BONE

BIOMECHANICS OF THE SHOULDERS AND UPPER LIMBS

Kenneth Alonso, MD, FACP

Pectoral girdle

- The pectoral girdle extends from the acromo-clavicular joint through the sterno-clavicular joint, the sternum, and terminates in the opposite acromo-clavicular joint.
- Anterior rami of spinal roots C5-T1 course through the pectoral girdle to terminate in the axilla.
- In the posterior triangle of the neck, the roots of C5 and C6 join to form the upper trunk of the brachial plexus; C8 and T1, the lower trunk.

Sterno-clavicular joint

- The sterno-clavicular joint is the most frequently moved non-axial joint of the body as almost any movement of the upper extremity is transferred proximally to this joint.
- The joint also has the least amount of bony stability of any major joint because less than half of the medial end of the clavicle actually articulates with the upper sternum.
- Functional saddle joint.
- Joint stability depends on the integrity of the surrounding ligaments.
- Dislocations are uncommon.

Clavicle

- The clavicle functions as a strut, connecting the shoulder girdle to the trunk, and provides support and mobility for upper extremity function.
- The clavicle also protects the adjacent lung, brachial plexus, and subclavian and brachial blood vessels.
- The majority of injuries to this area are simple sprains.
- The most common mechanism of injury is a blow to the shoulder.
- A sprain of the sterno-clavicular joint can result from the shoulder being forced forward suddenly or from a medially directed force applied to the shoulder.

Clavicle

- Clavicle fractures account for nearly half of significant injuries to the shoulder girdle and are the most common fracture of early childhood.
- Eighty percent of clavicle fractures involve the middle third, 15 percent the distal third, and 5 percent the medial third.
- Distal clavicle fractures with displacement typically are associated with rupture of the coraco-clavicular ligament and may require operative intervention to avoid nonunion.
- Medial clavicle fractures may be associated with intra-thoracic injuries.

Shoulder anatomy

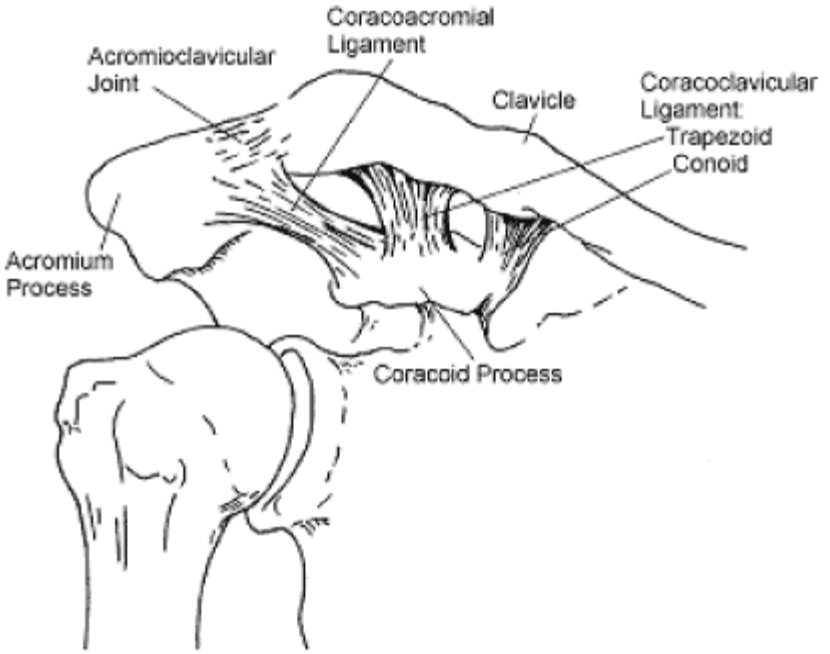


Fig. 271-2 Accessed 05/05/2010

Shoulder

- The scapula links the axial skeleton to the upper extremity and serves as a stabilizing platform for motion of the arm.
- Fracture of the scapula is infrequent.
- The acromio-clavicular joint is a diarthrodial joint (ball and socket) that, together with the sterno-clavicular joint, connects the upper extremity to the axial skeleton.
- The support of the acromio-clavicular joint is through the acromio-clavicular and coraco-clavicular ligaments and the strong attachment of the trapezius and deltoid muscles.

Shoulder

- Tendons of the rotator cuff muscles are major support to shoulder.
- The quadrangular space of the shoulder is bounded by the long head of the triceps, humerus, teres major and teres minor muscles.
- The posterior humeral circumflex artery and axillary nerve run through that space.
- The triangular space of the shoulder is bounded by the teres major and minor muscles as well as the long head of the triceps.
- A branch of the circumflex scapular artery runs through the space.

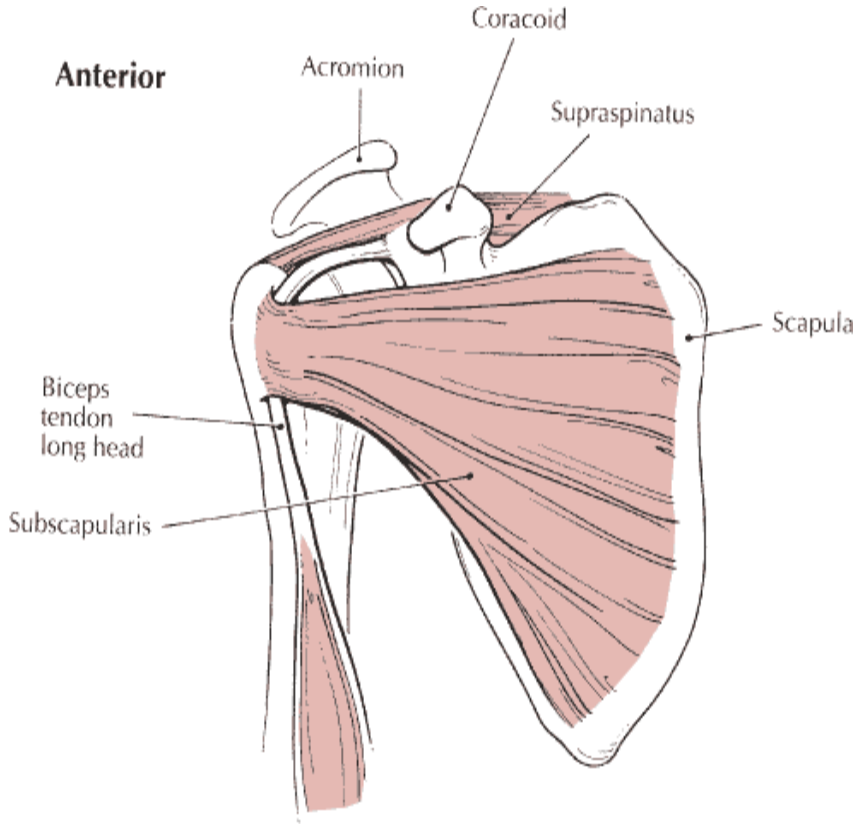
Rotator cuff

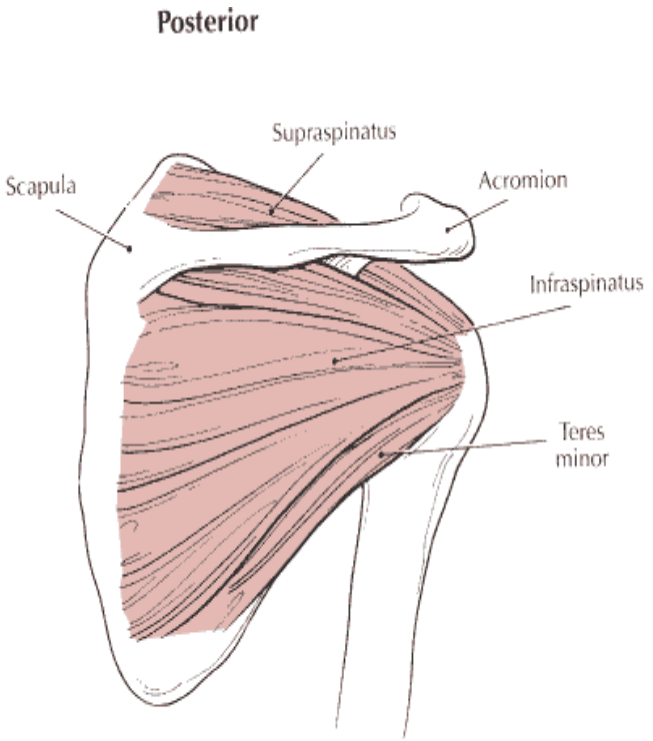
- Along with the pectoralis, the deltoid is the major mover of the upper extremity.
- The deltoid acts as a powerful and independent elevator of the arm.
- The anterior part of the deltoid flexes and medially rotates the arm.
- The middle part abducts the arm.
- The posterior part extends and laterally rotates the arm.
- The rotator cuff functions primarily as a dynamic stabilizer of the gleno-humeral joint.

