The Free Upper Limb

The bones of the **free upper limb** are
- The **humerus**
- The **radius** and **ulna**
- The **carpal bones**
- The **metacarpal bones**
- The **phalanges**

Bone of the Arm

Humerus (A–H)

The **humerus** articulates with the scapula and the radius and ulna. It consists of the **body** and **upper (proximal)** and **lower (distal) ends**. The proximal end is formed by the *head* (**1**), adjoining the *anatomical neck* (**2**). On the anterolateral surface of the proximal end lies laterally the greater tubercle (**3**), and medially is the *lesser tubercle* (**4**). Between these tubercles begins the *intertubercular sulcus* (**5**), which is bounded distally by the *crests of the lesser* (**6**) and *greater* (**7**) *tubercles*. The *surgical neck* (**8**) lies proximally on the body of the humerus. In the middle of the body lies laterally the *deltoid tuberosity* (**9**). The body may be divided into an *anteromedial surface* (**10**) with a *medial border* (**11**), and an *anterolateral surface* (**12**) with a *lateral border* (**13**), which becomes sharpened distally and is called the *lateral supracondylar ridge*. The *groove for the radial nerve* (**14**) lies on the posterior surface of the body. The distal end of the humerus bears on its medial side the large *medial epicondyle* (**15**) and on the lateral side the smaller *lateral epicondyle* (**16**).

The *trochlea* (**17**) and the *capitulum* (**18**) of the humerus form the *humeral condyles* for articulation with the bones of the forearm. The *radial fossa* (**19**) lies proximal to the capitulum and proximal to the trochlea is the somewhat larger *coronoid fossa* (**20**).

Medial to the trochlea (**D**) there is a shallow groove, the *groove for ulnar nerve* (**21**). On the posterior surface above the trochlea is a deep pit, the *olecranon fossa* (**22**).

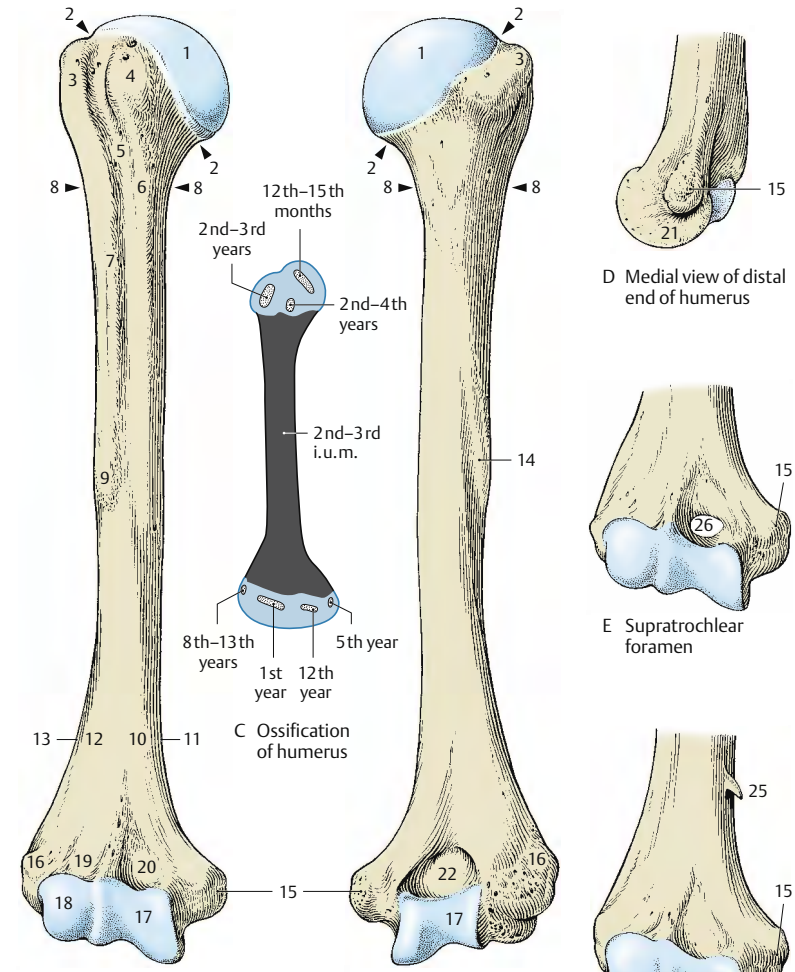
The humerus is twisted at its proximal end, i.e., the head is posteriorly rotated at about 20° in relation to the transverse axis of the distal end (**torsion**). The angle between the long axis of the humerus and that of the head averages 130°, and at the distal end, between the transverse axis of the joint and the long axis of the shaft of the humerus, there is an angle of 76° to 89°.

