Applied anatomy of the wrist, thumb and hand

CHAPTER CONTENTS

The anatomy of wrist, thumb and hand is complex because of the presence of many different functional joints: the distal radioulnar joint, the wrist joint (containing the radiocarpal and the intercarpal joints, the carpometacarpal joints, the trapezium–first metacarpal joint), the metacarpophalangeal joints and the interphalangeal joints. The contractile structures can be divided into extrinsic and intrinsic muscles. The former – the long tendons – are quite regularly affected, while the latter are clinically of less importance.

Joints, joint capsules and ligaments

Distal radioulnar joint

The joint is a uniaxial pivot joint. The articular surfaces are between the convex head of the ulna and the concave ulnar notch of the radius. A fibrocartilaginous articular disc binds the distal end of the ulnar notch on the radius to the ulnar styloid process. This disc is part of the so-called triangular fibrocartilage complex (TFCC) and sits between the ulnar head and the ulnar carpus (lunate and triquetrum). Therefore the distal radioulnar joint can be seen as L-shaped: the short leg is between radius and ulna and the longer leg between the distal ulna and the articular disc (see Putz, Fig. 318). It has a loose capsule, reinforced with some ligaments, that allows rotation movement of the radius about the ulna. The two bones are held together mainly by the triangular fibrocartilage complex (TFCC) and to a lesser degree by the interosseous membrane and the pronator quadratus muscle (Fig. 1).

The TFCC contains different parts: (a) the triangular fibrocartilage, which has a central component – the articular disc – and two adjoining ligaments, the dorsal and palmar radioulnar ligaments. These take their origin at the dorsal and volar edges of the sigmoid notch and insert onto the ulnar styloid base (b) a meniscus homologue. This thickened ulnar part of the TFCC, inserts into the triquetral and hamate bones and the base of the fifth metacarpal; (c) the ulnar collateral ligament; (d) the ulnolunate and ulnotriquetral ligaments; and (e) the sheath of the extensor carpi ulnaris tendon, which is strongly attached to the posterolateral aspect of the TFCC. The TFCC stabilizes the radioulnar and ulnocarpal joints, transmits and distributes load from the carpus to the ulna and facilitates complex movements to the wrist (Fig. 2).

This distal radioulnar joint allows pronation–supination movements of the forearm, inevitably in combination with movement at the upper radioulnar joint, around an axis which runs through the head of the ulna. The distal end of the radius makes a circumferential gliding movement around and in front of the head of the ulna (see online chapter *Applied anatomy of the elbow*). Pronation has an amplitude of ± 85° and is stopped by the radius impacting against the ulna and by tension in the dorsal radioulnar ligament and the interosseous membrane. Consequently, there is an elastic end-feel. Supination ceases at an angle of 90° when the posterior aspect of the ulnar

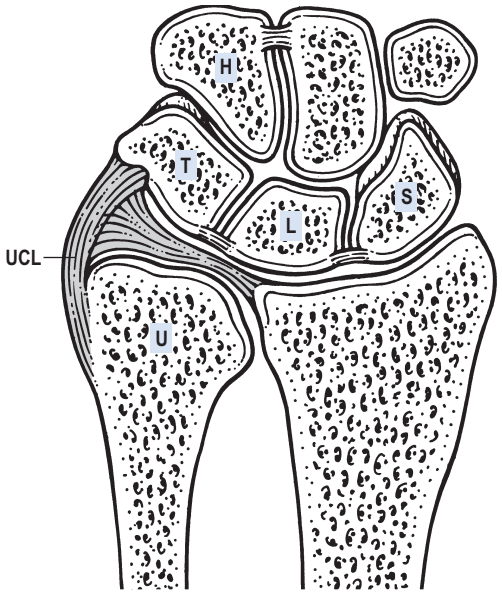

Fig 1 • Right distal radioulnar joint in supination. T, triquetrum; H, hamate; L, lunate; S, scaphoid; U, ulna; UCL, ulnocapitate ligament.

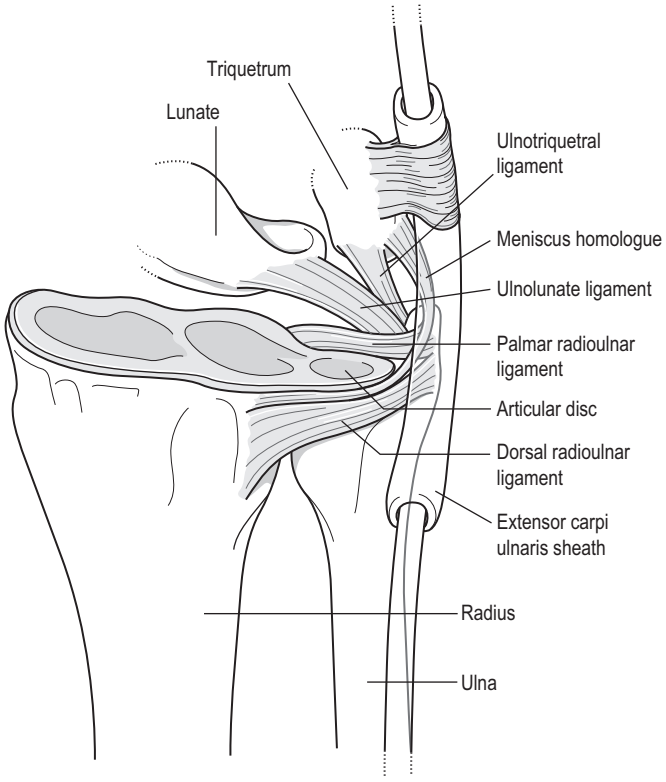

Fig 2 • Right distal radioulnar joint in pronation.

notch of the radius is brought into contact with the styloid process of the ulna through the extensor carpi ulnaris tendon. Its end-feel is also elastic (see Standring, Fig. 50.17).

