THE ELBOW COMPLEX

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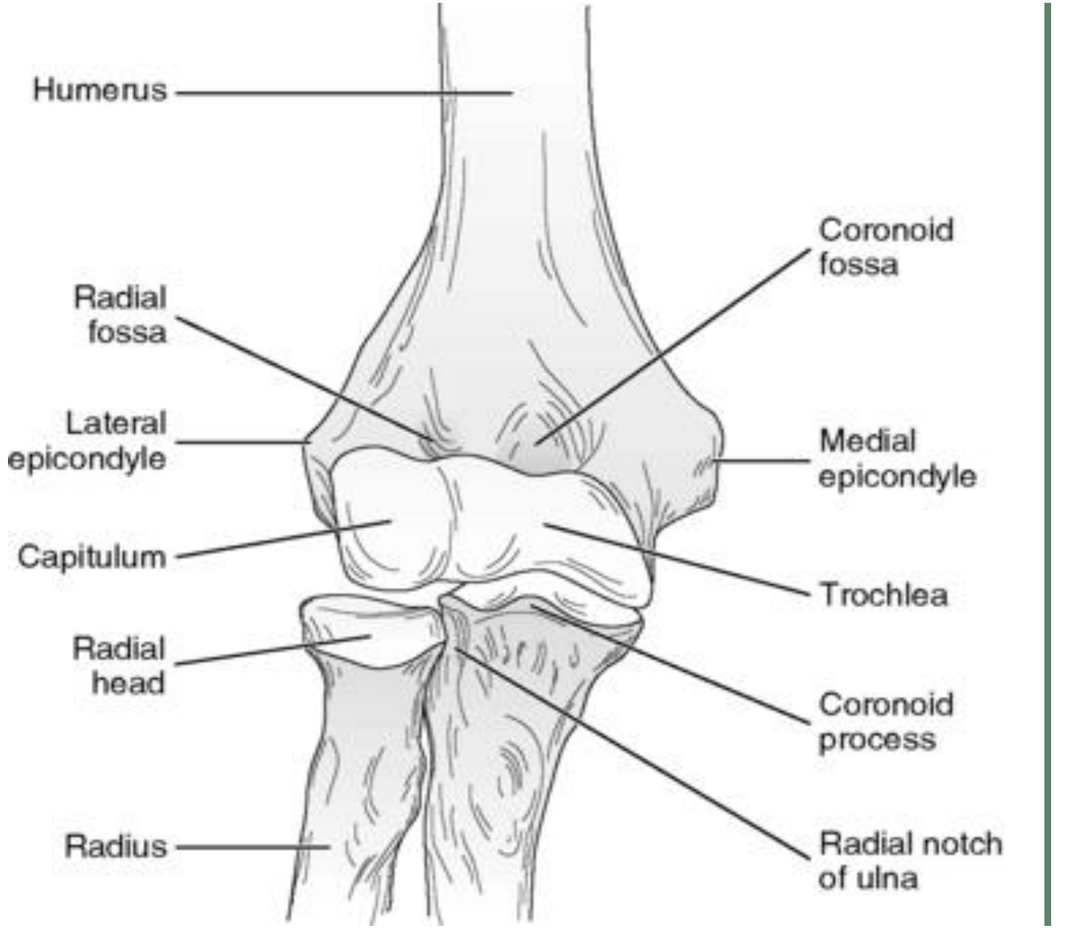
INTRODUCTION

- The elbow complex includes the elbow joint **(humeroulnar and humeroradial joints)** and the proximal and distal radioulnar joints.
- The elbow joint is considered to be a compound joint that functions as a modified or loose hinge joint. **One degree of freedom is possible at the elbow**, permitting the motions of flexion and extension, which occur in the sagittal plane around a coronal axis.
- **Two major ligaments** and **five muscles** are directly associated with the elbow joint.

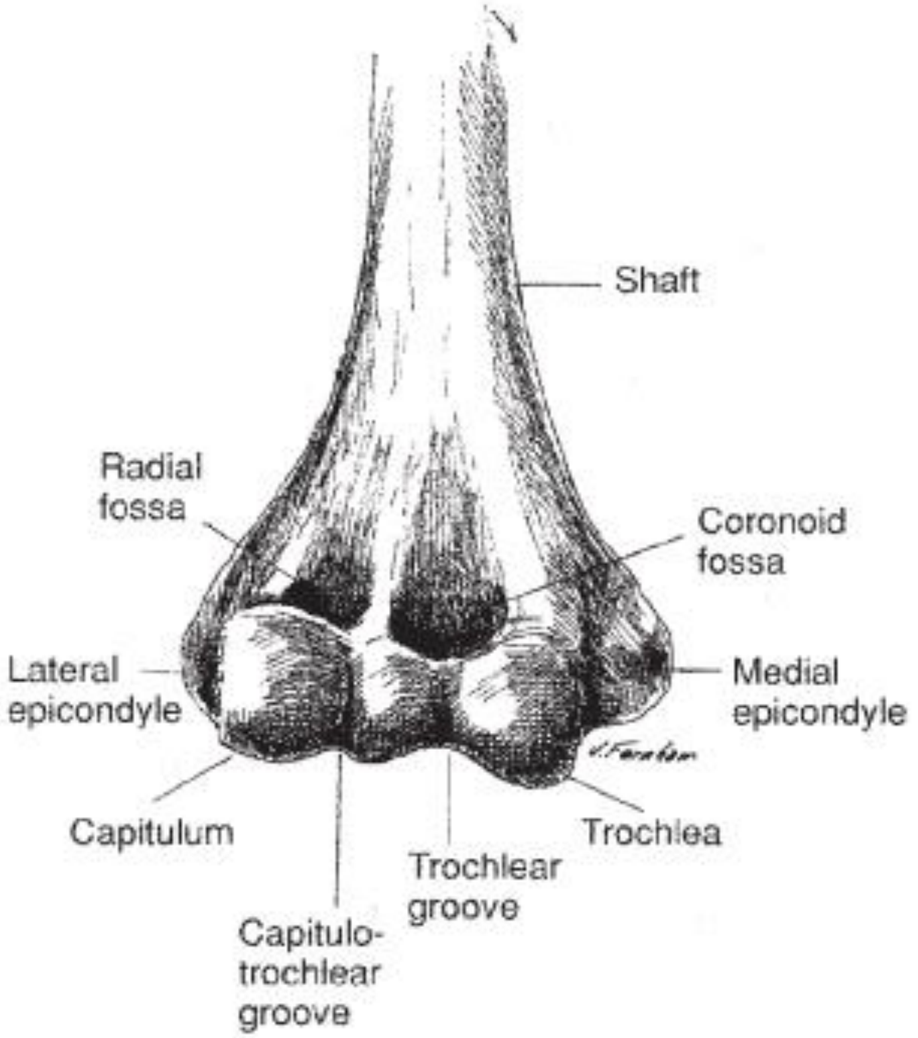
- Three of the muscles are flexors that cross the anterior aspect of the joint.
- The other two muscles are extensors that cross the posterior aspect of the joint.



STRUCTURE OF ELBOW JOINT (HUMEROULNAR AND HUMERORADIAL ARTICULATIONS)

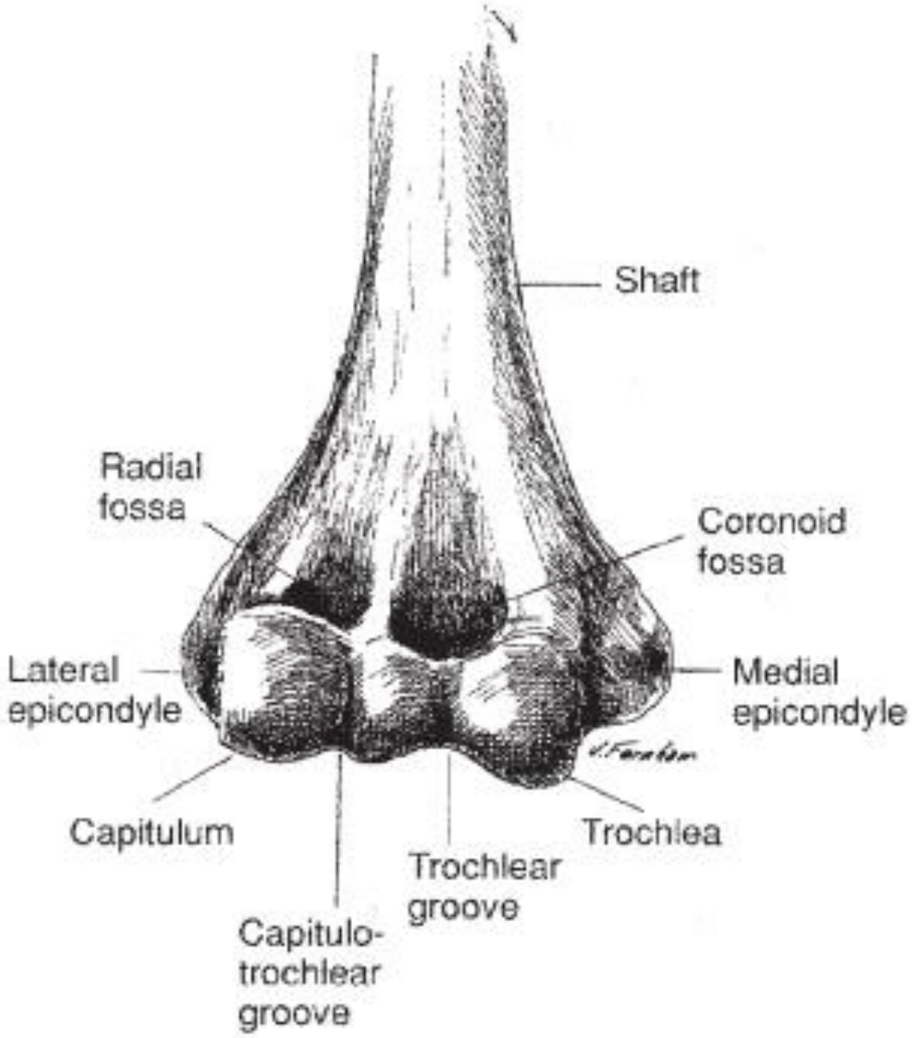
ARTICULATING SURFACES ON THE HUMERUS

- The articulating surfaces on the anterior aspect of the distal humerus are the hourglass-shaped **trochlea** and the spherical **capitulum.**
- These structures are situated between the medial and lateral humeral epicondyles.
- The **trochlea,** which forms part of the humeroulnar articulation, is set at an angle on the medial aspect of the distal humerus and lies slightly anterior to the humeral shaft.

