Physiotherapy Department

Biomechanics

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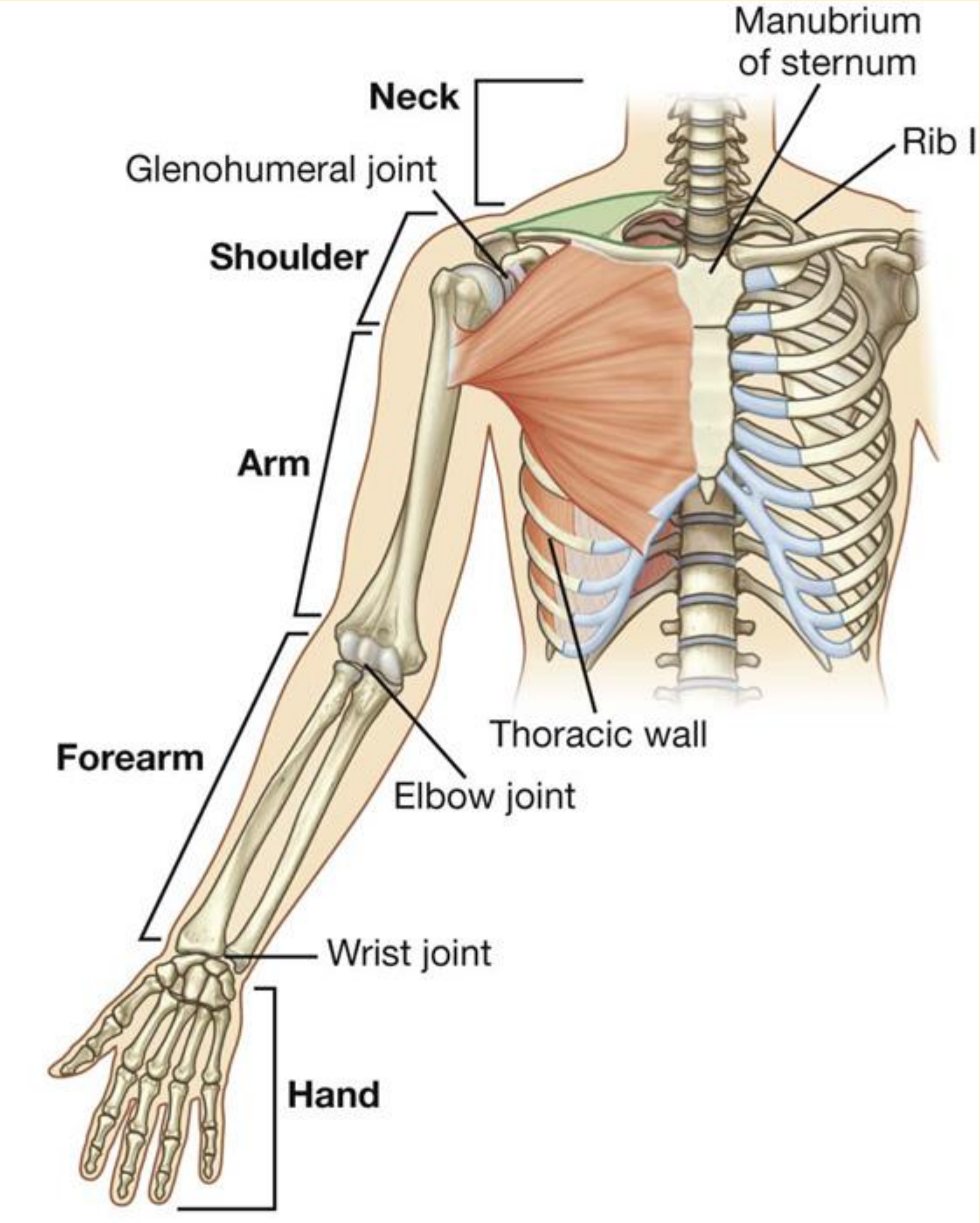
Biomechanics of the Joints of the Upper Limb



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Lecture 8

Biomechanics of Elbow, Wrist, and Hand Joints

05-11-2023

Synopsis

- Biomechanics of elbow complex
  - ➢Elbow joint
  - ➢Radioulnar joint

- Biomechanics of wrist joints

- Biomechanics of joints of the hand
  - ➢Metacarpophalangeal
  - ➢Interphalangeal

Objectives

- By the end of this lecture, students should understand and be able to describe the basic biomechanics of the following:

  - ➢Elbow complex
  - ➢Wrist complex
  - ➢Joints of the hand

Biomechanics of Elbow Complex

Elbow complex

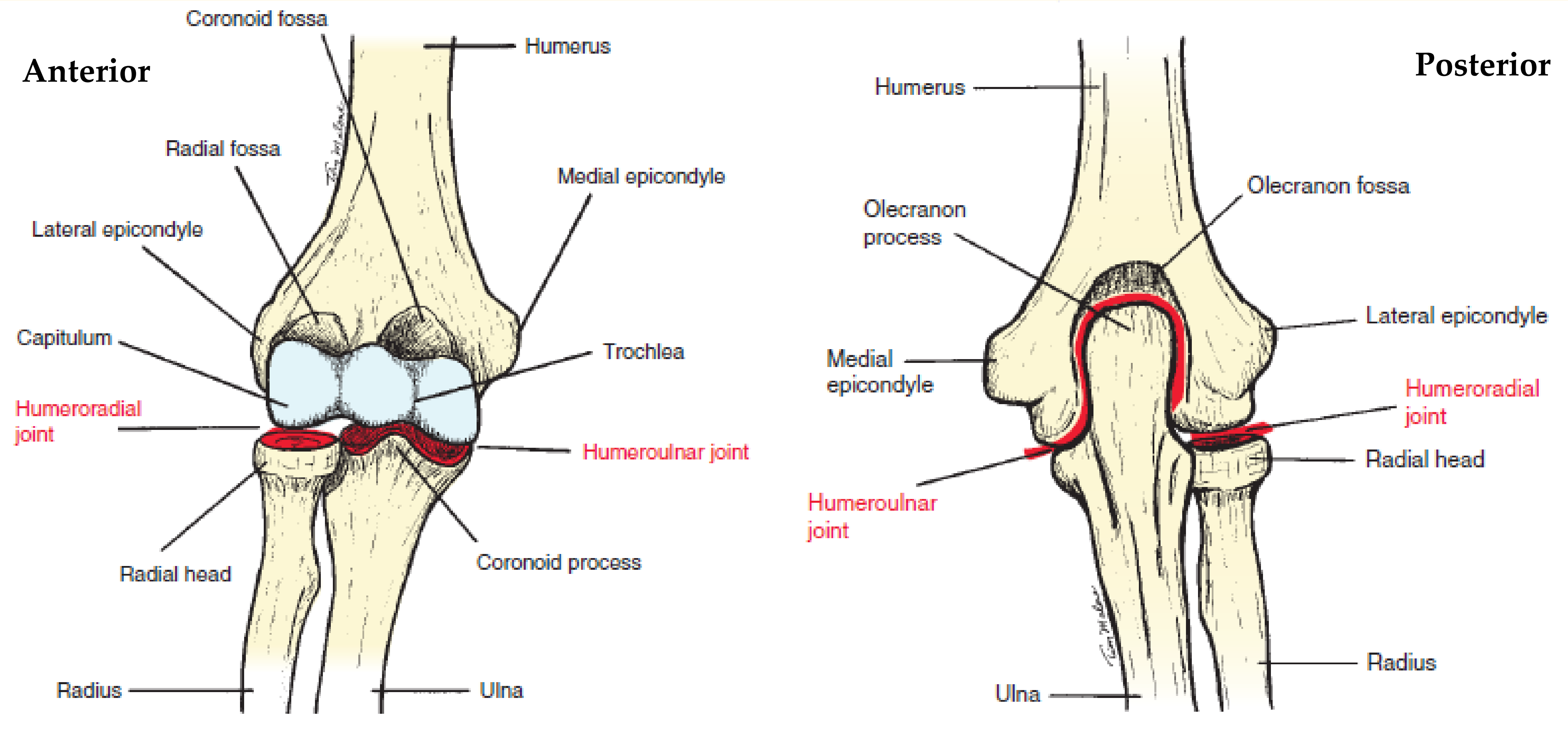
- A modified-hinge compound synovial joint, comprises four joint articulations:
  - ➢ Humero-ulna and humero-radial
  - ➢ Superior and inferior radioulnar

❖Humero-ulna and Humero-radial

Articulations:

- Humero-ulna: articulation between convex, hourglass-shaped trochlea located on the anterior medial surface of the distal humerus and the concave trochlear notch on the proximal ulna