Wrist joint

The wrist joint consists of two rows of carpal bones. The proximal row contains (from radius to ulna) the scaphoid, lunate, triquetral and pisiform bones, and the distal row the trapezium, trapezoid, capitate and hamate (Fig. 3, see Standring, Fig. 50.6A).

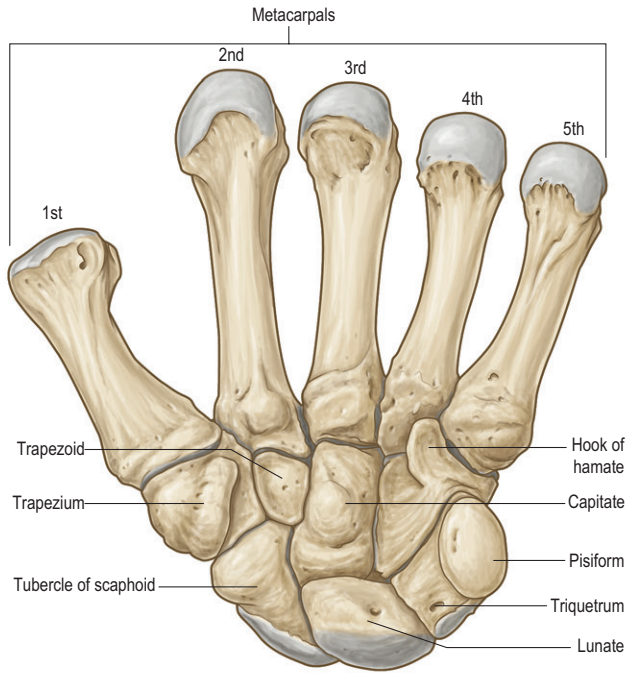

Fig 3 • Palmar carpus of the left hand. From Standring, Gray's Anatomy, 40th edn. Churchill Livingstone/Elsevier, Philadelphia, 2009 with permission.

The wrist joint is complex: there are two components, proximal and distal (see Putz, Fig. 326). Proximally the distal part of the radius and the articular disc articulate with the proximal row of carpal bones to form a condylar joint (radiocarpal joint) which has its concave surface at the radial side. The joint moves along two axes: anteroposterior for ulnar and radial deviation, and transverse for flexion and extension (Fig. 4).

Distally, the intercarpal joint is between the proximal and distal rows of bones (Fig. 5), is an open S-shape and acts as a hinge. It should not be considered as an independent joint because its function is to augment the mobility of the carpal bones and thus allow greater mobility at the wrist.

Movements are restricted by collateral (Fig. 5), palmar and dorsal ligaments (Fig. 6).

Radial and ulnar collateral ligaments

The radial collateral ligament, between the styloid process of the radius and the scaphoid bone, is taut when the hand is brought into ulnar deviation. The ulnar collateral ligament, between the styloid process of the ulna and the triquetral and pisiform bones, is under tension during radial deviation of the hand.

Dorsal ligaments

The dorsal wrist ligaments are comparatively thin. They are reinforced by the floor and septa of the fibrous tunnels for the six dorsal compartments (see below) and have a 'Z-shaped' configuration. The fibres of the dorsal radiocarpal ligaments are aligned more or less in the same axis as the forearm, those of

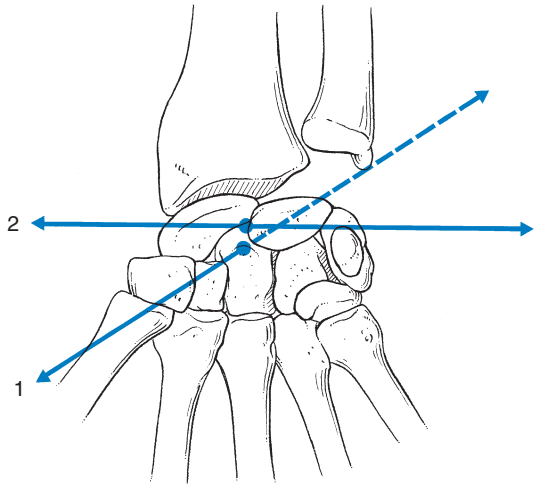

Fig 4 • The two axes of movement in the wrist joint: 1, anteroposterior axis along which ulnar/radial deviation takes place; 2, transverse axis along which flexion/extension takes place.

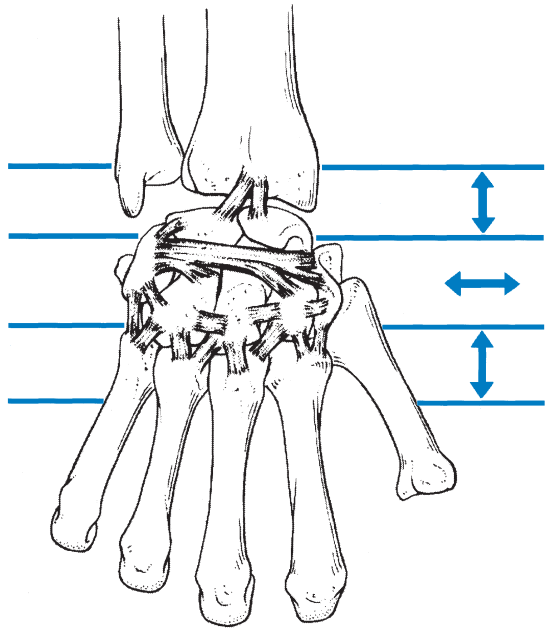

Fig 6 • The dorsal ligaments. The arrows emphasize the direction of the ligamentous fibres at the joint lines.