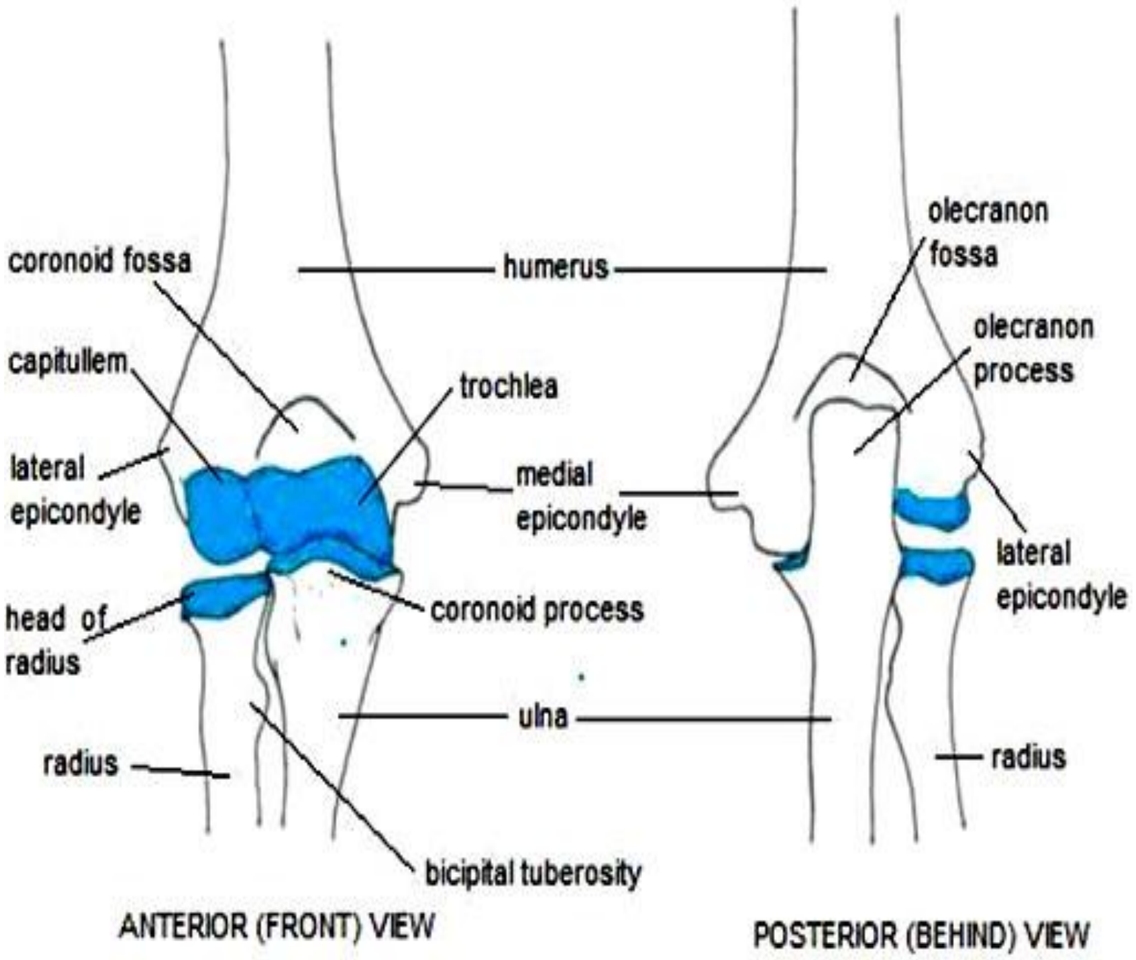

Shaft
Radial fossa
Coronoid fossa
Lateral epicondyle
Medial epicondyle
Capitulum
Trochlea
Trochlear groove
Capitulo-trochlear groove

- A groove called the **trochlear groove** spirals obliquely around the trochlea and divides it into medial and lateral portions.
- The medial portion of the trochlea projects distally more than the lateral portion and results in a valgus angulation of the forearm called the ***carrying angle.***
- The indentation in the humerus located just above the trochlea is called the **coronoid fossa** and is designed to receive the coronoid process of the ulna at the end of elbow flexion range of motion (ROM).

- The capitulum, which is part of the humeroradial articulation, is located on the anterior lateral surface of the distal humerus.
- The capitulum, like the trochlea, lies anterior to the shaft of the humerus. A groove called the **capitulotrochlear groove** separates the capitulum from the trochlea.
- The indentation located on the humerus just above the capitulum is called the **radial fossa** and is designed to receive the head of the radius in elbow flexion.

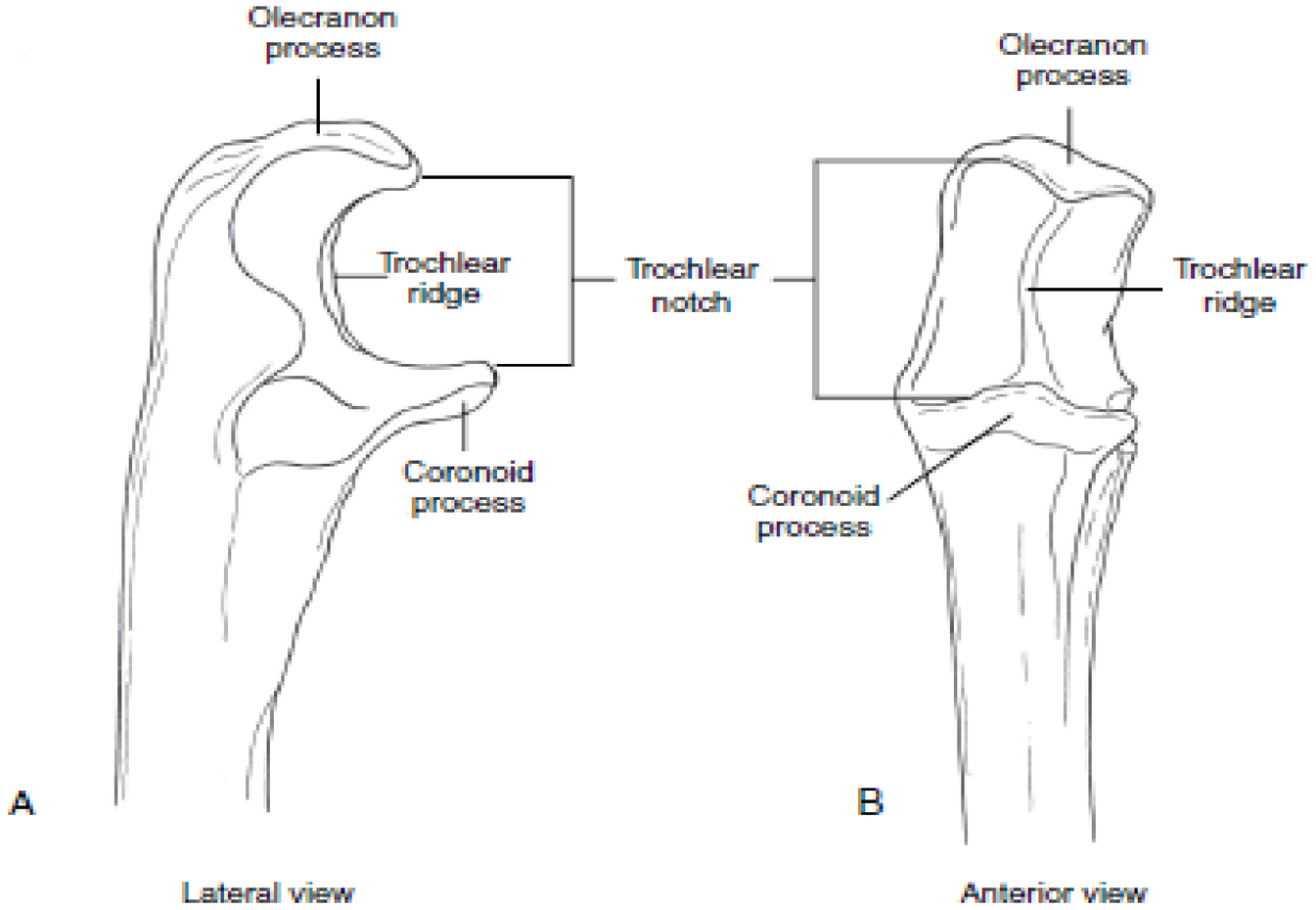

Shaft
Radial fossa
Coronoid fossa
Lateral epicondyle
Medial epicondyle
Capitulum
Trochlea
Trochlear groove
Capitulo-trochlear groove

- Posteriorly, the distal humerus is indented by a deep fossa called the **olecranon fossa,** which is designed to receive the olecranon process of the ulna at the end of the elbow extension ROM.

