Anatomy and Biomechanics

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Skin

The skin of the thumb on both dorsal and palmar aspect is the same as that of the fingers. The dorsal skin arises immediately from the thin skin of the dorsum of the hand. It has very different characteristics from that of the palmar aspect. It is thin and mobile over the proximal phalanx and has a few hairs in the proximal portion. At the interphalangeal (IP) joint, it creates several creases when the thumb is in extension (Fig. 2.1). The dorsal skin possesses a nail at the distal end of the thumb. It constitutes an external skeleton for the pulp of the thumb, thus improving precision handling.

The palmar skin of the thumb is very thick and hairless and is set off from the skin of the palm by two flexion creases of the metacarpophalangeal (MP) joint. In abduction of the thumb, proximal crease roughly continues the longitudinal line defined by the radial margin of the index finger. A deep IP joint crease marks off the skin over the proximal phalanx off from that of the tip (pulp) of the thumb (Fig. 2.1). It is firmly attached to deeper tissue layers by Grayson's ligaments, which lie proximal to the IP joint, and Cleland's ligaments, which arise from the tendon sheath near the bone and courses obliquely and distally, inserting into the skin on the radial and ulnar aspects of the thumb. These ligaments prevent the skin from bulging excessively during flexing of the thumb or the grasping of objects.

Fig. 2.1 The right thumb. Dorsal and palmar aspect

The skin on the dorsal aspect of the thumb is supplied by fine branches of the superficial radial nerve. The palmar aspect is supplied by the proper palmar digital nerves from the median nerve. In contrast to the fingers, the palmar nerves of the thumb do not give off dorsal branches, but they normally each branch into three main branches just before entering the pulp to provide sensory supply to the palmar skin of the distal phalanx of the thumb, so the pulp is a true sen-

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sory organ [1]. The normal value of two-point discrimination of the distal phalanx of the thumb is 2.5–5 mm.

Vascular Structures

Though there are many variations, the blood supply of the thumb is mainly made up of the princeps pollicis artery, the first common palmar digital artery which is the terminal branch of the superficial palmar arch and the dorsal digital artery originating primarily from the terminal portion of the radial artery before it descents into the palm of the hand [2–4].

The princeps pollicis artery is considered to be a branch of the radial artery or deep palmar arch and is also called the first palmar metacarpal artery. It is located between the first dorsal interosseous and the adductor pollicis (ADP) muscles and passing deep to the flexor pollicis longus (FPL) tendon proximal to the MP joint. And then it divided into two radial and ulnar palmar digital arteries; the ulnar palmar digital artery is nearly twice as thick as the radial palmar digital artery (Fig. 2.2) [2].

Both palmar arteries of the thumb communicate via the digito-palmar arch and the arcade of the distal phalanx of the thumb. The digito-palmar arch gives off branches which supply the FPL tendon

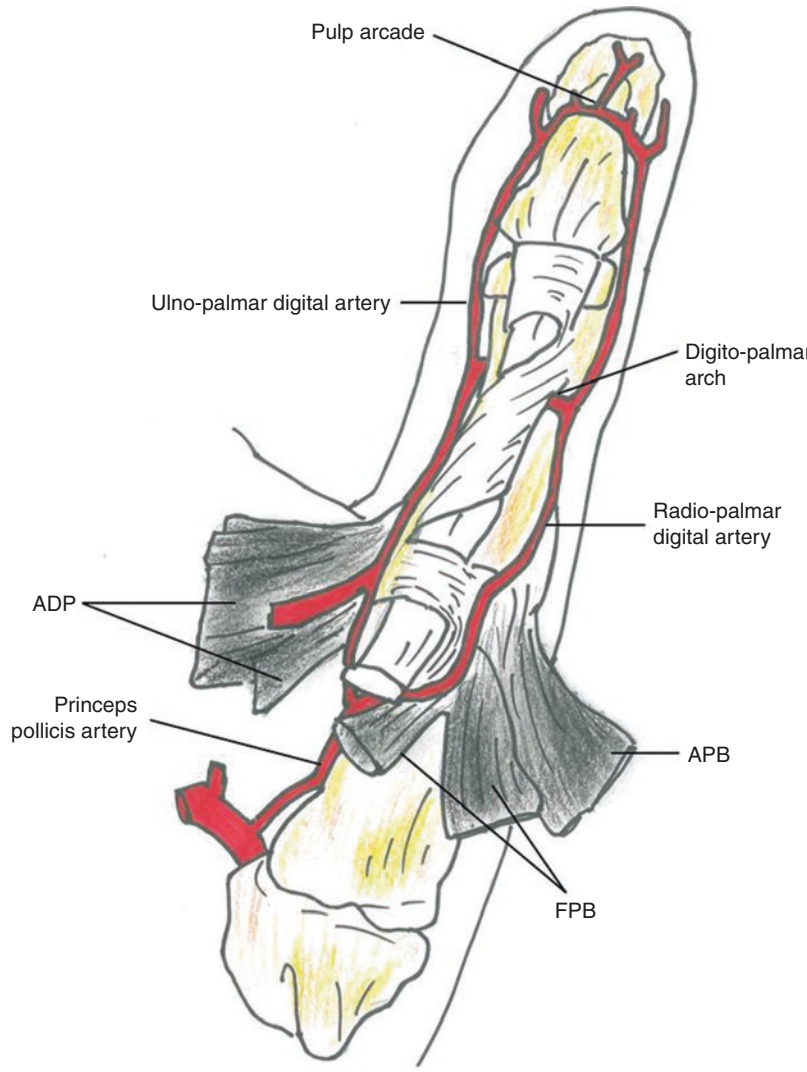

Fig. 2.2 The arterial supply of the thumb. (*APB* abductor pollicis brevis; *FPB* flexor pollicis brevis; *ADP* adductor pollicis)

via a short vinculum. The distal arcade supplied the distal phalanx and the nailbed of the thumb.