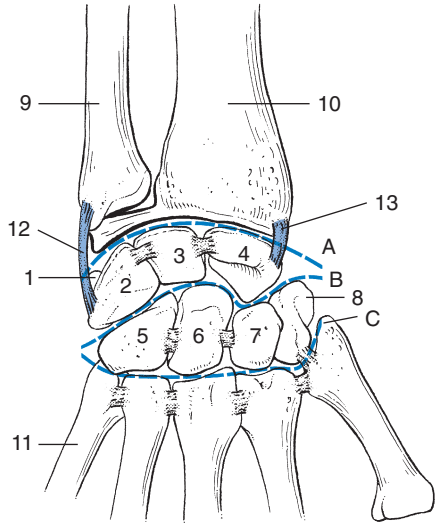

Fig 5 • The wrist and collateral ligaments (right hand dorsal view): 1, pisiform; 2, triquetrum; 3, lunate; 4, scaphoid; 5, hamate; 6, capitate; 7, trapezoid; 8, trapezium; 9, ulna; 10, radius; 11, metacarpal; 12, ulnar collateral ligament; 13, radial collateral ligament; A, radiocarpal joint line; B, intercarpal joint line; C, carpometacarpal joint line.

the intercarpal ligaments are more transverse to the carpus and the carpometacarpal ligaments are longitudinal again (see Standring, Fig. 50.15B). The pattern and shape of these ligaments is important for treatment with deep transverse friction which should be oblique to the direction of the fibres.

Palmar ligaments

On the palmar aspect of the wrist, a complex system of ligaments joins the different carpal bones to the radius and the ulna. These palmar ligaments are of little clinical importance and are taut during extension of the wrist.

Movements

The amplitude of radial deviation is only 15°, whereas ulnar deviation has an amplitude of approximately 45°, the wrist being held in the neutral position between flexion and extension. Flexion and extension both have a range of 85°, with the wrist in the neutral position between radial and ulnar deviation.

Flexion–extension has an end-feel of an elastic, capsular type. Radial and ulnar deviation has an end-feel that is quite hard but is clinically of less importance.

Carpometacarpal joints

The joints between the distal row of carpal bones and the second to fifth metacarpal bones are scarcely mobile, except for the joint with the fifth metacarpal, which permits slight movement in a palmar direction necessary to allow opposition of the fifth finger. They are provided with dorsal and palmar carpometacarpal ligaments, the fibres of which are in line with the axis of the metacarpal bones. Intercarpal ligaments 'tie' the bones together.

Trapezium–first metacarpal joint

The shape of the articular surfaces of both the trapezium and the first metacarpal bone ('saddle') allows movement in two

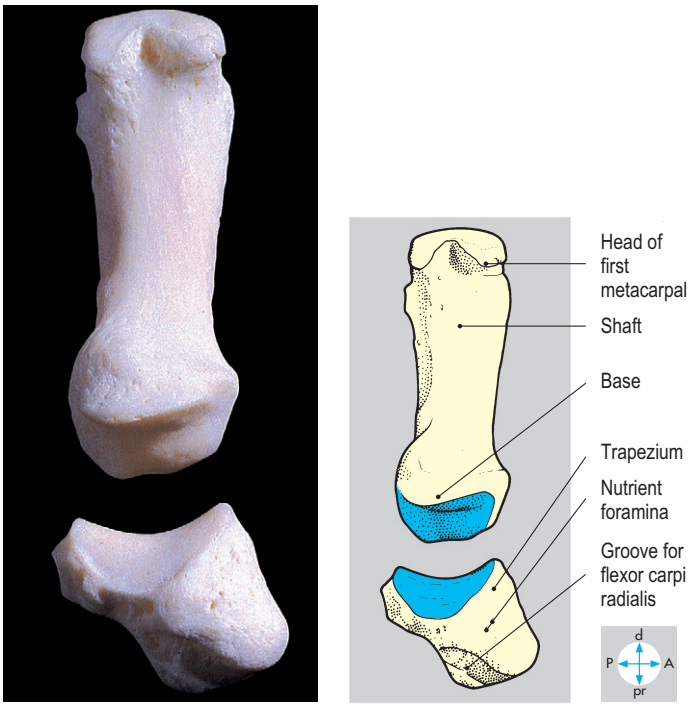

Fig 7 • Palmar view of the left trapezium–metacarpal joint. From Gosling et al, Human Anatomy, 5th edn. Mosby/Elsevier, Philadelphia, 2008 with permission.

directions: abduction–adduction and opposition–reposition (Fig. 7). The joint capsule is slack so as to allow free movement but strong ligaments control the range.

Metacarpophalangeal joints

The metacarpophalangeal joint of the thumb is different from that of the other fingers. It is a hinge and allows only a flexion movement (80–90°) and in hypermobile individuals some extension. Two sesamoid bones are often embedded in the palmar part of the capsule.

The metacarpophalangeal joint of each of the second to fifth fingers is a 'ball-and-socket' joint with a slack joint capsule, which is reinforced by strong palmar ligaments and collateral ligaments (see Gosling, Fig. 3.102). The collateral ligaments are taut when the joint is flexed.

The possible movements are flexion (90°, Fig. 8) and extension (sometimes to 90°, dependent on the laxity of the joint capsule), as well as abduction and adduction (the index finger having the greatest mobility). The rotatory movements are not clinically important.