Rotator cuff

- The rotator cuff muscles also contribute significantly to the power of the upper extremity
- Providing 30 to 50 percent of the power in abduction and 90 percent in external rotation.
- The rotator cuff consists of the four muscles: supraspinatus, infraspinatus, teres minor, and subscapularis.
- All originate on the scapula, traverse the gleno-humeral joint, and insert on the proximal humerus.
- During arm elevation, the tendon of the long head of the biceps depresses the humeral head, helping it remain centered in the glenoid.

Rotator cuff





Source: Tintinalli JE, Kelen GD, Stapczynski JS: *Tintinalli's Emergency Medicine: A Comprehensive Study Guide*, 6th Edition: http://www.accessemergencymedicine.com

Source: Tintinalli JE, Kelen GD, Stapczynski JS: *Tintinalli's Emergency Medicine: A Comprehensive Study Guide*, 6th Edition: http://www.accessemergencymedicine.com

Fig. 283-1and 283-2 Accessed 05/05/2010

Rotator cuff muscles

- The supraspinatus originates on the posterior and superior aspect of the scapula, passes beneath the acromion, and inserts on the great tuberosity of the humerus.
- It initiates arm elevation and (with the deltoid) abducts the shoulder.
- Its principal function is to balance the power of the deltoid, keeping the humerus centered in the glenoid during deltoid contraction.

Rotator cuff muscles

- The infraspinatus originates on the posterior scapula just inferior to the scapular spine.
- It inserts on the posterior aspect of the greater tuberosity and acts primarily as a lateral rotator of the arm.

Rotator cuff muscles

- The teres minor originates on the lateral border of the scapula just inferior to the infraspinatus and inserts on the posterior aspect of the humerus.
- It works with the infraspinatus to provide lateral rotation and to assist in maintaining the humeral head in the glenoid cavity of the scapula.

Rotator cuff muscles

- The subscapularis is the only rotator cuff muscle that arises from the anterior aspect of the scapula.
- It attaches to the lesser tuberosity of the humerus and medially roates and adducts the arm.
- It helps hold the humeral head in the glenoid cavity. Innervated by upper and lower subcapsular nerves.

Rotator cuff muscles

- The teres major adducts and medially rotates the arm.
- The long head of the biceps tendon, although not formally considered part of the rotator cuff, assists in rotator cuff function.
- This tendon courses superiorly in the bicipital groove of the humerus between the greater and lesser tuberosities, passes between the subscapularis and supraspinatus tendons, and penetrates the glenohumeral joint to insert on the labrum.

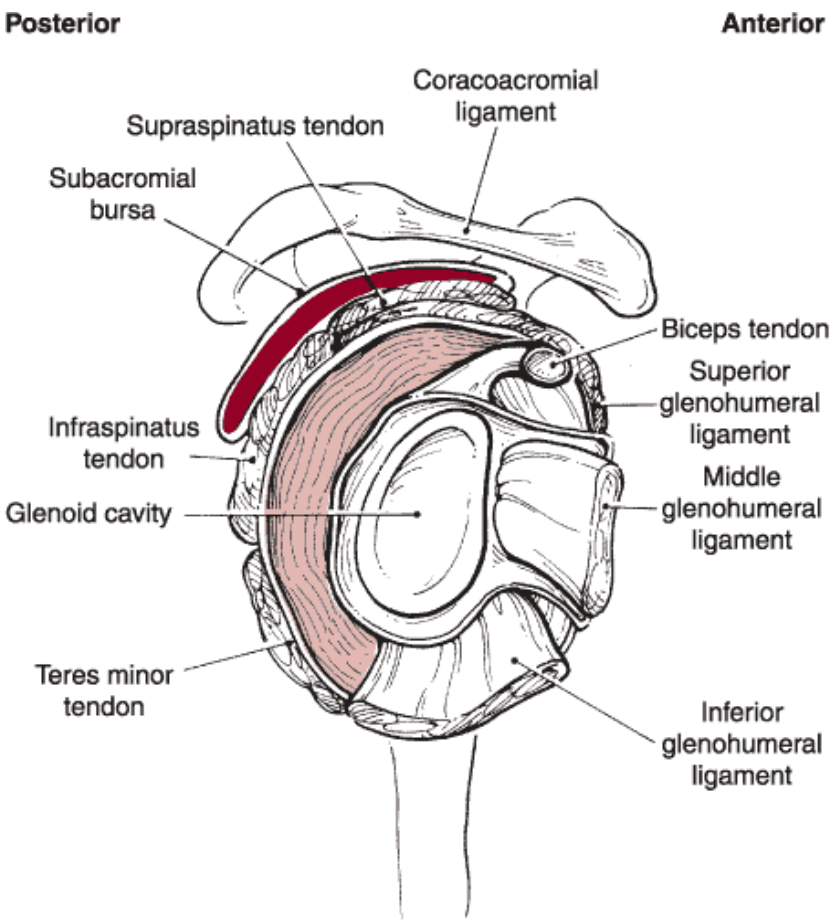
Rotator cuff injury

- Partial-thickness tears are twice as common as full-thickness tears and most commonly occur on the inferior aspect of the tendon.
- Partial-thickness rotator cuff tears are more likely to occur from an acute injury, especially in younger patients.
- The supraspinatus, due to its location within the coraco-acromial arch, is the most commonly affected tendon of the rotator cuff.

Rotator cuff injury

- Repetitive overhead use of the arm or movement of the shoulder above the horizontal causes encroachment of the sub-acromial space by the humeral head.
- This results in a loss of the normal gliding mechanism between the rotator cuff and related soft tissues within the coraco-acromial arch.
- Impingement syndrome refers to the pathologic changes that occur to the rotator cuff, sub-acromial bursa, and other soft tissues within the coraco-acromial arch due to this repetitive compression.

Coraco-acromial arch



Source: Tintinalli JE, Kelen GD, Stapczynski JS: *Tintinalli's Emergency Medicine: A Comprehensive Study Guide*, 6th Edition: http://www.accessemergencymedicine.com

Fig. 283-3 Accessed 05/05/2010

Shoulder

- All muscles of the shoulder are innervated by C5-C6.
- The clavicular part of the pectoralis major and the anterior part of the deltoid flexes the shoulder from a pendent position.
- From a fully extended position, the sternocostal head of the pectoralis major is the major force.
- The posterior part of the deltoid extends the shoulder from a pendent position.
- From a fully flexed position, the latissimus dorsi, the sternocostal head of the pectoralis major, and the long head of the triceps are the major force.

Shoulder

- The deltoid abducts the shoulder from a pendent position. The supraspinatus is important in initiating movement, leading to an upward rotation of the scapula.
- The pectoralis major and the latissimus dorsi adduct the shoulder from a pendent position.
- The subscapularis rotates the shoulder medially; the infraspinatus, laterally.
- With the arm elevated, the pectoralis major, deltoid (anterior fibers), and latissimus dorsi rotate the shoulder medially; the teres minor and the deltoid (posterior fibers), laterally.

Shoulder

- The mechanism of injury is usually direct trauma to the acromio-clavicular joint from a fall with the arm adducted.
- An indirect mechanism is a fall on the outstretched hand with transmission of force to the acromio-clavicular joint.
- The result is that the scapula and shoulder girdle are driven inferiorly while the clavicle remains in its normal position.

Shoulder

- Anterior dislocations of the gleno-humeral joint are the most common major joint dislocations.
- The patient is usually in severe pain.
- The arm is in slight abduction and external rotation.
- The shoulder is "squared off," lacking the normal rounded contour.
- The patient resists abduction and internal rotation.
- The combination of abduction, extension, and external rotation with sufficient force will cause an anterior dislocation.

Shoulder

- In sub-coracoid dislocation, the most common type, the humeral head is displaced anterior to the glenoid and inferior to the coracoid.
- In a subglenoid dislocation, the humeral head lies inferior and anterior to the glenoid fossa.
- In a subclavicular dislocation, the head of the humerus is displaced medial to the coracoid below the clavicle.

Examination of the shoulder

- Shoulder instability is best diagnosed by the presence of anterior release (positive likelihood ratio, LR+, 8.3; LR-, 0.1). Relocation of the shoulder has an LR+ of 6.5; LR-, 0.2.
- Lateral injury is best diagnosed by abnormalities in biceps loading. LR+, 29, while LR- is 0.1.
- There is no single test that evaluates well posterior injury.
- Traumatic injuries are usually unidirectional and require surgical repair.
- Atraumatic injuries are multidirectional, often bilateral, and are best rehabilitated (rotator cuff exercises, for example).