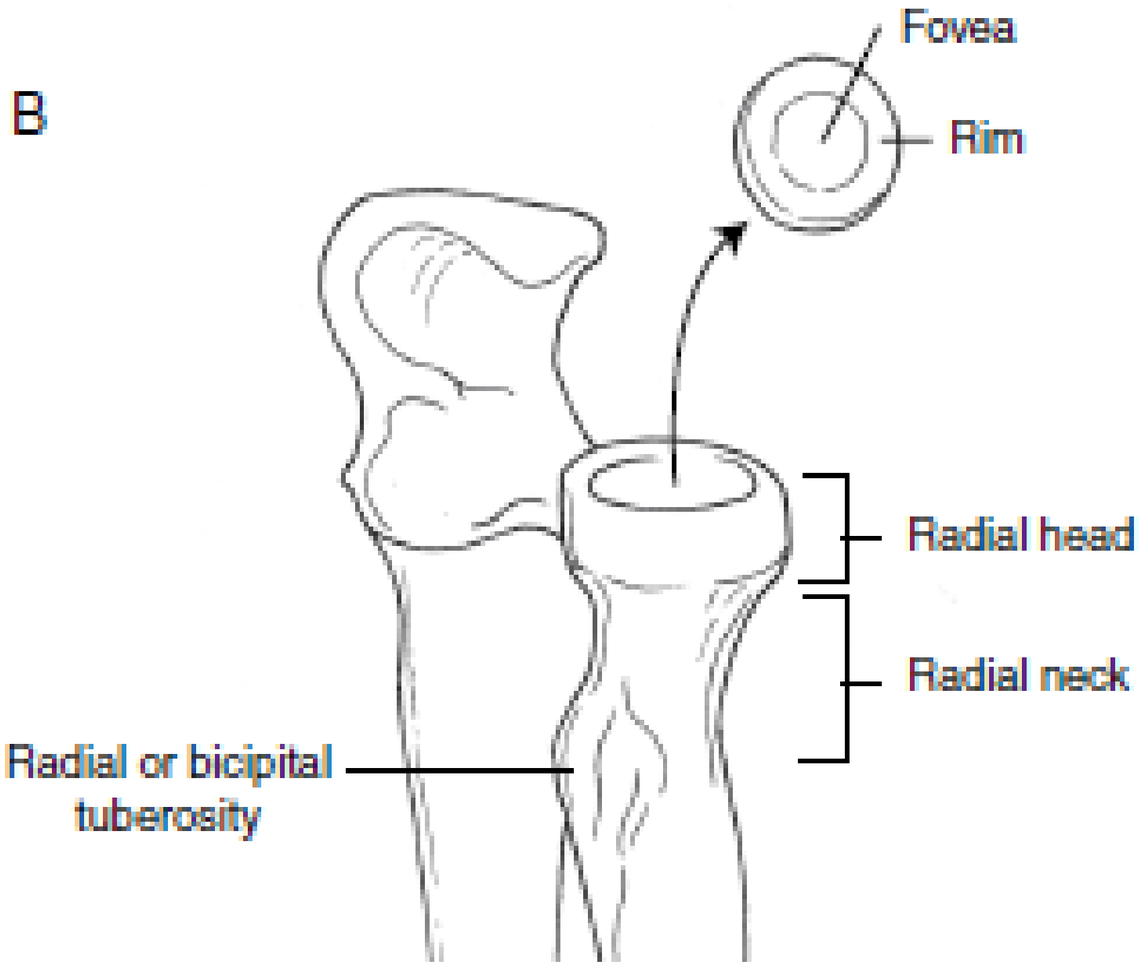


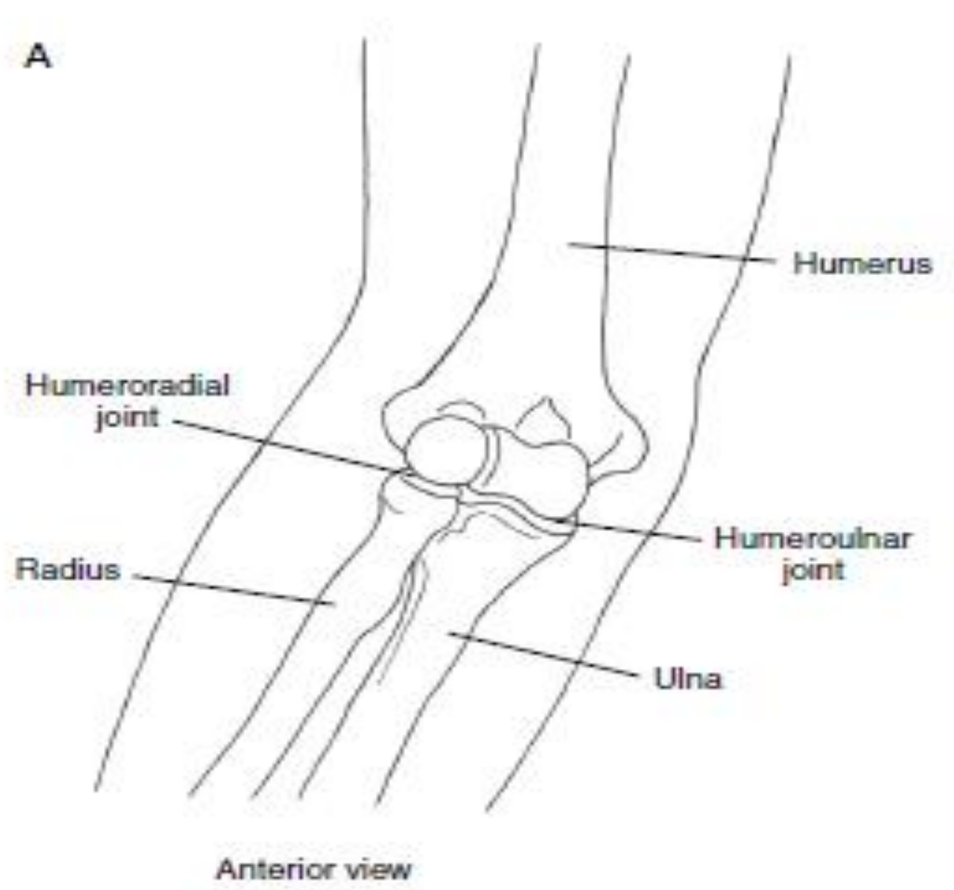
ARTICULATING SURFACES ON THE RADIUS AND ULNA

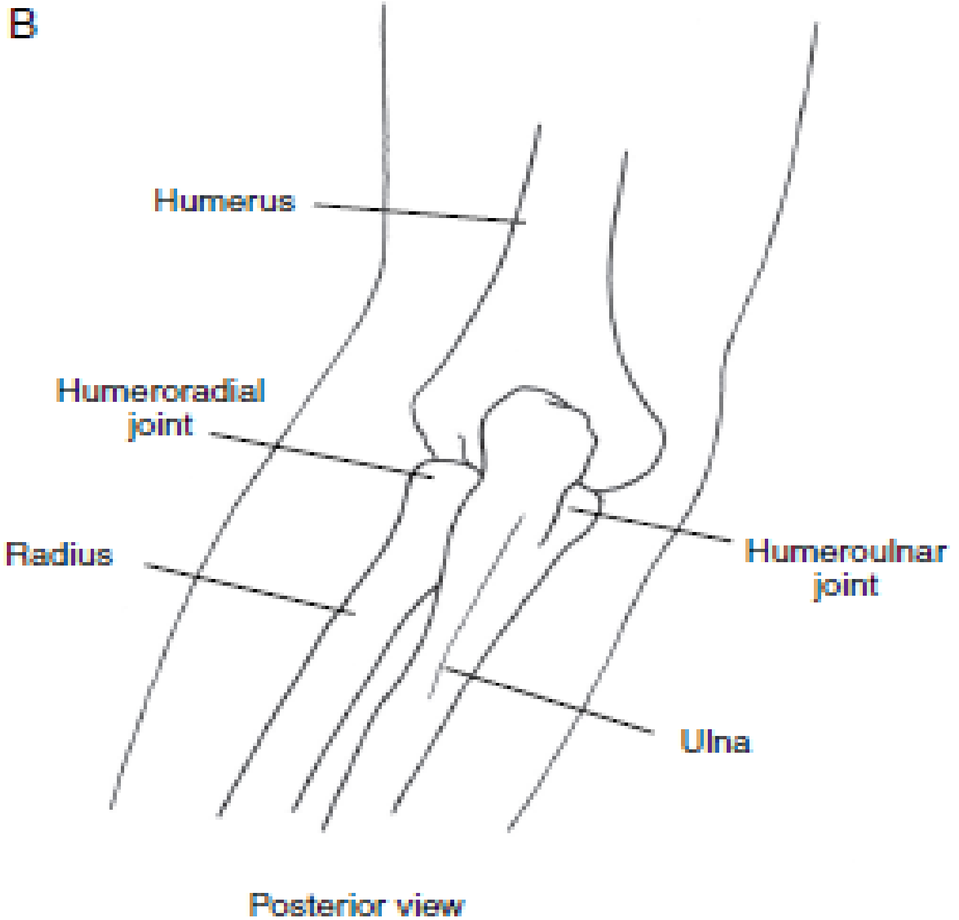
- The ulnar articulating surface of the humeroulnar joint is a deep semicircular concave surface called the **trochlear notch.**
- The proximal portion of the notch is divided into two unequal parts by the **trochlear ridge**, which corresponds to the **trochlear groove** on the humerus.
- The ulnar coronoid process forms the distal end of the notch, whereas the olecranon process projects over the proximal end of the notch.


Olecranon process
Trochlear ridge
Trochlear notch
Coronoid process
A
Lateral view
Olecranon process
Trochlear ridge
Coronoid process
B
Anterior view

- The radial articulating surface of the humeroradial joint is composed of the proximal end of the radius, known as the **head of the radius.**
- The radial head has a slightly cup-shaped concave surface called the **fovea** that is surrounded by a rim.
- The radial head's convex rim fits into the **capitulotrochlear groove.**

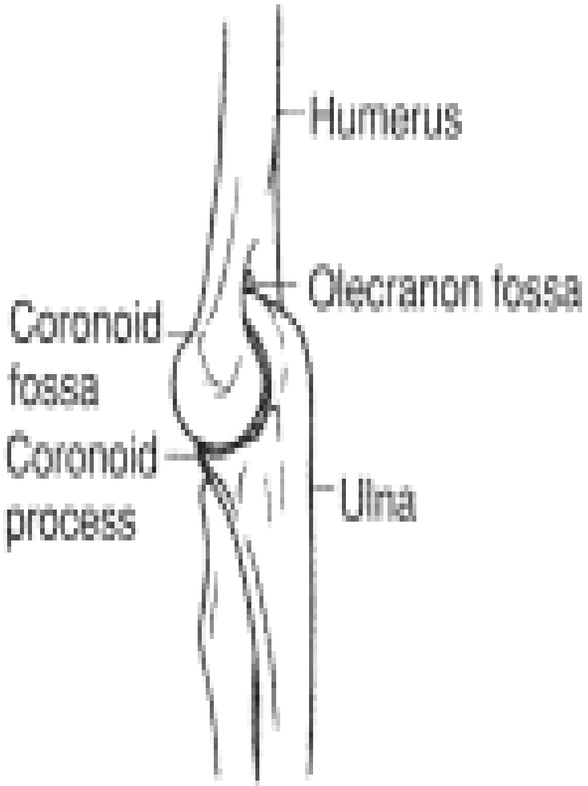

B
Fovea
Rim
Radial head
Radial neck
Radial or bicipital tuberosity


A
Humerus
Humeroradial joint
Humeroulnar joint
Radius
Ulna
Anterior view


B
Humerus
Humeroradial joint
Radius
Humeroulnar joint
Ulna
Posterior view

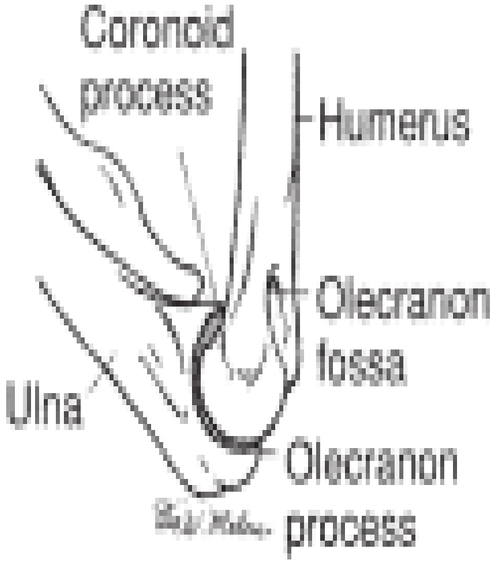
ARTICULATION

- Articulation between the ulna and humerus at the humeroulnar joint occurs primarily as a sliding motion of the ulnar trochlear ridge on the humeral trochlear groove.
- In extension, sliding continues until the olecranon process enters the olecranon fossa.
- In flexion, the trochlear ridge of the ulna slides along the trochlear groove until the coronoid process reaches the floor of the coronoid fossa in full flexion.