The **proximal epiphysial line** (**23**) runs transversely through the lesser tubercle and inferior to the greater tubercle. It crosses the zone of attachment of the capsule (see p. 117) in such a way that a small part of the shaft comes to lie within the capsule. At the **distal end** there are two epiphyses and **two epiphysial lines** (**24**). One epiphysis carries the medial epicondyle and the other the joint surfaces and the lateral epicondyle.

Ossification: In general, development of the ossification centers and fusion of the epiphyses occur somewhat earlier in females than in males. The perichondral bone anlage in the shaft appears in the 2nd–3rd intrauterine month. The endochondral ossification centers in the epiphyses appear between the 2nd week of life and the 12th year. Three centers appear proximally soon after birth, and distally four ossification centers develop later. The distal epiphysial disks fuse during puberty and the proximal disks at the end of puberty.

Variants: Just above the medial epicondyle a *supracondylar process* (**25**) is occasionally found, and above the trochlea there may be a *supratrochlear foramen* (**26**).

Clinical tip: 50% of fractures of the humerus occur in the **shaft**. There is a risk of damage to the radial nerve!



Radiocarpal and Midcarpal Joints (A–E)

The **radiocarpal** or **wrist joint** is an ellipsoid joint formed on one side by the **radius** (**1**) and the **articular disk** (**2**) and on the other by the **proximal row of carpal bones**. Not all the carpal bones of the proximal row are in continual contact with the socket-shaped articular facet of the radius and the disk. The *triquetrum* (**3**), only makes close contact with the disk during ulnar abduction and loses contact on radial abduction.

The **capsule** of the wrist joint is lax, dorsally relatively thin, and is reinforced by numerous ligaments. The joint space is unbranched and sometimes contains *synovial folds*. Often the wrist joint is in continuity with the midcarpal joint.

The **midcarpal joint** is formed by the **proximal** and **distal row of carpal bones** and has an S-shaped joint space. Each row of carpal bones can be considered as a single articular body, and they interlock with each other. Although there is a certain limited degree of mobility between members of the proximal row of carpal bones, this is not true of the distal row because they are joined one to another (**4**), as well as to the metacarpal bones by strong ligaments. Thus, the distal row of carpal bones and the metacarpals form a functional entity.

The **joint capsule** is tense on the palmar surface and lax dorsally. The joint space is branched and has connections with the radiocarpal joint, and around the *trapezium* (**5**) and *trapezoid* (**6**) there are also connections with adjacent carpometacarpal joints.

Sometimes the joint space contains numerous *synovial folds* (**7**). The space between the lunate and triquetrum and the capitate and hamate is padded by synovial folds which may be visible in radiographs.

Ligaments in the Region of the Wrist (A–E)

Four groups of ligaments can be distinguished:

Ligaments which unite the forearm bones with the carpal bones (violet). These include the *ulnar collateral ligament* (**8**), the *radial collateral ligament* (**9**), the *palmar radiocarpal ligament* (**10**), the *dorsal radiocarpal ligament* (**11**), and the *palmar ulnocarpal ligament* (**12**).