Lesions causing shoulder instability

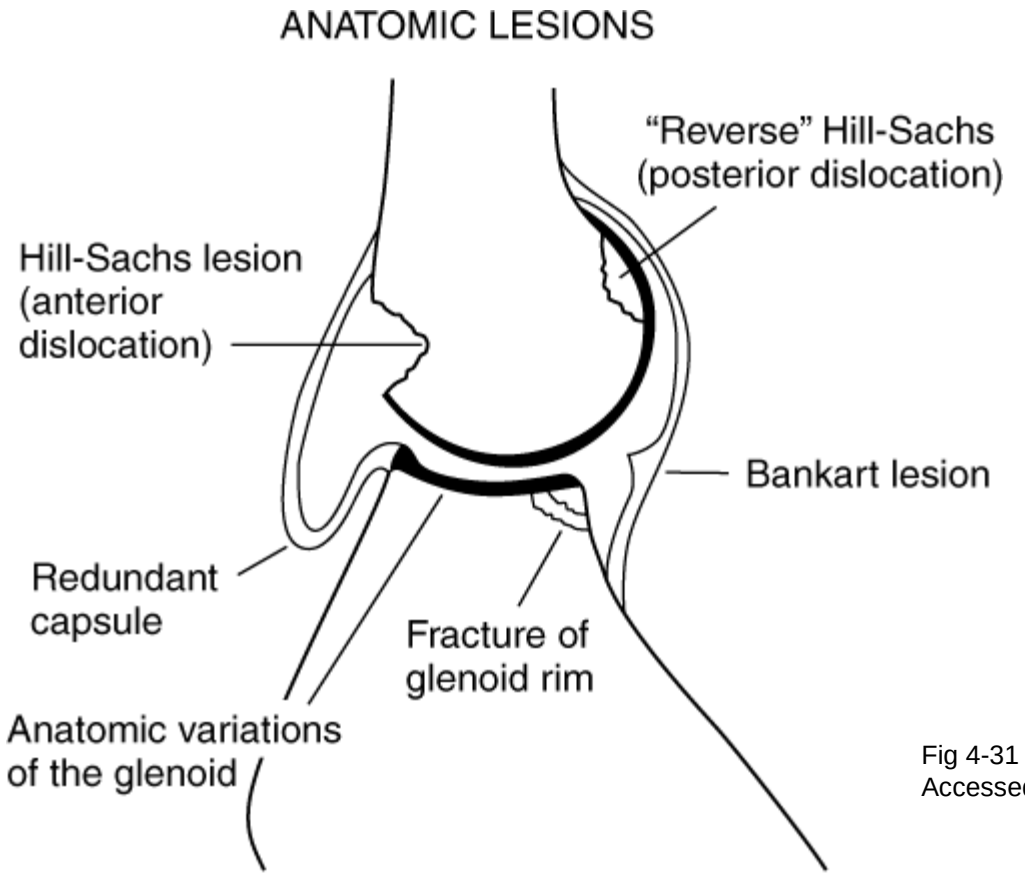


Fig 4-31
Accessed 09/21/2010

Axilla

- Anteriorly the axilla is bordered by the pectoralis major and minor as well as the subclavius muscles.
- The lateral border is the bicipital groove.
- Posteriorly are located the latissimus dorsi, teres major, and subscapularis muscles.
- The medial border is the serratus anterior muscle and the upper five ribs with their intercostal muscles.
- The base of the axilla is the axillary fascia.
- At the apex are the clavicle, first rib, and the coracoid process.

Anterior appendicular muscles

- The pectoralis major adducts and medially rotates the humerus.
- The clavicular head fixes the humerus and the sternocostal head extends it from the flexed position. It draws the scapula anteriorly and inferiorly.
- In Polard's syndrome, it is lost.

Anterior appendicular muscles

- The pectoralis minor stabilizes the scapula by drawing it inferiorly and anteriorly against the thoracic wall.
- The subclavius anchors and depresses the clavicle.
- The serratus anterior protracts the scapula and holds it against the thoracic wall. It rotates the scapula.
- Winged scapula results from T1 injury.

Superficial posterior axio-appendicular muscles

- Superior fibers of the trapezius elevate the scapula (when squaring the shoulders).
- Middle fibers retract the scapula (posteriorly).
- Inferior fibers depress the scapula and lower the shoulder.
- Both superior and inferior fibers act together in rotating the scapula on the thoracic wall. Superior and medial fibers brace the shoulder, fixing the scapula.
- The latissimus dorsi extend, adduct, and medially rotate the humerus. It raises the body toward the arms during climbing.

Deep posterior axio-appendicular muscles

- The levator scapulae elevate the scapula and tilts its glenoid cavity inferiorly by rotating the scapula.
- The rhomboid major and minor muscles retract the scapula and rotate it to depress the glenoid cavity. They fix the scapula to the thoracic wall.

Brachial plexus

- As the brachial plexus descends to the axilla through the pectoral girdle, the upper and lower trunks contribute to the middle trunk (C7) to form the posterior cord of the brachial plexus, while the middle trunk contributes to the upper trunk to form the lateral cord of the brachial plexus.
- The lower trunk receives no contribution from the other trunks and continues as the medial cord of the brachial plexus.
- The phrenic (C3-C5) and long thoracic nerves (C5-C7) arise from cervical ventral rami.

Brachial plexus

- The upper trunk gives rise to the suprascapular nerve and the nerve to the subclavius (C5-C6).
- The posterior cord gives rise to axillary and radial nerves (C5-T1). The upper and lower subscapular as well as the thoraco-dorsal nerves arise from the posterior cord.
- The medial cord gives off a medial root which joins with a lateral root from the lateral cord to give rise to the median nerve (C5-T1). The medial pectoral, medial brachial and antebrachial nerves arise from the medial cord.

Brachial plexus

- The ulnar nerve arises from the medial cord (C7-T1).
- The musculocutaneous nerve arises from the lateral cord (C5-C7).

Brachial plexus injury

- Winged scapula.
- The long thoracic nerve innervates the serratus anterior. The muscle fixes the scapula against the chest wall. Fixation is lost if the nerve is damaged.
- Erb-Duchenne palsy.
- Injury to the musculoskeletal nerve (usually at parturition if the head is pulled away from shoulder).
- There is a deficit in abduction (deltoid), lateral rotation (infraspinatus and teres minor) and supination (biceps).
- The hand and wrist are in the position of discreetly awaiting a tip.

Brachial plexus injury

- Klumpke palsy.
- Injury to the ulnar nerve (usually at parturition when head is extracted, rotated, and arm extended).
- There is flexion and supination of the elbow, extension of the wrist, hyperextension of the metacarpophalangeal joints, and flexion of the interphalangeal joints with the “claw hand” posture.
- Usually manifests in the newborn period as weakness restricted to or mainly involving the hand. There may be no reflex or spontaneous movements of the intrinsic hand muscles.

Muscles of the arm

- The biceps brachii supinate the forearm, and, when supine, flexes the forearm. The short head resists dislocation of the shoulder. (Musculocutaneous nerve injury inhibits flexion.)
- The brachialis flexes the forearm in all positions.
- The coracobrachialis helps flex and adduct the arm. It resists dislocation of the shoulder.
- The triceps brachii is the chief extensor of the forearm.
- The long head resists dislocation of the humerus, particularly during abduction.
- The anconeus assists the triceps in extending the forearm. It stabilizes the elbow and may abduct the ulna during pronation.