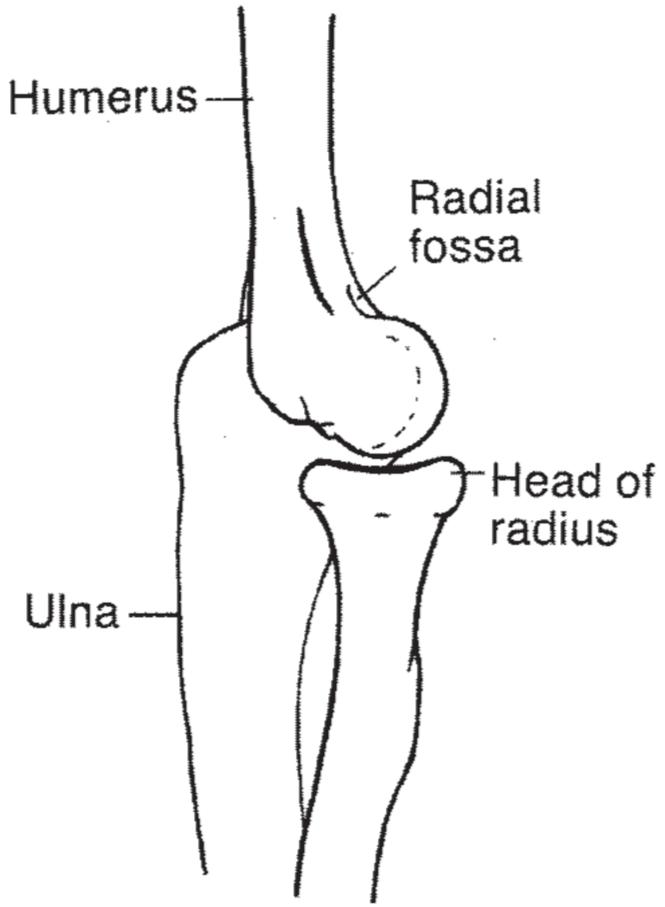
A Extension

Humeroulnar joint

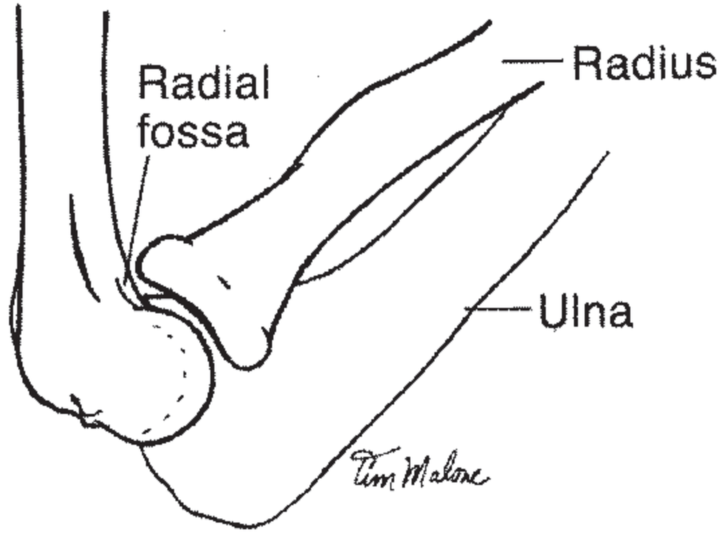


B Flexion

- Articulation between the radial head and the capitulum at the humeroradial joint involves sliding the shallow concave radial head over the convex surface of the capitulum.
- The humeral capitulum is slightly smaller than the corresponding radial fovea, so the joint surfaces are slightly incongruent.
- In full extension, no contact occurs between the articulating surfaces.
- In flexion, the rim of the radial head slides in the capitulotrochlear groove and enters the radial fossa as the end of the flexion range is reached.



Extension

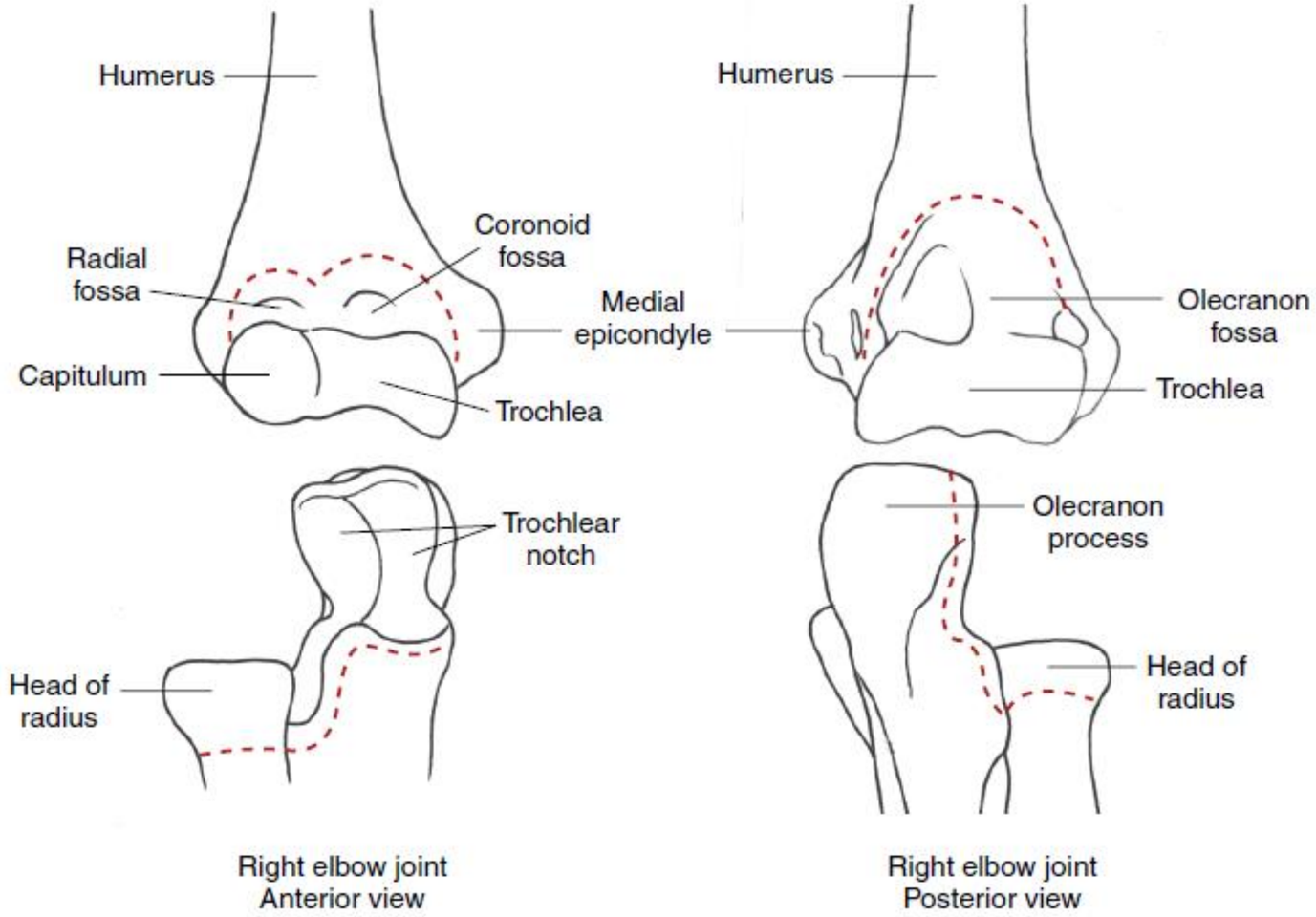


Flexion

JOINT CAPSULE

- The humeroulnar and humeroradial joints and the superior radioulnar joint are enclosed in a single joint capsule.
- Anteriorly the proximal humeral attachment of the capsule is just above the coronoid and radial fossae.
- Distally, the capsule attaches into the ulna along the margin of the coronoid process and blends with the proximal border of the annular ligament.
- Medially and laterally, the capsule is continuous with the collateral ligaments.

- Posteriorly, the capsule is attached to the humerus along the upper edge of the olecranon fossa and to the back of the medial epicondyle.
- The capsule is fairly large, loose, and weak anteriorly and posteriorly, and it contains folds that are able to expand to allow for a full range of elbow motion.
- Fat pads are located between the capsule and the synovial membrane adjacent to the olecranon, coronoid, and radial fossae.
- Laterally and medially, the capsule is reinforced by the collateral ligaments.



Right elbow joint
Anterior view

Right elbow joint
Posterior view

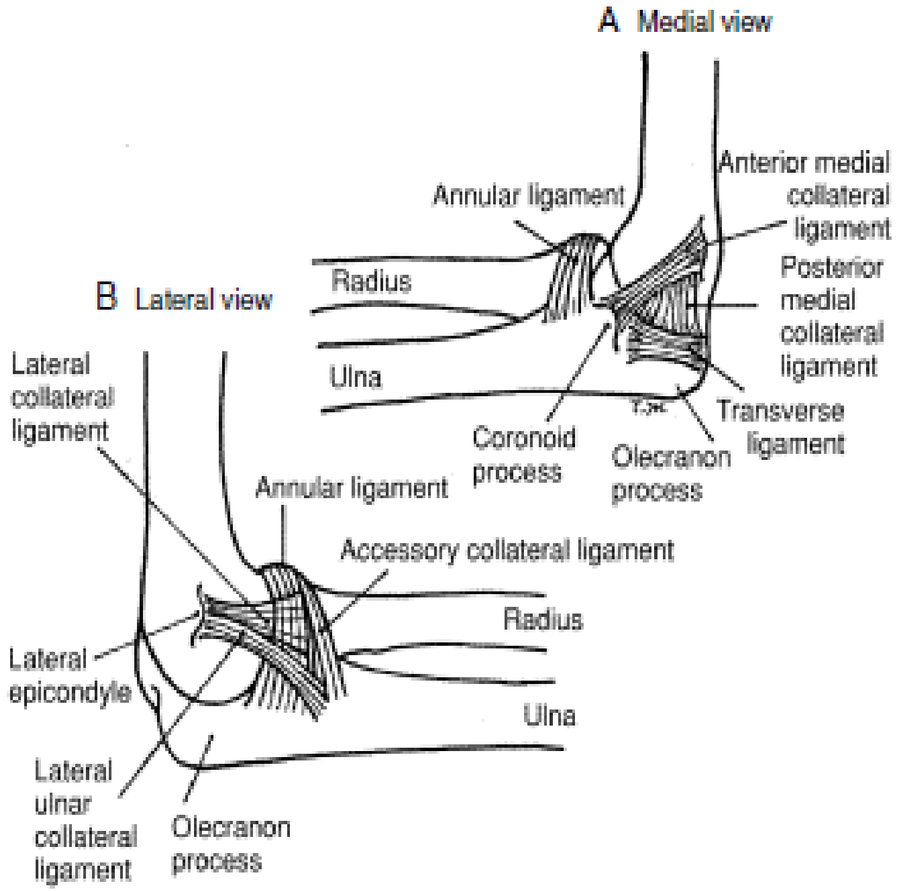
LIGAMENTS

- Most hinge joints in the body have collateral ligaments, and the elbow is no exception.
- Collateral ligaments are located on the medial and lateral sides of hinge joints to provide medial/lateral stability and to keep joint surfaces in apposition.
- The two main ligaments associated with the elbow joints are the **medial (ulnar) and lateral (radial) collateral ligaments.**

MEDIAL (ULNAR) COLLATERAL LIGAMENT

- The medial collateral ligament consists of either two parts, anterior and posterior, or three parts, anterior, transverse, and posterior.
- The anterior and posterior parts may be referred to as either the **anterior and posterior oblique ligaments** or simply **anterior** and **posterior bundles.**
- **The anterior part of the MCL** extends from the anterior aspect, tip, and medial edge of the medial epicondyle of the humerus to attach on the ulnar coronoid process.