Ligaments which unite the carpal bones with one another, or **intercarpal ligaments** (red). These comprise the *radiate carpal ligament* (**13**), the *pisohamate ligament* (**14**), and the *palmar intercarpal* (**15**), *dorsal intercarpal* (**16**), and *interosseous intercarpal ligaments* (**4**).

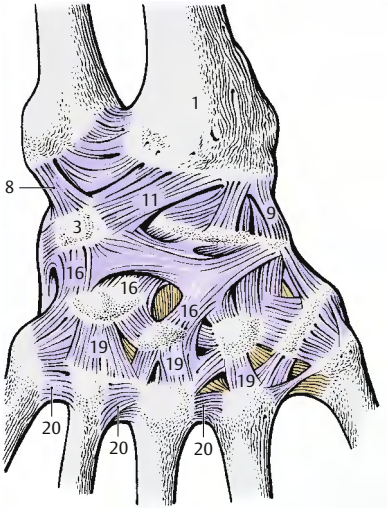
Ligaments between the carpal and metacarpal bones, or **carpometacarpal ligaments** (blue). To this group belongs the *pisometacarpal ligament* (**17**), the *palmar carpometacarpal ligaments* (**18**), and the *dorsal carpometacarpal ligaments* (**19**).

Ligaments between the metacarpal bones, or **metacarpal ligaments** (yellow). These are organized into *dorsal* (**20**), *interosseous* (**21**), and *palmar* (**22**) *metacarpal ligaments*.

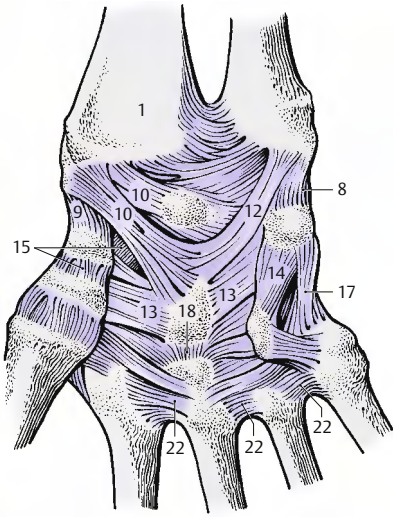
Almost all of these ligaments strengthen the joint capsules and partly guide the movements of the joints of hand.

The joints between the carpal bones of a row are designated as **intercarpal joints**. Only the joint between the triquetrum and the *pisiform*, the **pisiform joint** deserves special attention.

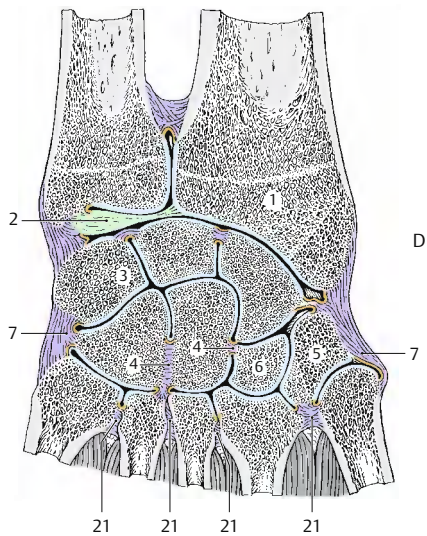
Clinical tip: Several more ligaments are described in hand surgery. They are important in cases of surgical intervention.



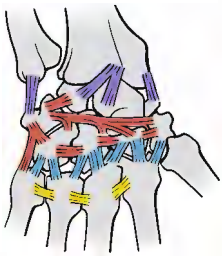
A Ligaments of right wrist, dorsal surface



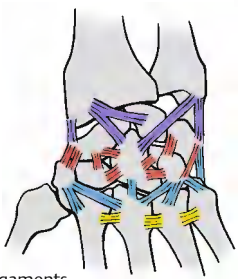
B Ligaments of right wrist, palmar surface



C Section through right wrist, dorsal view



D Diagram of ligaments of right wrist, dorsal surface



E Diagram of ligaments of right wrist, palmar surface

Shoulder Muscles Inserted on the Humerus

Dorsal Muscle Group, continued (A–D)