The dorsal digital arteries of the thumb have a high variation in their origins and courses. There are few exceptions; these arteries usually arise from the first dorsal metacarpal artery, which itself arises into two or three branches from the terminal portion of the radial artery before it descends into the palm. Radio-dorsal arteries arise from the anatomical snuff box and course distally along the abductor pollicis brevis (APB), and they end in a dorsal arterial arcade at the level of the nail matrix. Ulno-dorsal arteries have various origins, such as the first dorsal metacarpal artery, the dorsal branch of the radial artery, and branches of the princeps pollicis artery, but they may be absent in 30% of the population [5, 6]. There are normally anastomoses between the dorsal and palmar arteries of the thumb at the level of the head of the proximal phalanx [7].

A well-developed ulno-dorsal venous network and a less well-developed radio-palmar venous network provide superficial venous drainage in the thumb. They drain into the cephalic vein.

Fig. 2.3 Osteoarticular column of the thumb

Bones of the Thumb

The osteoarticular column of the thumb is formed from the whole of the lateral ray of the hand (Fig. 2.3). Therefore, it begins with the scaphoid, passing then to the trapezium. After this comes the first metacarpal, and finally it ends with only two phalanges. Thus, the thumb has an important characteristic that the column itself articulates with the rest of the hand at a point much more proximal than the other digits. Also it is clearly much shorter than they are, since the tip of the thumb reaches only the middle of the proximal phalanx of the index finger.

Trapezium

Trapezium changes its shape from proximal to distal; owing to this characteristic, it was called a multiangular bone. The bone is situated at the radial column of the wrist between the scaphoid and first metacarpal [8]. The proximal surface is smooth and contains a small, slightly concave facet which articulates with the scaphoid. The distal surface is oval and saddle shaped and faced distolaterally. It articulates with the base of the first metacarpal. The dorsal surface is elongated and rough and rests in relationship to the radial artery. The palmar surface is narrow and rough. At its palmar part is a deep groove, which is medial and contains the flexor carpi radialis (FCR) tendon. The groove is bounded laterally by a tubercle. This surface gives origin to the opponens pollicis (OPP), flexor pollicis brevis (FPB), and APB and provides attachment to the two layers of the flexor retinaculum. The lateral surface is broad and rough for the attachment of the radial collateral ligament and capsular ligament of the carpometacarpal (CMC) joint of the thumb. The medial surface is large and presents two facets: a large, concave, proximal one, which articulates with the

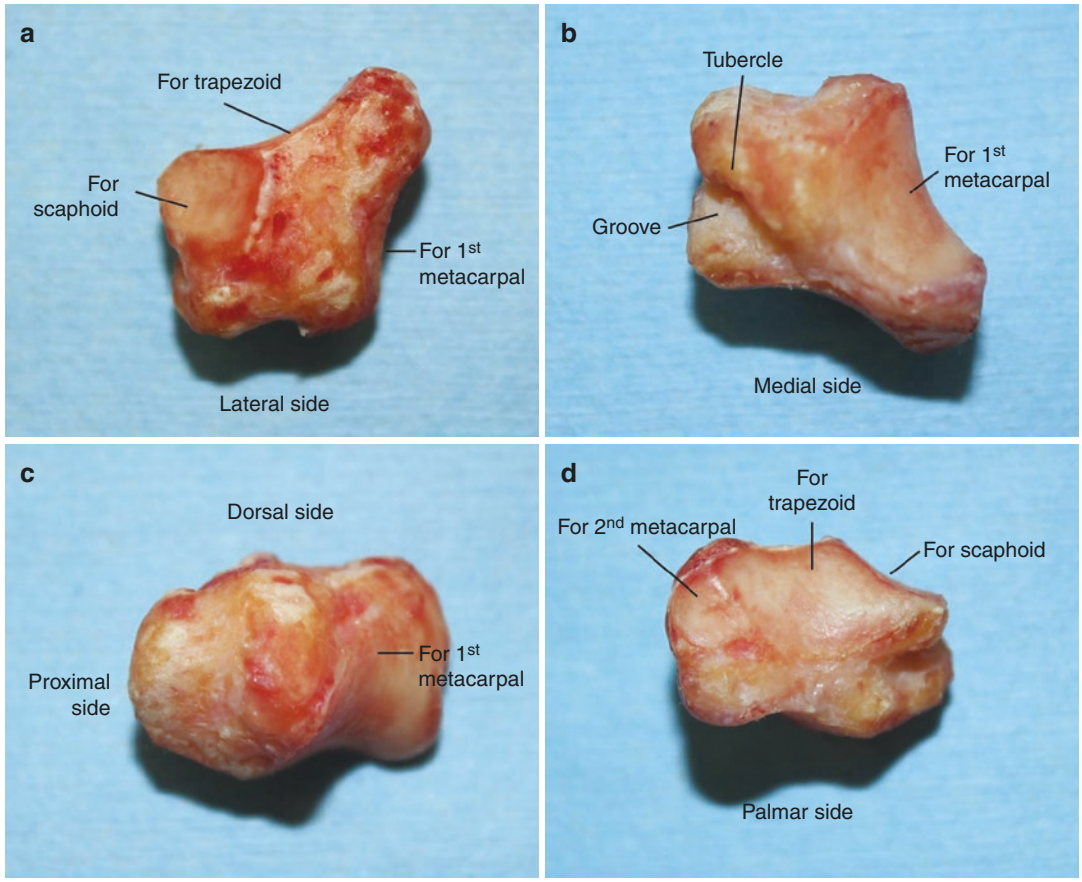

Fig. 2.4 The left trapezium. (**a**) From the dorsal aspect, (**b**) from the palmar aspect, (**c**) from the radial aspect, (**d**) from the medial aspect

trapezoid, and a small, distal one, which articulates with the second metacarpal (Fig. 2.4).

