands with Martin–Gruber and Riche Cannieu connections between median and ulnar nerves.

The ulnar nerve reaches the volar wrist medial to the ulnar artery, passing over the flexor retinaculum through Guyon's canal. It divides at the hypothenar eminence into deep and superficial branches. The superficial branch provides sensation to the palmar aspect of the little and ulnar half of the ring finger. The deep branch supplies motor fibres to the hypothenar muscles, the ulnar two lumbricals, adductor pollicis and the palmar and dorsal interosseous muscles. The ulnar nerve proximal to the flexor retinaculum gives off a palmar and dorsal cutaneous branch. The palmar cutaneous branch supplies the medial skin of the palm, while the dorsal cutaneous branch supplies the medial skin of the dorsum of the hand

and the dorsum of the little and ulnar half of the ring fingers.

The superficial branch of the radial nerve supplies sensation to the dorsum of the hand, thumb, index, middle and radial half of the ring fingers short of the nail beds.

Conclusions

A sound knowledge of hand anatomy facilitates systematic and thorough assessment of hand injuries. **BJHM**

Conflict of interest: none.

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Further reading

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