Humerus

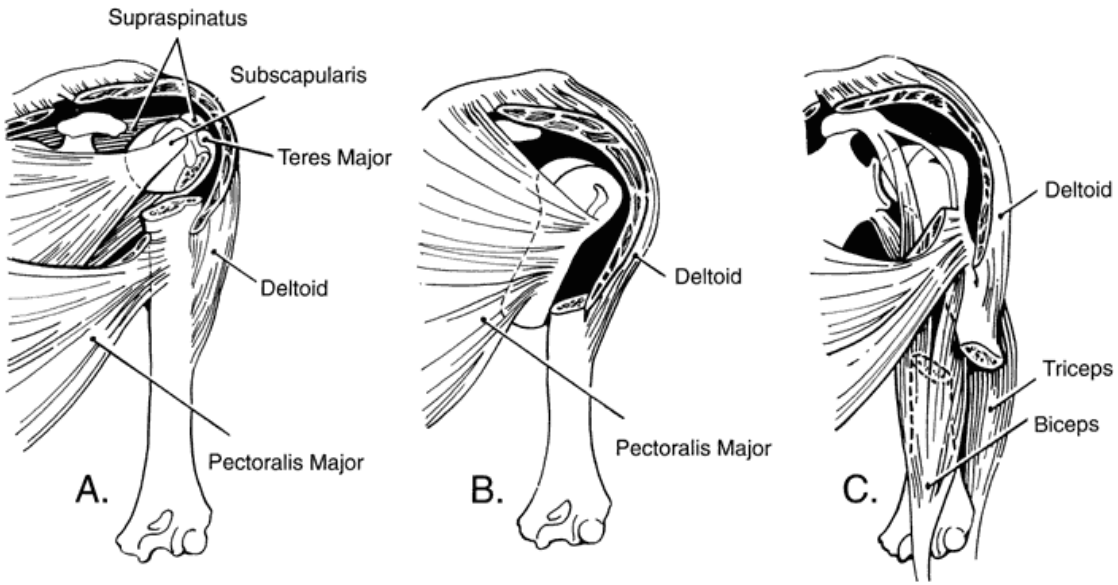
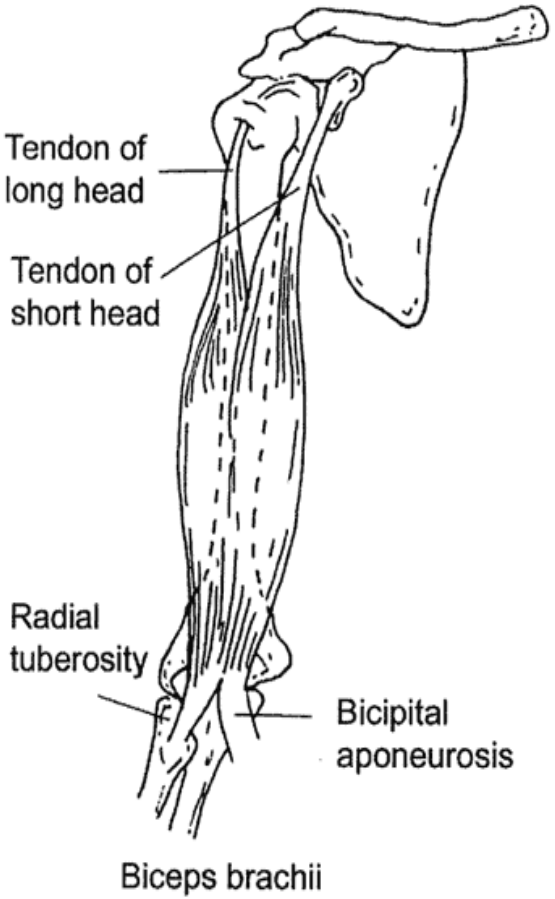


Fig. 271-9 Accessed 05/05/2010

The actions of the muscles inserting on the humeral shaft determine fracture angulation and displacement. Humeral fractures anterior view:
A. Angulation of fragments with fracture line distal to rotator cuff insertion.
B. Angulation of fragments with fracture line distal to pectoralis major insertion.
C. Angulation of fragments with fracture line distal to deltoid insertion.

Anatomy of the arm



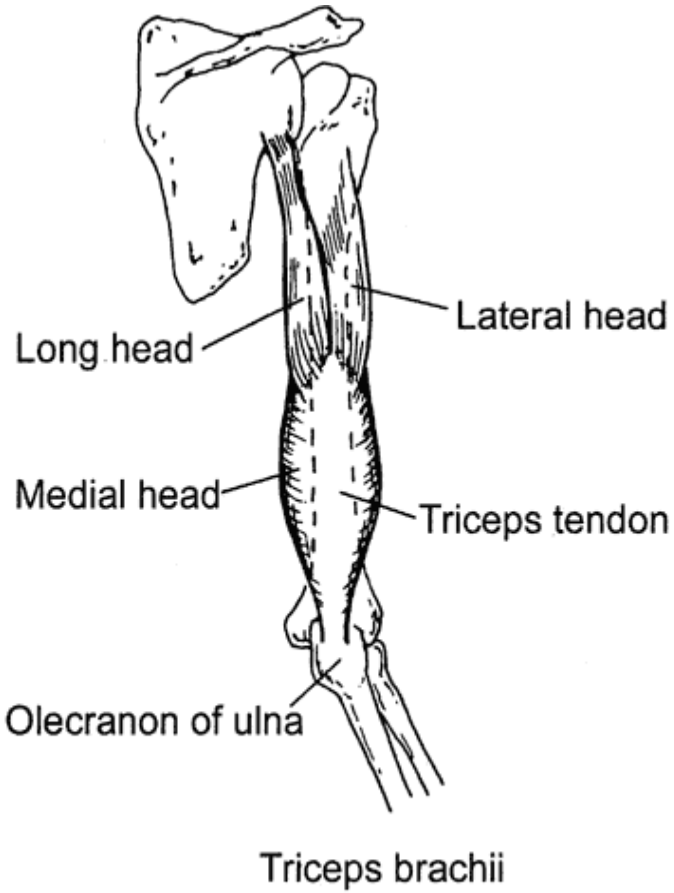


Fig. 270-10 and 270-11 Accessed 05/05/2010

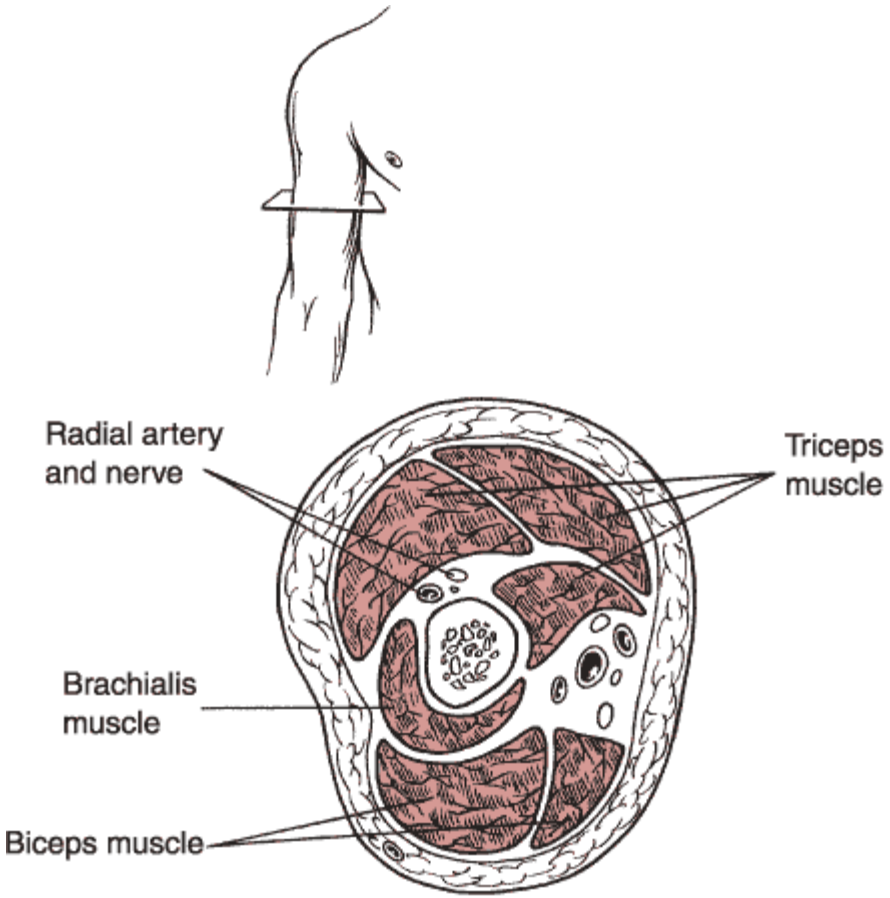
Arm

- The vast majority of all injuries to the biceps are proximal, and nearly all involve the proximal long head.
- Injuries are usually the result of repetitive microtrauma and overuse.
- Injury to the triceps is rare and almost always occurs distally.
- Rupture is more common in young men and results from either a fall on an outstretched hand causing a forceful flexion of an extended forearm, or a direct blow to the olecranon.

Fracture of the humerus

- Fracture of the surgical neck of the humerus injures the axillary nerve.
- Deltoid is affected.
- There is loss of arm abduction.
- Spiral fracture of the midshaft injures the radial nerve.
- Wrist drop and limited elbow extension are noted.