First Metacarpal

The first metacarpal bone is short and broad [9]. Its long axis diverges distolaterally from the other metacarpals. It is more anterior and rotated medially on its long axis through 90°, so that its palmar surface is directed medially toward the radial side of the second metacarpal and its dorsal surface is directed laterally. The shaft is flattened and broad, and its dorsal surface is slightly convex. Its palmar surface is concave and divided by a ridge into a larger lateral (anterior) part, which gives attachment of the OPP, and a smaller medial (posterior) part, which gives origin to the radial head of the first dorsal interosseous muscle. The base has a characteristic saddle-shaped articular surface for articulation with trapezium. It has a small tubercle on its lateral side for the insertion of the abductor pollicis longus (APL). The head is rounded and less convex than in other metacarpals and is transversely broad. Two articular eminences are on the palmar surface of the head for the sesamoid bones; the lateral is larger than the medial (Fig. 2.5).

The Proximal Phalanx

The shaft of the proximal phalanx is short, tapers distally, and is convex dorsally. The base presents oval and concave articular surface. Further, it is transversely broad and articulate with the

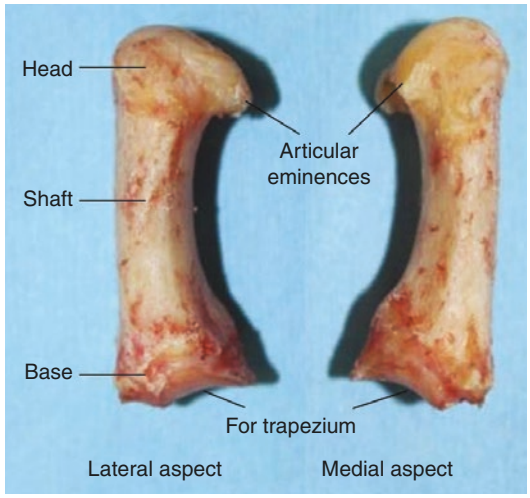

Fig. 2.5 The left first metacarpal bone

rounded, smooth heads of the metacarpal bone. The head is smaller than the base and ends in two condyles, which are dissimilar, the medial one being more protruding and longer palmarly and medially than its lateral one.

The Distal Phalanx

The distal phalanx is convex on dorsal and flat on palmar surfaces. The base is oval, concave articular surface and articulates with the head of the proximal phalanx. The head of the distal phalanx is nonarticular and carries a rough, horse-shaped palmar tuberosity, called the ungual tuberosity, to which the pulp of the thumb tip is attached.

Joints of the Thumb

Trapeziometacarpal Joint (TM Joint)

The TM joint of the thumb is a biconcave-convex or reciprocal saddle joint. The trapezial articular surface is in convex from dorsal to palmar and concave from radial to ulnar, and the midsagittal diameter is 11.96 ± 1.32 mm [10]. The joint surface is actually asymmetrical, and the articulating surface is located mainly on the volar aspect [11].

The articular surface of the first metacarpal is asymmetrical as well. In this surface a groove is present in the radio-ulnar direction. This groove forms the concavity of the joint surface. It is deepest in the center and becomes shallow at the radial and ulnar extremities. In the center the groove flares out, forming a widening of the joint surface in the palmar direction, and it has a triangular beak on its palmar surface. The midsagittal diameter is 16.03 ± 1.27 mm (Fig. 2.6).

The trapezium and first metacarpal articulate such that the concave surface of the trapezium opposes the convex surface of the first metacarpal. As a result, it configurates an interlocking appearance and two reciprocally opposed saddles, whose longitudinal axes are perpendicular. This configuration allows flexion and extension axis as well as an abduction and adduction axis [6, 12]. The discrepancy in the diameters of the articulating surfaces of trapezium and first metacarpal implicates the joint stability. As a result, the bony articular structures provide little inherent constraint for joint stability. Therefore, TM joint stability mainly relies on the joint capsule, the reinforced ligaments, and the tendons that pass the joint. This feature of this joint also allows for rotation.

The axis of the thumb at the TM joint rests in a pronated position, flexed approximately 80° relative to the plane of the other metacarpals. This optimizes thumb position for opposition to the pulp of one of the four fingers or all of them simultaneously.

The capsule of the TM joint of the thumb is broad and sufficiently lax to allow its wide range of motion including rotation. Several reinforcing ligaments are also necessary to provide stability of the joint through its range of motion. There are four basic ligaments (Fig. 2.7) [11–13]. Anterior oblique ligaments arise from the volar tubercle of the trapezium and extend to the volar beak of the first metacarpal base. It is under tension in thumb abduction, extension, and opposition positions. It is also referred to as the volar ligament of ulnar ligament. Posterior oblique ligament arises from a dorso-ulnar eminence of the trapezium and extends in a palmar spiral to insert with the anterior oblique ligament on the volar beak of the first

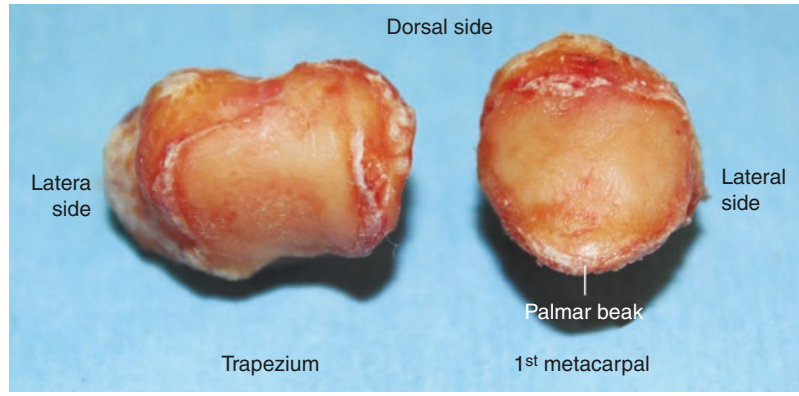

Fig. 2.6 The articular surfaces in the trapeziometacarpal joint of the left thumb