- The anterior portion of the MCL is considered to be the primary restraint of valgus stress from 20 to 120 degree of elbow flexion.
- Mechanoreceptors (Golgi organs, Ruffini terminals, Pacini corpuscles, and free nerve endings) are densely distributed near the ligament's humeral and ulnar attachments.

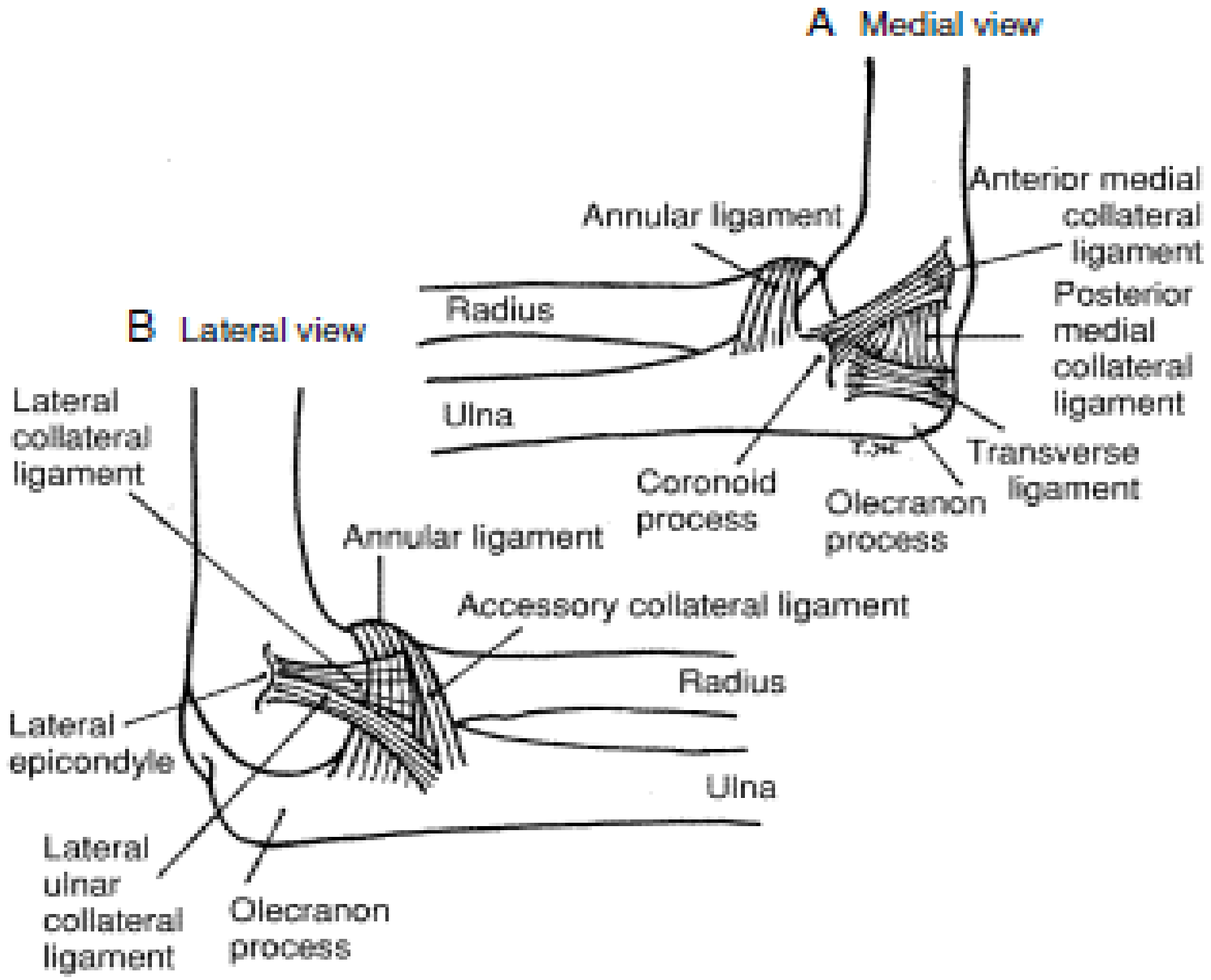


- **The posterior portion of the MCL** extends from the posterior aspect of the medial epicondyle of the humerus to attach to the ulnar coronoid and olecranon processes.
- The posterior MCL limits elbow extension but plays a less significant role than the anterior MCL in providing valgus stability for the elbow.
- **The oblique (transverse) fibers of the MCL** extend between the olecranon and ulnar coronoid processes. This portion of the ligament assists in providing valgus stability and helps to keep the joint surfaces in approximation.

LATERAL (RADIAL) COLLATERAL LIGAMENTOUS COMPLEX

- The **lateral collateral ligamentous complex** includes the **lateral (radial) collateral ligament (LCL),** the **lateral ulnar collateral ligament (LUCL),** and the **annular Ligament.**
- The lateral (radial) collateral ligament is a fan-shaped structure that extends from the inferior aspect of the lateral epicondyle of the humerus to attach to the annular ligament (the ligament encircling the head of the radius) and to the olecranon process.

- Ligamentous tissue extending from the lateral epicondyle to the lateral aspect of the ulnar and the annular ligament is referred to as the lateral ulnar collateral ligament.
- The LCL provides reinforcement for the humeroradial articulation, offers some protection against varus stress in some positions of the elbow, and assists in providing resistance to longitudinal distraction of the joint surfaces.
- Some fibers of the LCL remain taut throughout the flexion ROM when either a varus or valgus moment is applied.

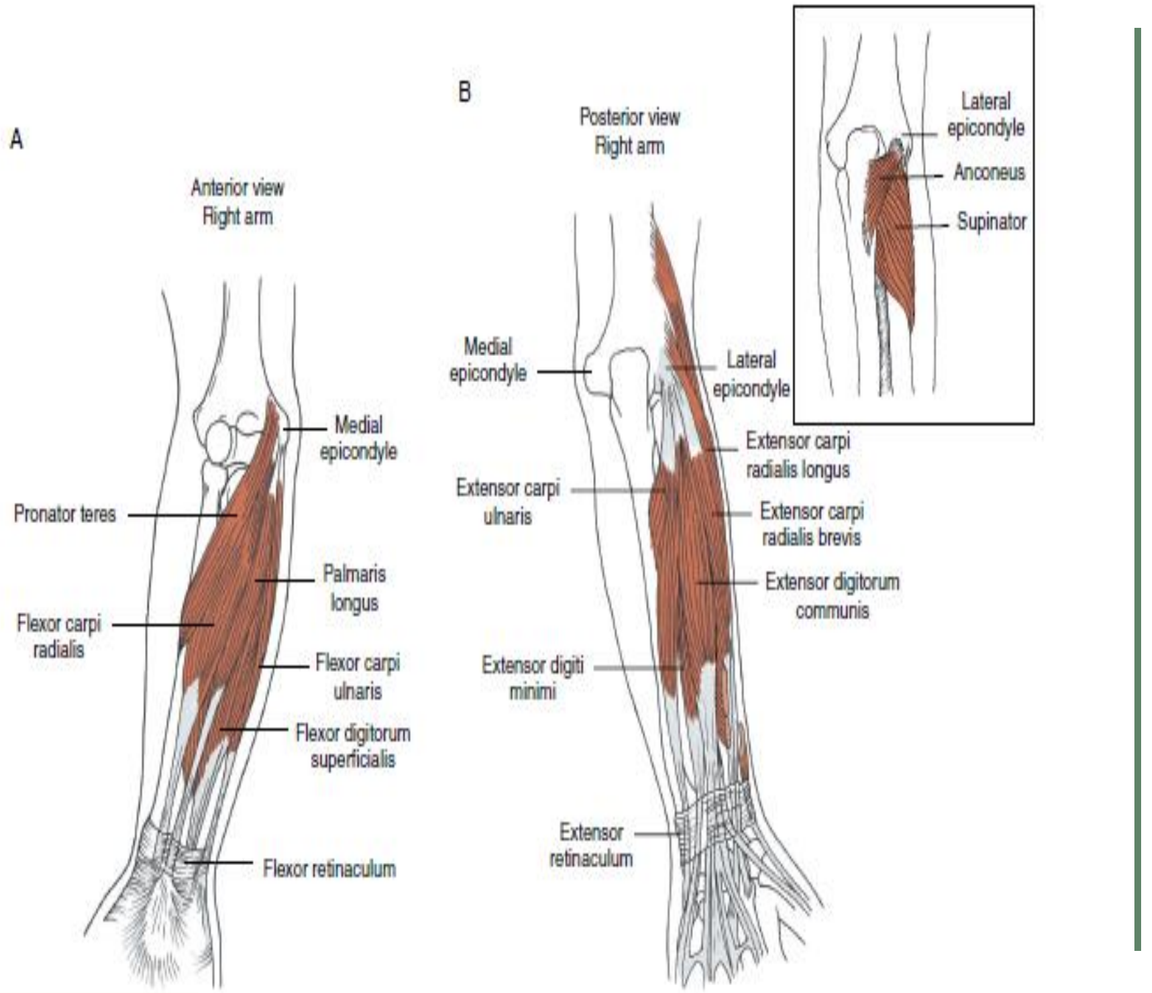

A Medial view
Annular ligament
Anterior medial collateral ligament
Radius
Posterior medial collateral ligament
B Lateral view
Ulna
Lateral collateral ligament
Transverse ligament
Coronoid process
Olecranon process
Annular ligament
Accessory collateral ligament
Radius
Lateral epicondyle
Ulna
Lateral ulnar collateral ligament
Olecranon process

- The LCL was the primary soft tissue restraint and the LUCL and the annular ligament were secondary restraints to combined forced varus and supination stresses and forced valgus stress.
- The LUCL has the potential for assisting the LCL in resisting varus stress at the elbow and assisting in providing lateral support to the elbow joint.

MUSCLES

- Nine muscles cross the anterior aspect of the elbow joint, but only three of these muscles (the **brachialis, biceps brachii,** and **brachioradialis**) have primary functions at the elbow joint.
- The **supinator teres** and **pronator teres** have major functions at the radioulnar joints.
- The remaining four muscles (**flexor carpi radialis, flexor carpi ulnaris, flexor digitorum superficialis,** and **palmaris longus**).

- These muscles arises from a common tendon from the medial epicondyle of the humerus, have primary functions at other joints, including the wrist, hand, and fingers, but are considered to be weak flexors of the elbow.