Compartments



Source: Tintinalli JE, Kelen GD, Stapczynski JS: *Tintinalli's Emergency Medicine: A Comprehensive Study Guide*, 6th Edition: http://www.accessemergencymedicine.com

Fig. 278-1 Accessed 05/05/2010

Anatomy of the elbow

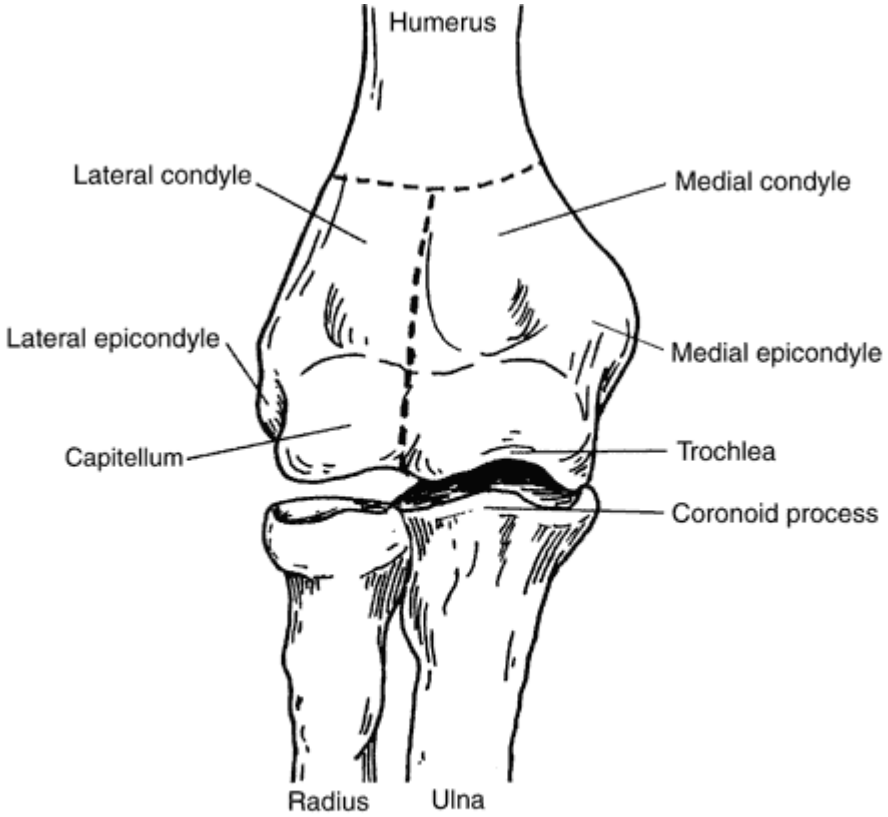


Fig. 270-7 Accessed 05/05/2010

Anatomy of the elbow

- Hinge joint between trochlea of humerus and trochlear notch of ulna.
- Head of radius articulates with capitulum.
- Annular ligament forms about head of radius.

Distal humerus and elbow

- Lateral epicondyle fractures almost never occur.
- Isolated medial epicondyle fractures are considered extra-articular injuries and usually occur in children and adolescents.
- Mechanisms include a posterior elbow dislocation, repeated valgus stress, such as throwing a baseball ("Little League elbow"), or a direct blow.
- Lateral condyle fractures occur in children.
- They result from a direct blow to the lateral elbow or from varus stress with the forearm extended, as in a fall on an outstretched hand.

Distal humerus and elbow

- Medial condyle fractures are not common.
- Ulnar nerve injury. “Claw hand.”
- Radial head fractures are the most common fractures of the elbow.
- They result from a fall on an outstretched hand causing the radial head to be driven into the capitellum.

Distal humerus and elbow

- The olecranon is usually fractured by direct trauma, or by a fall on an outstretched hand with the elbow in flexion.
- Associated injuries are common, including open wounds, dislocations, other fractures (especially of the radial head), and ulnar nerve injury.

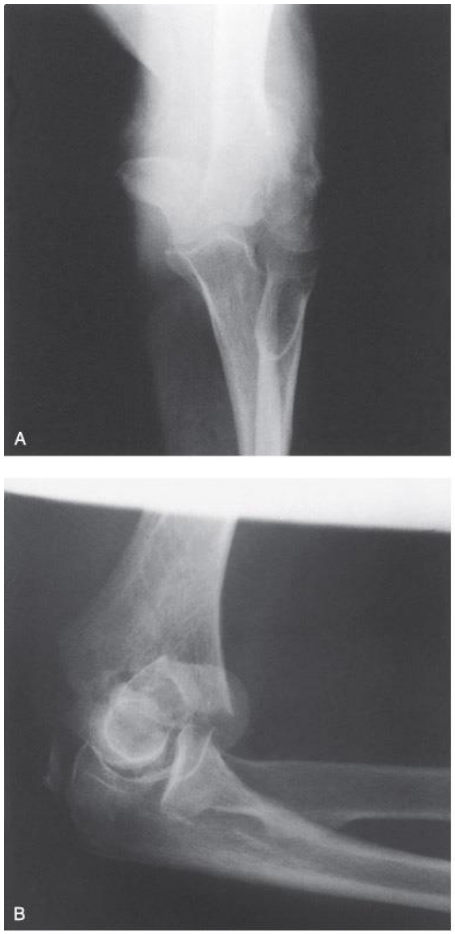
Inflammation of the elbow

- Swelling, inflammation, tearing of extensor tendon (lateral epicondyle) is called tennis elbow.
- At the medial epicondyle, it is called pitcher's or golfer's elbow.
- The apophysis of the medial condyle is the last of the growth plates to close at the elbow (age 18-19 years).
- Inflammation of the olecranon bursa is called student's, draftsman's, or miner's elbow.
- Nursemaid's elbow is associated with dislocation of the elbow (held fixed at a right angle).

Elbow injury

- The elbow with its ulno-humeral articulation is one of the most stable joints in the body.
- Inherent stability in the flexion-extension plane is augmented by the muscular attachments and collateral ligaments.
- The vast majority of elbow dislocations are posterior.
- The mechanism of injury is usually due to a fall on the outstretched hand.
- Presents with the elbow in 45 degrees of flexion.
- Radiographs may reveal a fat-pad sign in undisplaced fractures.

Dislocation of the elbow



Figs. 270-1 and 270-4 Accessed 05/05/2010

Posterior. (A) Intercondylar. (B) Any distal humerus fracture in an adult should initially be assumed to be intercondylar rather than supracondylar .

Anterior and posterior fat pad signs

Fig. 270-5 Accessed 05/05/2010

Elbow injury

- The mechanism of an intercondylar injury is a force directed against the posterior elbow, driving the olecranon against the humeral articular surface, separating the condyles and producing the typical fracture.
- These fractures are associated with severe soft-tissue injuries.

Elbow injury

- Supracondylar fractures of the humerus account for 60 percent of all fractures of the elbow in children.
- Ninety-five percent of these extra-articular fractures are displaced posteriorly as a result of an extension force.
- When the mechanism of injury is due to a flexion force, the much less common anterior displacement occurs.

Elbow injury

- In an extension-type fracture, the patient will have significant edema and tenderness at the elbow.
- The olecranon is prominent, and there is a depression proximally over the area of the triceps muscle.
- This appearance may be easily mistaken for a posterior elbow dislocation.
- Acute vascular injuries must always be suspected in patients with supracondylar fractures.
- Absence of a radial pulse is common in children. This is most frequently due to transient arterial spasm.
- The most serious complication is Volkmann's ischemic contracture.

Flexor muscles of the forearm

- Arise from the medial epicondyle of the humerus.
- Occupy the anterior compartment.
- The pronator teres pronates and flexes the forearm at the elbow. Innervated by the median nerve.
- The flexor carpi radialis flexes and abducts the hand at the wrist. Innervated by the median nerve.
- The flexor carpi ulnaris flexes and adducts the hand at the wrist. Innervated by the ulnar nerve.

Flexor muscles of the forearm

- The palmaris longus flexes the hand at the wrist and tenses the palmar aponeurosis.
- Innervated by the median nerve.
- The brachioradialis is a weak forearm flexor; maximal force when forearm is midpronated. Only forearm muscle that does not act on the hand.
- The flexor digitorum superficialis flexes middle phalanges at proximal interphalangeal joints of middle four fingers. It also flexes proximal phalanges at the metacarpophalangeal joints. It arises in the deep flexor compartment.
- Innervated by median and ulnar nerves.

Extensor muscles of the forearm

- Superficial muscles arise from the lateral epicondyle and its supra-condylar ridge. Innervated by the radial nerve.
- Occupy the posterior compartment.
- The extensor carpi radialis longus and brevis extend and abduct the hand at the wrist joint. The longus is active during clenching.
- The extensor digitorum extends the medial four fingers primarily at metacarpophalangeal joints; the extensor digit minimi extends the 5^{th} finger.
- The extensor carpi ulnaris extends and adducts the hand at the wrist joint. It is active during clenching.