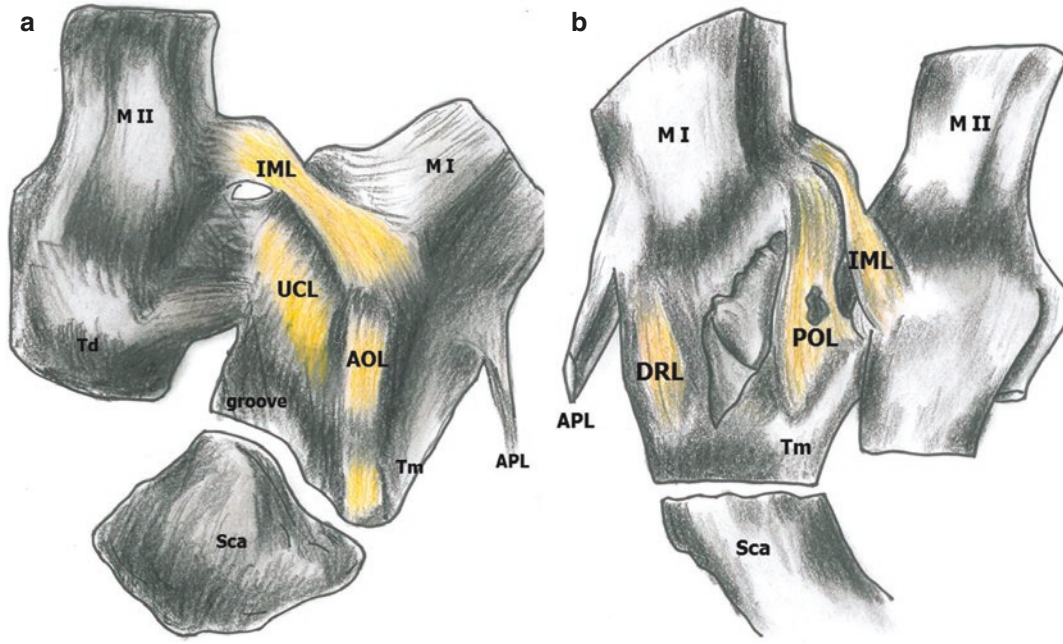

Fig. 2.7 Volar view and dorsal view of the right trapeziometacarpal joint. (*M I* first metacarpal bone; *M II* second metacarpal bone; *Td* trapezoid; *Tm* trapezium; *IML* intermetacarpal ligament; *UCL* ulnar collateral ligament; *AOL* anterior oblique ligament; *APL* abductor pollicis longus; *DRL* dorsoradial ligament; *POL* posterior oblique ligament). Volar view (**a**) and dorsal view (**b**) of the right trapeziometacarpal joint

metacarpal. This ligament tightens with the thumb flexion, abduction, and opposition positions. The dorsoradial ligament arises from the dorsoradial eminence of the trapezium and inserts on the dorsal edge of the first metacarpal base. It is taut in adduction and flexion positions and also referred to as dorsal ligament or radial collateral ligament. The first intermetacarpal ligament traverses the first and second metacarpal bases, and it is taut in abduction positions. In addition, the fibers of the APL tendon close to their insertions also reinforce the dorsal capsule.

The TM joint provides approximately 60° of flexion and extension, 40° of abduction and adduction, and 10° rotation [12]. Flexion is produced by FPB and OPP and aided by FPL when the other joints of the thumb are flexed. Extension is produced by APL and extensor pollicis brevis (EPB) and longus (EPL). Abduction is produced by APB and APL. Adduction is pro-

duced by ADP. Opposition is produced by APB, OPP, and FPB that simultaneously flex and pronate the abducted thumb. Interpulpal pressure, or that generated by digital grasping, is increased by ADP and FPL [7]. Circumduction is produced by extensors, abductors, flexors, and adductors acting consecutively in this or reversed order [12].

Metacarpophalangeal Joint (MP Joint)

The MP joint of the thumb is not a hinge but a condylar joint. This joint is different from the MP joint of the other fingers, because it has the following characteristics: (1) it has constant presence of sesamoids, (2) it has the vicinity of the insertions of the thenar muscles, and (3) it has lesser mobility, in the flexion-extension and in the abduction-adduction planes. These differences are related to the main role of this joint, namely, to stabilize the thumb in power grip, especially by locking the thumb in the grasping of large objects.

The articular surface configuration of the first metacarpal head is more quadrilateral and less sphenoidal than the other metacarpals. The medial condyle extends slightly more distally than the lateral condyle, which accounts for the small amount of pronation that occurs with joint flexion. The chief difference is that the surface spreads over the palmar tubercles which protrude condyle-like (especially the lateral one) to correspond to the sesamoids.

The articular surface of the base of the proximal phalanx is oval, shallow concave and transversely broad (Fig. 2.8). The difference in the area of contact between the two articular surfaces permits usually less flexion and extension (average 53° of flexion and 8° of extension), and there is limitation in abduction and adduction (average 10°) than in fingers. Rotation is restricted by its ligamentous structures.