Interphalangeal joints

The interphalangeal joints are hinges that allow flexion without extension, except in some individuals for the interphalangeal joint of the thumb and the distal interphalangeal joint of the fingers (see Gosling, Fig. 3.102). In the proximal interphalangeal joints, the range of flexion is more than 90° and increases from the index to little finger in which flexion can be 135°, which allows a 'fist' to be made.

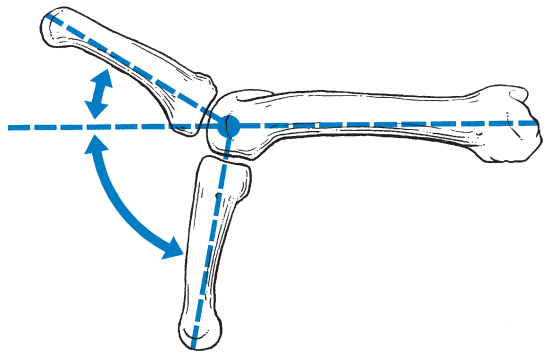

Fig 8 • Flexion and extension of the metacarpophalangeal joint.

Distally the amplitude of flexion varies between 80° and 90°, the little finger again being the most mobile. The joint capsules are reinforced by palmar and collateral ligaments.

The slight rotatory movements possible at the interphalangeal joints are not important from a clinical point of view.

Muscles and tendons

Clinically, the long tendons of the wrist, thumb and fingers – the tendons of the extrinsic muscles – are of more importance than the small muscles of hand, thenar and hypothenar – the intrinsic muscles.

Extrinsic muscles and tendons

As lesions are usually well localized, a topographical description of the tendinous structures is necessary. An understanding of exactly where they lie and where they insert is important.

Dorsal aspect

On the dorsal aspect of the wrist six osteofibrous tunnels can be distinguished (Fig. 9, see Standring, Fig. 50.14), which contain the tendon sheaths of the extensors of the wrist and fingers (Table 1) and the abductor of the thumb.

Tunnel 1

This contains the tendons of the abductor pollicis longus and the extensor pollicis brevis (see Standring, Fig. 50.38):

- *The abductor pollicis longus* inserts partly at the base of the first metacarpal bone, radial to the extensor pollicis brevis and partly into the trapezium. Its main function is abduction of the thumb, a movement that takes place between the trapezium and the first metacarpal.
- *The extensor pollicis brevis* inserts at the base of the proximal phalanx of the thumb and is responsible for extension of the thumb. Additionally, because of its close relationship with the abductor longus, it helps in abduction.

Both muscles lie in a common tendon sheath and have a further function: radial deviation and palmar flexion of the wrist.

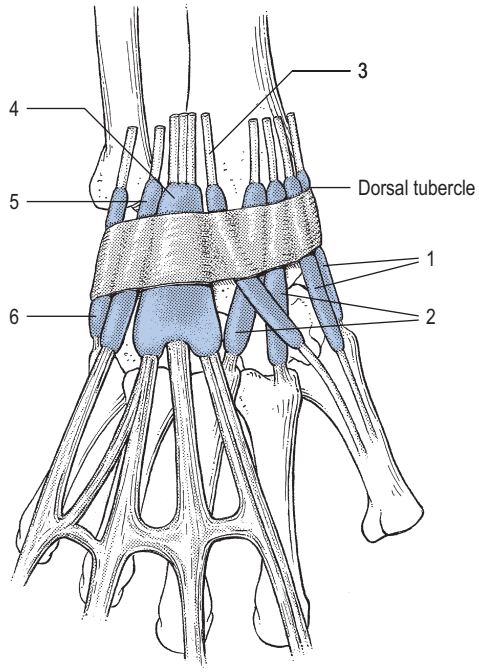

Fig 9 • The extensor tendons and their sheaths (numbers indicate the tunnels described in the text).

Table 1 The extensors

Muscle	Innervation	
	Peripheral nerve	Nerve root
Abductor pollicis longus	Radial	C7–C8
Extensor pollicis brevis	Radial	C7–T1
Extensor carpi radialis longus	Radial	C6–C7
Extensor carpi radialis brevis	Radial	C7
Extensor pollicis longus	Radial	C7–C8
Extensor indicis proprius	Radial	C6–C8
Extensor digitorum communis	Radial	C6–C8
Extensor digiti minimi	Radial	C6–C8
Extensor carpi ulnaris	Radial	C7–C8

Together they form the radial border of the 'anatomical snuffbox'.

Tunnel 2

The second tunnel contains the tendons of extensor carpi radialis longus and brevis. They diverge level with the carpus:

- *The extensor carpi radialis longus* inserts into the dorsal and radial aspect of the base of the second metacarpal bone and combines with the extensor carpi ulnaris to perform dorsiflexion of the wrist. In conjunction with the flexor carpi radialis muscle, it produces radial deviation.
- *The extensor carpi radialis brevis* attaches to the dorsal and radial aspect of the base of the third metacarpal bone. It extends the wrist and brings it back from ulnar deviation into a neutral position.

Tunnel 3

The third tunnel contains the tendon of the extensor pollicis longus, which runs along the ulnar aspect of the dorsal tubercle of the radius and then deviates 45° towards the thumb. Level with the carpus it passes over the tendons of the second tunnel and so forms the ulnar border of the anatomical snuffbox. It then continues over the dorsal aspect of the thumb towards the base of the distal phalanx. Its main function is to extend the thumb, although is also helps in extension of the wrist and abduction of the thumb.

Tunnel 4

Five different tendons are found here: the tendon of the extensor indicis proprius and the four tendons of the common extensor digitorum:

- *The extensor indicis proprius*: the fibres of the extensor indicis proprius blend with the dorsal aponeurosis of the index finger. It extends the index finger.
- *The extensor digitorum*: the tendons of the extensor digitorum merge with the dorsal aponeurosis of the second to fifth fingers and extend the fingers, especially the proximal phalanges. Their secondary functions are extension and ulnar deviation of the wrist.