Extensor muscles of the forearm

- The medial portion of the flexor digitorum profundis flexes distal phalanges 4 and 5 at the distal interphalangeal joints; the lateral portion flexes distal phalanges 2 and 3.
- The flexor pollicis longus flexes the phalanges of the thumb.
- The pronator quadratus pronates the forearm. The deep fibers bind the radius and ulna together.
- Innervated by the median nerve.
- Occupies the deep extensor compartment.

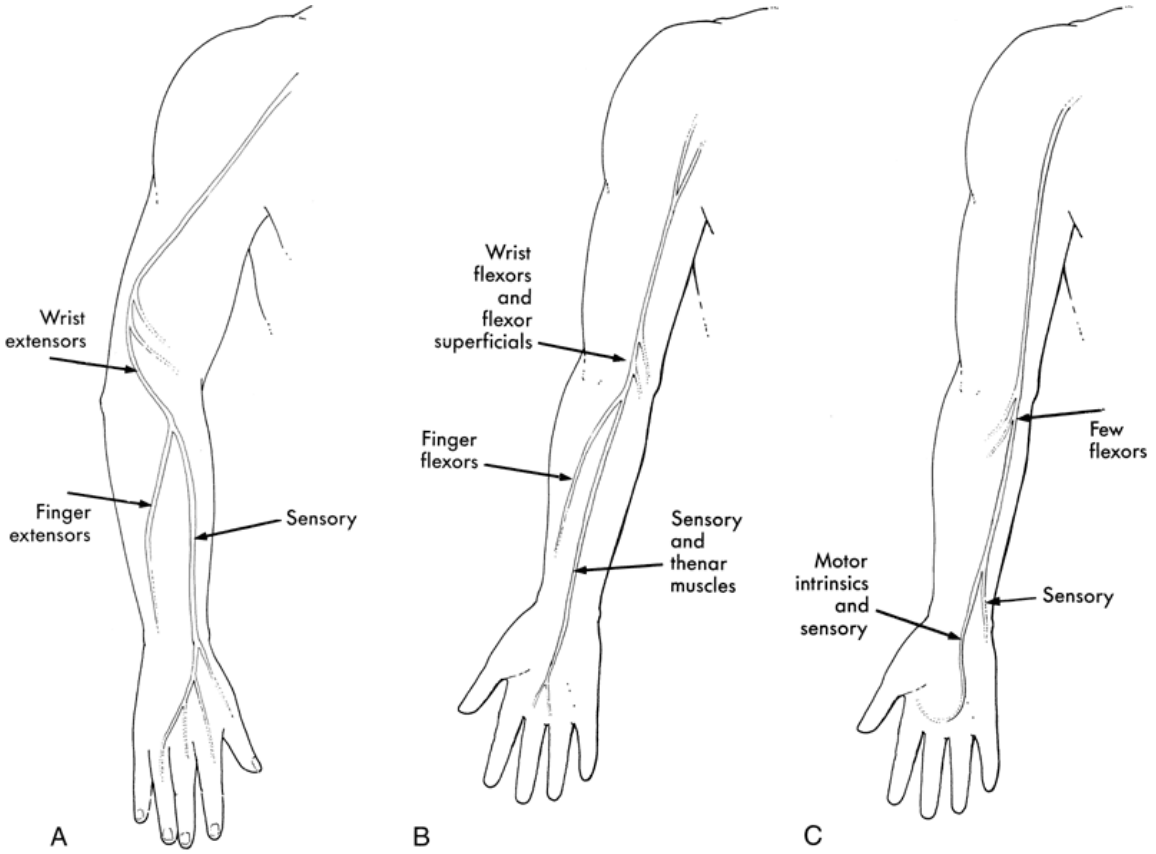
Extensor muscles of the foreamr

- The supinator supinates the forearm; rotates radius to turn palm anteriorly or superiorly if the elbow is flexed.
- Innervated by the radial nerve.
- Occupies the deep extensor compartment.
- Supination and pronation occur at the radio-ulnar joints.
- The extensor indicis extends the 2nd finger independently. Aids in extending the hand at the wrist.
- The abductor pollicis longus abducts the thumb and extends it at the metacarpophalangeal joint.

Extensor muscles of the forearm

- The extensor pollicis longus extends the distal phalanx of the thumb at the interphalangeal joint as well as extends the metacarpophalangeal and carpometacarpal joints.
- The extensor pollicis brevis extends the proximal phalanx of thethumb at the metacarpophalangeal joint. It extends the carpometacarpal joint as well.

Forearm innervation



(Reproduced with permission from Chin HW, Propp DA, Orban DJ: Forearm and wrist, in Rosen P, Barkin RM, et al (eds): *Emergency Medicine Concepts and Clinical Practice,* 3d ed. Vol 1. St. Louis: Mosby–Year Book, 1992.) Fig. 270-9 Accesssed 05/05/2010

Forearm

- The single best test of radial nerve motor function is to have the patient extend both the wrist and fingers against resistance.
- Sensation is tested over the dorsum of the thumb index web space.
- A simple test of anterior inter-osseous nerve function is the ability to make a circle, or "OK" sign, with the thumb and index finger.
- Abduction of the thumb (recurrent branch of the median nerve) and intact sensation on the radial side of the palm complete the evaluation of the median nerve.

Compartments

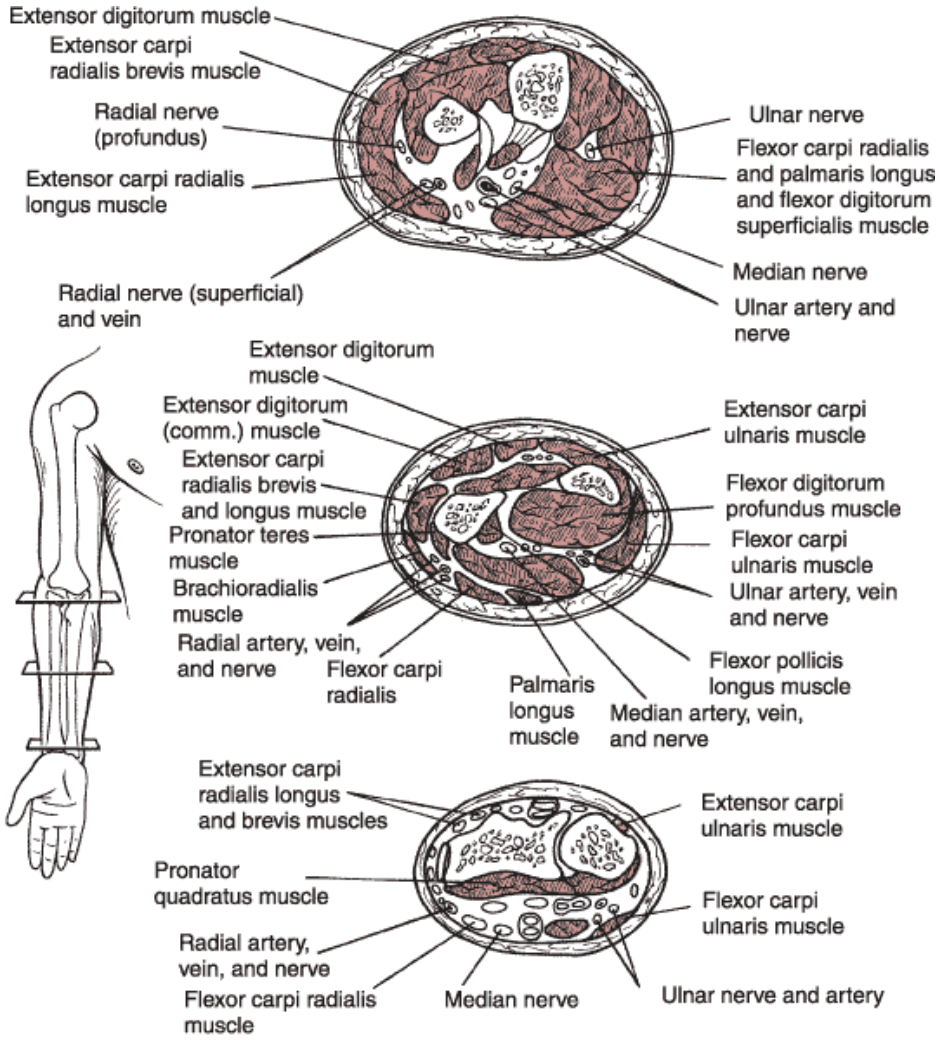


Fig. 278-2 Accessed 05/05/2010

De Quervain’s tenosynovitis

- Common golf injury involving the abductor pollicis longus and extnensor pollicus brevis.
- During the golf swing the lead wrist may take a ulnar deviated position at ball strike.

Carpal tunnel syndrome

- The anatomic carpal tunnel is created by the transverse carpal ligament and houses the median nerve, artery and vein; flexor digitorum profundus and superficalis as well as the palmaris longus muscles.
- Thenar muscles and lateral two lumbricals are innervated by the median nerve.
- Worse at night.
- Work related repetetive injury
- May be precipitated by use of growth hormone as an anti-aging strategy.