The capsule of the MP joint of the thumb is reinforced radially and ulnarly by the collateral and accessory collateral ligament. Volarly it comprises the thick fibrocartilaginous volar plate, whereas dorsally, the capsule is very thin and inserts into the dorsal base of the proximal phalanx, along with the thumb sagittal band [12, 13]. The EPL and EPB tendons are intimately associated with the dorsal capsule and serve to reinforce it.

The collateral ligaments arise from the ulnar and radial side dorsolateral region of the metacarpal head and run distally and volarly to insert into the base of the proximal phalanx. The accessory collateral ligaments arise from more proximal and volar to the collateral ligaments at the metacarpal head. They run obliquely to insert into the volar plate and the sesamoids, which are also restrained on the radial side by the FPB tendon and APB tendon and on the ulnar side by the ADP tendon and by A1 pulley [14, 15]. The collateral ligaments are taught in flexion and relaxed in extension, whereas the accessory collateral ligaments are taught in extension and relaxed in flexion [14, 16].

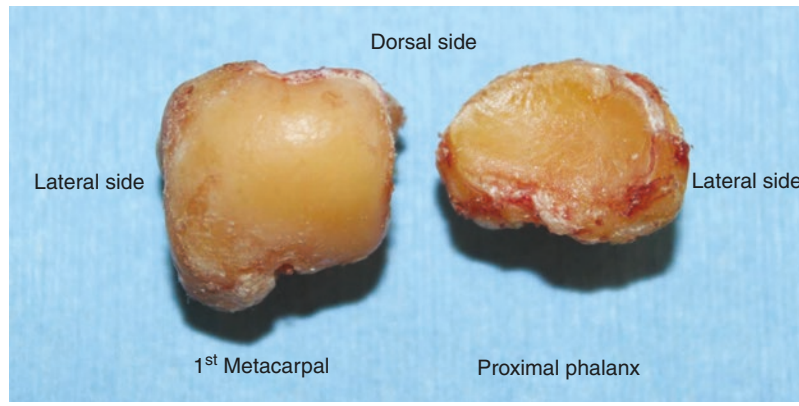

Fig. 2.8 The articular surfaces in the metacarpophalangeal joint of the left thumb

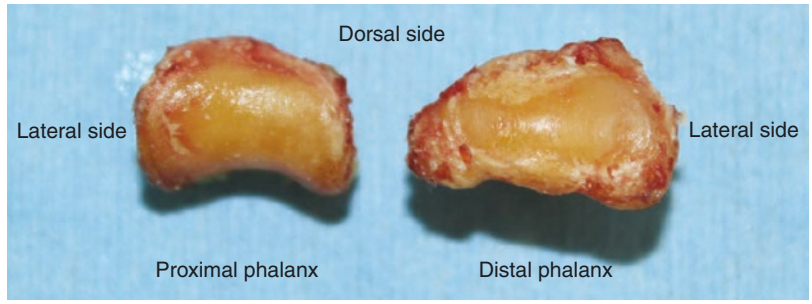

Fig. 2.9 The articular surfaces in the interphalangeal joint of the left thumb

The volar plate is a thick, fibrocartilaginous capsule and resists MP joint hyperextension. The edges of the volar plate provide an attachment for the thenar muscles and collateral ligaments. It originates at the volar neck of the metacarpal and inserts into the base of the proximal phalanx. The proximal one third of the plate is thinner than the distal portion. The distal portion of the plate is thick and contains the two sesamoids. They move with the proximal phalanx during flexion and extension, and their articular surface matches a corresponding surface on the head of the metacarpal. The volar plate is additionally reinforced by the insertion of the intrinsic thumb muscles into the sesamoids.

Both sesamoids are connected by a stout transverse fibrous band that is part of the fibrous tunnel within which runs the FPL. Anatomically sesamoids also provide insertion points for the intrinsic muscles and mechanical advantage for these muscles by increasing their moment arm and stability to the FPL as it crosses the MP joint [15].

Interphalangeal Joint (IP Joint)

The interphalangeal joint of the thumb is a simple hinge joint. It had a single fixed transverse axis, which passes through the center of curvature of the condyles of the phalangeal head, around which flexion-extension movement occurs in a range of 90°.

In practice, as it flexes, the distal phalanx undergoes 5–10° of pronation due to the asymmetry of the two condyles of the proximal phalanx [17]. The medial condyle protrudes further distally and palmarly than the lateral condyle (Fig. 2.9). Its ligamentous structure is similar to the IP joints of the fingers. However, the volar plate is significantly thicker and displaces the FPL tendon for palmarward from the joint space. A sesamoid is sometimes embedded in the volar plate.

Functional Anatomy of the Muscles and Tendons of the Thumb

The nine motor muscles act on the thumb. Every joint can be moved by itself or together with others. All forces exerted by the muscles act as dynamic stabilizers of the thumb, facilitating pinch and grasp function.

It may be divided into two groups:

1. The intrinsic muscles, which are situated in the thenar eminence and work simultaneously on the TM, MP, and IP joints. Therefore, they are responsible for performing the different types of grip. These muscles include APB, FPB, OPP, and ADP.
2. The extrinsic muscles, whose muscle bellies are situated in the forearm. These muscles include APL, EPB, EPL and FPL. They are responsible for thumb motion and stability and are the ones used to release the grip except the FPL [8, 13, 18–20].