Insertion on the lesser tubercle and its crest subscapularis, teres major and latissimus dorsi

The **subscapularis** (**1**) arises in the *subscapular fossa* (**2**) *and is inserted on the lesser tubercle* (**3**) *and the proximal part of its crest*. Near to its attachment between the subscapularis and the joint capsule occurs the subtendinous bursa of the *subscapularis* (**4**), and between it and the base of the coracoid process lies the *subcoracoid bursa* (**5**). Both bursae are connected with the joint space. It produces medial (internal) rotation of the arm.
Nerve supply: subscapular nerve (C5–C8).

Variant: The occurrence of accessory bundles.

Clinical tip: Paralysis of the subscapularis produces maximal lateral (external) rotation of the upper limb, which indicates that it is a particularly strong medial rotator of the arm.
The term **"rotator cuff"** is often incorrectly used for the subscapularis, supraspinatus (**6**), infraspinatus (**7**), and teres minor (**8**) muscles. It is more correct to use the term "muscle-tendon cuff" or "tendon hood."

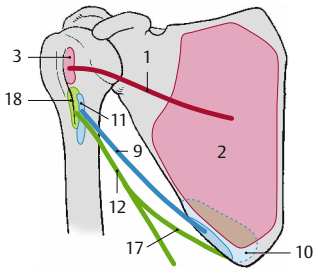
The **teres major** (**9**), which *arises from the lateral border* (**10**) *of the scapula near the inferior angle, is inserted on the crest of the lesser tubercle* (**11**), near the subtendinous bursa of the teres major. Its main function is retroversion of the arm toward the midline, a movement requiring retroversion and simultaneously a small medial rotation. It is particularly prominent if the arm has previously been anteverted and slightly abducted. The muscle also helps in adduction.
Nerve supply: thoracodorsal nerve (C6–C7).

Variant: Fusion with the latissimus dorsi or complete absence of the muscle.

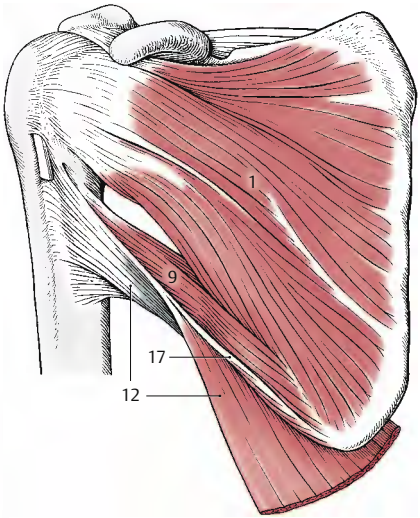
The **latissimus dorsi** (**12**) is broad and flat, and is the largest muscle in humans. *It arises from the spinous processes of the seventh to twelfth thoracic vertebrae* (**13**) as the **vertebral part**, from the *thoracolumbar fascia* (**14**) *and the posterior third of the iliac crest* (**15**) as the **iliac part**, *from the 10th– 12th ribs* (**16**) as the **costal part**, and, in addition, very often from the *inferior angle of the scapula* as the **scapular part** (**17**). The latissimus dorsi thus usually arises in four parts which have different functions. It develops embryologically with the teres major, with which it is inserted on the *crest of the lesser tubercle* (**18**). The subtendinous bursa of the latissimus dorsi lies immediately before the junction of both muscles. The latissimus dorsi provides the muscular basis of the posterior axillary fold. It lowers the raised arm and adducts it. When the arm is adducted, it pulls it backward and medially, and rotates it so far medially that the back of the hand can cover the buttock. The latissimus dorsi is often called the "dress coat pocket" muscle. Both latissimi can act together to pull the shoulders backward and downward. They function, too, during forced expiration and in coughing (coughing muscle).
Nerve supply: thoracodorsal nerve (C6–C8).

Variant: The occurrence of aberrant muscle fibers that run into the pectoralis major as a muscular arch across the axilla.