Fracture of radius

- Colle's fracture
- Caused by falling on dorsi-flexed hand. (Extension fracture of the radius.)
- Distal radius fracture with dorsal angulation or displacement of distal fragment.
- Smith's fracture
- Caused by falling on palmar flexed hand.
- Reverse of Colles' fracture. (Flexion fracture of the radius.)
- Distal radius fracture, with palmar angulation of distal fragment.

Colle's fracture

Fig. 262-10 Accessed 05/05/2010

Smith fracture

Fig. 262-12 Accessed 05/05/2010

Dislocation of the wrist

- Lunate dislocation. The lunate is rotated and dislocated toward palmar side. Most commonly dislocated carpal bone.
- Peri-lunate dislocation. The lunate is in normal alignment with radius, but rest of carpal bones are dislocated posteriorly.
- Perilunate and lunate dislocations can fracture any of the carpal bones that surround the lunate in an arc pattern.
- Scaphoid is most commonly fractured carpal bone.
- May result in avascular necrosis.
- Pain in the anatomical snuffbox.

Scapho-lunate dislocation

Fig. 262-4 Accessed 05/05/2010

Scaphoid fracture

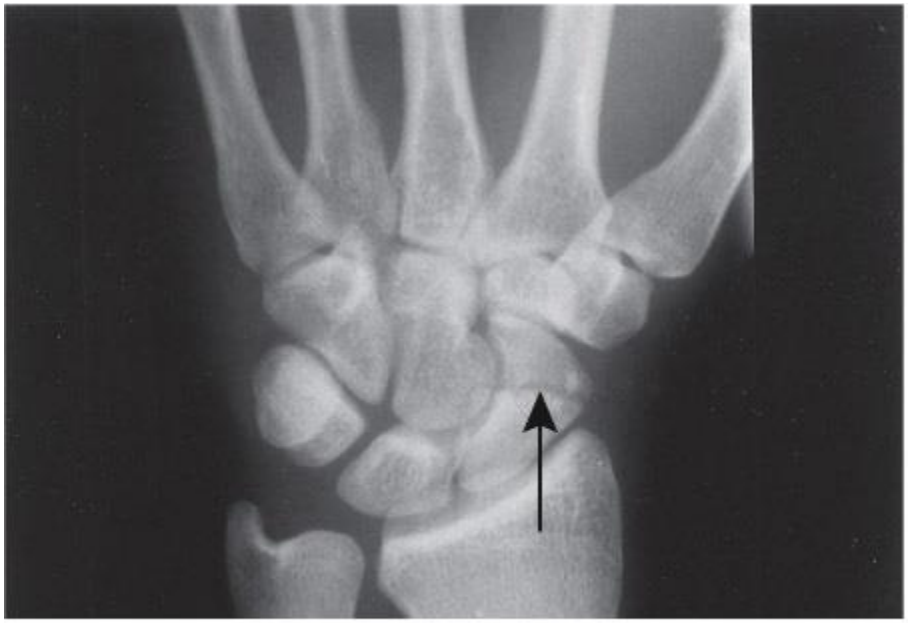


Fig. 262-9 Accessed 05/05/2010

Thenar muscles of the hand

- The opponens pollicis opposes the thumb by drawing the first metacarpal medially to the center of the palm and rotating it medially.
- The abductor pollicis brevis abducts the thumb and assists in opposition of the thumb. May share a common sesamoid tendon at the attachment with the flexor pollicis brevis.
- The flexor pollicis brevis flexes the thumb at the carpometacarpal and metacarpophalangeal joints and assists in opposition of the thumb.
- All innervated by the median nerve.

Thenar muscles of the hand

- The adductor pollicis adducts the thumb toward the lateral border of the palm, giving power to the grip.
- Innervated by the ulnar nerve.
- Thenar muscle.

Short muscles of the hand

- The lumbricals flex the meatacarpo-phalangeal joints and extend the interphalangeal joints of the second-fifth fingers.
- The dorsal interossei (first-fourth) abduct the second-fourth fingers from the axial line.
- They act with the lumbricals in flexing metacarpo-phalangeal joints and extending interphalangeal joints.

Short muscles of the hand

- The palmar interossei (first-third) adduct the second, fourth, fifth fingers toward the axial line.
- They act with the lumbricals in flexing metacarpo-phalangeal joints and extending interphalangeal joints
- Z-movement expands extension of the second-fourth fingers.

Fingers

- The flexor digitorum superficialis splits prior to its attachment to the middle phalanx to allow the flexor digitorum profundus to pass through and insert on the base of the digital phalanx.
- The extensor hood is formed with the extensor digitorum, the lumbricals, and the interossei muscles.

Hypothenar muscles of the hand

- The abductor digiti minimi abducts the fifth finger and assists in flexion of its proximal phalanx.
- The flexor digiti minimi brevis flexes the proximal phalanx of the fifth finger.
- The opponens digiti minimi draws the metacarpal anteriorly and rotates it, bringing the fifth finger into opposition with the thumb.

Compartments

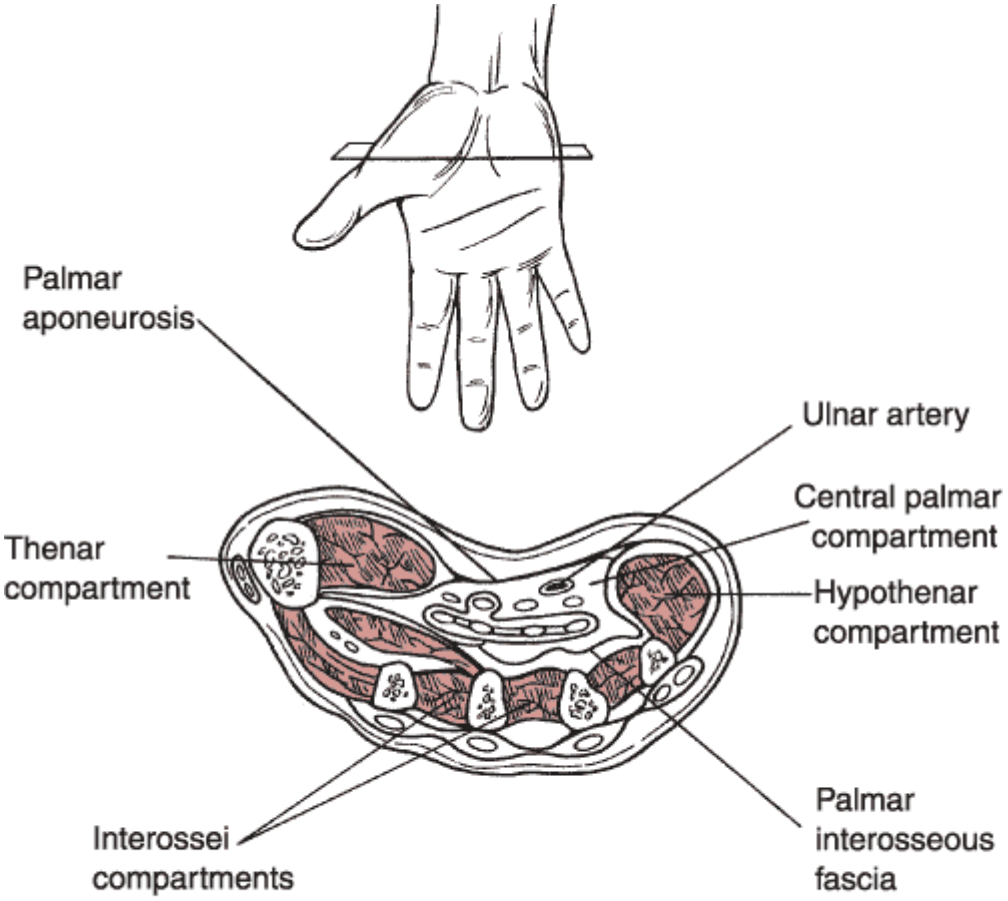


Fig. 278-3 Accessed 05/05/2010

Vessels

- The axillary artery gives rise to the brachial artery (medial aspect of the arm) and divides into radial and ulnar arteries below the elbow.
- The ulnar and radial arteries form superficial and deep palmar arches, respectively, that supply the hand (anastamose).

Vessels

- Lymph node drainage follows the course of veins.
- Along the ulnar side, the hand drains to supratrochlear nodes
- The elbow, to lateral axillary nodes.
- Deep drainage is to lateral axillary nodes.
- This follows the basilic vein.
- Along the radial side, the hand and elbow drain to infraclavicular nodes to apical axillary nodes.
- This follows the cephalic vein.