Intrinsic Muscles

Abductor Pollicis Brevis (APB)

It lies directly beneath the skin and radial to the FPB. It provides the shape and contour of the radial side of the thenar eminence. APB arises pri-

marily from the flexor retinaculum. Accessory bundles of fibers may also arise from the scaphoid tubercle, the trapezium, and the tendons of palmaris longus (PL) and APL [6]. It inserts into the radial base of the proximal phalanx, the lateral side of the capsule of the MP joint, and the radial sesamoid at the MP joint and onto the dorsal aponeurosis of the extensor pollicis longus (Fig. 2.10a). The muscle is supplied by the recurrent branch of the median nerve (95%) or ulnar nerve (2.5%) or

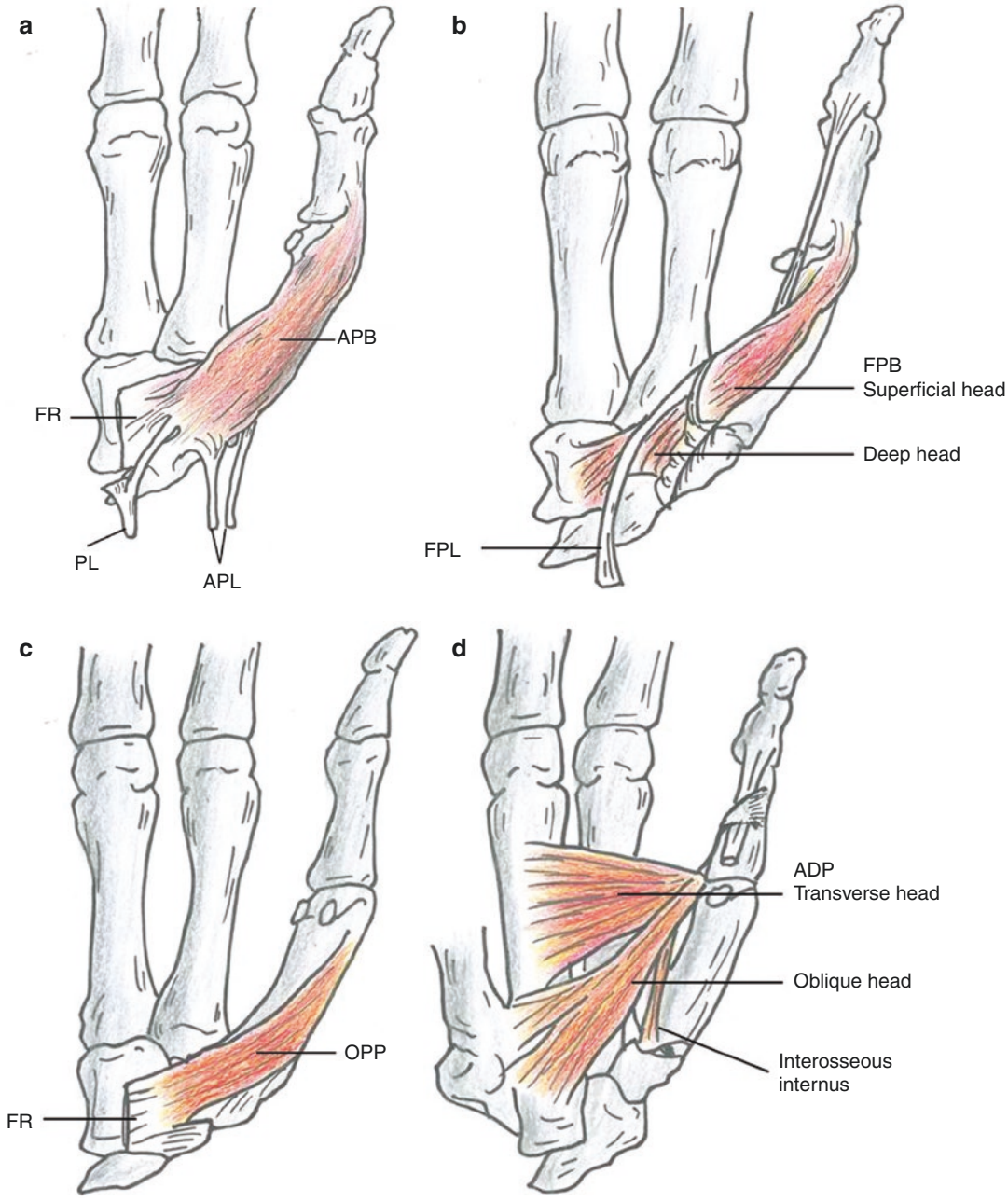

Fig. 2.10 Intrinsic muscle of the thumb. (**a**) Abductor pollicis brevis, (**b**) flexor pollicis brevis, (**c**) opponens pollicis, (**d**) adductor pollicis. (*APB* abductor pollicis brevis; *FR* flexor retinaculum; *PL* palmaris longus; *APL* abductor pollicis longus; *FPB* flexor pollicis brevis; *FPL* flexor pollicis longus; *OPP* opponens pollicis; *ADP* adductor pollicis)

by dual innervation (2%) [13, 20]. The vascular supply of this muscle is from the superficial palmar branch of the radial artery and often by a separate branch arising directly from the radial artery. The main function of the APB is abduction and flexion of the thumb metacarpal, performing the action of pulling the thumb away from the palm at a right angle to the palm. In addition it can act as a secondary flexor in the MP joint and also in extensor in the IP joint via its insertions into the dorsal aponeurosis of the extensor pollicis longus: pronation of the thumb occurring through the CMC joint is simultaneous with flexion of the thumb metacarpal. These actions produce opposition [18, 20]. Therefore, the APB alone can produce opposition of the thumb, and it is the most important muscle of the intrinsic thenar muscle.