Tunnel 5

This contains just one tendon, the extensor digiti minimi, which runs over the distal radioulnar joint and then parallel to the fifth tendon of the extensor digitorum into the dorsal aponeurosis of the fifth finger. Its function is identical to that of the extensor digitorum.

Tunnel 6

The extensor carpi ulnaris lies in a groove at the ulnar aspect of the head of the ulna. It then crosses the lateral aspect of the carpus to insert in the dorsal and ulnar aspect of the base of the fifth metacarpal bone. On account of its position, it functions mainly as a strong ulnar deviator of the wrist and also acts as an opponent to the abductor pollicis longus. Its extension function is very much secondary.

Palmar aspect

On the palmar aspect of the wrist lie the tendons of the flexors of wrist and fingers (Table 2). These are enclosed by the carpal tunnel and the tunnel of Guyon, which are of great importance.

The carpal tunnel

The palmar aspect of the carpus is concave and covered with the transverse carpal ligament, also called the flexor retinaculum. An osteofibrous canal is thus formed, of which the palpable boundaries are: proximally the scaphoid and pisiform bones and distally the trapezium and hamate bones (Fig. 10).

Table 2 The flexors

Muscle	Innervation	
	Peripheral nerve	Nerve root
Flexor carpi radialis	Median	C7–T1
Palmaris longus	Median	C7–T1
Flexor digitorum superficialis	Median	C7–T1
Flexor digitorum profundus	Median Ulnar	C7–T1
Flexor carpi ulnaris	Ulnar	C7–C8
Flexor pollicis longus	Median	C7–C8

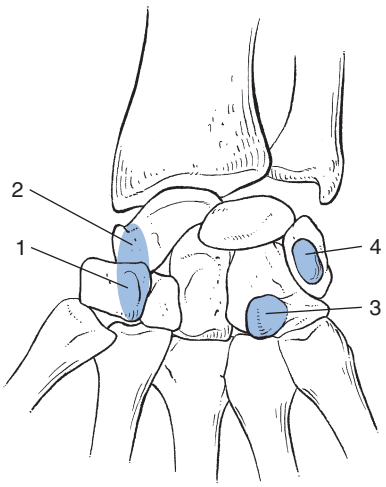

Fig 10 • Boundaries of the carpal tunnel: 1, trapezium; 2, scaphoid; 3, hamate; 4, pisiform.

The canal lies thus more distally and more towards the ulnar aspect than is often thought – at the heel of the hand.

Within the carpal tunnel are found: the median nerve; the tendons of the flexor carpi radialis and the flexor pollicis longus, in separate sheaths; and the superficial and deep flexors of the digits, within a common tendon sheath (Fig. 11).

The tendinous structures (Fig. 12, see Standring, Fig. 50.31) are the following:

- *The flexor carpi radialis* traverses the carpal tunnel along the scaphoid bone and inserts at the palmar aspect of the base of the second metacarpal. It flexes the wrist and helps in radial deviation.
- *The palmaris longus* muscle is absent in 15% of individuals. It is inserted into the palmar aponeurosis in the palm and helps in palmar flexion of the wrist as well as tensing the palmar fascia.
- *The tendons of the superficial flexors of the fingers* run, in a common sheath, through the carpal tunnel and insert into the middle phalanges of the second to fifth fingers; in doing this they separate each of the deep flexor digitorum tendons in two. Their functions are mainly flexion of the proximal phalanges of the fingers and ulnar deviation of the wrist.
- *The tendons of the deep flexors of the fingers* run through the carpal tunnel in a common tendon sheath with the superficial extensor digitorum and insert at the base of the distal phalanges of the second to fifth fingers. The muscle flexes the fingers and also the wrist.
- *The flexor carpi ulnaris* attaches to the pisiform, which some consider a sesamoid bone in the tendon of the flexor carpi ulnaris. Distal to the pisiform, the tendon divides into two ligamentous structures: the pisohamate ligament (which covers the tunnel of Guyon) and the pisiform–fifth metacarpal ligament. Together with the flexor carpi radialis, the flexor carpi ulnaris flexes the wrist and, with the extensor carpi ulnaris, performs ulnar deviation of the wrist.
- *The flexor pollicis longus* originates with a radial head at the anterior aspect of the radius, just distal to the insertion of the supinator brevis muscle and also from the interosseous membrane. There is an additional humeral head at the medial epicondyle. It runs lateral to the flexor carpi radialis muscle under which it crosses proximal to the wrist and then runs in a separate tendon sheath through the carpal tunnel to insert at the base of the distal phalanx of the thumb. It flexes the thumb and slightly flexes and radially deviates the wrist.

The tunnel of Guyon

This tunnel lies between the pisiform and the hamate bone and is covered by the pisohamate ligament, which is a continuation of the flexor carpi ulnaris tendon. The ulnar nerve and artery are also enclosed within this tunnel (Fig. 13, see Standring, Fig. 50.46).

Intrinsic muscles (Table 3)

Apart from the dorsal interossei, the intrinsic muscles of the hand (see Putz, Fig. 374) are seldom strained:

- *The thenar muscles*: these are clinically less important and include the abductor pollicis brevis, opponens pollicis, flexor pollicis brevis with its superficial and deeper head and the adductor pollicis with its transverse and oblique head.
- *The hypothenar muscles* are the abductor digiti minimi, flexor digiti minimi brevis and opponens digiti minimi.
- *The lumbrical muscles*: there are four lumbrical muscles. They originate at the radial aspect of the *tendons* of the deep flexor digitorum muscle and insert at the dorsal aponeurosis of the fingers and at the joint capsules of the metacarpophalangeal joints. They flex the metacarpophalangeal joints and extend the interphalangeal joints.
- *The palmar interossei*: the three palmar interossei adduct the fingers towards the middle finger, flex the metacarpophalangeal joints and extend the interphalangeal joints of the fingers (Fig. 14).