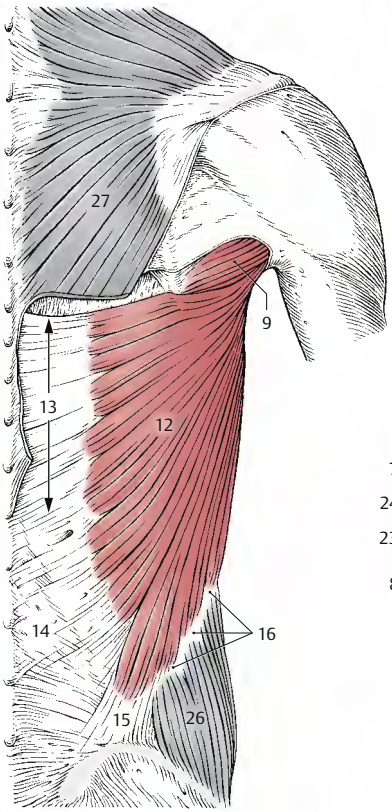
19 Long head of triceps muscle
20 Long head of biceps muscle
21 Coracoacromial ligament
22 Glenoid cavity
23 Glenoid lip
24 Joint capsule
25 Bursa of supraspinatus muscle
26 External oblique abdominal muscle
27 Trapezius muscle (partly resected)



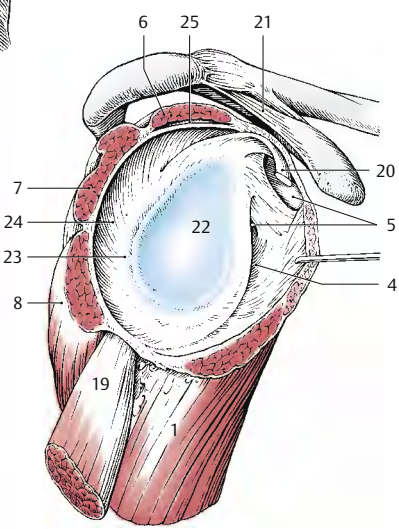
D Diagram of origin, course, and insertion of muscles



A Anterior view of dorsal shoulder muscles inserting on the lesser tubercle and its crest



B Posterior view of latissimus dorsi muscle



C Muscle-tendon cuff

Function of the Shoulder Girdle Muscles, continued (A–D)

The muscles which produce **Anteversion** (flexion; **A**) include
- The clavicular and some of the acromial fibers of the deltoid (red, pectoral branches and axillary nerve)
- The biceps brachii (blue, musculocutaneous nerve, see p. 154)
- The pectoralis major (yellow, pectoral nerves)
- The coracobrachialis (orange, musculocutaneous nerve)
- The serratus anterior (green, long thoracic nerve)

Clinical tip: Anteversion is still possible in paralysis of the serratus anterior, but it is accompanied by marked elevation of the scapula from the thoracic wall (winged scapula).

Retroversion (extension; **B**) is brought about by
- The teres major (red, thoracodorsal nerve)
- The latissimus dorsi (blue, thoracodorsal nerve)
- The long head of the triceps brachii (yellow, radial nerve)
- The deltoid (orange, axillary nerve)

There is always some associated movement at the acromioclavicular joint.

Lateral (external) rotation (**C**) is produced by
- The infraspinatus (red, suprascapular nerve),
  the teres minor (blue, axillary nerve)
- The spinal part of the deltoid (yellow, axillary nerve)

The strongest lateral rotator, the infraspinatus, performs much more work than all the others combined. With lateral rotation, the scapula and clavicle are simultaneously pulled backward by the trapezius and rhomboid muscles. Thus, this action also involves movements at the sternoclavicular and acromioclavicular joints.

Clinical tip: During sudden lateral rotation, the antagonistic pulling force of the most powerful medial rotator, the subscapularis, may result in avulsion of the lesser tubercle.