Flexor Pollicis Brevis (FPB)

It lies medial to the APB and has superficial (lateral) and deep (medial) heads. The tendon of the FPL separates the muscle into two parts. The superficial head arises from the distal border of the flexor retinaculum and the tubercle of the trapezium, passing radially to the tendon of the FPL. It inserts on the radial base of the proximal phalanx. The deep head arises from the trapezoid, capitate, and palmar ligaments of the distal carpal row, passing deep to the tendon of the FPL, and inserts into the radial sesamoid and the base of the proximal phalanx. An expansion of the tendon inserts onto the dorsal apparatus of the thumb. The vascular supply of the muscle is from the superficial palmar branch of the radial artery and branches of the princeps pollicis artery. Innervation of the FPB can be quite variable; the superficial head is mainly innervated by the recurrent branch of the median nerve (60%), whereas the deep head is usually innervated by the deep motor branch of the ulnar nerve (Fig. 2.10b). Although the function of the muscle is not clearly understood, the main function of the FPB is flexion of the MP joint, extension of the IP joint, and pronation of the thumb metacarpal at CMC joint [13, 17].

Opponens Pollicis (OPP)

It is a short and thick muscle that lies mostly deep into the APB. It arises from the flexor retinaculum, CMC joint capsule, and the tubercle of trapezium and fans out to insert on the whole-length volar radial aspect of the first metacarpal (Fig. 2.10c). The vascular supply of the muscle is from the superficial palmar branch of the radial artery and branches from the princeps pollicis, first palmar metacarpal, radialis indicis arteries, and the deep palmar arch. It is mainly innervated by the recurrent branch of the median nerve but can also have dual median and ulnar innervation or just ulnar nerve innervation. The function of the OPP is flexion, abduction, and pronation of the thumb metacarpal. It initiates the movement of opposition at the level of the thumb metacarpal and enhances the work of opposition of the APB [13, 18, 20].

Adductor Pollicis (ADP)

It is the largest, most powerful thenar muscle and arises by two heads, an oblique and a transverse head. The transverse head is a triangular muscle arising from the distal two thirds of the palmar surface of the third metacarpal. The oblique head usually arises from the base of the second and third metacarpals, capitate, trapezoid, palmar intercarpal ligament, and the sheath of the flexor carpi radialis tendon. The two heads converge, and their fibers rotate so that the transverse head inserts mainly into the ulnar base of the proximal phalanx and ulnar sesamoid of the MP joint, while the oblique head inserts mainly into the dorsal extensor apparatus. An oblique bundle of fibers runs from the ulnar sesamoid across the FPL tendon and reinforces its fibrous sheath (Fig. 2.10d). The vascular supply of the muscle is from the princeps pollicis and radialis indicis arteries and branches from the deep palmar arch. It is mainly innervated by the deep motor branch of the ulnar nerve. The function of the ADP is adduction of the thumb metacarpal and extension of the IP joint via its insertion onto the dorsal apparatus of the thumb.

First Palmar Interosseous Muscle

It arises from the ulnar side of the base of the first metacarpal and inserts into the ulnar sesamoid of the MP joint, and it is often rudimentary [8].

Extrinsic Muscles

Flexor Pollicis Longus (FPL)

The fibrous sheath for the FPL begins at the wrist approximately 2.0 cm proximal to the radial styloid and ends just distal to the IP joint [21]. The fibrous sheath is a double-walled hollow tube and lined by a thin synovial membrane that provides a sealed lubrication system containing synovial fluid. The fibrous wall layer is reinforced by ligamentous pulleys. There are three constant pulleys: two annular and one oblique (Fig. 2.11).

The A1 annular pulley is located at the MP joint. It is stronger, 7–9 mm wide, and about 0.5 mm thick. Its proximal two thirds fused with the volar plate of the MP joint, and its distal one third fused with the base of the proximal phalanx. The A2 annular pulley is located just proximal to the IP joint and is fused with volar plate of the IP joint. It is slightly wider (8–10 mm) but significantly thinner (0.25 mm). The oblique pulley begins at the ulnar aspect of the base of the proximal phalanx and continues in a distal and oblique direction to end on the radial aspect of the proximal phalanx near the IP joint. It is 9–10 mm wide and about 0.5–0.15 mm thick. The proximal end of the oblique pulley arises from one portion of the inserting tendons of the ADP. The oblique pulley is the most important pulley in the thumb for preserving normal flexion of the thumb [21–23].

The inserting tendon of the FPL passes through the carpal tunnel. At the thenar eminence, it is located between the OPP and the oblique head of the ADP. It inserts into the palmar surface of the base of the distal phalanx. During the course, it is accompanied by carpal, metacarpal, and phalangeal mesotendons that occur in the form of short and long vincula. The arterial supply of the tendon arises from the two digital arteries of the thumb, the princeps pollicis artery and the superficial palmar arch, and the accompanying artery of the median nerve [24]. It is innervated by the anterior interosseous branch of the median nerve, and the principal function is flexion of the phalanges. The excursion of the FPL tendon is 7.7 mm in the MP joint and 10.9 mm in the IP joint. Therefore, a total excursion over the first metacarpal is 19.6 mm.

Extensor Pollicis Longus (EPL)

The tendon of the EPL is formed just proximal to the wrist and passes through the third extensor compartment. After it turns around the Lister's tubercle, it obliquely crossed the extensor carpi radial longus and brevis; with slight ulnar displacement, it then continues obliquely to the center of the MP joint and past the center of the