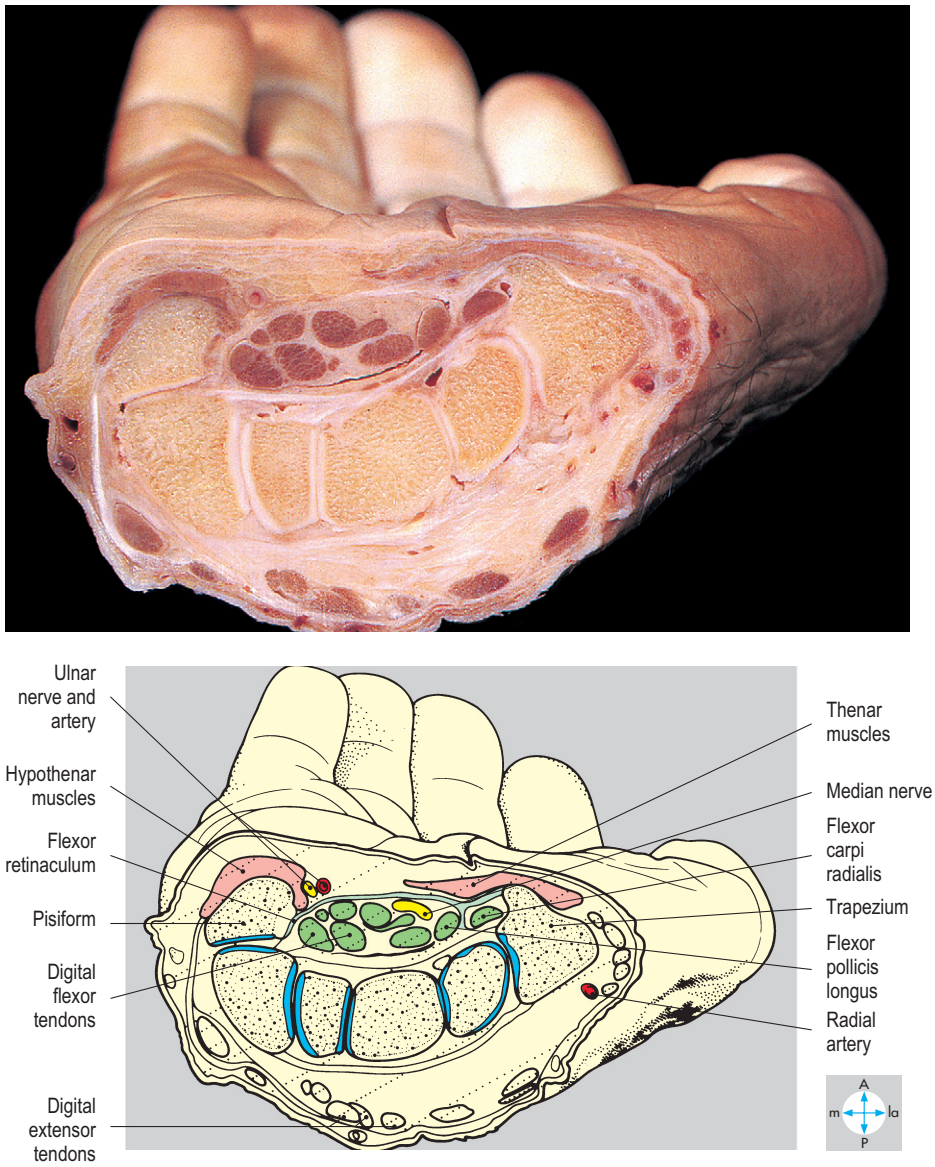

Fig 11 • Proximal view of the right carpal tunnel. From Gosling et al, Human Anatomy, 5th edn. Mosby/Elsevier, Philadelphia, 2008 with permission.

The dorsal interossei

More important are the four dorsal interossei. They originate from the sides of the five metacarpal bones, each having two heads, each in the side of two adjacent metacarpal bones (Fig. 15). They course towards the proximal phalanges, where they attach into the extensor aponeurosis of the fingers. The first dorsal interosseus goes to the radial aspect of the index finger. The second dorsal interosseus goes to the radial aspect of the middle finger, the third to the ulnar aspect of the middle finger. The fourth dorsal interosseus goes to the ulnar aspect of the fourth finger.

The dorsal interossei abduct the fingers away from the middle finger (Fig. 14). They also flex the metacarpophalangeal joints and extend the interphalangeal joints.

The palmar aponeurosis

The palmar aponeurosis of the hand is a continuation of the flexor retinaculum (the reinforcement of the distal part of the antebrachial fascia, also called transverse ligament of the carpus) and consists of transverse and longitudinal fibres (see Standring, Fig. 50.4A). The latter are part of the tendon sheaths of the flexor tendons (deep transverse metacarpal ligaments) and also connect to the capsules of the metacarpophalangeal joints. The aponeurosis is also connected to the deep fascia of the hand, which is attached to its skeleton. Together with the ligaments, septa and fasciae, the palmar aponeurosis forms a functional unit. During a strong grip it fixes the skin of the palm to the metacarpal bones and protects the soft tissues of the mid-hand.