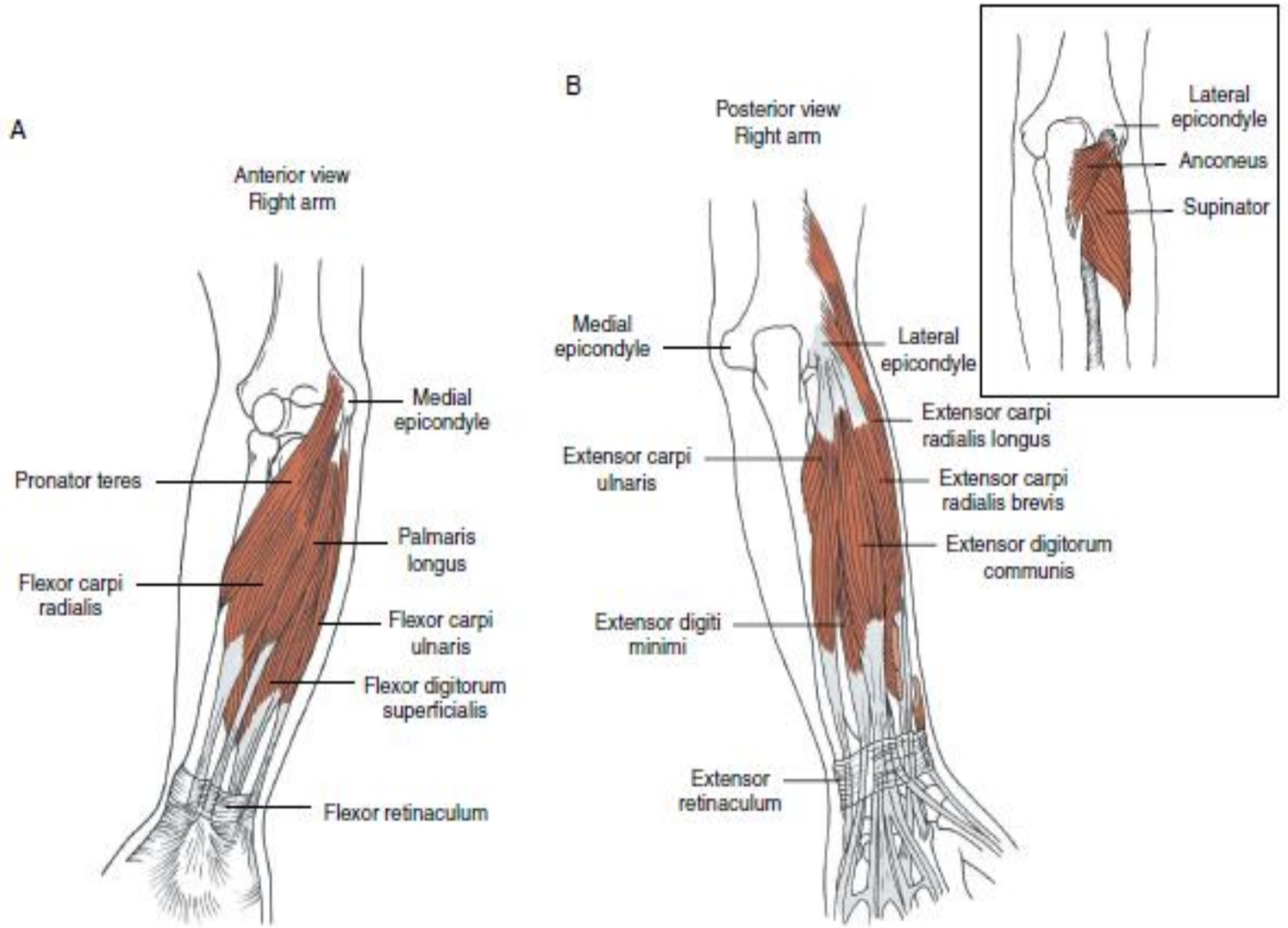
- The major flexors of the elbow are the brachialis, the biceps brachii, and the brachioradialis.
- The **brachialis muscle** arises from the anterior surface of the lower portion of the humeral shaft and attaches by a thick, broad tendon to the ulnar tuberosity and coronoid process.
- The **biceps brachii** arises from two heads, one short and the other long. The short head arises as a thick, flat tendon from the coracoid process of the scapula, and the long head arises as a long, narrow tendon from the scapula's supraglenoid tubercle.

- The muscle fibers arising from the two tendons unite in the middle of the upper arm to form the prominent muscle bulk of the upper arm.
- Muscle fibers from both heads insert by way of the strong flattened tendon on the rough posterior area of the tuberosity of the radius.
- The **brachioradialis muscle** arises from the lateral supracondylar ridge of the humerus and inserts into the distal end of the radius just proximal to the radial styloid process.

- The two extensors of the elbow are the **triceps** and the **anconeus.**
- The **triceps** has three heads, (long, medial, and lateral). The long head crosses both the glenohumeral joint at the shoulder as well as the elbow joint.
- The long head arises from the infraglenoid tubercle of the scapula by a flattened tendon that blends with the glenohumeral joint capsule.
- The medial and lateral heads cross only the elbow joint.

- The medial head covers an extensive area as it arises from the entire posterior surface of the humerus.
- In contrast, the lateral head arises from only a narrow ridge on the posterior humeral surface.
- The three heads insert via a common tendon into the olecranon process.
- The **anconeus** is a small triangular muscle that arises from the posterior surface of the lateral epicondyle of the humerus and extends medially to attach to the lateral aspect of the olecranon process.

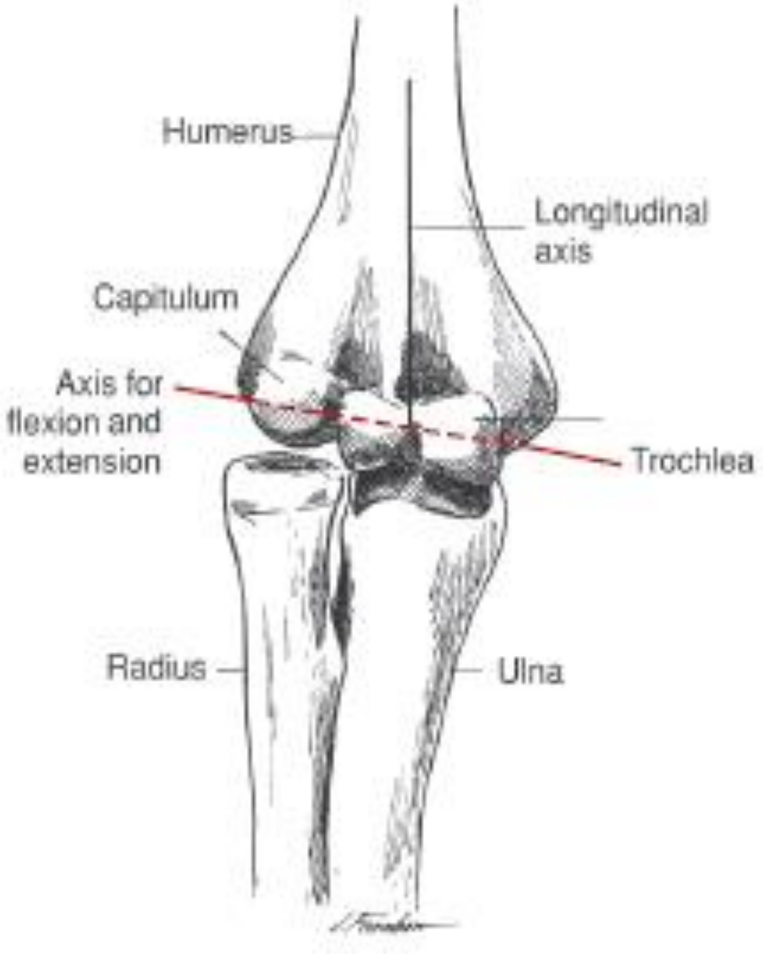
- In addition to the anconeus muscle, a number of muscles with primary actions at the wrist and fingers insert into the lateral humeral epicondyle by way of a common extensor tendon.
- These muscles include the **extensor carpi radialis longus, extensor carpi radialis brevis, extensor digitorum communis, extensor carpi ulnaris,** and **extensor digiti minimi**


A
Anterior view
Right arm
Medial epicondyle
Pronator teres
Palmaris longus
Flexor carpi radialis
Flexor carpi ulnaris
Flexor digitorum superficialis
Flexor retinaculum
B
Posterior view
Right arm
Lateral epicondyle
Anconeus
Supinator
Medial epicondyle
Lateral epicondyle
Extensor carpi radialis longus
Extensor carpi ulnaris
Extensor carpi radialis brevis
Extensor digitorum communis
Extensor digiti minimi
Extensor retinaculum

FUNCTION OF ELBOW JOINT

AXIS OF MOTION

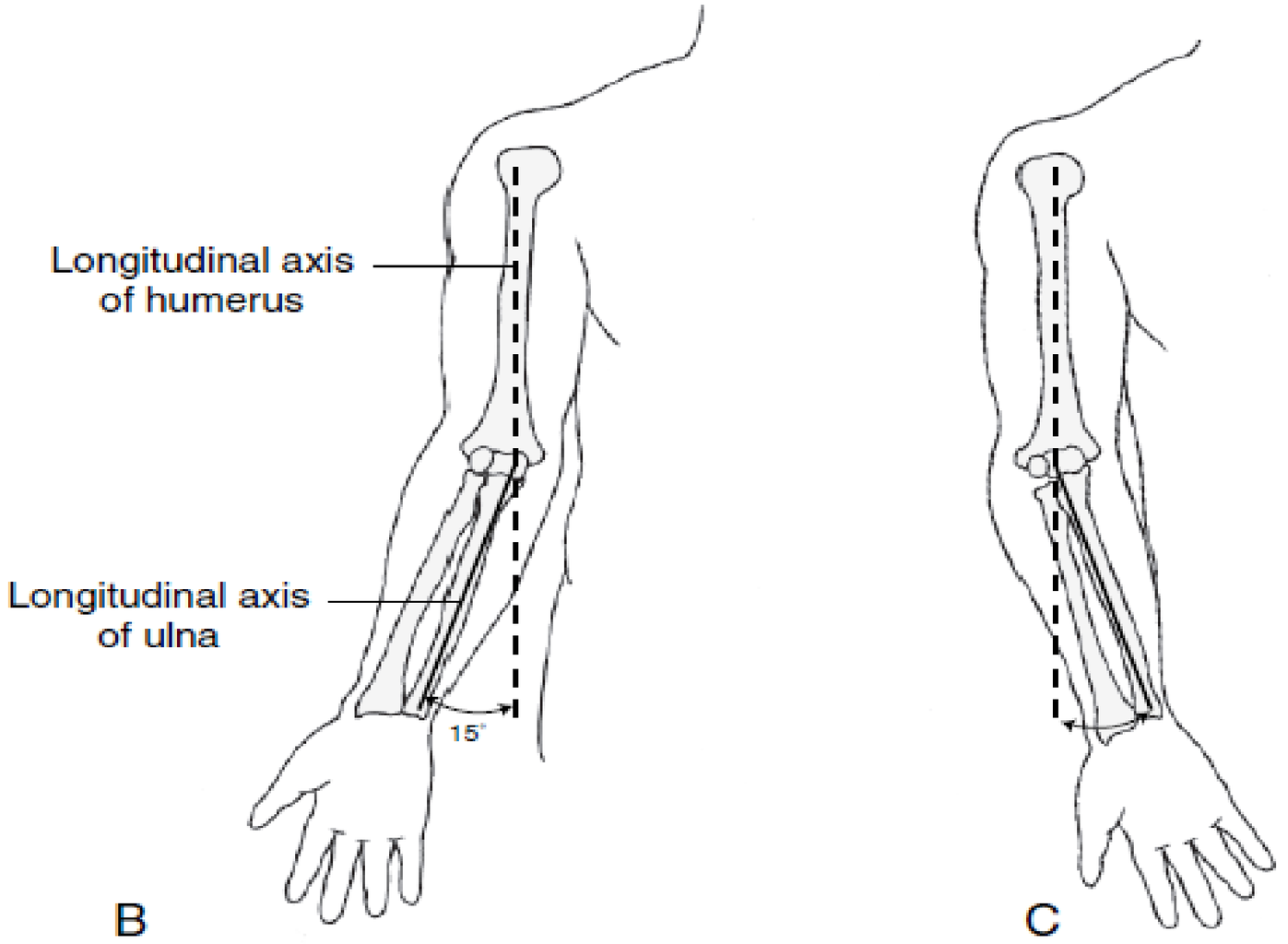
- Traditionally, the axis for flexion and extension has been described as being a relatively fixed axis that passes horizontally through the center of the trochlea and capitulum and bisects the longitudinal axis of the shaft of the humerus.