Medial (internal) rotation (**D**) is carried out by
- The subscapularis (red, subscapular nerve)
- The pectoralis major (blue, pectoral nerves)
- The long head of the biceps (yellow, musculocutaneous nerve)
- The clavicular part of the deltoid (orange, pectoral branches)
- The teres major (green, thoracodorsal nerve)
- The latissimus dorsi (brown, thoracodorsal nerve)

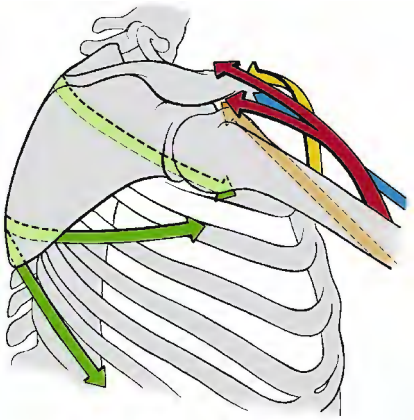
By far the strongest action is produced by the subscapularis and the weakest by the latissimus dorsi. When the elbow is extended, the short head of the biceps (not illustrated) also contributes slightly.

The cited movements, however, do not occur exclusively at the shoulder joint. In the living person, an associated movement of the shoulder girdle always takes place, as well as that of the trunk with certain movements.

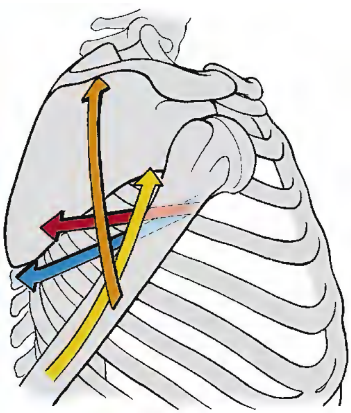
The color of the arrows shows the order of importance of the muscles in the individual movements:

red
blue
yellow
orange
green
brown

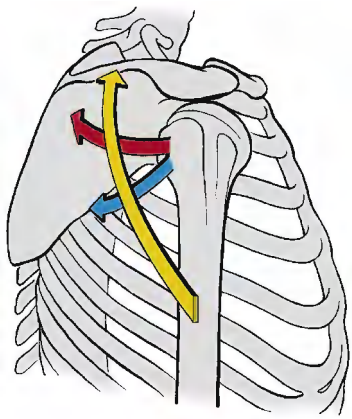
A–D
Function of the shoulder girdle muscles (continued)



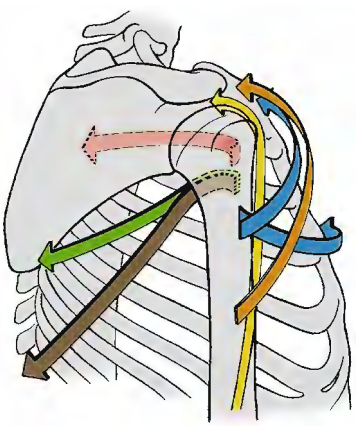
A Anteversion



B Retroversion



C Lateral rotation



D Medial rotation

Muscles of the Forearm

Classification of the Muscles (A–D)

The forearm muscles are divided into three groups according to their relationship to the various joints, their attachments and their mode of action.

- **The first group** comprises muscles attached to the radius, which are only involved in movements of the bones of the forearm.
- **The second group** of forearm muscles extends to the metacarpus and produces movement at the wrist.
- **The third group** comprises those muscles that extend to the phalanges and are responsible for finger movements.

Another system of classification is based on the position of the muscles in relation to each other. The ulna and radius with the interosseous membrane separate a ventral muscle group, the flexors, from a dorsal group of extensors. Connective tissue septa between the ventral and dorsal muscles separate a radial group. The flexors and extensors can be divided into superficial and deep muscles.

Finally, the muscles of the forearm may also be divided into two groups according to their innervation—from either the ventral or dorsal portions of the plexus.

From the practical point of view, the muscles will be classified according to their positions relative to one another. This also provides the most comprehensive functional subdivision.