Nerve distribution

- The ulnar nerve sensory distribution is along the ventral lateral aspect of the forearm to the lateral aspect of the 4th finger and to the 5th finger of the hand.
- It innervates the lumbrical muscles of those fingers (balance flexor and extensor muscles of forearm).
- Ulnar nerve injury is associated with a “claw hand.” Hypothenar muscle and interosseous muscle wasting.
- With flexion at wrist, there is radial deviation.
- Loss of abduction of thumb.

Nerve distribution

- The median nerve sensory distribution is along the ventral medial aspect of the forearm to the thumb, 2nd and 3rd fingers, and the medial aspect of the 4th finger. It innervates the 2nd-4th fingers.
- Median nerve injury is associated with a “hand of blessing.”
- Thenar eminence wasted.
- Paresis upon flexing, abducting, and opposing thumb.

Nerve distribution

- The radial nerve runs through the anatomical snuff box.
- It provides sensation to the dorsal aspect of the thumb and the 2nd and 3rd fingers. (Finger tips are supplied by the median nerve.)
- Radial nerve injury is associated with “wrist drop.”

Hand injury

- Dislocations of the PIP joint are common ligamentous injuries of the hand.
- They occur usually due to axial load and hyperextension.
- Dorsal dislocation occurs when the volar plate ruptures.
- Lateral dislocations occur when one of the collateral ligaments ruptures with at least a partial avulsion of the volar plate from the middle phalanx.

Hand injury

- Dislocations of the MP joint are less common than at the PIP joint.
- The mechanism is usually due to hyperextension forces that rupture the volar plate causing dorsal dislocation.
- In simple dislocations (subluxation), the joint appears to be hyperextended 60 to 90 degrees and the articular surfaces are still in contact.
- Reduction here does not involve hyperextension.

Hand injury

- Dislocations of the MP joint of the thumb are usually dorsal from a hyperextension force causing rupture of the volar plate.
- Rupture of the ulnar collateral ligament (gamekeeper's thumb, skier's thumb) occurs when the mechanism causes radial deviation (abduction) of the MP joint.
- The tear usually occurs at the insertion into the proximal phalanx.
- Often significant injury to the dorsal capsule and volar plate occurs.

Carpal tunnel syndrome

- Carpal tunnel syndrome classically must have symptoms in 2 of first 3 digits, though there may be pain in 4^{th} or 5^{th} digits, wrist, or pain radiation proximal to wrist.
- With thumb abduction weakness, the symptoms and sign point to an electro-diagnostic abnormality.
- A normal electro-diagnostic study, however, does not exclude carpal tunnel syndrome.
- Other tests not useful.

Extensor and flexor tendons of the digit

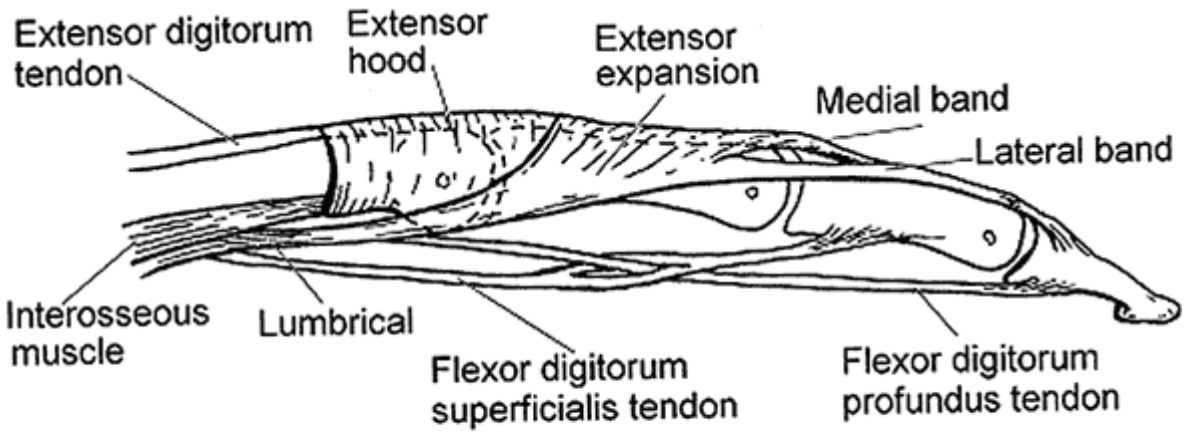


Fig. 262-4 Accessed 05/05/2010

Flexor tendon injury

- Zone I
- Extends from the insertion of flexor digitorum superficialis to the flexor digitorum profundus tendon.
- Patients with these injuries lose flexion at the DIP. Retrieval of the proximal tendon is often difficult.
- Zone II
- Involves the portion of the digital canal occupied by both tendons.
- Lacerations in this zone are common, and partial lacerations are more common then complete.

Flexor tendon injury

- Zone III
- Extends from the distal edge of the carpal tunnel to the proximal edge of the flexor sheath. The lumbrical muscles originate from the flexor digitorum profundus in this region.
- Outcomes are generally favorable.
- Zone IV
- Involves the carpal tunnel and related structures.
- The area must be explored carefully because so many vital structures go through the carpal tunnel.
- Isolated injuries are the exception.

Flexor tendon injury

- Zone V
- Involves injuries to tendons proximal to the carpal tunnel.
- Injuries here tend to be severe and often involve multiple tendons as well as the median or ulnar nerve.

Extensor tendon injury

- Zones I, II, III
- Involves the area over the distal phalanx and DIP.
- Injury can occur from blunt or sharp trauma.
- Complete laceration or rupture of the tendon at this level will result in the DIP joint flexed 40 degrees.
- This injury after blunt trauma is often referred to as "mallet finger.“
- The most common tendon injury in athletes.
- This injury has been classified as type I if there is tendon only rupture, type II if there is a small avulsion fracture, and type III if greater than 25 percent of the articular surface is involved.

Extensor tendon injury

- Chronic untreated mallet finger may develop a swan-neck deformity . This is caused when the lateral bands are displaced proximally and dorsally, resulting in increased extension forces on the PIP joint.
- The metacarpo-phalangeal joint is flexed; the proximal interphalangeal joint is hyperextended; slight distal interphalangeal joint flexion due to contracture of intrinsic muscles.
- Common in rheumatoid arthritis.

Extensor tendon injury

- Zones III, IV
- Involves the area over the PIP.
- The central tendon is the most commonly injured structure.
- Complete disruption of the central tendon may result in the volar displacement of the lateral bands, causing them to be flexors, along with the unopposed flexor digitorum profundus.
- Additionally, the extensor hood retracts, causing extension of the MP and the DIP joints, resulting in the boutonnière deformity.

Boutonniére deformity

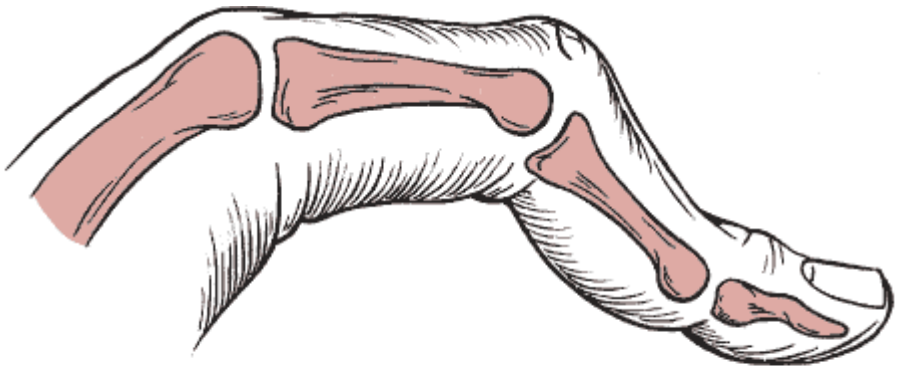


Fig. 262-10 Accessed 05/05/2010

Extensor tendon injury

- Zones V
- Involves the area over the MP.
- Open injuries to this area should be considered human bites until proven otherwise.
- Zone VI
- Involves the area over the dorsum of the hand.
- Because the tendons in this area are so superficial, even minor-appearing lacerations may be associated with one or more tendon injuries.

Extensor tendon injury

- If the laceration is proximal to the junctura tendineae, the patient may be able to extend the involved MP joint, because weak extensor forces are transmitted to the junctura from adjacent extensor tendons.
- Zone VII
- Involves the area over the wrist. The extensor retinaculum, the thick, fibrous structure on the dorsum of the wrist, contains 12 extensor tendons and 6 retinacular compartments that are lined with synovium.

Extensor tendon injury

- Zone VIII
- Involves the area of the distal forearm. The tendons frequently retract into the forearm.