LONG AXES OF THE HUMERUS AND FOREARM

- When the upper extremity is in the anatomic position, the long axis of the humerus and the long axis of the forearm form an acute angle medially when they meet at the elbow.
- The angulation in the frontal plane is caused by the configuration of the articulating surfaces at the humeroulnar joint.

- The medial aspect of the trochlea extends more distally than does the lateral aspect, which shifts the medial aspect of the ulna trochlear notch more distally and results in a lateral deviation (or valgus angulation) of the ulna in relation to the humerus.
- This normal valgus angulation is called the **carrying angle** or **cubitus valgus.** The average angle in full elbow extension is about 15 degree.
- An increase in the carrying angle beyond the average is considered to be abnormal, especially if it occurs unilaterally. A varus angulation at the elbow is referred to as **cubitus varus** and is usually abnormal.


Longitudinal axis
of humerus
Longitudinal axis
of ulna
15°
B
C

- Functional use of the carrying angle results from a combination of shoulder lateral rotation, elbow extension, and forearm supination, which enables a person to carry a bucket in one hand in such a manner as to avoid contact between the carried load and lower limb on the same side.
- This position also helps in leading the hand towards a position above the center of mass of the weight.
- Normally, the carrying angle disappears when the forearm is pronated and the elbow is in full extension and when the supinated forearm is flexed against the humerus in full elbow flexion.

MOBILITY AND STABILITY

- A number of factors determine the amount of motion that is available at the elbow joint.
- These factors include the type of motion (active or passive), the position of the forearm (relative pronation-supination), and the position of the shoulder.
- The range of active flexion at the elbow is usually less than the range of passive motion, because the bulk of the contracting flexors on the anterior surface of the humerus may interfere with the approximation of the forearm with the humerus.

- The active range of motion for elbow flexion with the forearm supinated is typically considered to be from about 135° to 145°, whereas the range for passive flexion is between 150° and 160°.
- The position of the forearm also affects the flexion range of motion. When the forearm is either in pronation or in neutral (midway between supination and pronation), the range of motion is less than it is when the forearm is supinated.

- The position of the shoulder may affect the range of motion available to the elbow because of the two joint muscles that cross both the shoulder and elbow.
- These muscles, the biceps brachii and the triceps brachii, may limit range of motion at the elbow if a full range of motion is attempted at both joints simultaneously.

- Other factors that limit the range of motion but help to provide stability for the elbow are the configuration of the joint surfaces, the ligaments, and the joint capsule.
- The elbow has inherent articular stability at the extremes of extension and flexion.
- In full extension, the humeroulnar joint is in a **close-packed position.** In this position, bony contact of the olecranon process in the olecranon fossa limits the end of the extension range, and the configuration of the joint structures helps provide valgus and varus stability.

- The flexor carpi ulnaris and the pronator teres overlay the anterior bundle of the medial collateral ligament and contribute to medial support of the elbow.
- The bony components provide half of the resistance to varus stress in full extension, and the lateral collateral complex and joint capsule provide the other half of the resistance.
- Resistance to joint distraction in the extended position is provided entirely by soft tissue structures.

- The anterior portion of the joint capsule provides the majority of the resistance to anterior displacement of the distal humerus out of the trochlear notch; the medial and lateral collateral ligaments contribute only slightly.
- Approximation of the coronoid process with the coronoid fossa and of the rim of the radial head in the radial fossa limits extremes of flexion.

- Co-contractions of the flexor and extensor muscles of the elbow, wrist, and hand help to provide stability for the elbow during forceful motions of the wrist and fingers and in activities in which the arms are used to support the body weight.
- During pulling activities, such as when a person grasps and attempts to pull a fixed rod toward the body, the elbow joints are compressed by the contractions of muscles that cross the elbow and act on the wrist and hand.

MUSCLE ACTION

❖ ELBOW FLEXORS

- **The brachialis** is considered a mobility muscle because its insertion is close to the elbow joint axis. Also, the muscle has a large strength potential in that it has a large physiological cross-sectional area (PCSA) and a large work capacity (volume).
- According to EMG studies, the brachialis muscle works in flexion of the elbow in all positions of the forearm, with and without resistance. It also is active in all types of contractions (isometric, concentric, and eccentric) during slow and fast motions.

- Its moment arm (MA) is greatest at slightly more than 100° of elbow flexion, at which point its ability to produce torque is greatest.
- Because the brachialis is inserted on the ulna, it is unaffected by changes in the forearm position brought about by rotation of the radius.

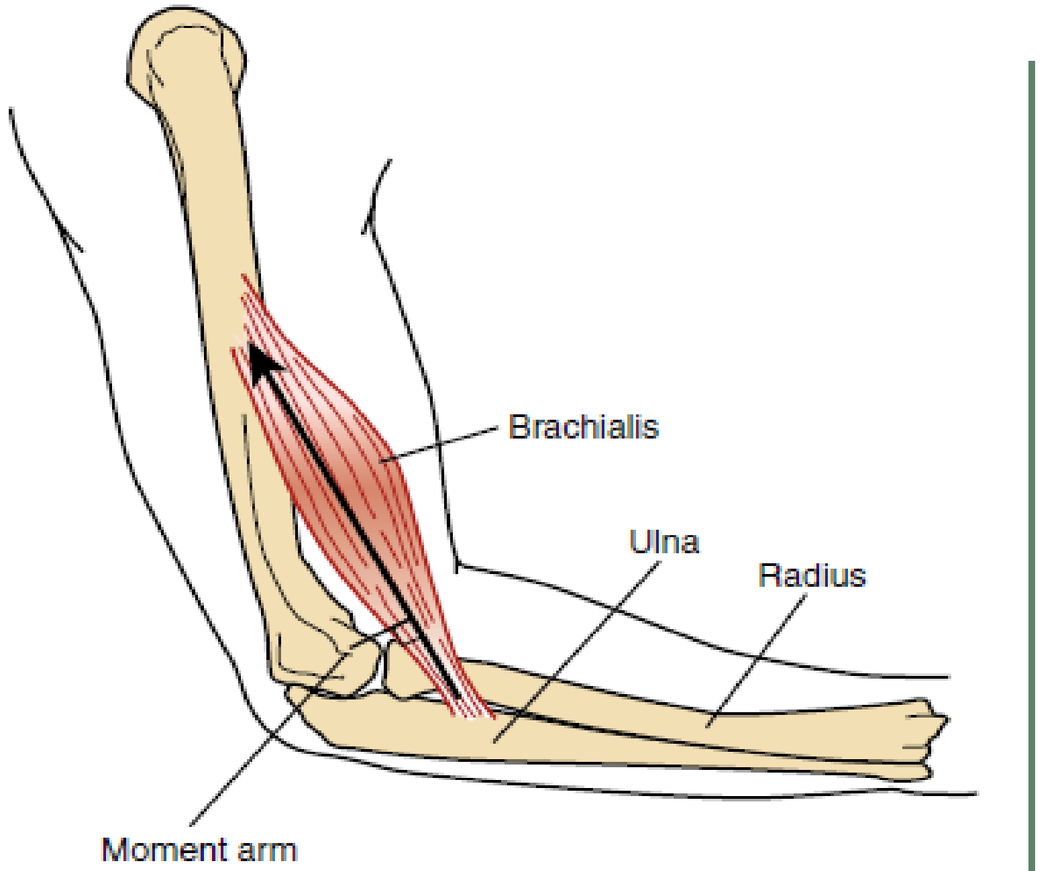
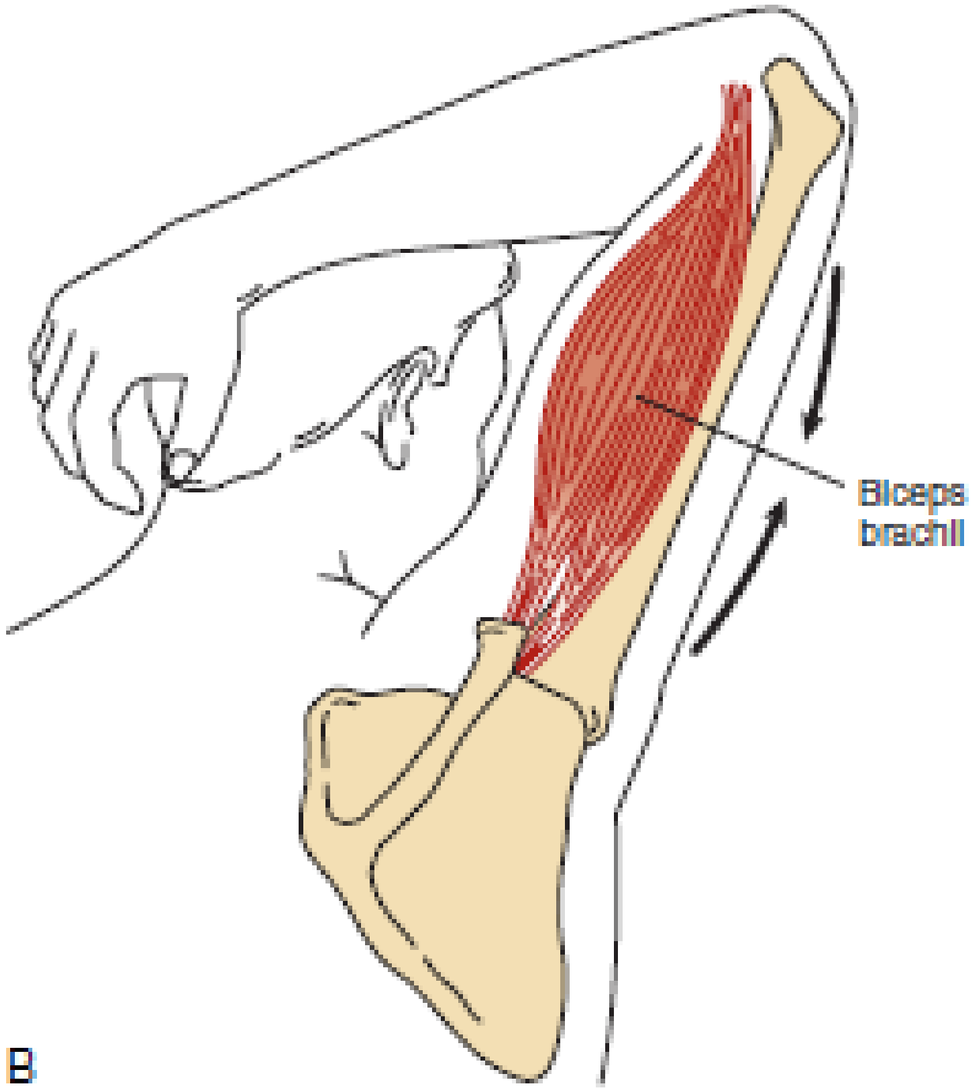


Figure 8–17 Moment arm of the brachialis at 100° of elbow flexion.