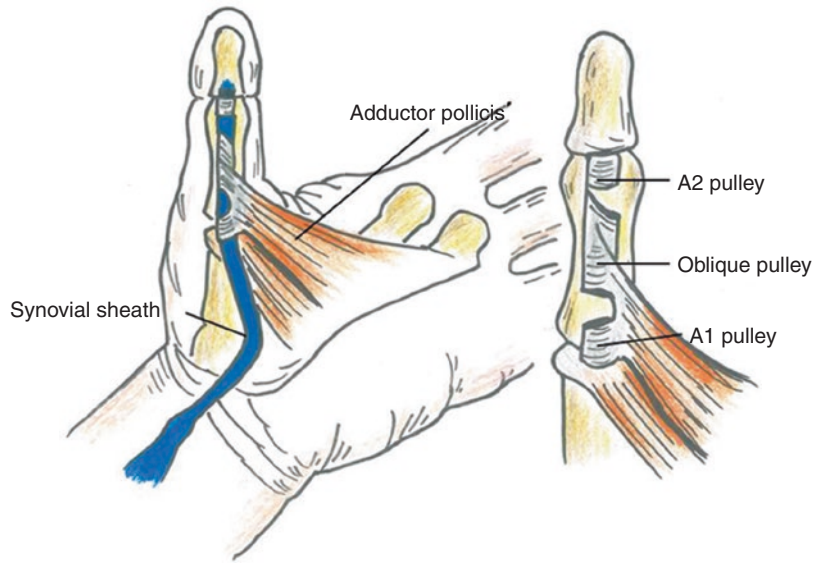

Fig. 2.11 The left thumb flexor sheath

proximal phalanx and is attached to the dorsal base of the distal phalanx.

The transverse retinacular ligament is a thin membrane that arises from the flexor tendon sheath immediately distal to the MP joint. It inserts into the dorsal aponeurosis over the proximal phalanx. The oblique retinacular ligament arises from the lateral margin of the base of the proximal phalanx and from the tendon of the APB and ADP. It traverses the MP joint palmar to dorsal and reaches the EPL tendon at the distal half of the proximal phalanx and inserts the tendon into the distal phalanx (Fig. 2.12). Both retinacular ligaments control the dorsal aponeurosis of the thumb.

EPL is innervated by the posterior interosseous nerve. It extends the distal phalanx and also extends the metacarpal and proximal phalanx with the associated action of the EPB and APL. Due to the obliquity of its tendon, it adducts the extended thumb and rotates it laterally.

Extensor Pollicis Brevis (EPB)

This tendon runs between APL and EPL and is inserted into the base of the proximal phalanx (Fig. 2.12). Because the EPB and the EPL tendon are two separate tendons, it is possible to extend the MP and IP joints independently of one another. It is innervated by the posterior interosseous nerve. It extends up to the proximal phalanx and first metacarpal.

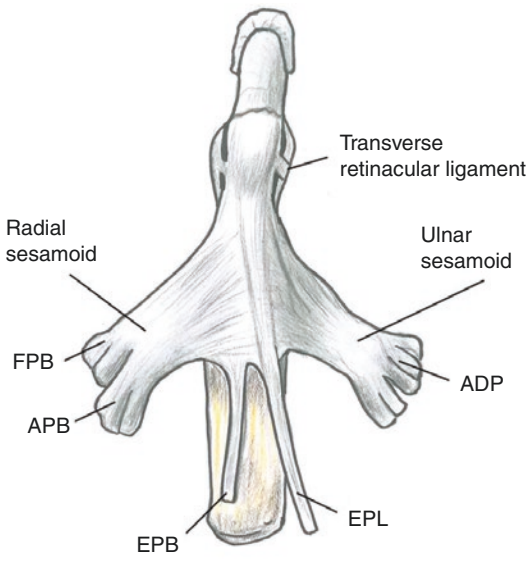

Fig. 2.12 Dorsal aponeurosis of the right thumb. (*FPB* flexor pollicis brevis; *APB* abductor pollicis brevis; *EPB* extensor pollicis brevis; *EPL* extensor pollicis longus; *ADP* adductor pollicis)

Abductor Pollicis Longus (APL)

This tendon is formed just proximal to the wrist and runs under the first extensor compartment, accompanied by the tendon of EPB. It usually splits into two slips: one is inserted into the base of the first metacarpal and the other is inserted into the trapezium. It is innervated by the posterior interosseous nerve. It is a pure extensor of the TM joint and abducts the first metacarpal.

Dynamics of Opposition

In terms of biomechanical motion, there are seven maneuvers in the hand in order to perform most of the hand function [19]. For the hand function, the opposition is the most important function in the thumb. The axis of the thumb has its foundation at the TM joint and rests in a pronated and flexed position approximately 80° relative to the plane of the other metacarpals. This unique position allows opposition of the thumb to digits.

Thumb opposition involves the complex motions of abduction, flexion, pronation of the thumb metacarpal, radial deviation of the proximal phalanx, and thumb motion toward the fingers. Abduction is moving the thumb away from the palm. It occurs primarily at the TM joint approximately 40° to 50° and additionally occurs at MP joint depending on the degree of normal ligament laxity and the morphology of the joint. Therefore, the total abduction of the thumb is variable. The muscles involved in thumb abduction are the intrinsic thenar muscles. These muscles include the APB, OPP, and the superficial head of the FPB. These muscles act simultaneously on the TM and the MP joints [18, 20, 25]. APB is the most important muscle in thumb opposition, but the extrinsic APL contributes little.

The flexion component of opposition occurs all at three joints in the thumb. TM joint flexion permits positioning of the head of the thumb metacarpal in the same sagittal plane as that of the head of the middle finger metacarpal. MP and IP joint flexion facilitates the thumb toward the fingers, and it depends on the sizes of the objects and prehensile activity. The involved muscles are the intrinsic thumb muscles. For forceful flexion, there are important contributions from the ADP and from the FPL [24]. The pronation component of opposition occurs simultaneously with flexion and abduction of the TM joint caused by the configurations of its articular surfaces and ligaments [10–12].

Summary

The thumb is a very unique portion in the human body and one of the sites with the most complex biomechanical system. The functional mobility of the thumb is the most important part of the function of the hand. Therefore, a careful understanding of the functional anatomy of the thumb will help physicians to provide the best nonsurgical or surgical treatment for the impaired hand function and thumb.

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