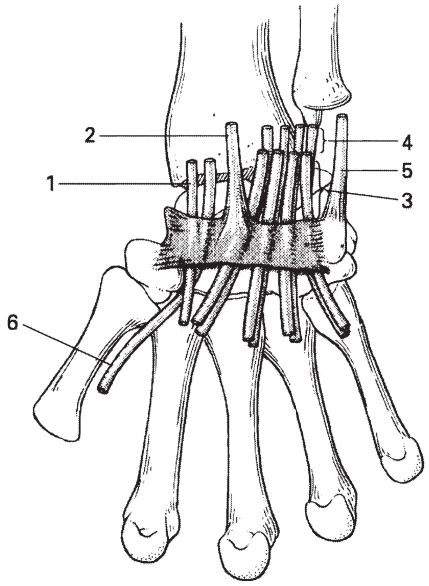

Fig 12 • The flexor tendons: 1, flexor carpi radialis; 2, palmaris longus; 3, superficial flexors of the fingers (4 tendons); 4, deep flexors of the fingers (4 tendons); 5, flexor carpi ulnaris; 6, flexor pollicis longus.

Table 3 The intrinsic muscles

Muscle	Innervation	
	Peripheral nerve	Nerve root
Abductor pollicis brevis	Median	C8–T1
Oppens pollicis	Median	C6–C7
Flexor pollicis brevis		
Superficial head	Median	C8–T1
Deep head	Ulnar	C8–T1
Adductor pollicis	Ulnar	C8–T1
Abductor digiti minimi	Ulnar	C8–T1
Flexor digiti minimi brevis	Ulnar	C8–T1
Opponens digiti minimi	Ulnar	C8–T1
Lumbricals		
Radial two lumbricals	Median	C8–T1
Ulnar two lumbricals	Ulnar	C8–T1
Dorsal interossei	Ulnar	C8–T1
Palmar interossei	Ulnar	C8–T1

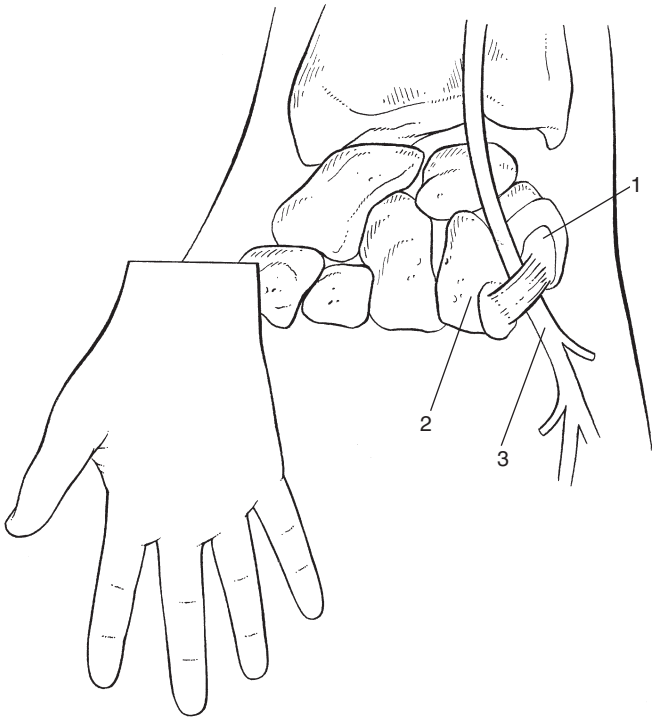

Fig 13 • The tunnel of Guyon: 1, pisiform; 2, hamate; 3, ulnar nerve.

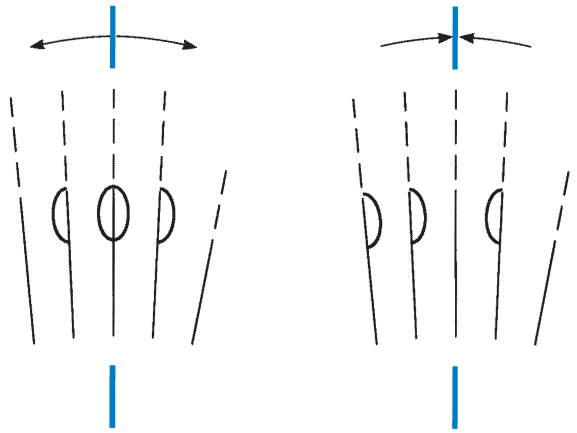

Fig 14 • (Left) Abduction, four dorsal interossei; (right) adduction, three palmar interossei.

Nerve structures

The three most important nerves in the wrist and hand are the median, ulnar and radial nerves. The median nerve is most frequently affected in the carpal tunnel, whereas the ulnar nerve becomes compressed in the region of Guyon's tunnel (see Standring, Fig. 50.45A). Lesions of the radial nerve at the wrist are less common.

Median nerve

The median nerve enters the hand through the carpal tunnel, in between the tendons of the flexor pollicis longus and flexor digitorum superficialis. Distal to the transverse ligament, the nerve divides into two branches (Fig. 16). A short motor branch goes to the thenar eminence, where it usually supplies the abductor pollicis brevis and opponens pollicis muscles, and sometimes the flexor pollicis brevis and the first and second

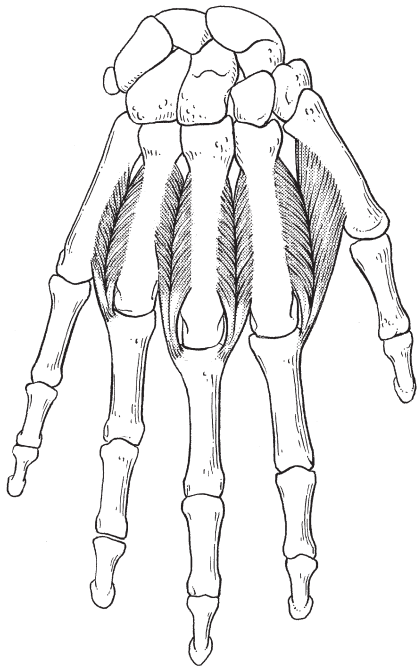

Fig 15 • The dorsal interossei.