- The **biceps brachii,** like the brachialis, is also considered to be a mobility muscle because of its insertion close to the elbow joint axis.
- The long head of the biceps brachii has the largest volume among the flexors, but the muscle has a relatively small physiological cross-sectional area.
- The functioning of the biceps is affected by the position of the shoulder because both heads of the muscle cross both the shoulder and the elbow. If full flexion of the elbow is attempted with the shoulder in full flexion, especially when the forearm is supinated, the muscle's ability to generate torque is diminished.



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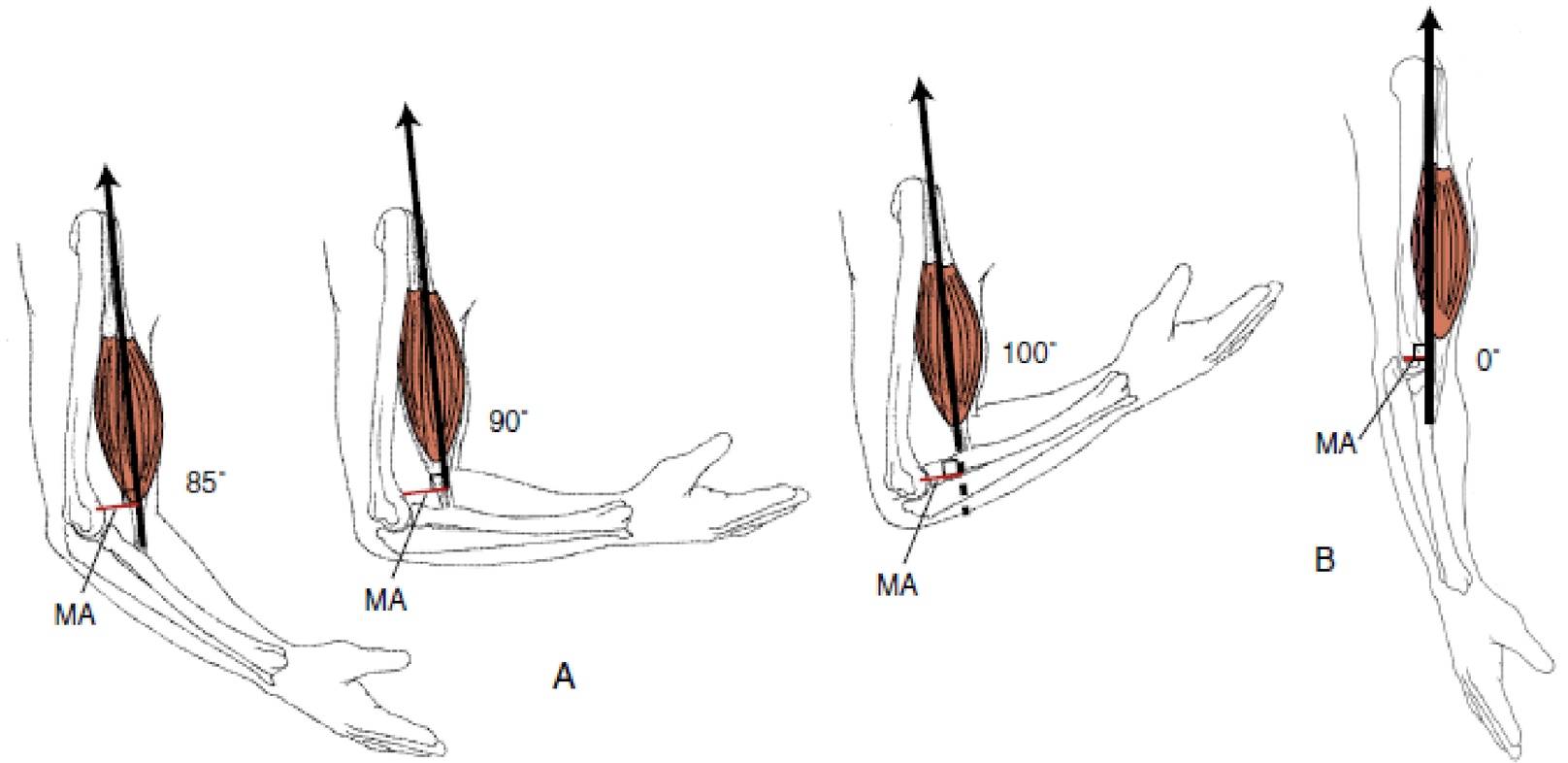


- The moment arm of the biceps is largest between 80° and 100° of elbow flexion, and therefore the biceps is capable of producing its greatest torque in this range

- The biceps brachii is active during unresisted elbow flexion with the forearm supinated and when the forearm is midway between supination and pronation in both concentric and eccentric contractions, but it tends *not* to be active when the forearm is pronated.
- The biceps brachii and the supinator act as supinators through the entire range of forearm rotation.

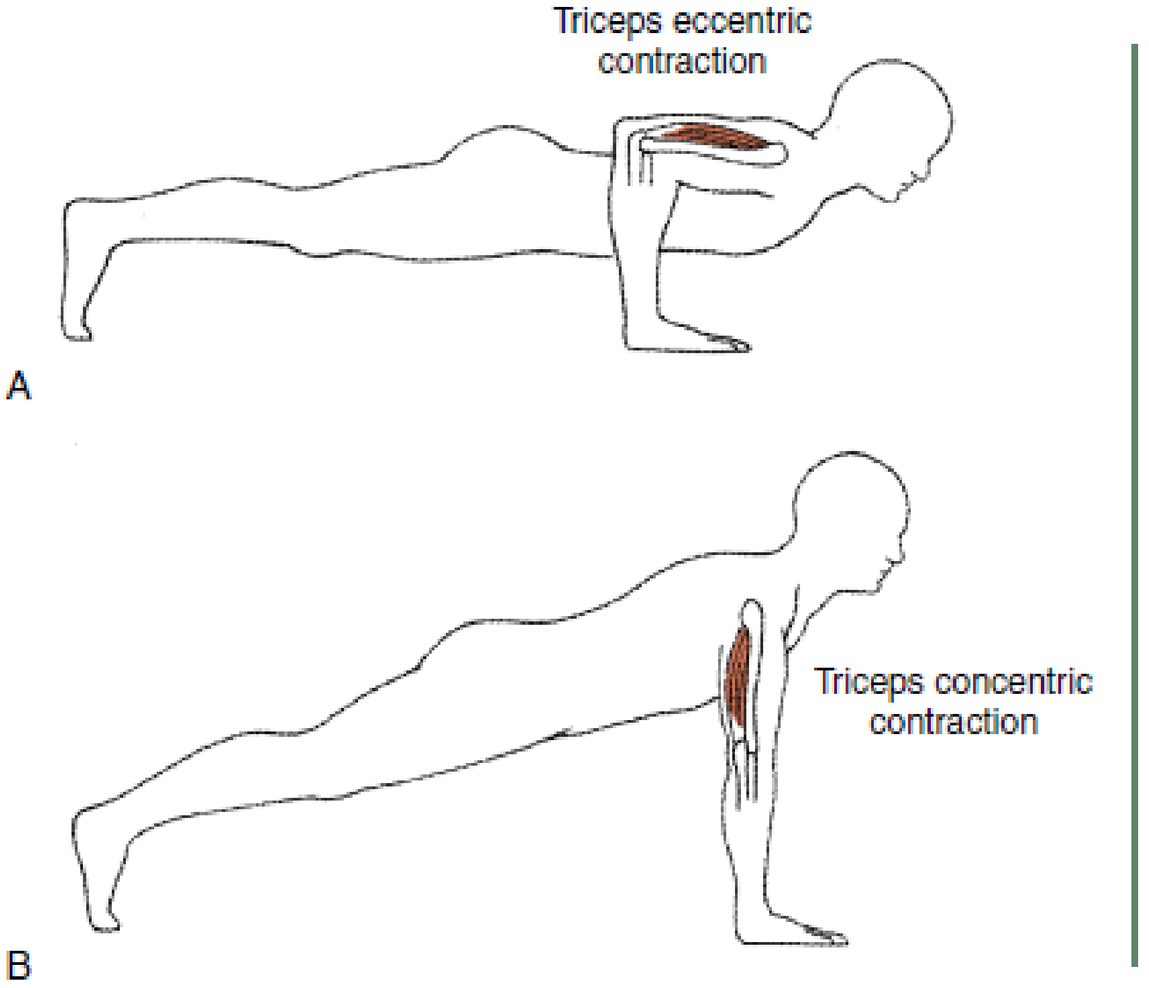
- The **brachioradialis** is inserted at a distance from the joint axis, and therefore the largest component of muscle force goes toward compression of the joint surfaces and hence toward stability.
- The peak moment arm for the brachioradialis occurs between 100° and 120° of elbow flexion.
- The brachioradialis does not cross the shoulder and therefore is unaffected by the position of the shoulder. The position of the elbow joint was found to affect brachioradialis muscle activity only during voluntary maximum eccentric contractions.

EXTENSORS:

- The effectiveness of the **triceps brachii** as a whole is affected by changes in the position of the elbow but not by changes in position of the forearm, because the triceps attaches to the ulna and not the radius.
- Activity of the long head of the triceps is affected by changing shoulder joint positions because the long head crosses both the shoulder and the elbow.
- The long head's ability to produce torque may diminish when full elbow extension is attempted with the shoulder in hyperextension.

- The medial and lateral heads of the triceps, being one-joint muscles, are not affected by the position of the shoulder.
- The medial head is active in unresisted active elbow extension, but all three heads are active when heavy resistance is given to extension or when quick extension of the elbow is attempted in the gravity-assisted position.
- Maximum isometric torque is generated at a position of 90° of elbow flexion.

- The triceps is active eccentrically to control elbow flexion as the body is lowered to the ground in a push-up.
- The triceps is active concentrically to extend the elbow when the triceps acts in a closed kinematic chain, such as in a push-up.



- The other extensor of the elbow, **the anconeus**, assists in elbow extension and apparently also acts as a stabilizer during supination and pronation.