Ventral Group of Forearm Muscles

Superficial Layer (see p. 160)

- Pronator teres (**1**)
- Flexor digitorum superficialis (**2**)
- Flexor carpi radialis (**3**)
- Palmaris longus (**4**)
- Flexor carpi ulnaris (**5**)

Deep Layer (see p. 162)

- Pronator quadratus (**6**)
- Flexor digitorum profundus (**7**)
- Flexor pollicis longus (**8**)

Radial Group of Forearm Muscles (see p. 164)

- Extensor carpi radialis brevis (**9**)
- Extensor carpi radialis longus (**10**)
- Brachioradialis (**11**)

Dorsal Group of Forearm Muscles

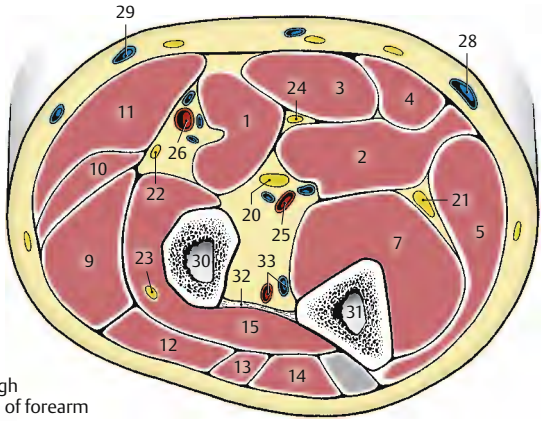
Superficial Layer (see p. 166)

- Extensor digitorum (**12**)
- Extensor digiti minimi (**13**)
- Extensor carpi ulnaris (**14**).

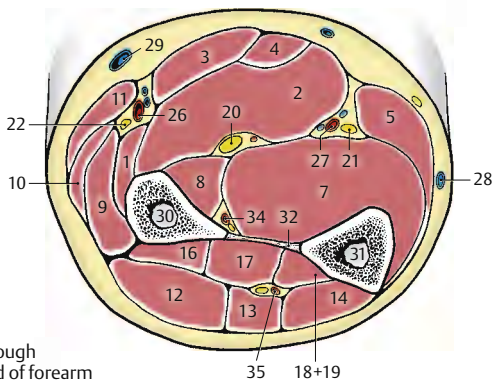
Deep Layer (see p. 168)

- Supinator (**15**)
- Abductor pollicis longus (**16**)
- Extensor pollicis brevis (**17**)
- Extensor pollicis longus (**18**)
- Extensor indicis (**19**)

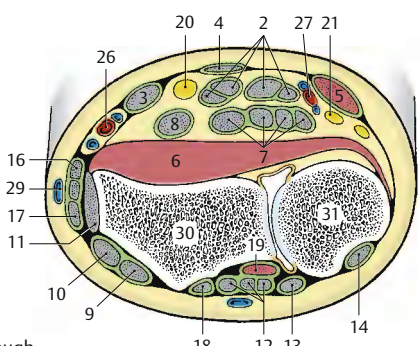
20 Median nerve
21 Ulnar nerve
22 Superficial branch of radial nerve
23 Deep branch of radial nerve
24 Muscular branch of median nerve
25 Brachialis artery
26 Radial artery
27 Ulnar artery
28 Basilic vein
29 Cephalic vein
30 Radius
31 Ulna
32 Interosseous membrane
33 Common interosseous artery and vein
34 Anterior interosseous artery
35 Posterior interosseous artery



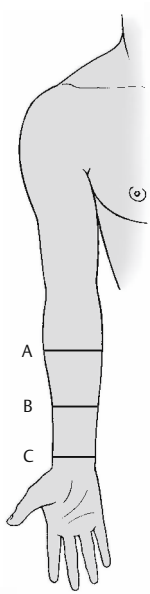
A Section through proximal third of forearm



B Section through middle third of forearm



C Section through distal third of forearm



D Planes of the section