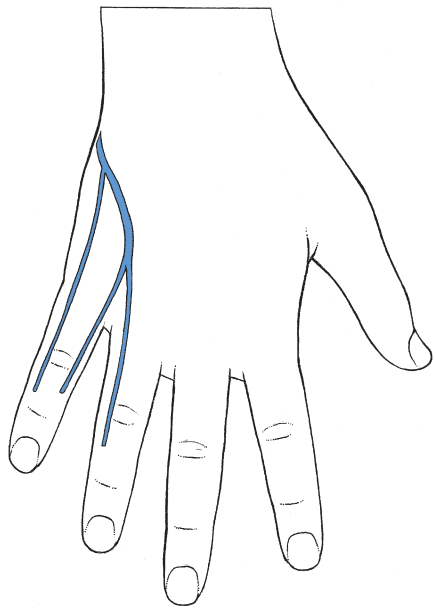

Fig 17 • The ulnar nerve: dorsal cutaneous branch.

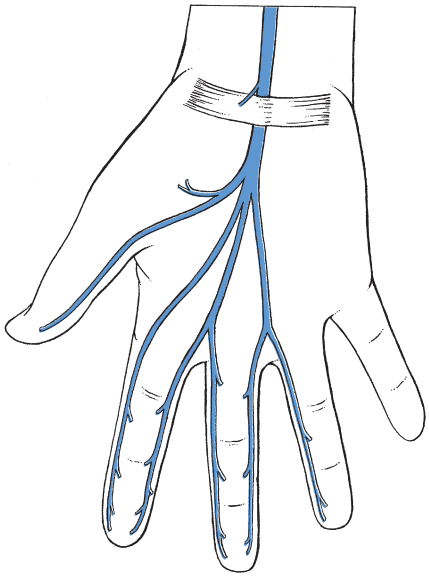

Fig 16 • The median nerve.

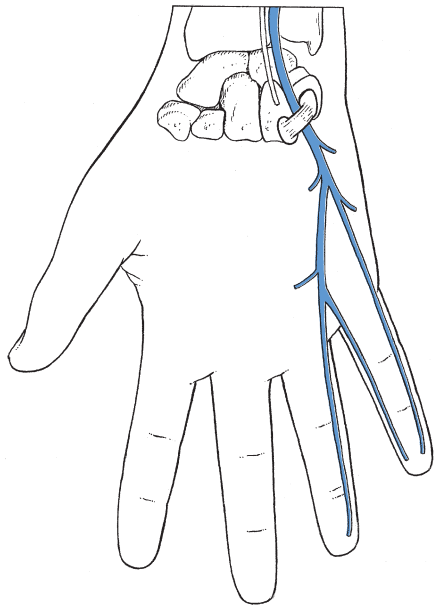

Fig 18 • The ulnar nerve: palmar branch.

lumbrical muscles. The sensory palmar digital branches innervate the palmar surface and the dorsal aspect of the distal phalanges of the thumb, the second and third fingers and the radial half of the fourth finger.

Ulnar nerve

Proximal to the wrist, the palmar cutaneous branch of the ulnar nerve arises and runs across the palmar aspect of the forearm and wrist, outside the tunnel of Guyon, to supply the proximal part of the ulnar side of the palm. A few centimetres more distally, the dorsal cutaneous branch arises and supplies the ulnar side of the dorsum of the hand (Fig. 17), the dorsal aspect of the fifth finger and the ulnar half of the fourth finger.

The ulnar nerve, together with the ulnar artery, passes between the pisiform and the hook of the hamate through the tunnel of Guyon. As it leaves the tunnel it divides into a mainly sensory superficial terminal branch, which supplies the distal ulnar border of the palm of the hand and the palmar surfaces of the fifth and ulnar half of the fourth finger (Fig. 18) and a deep terminal branch, which is entirely motor and innervates nearly all of the small muscles of the hand.

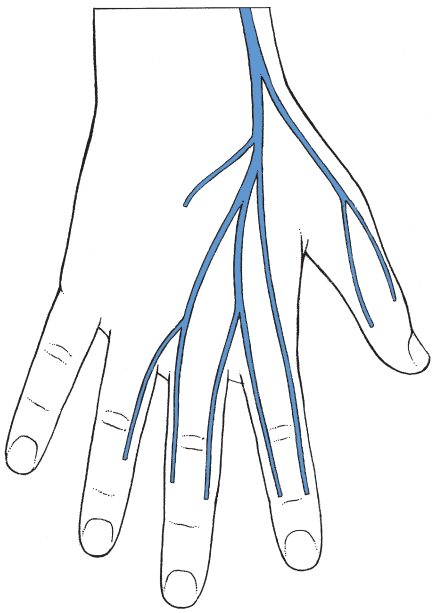

Fig 19 • Terminal digital branches of the superficial radial nerve.

Radial nerve

At the elbow, the radial nerve divides into the posterior interosseous nerve (a deep motor branch), which innervates the extensor muscles of the wrist and fingers, and the superficial radial nerve (a superficial sensory branch), which lies under the tendon of the brachioradialis muscle. In the hand, the superficial radial nerve divides into terminal digital branches that supply the dorsolateral aspect of the hand and the dorsal aspect of the first three and a half fingers, except the distal phalanges (Fig. 19).