- Humero-radial: articulation between convex capitulum located on the anterior lateral surface of the distal humerus and concave, shallow, cup-shaped surface of the proximal end of the radial head



Articular facets and articulations at the elbow complex

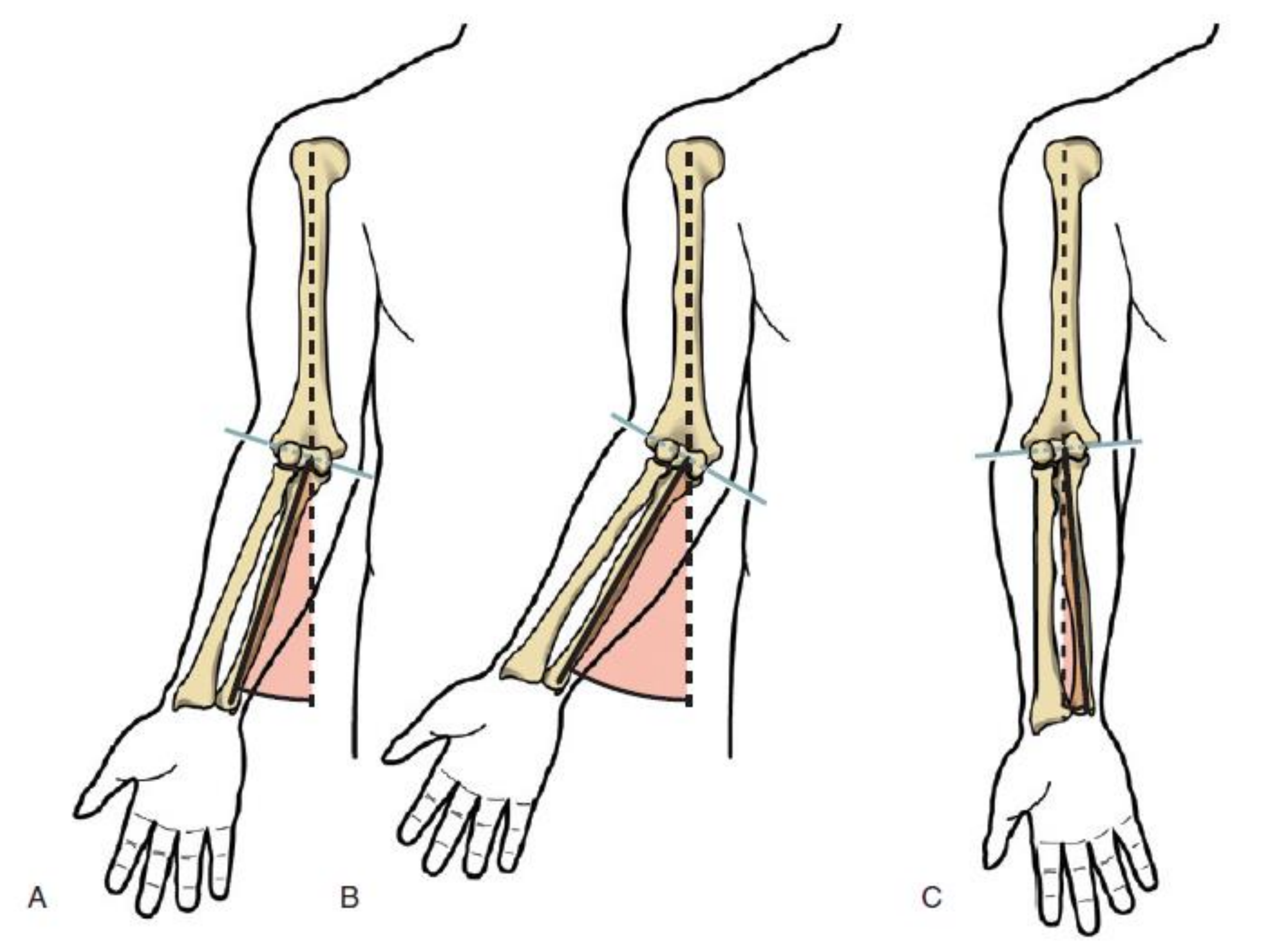
Biomechanics of Elbow Complex

- The elbow's axis of rotation extends slightly obliquely in a mediolateral direction through the capitulum and the trochlea

- Normal cubitus valgus of the elbow has an angle of about 15 degrees from the longitudinal axis of the humerus

- Excessive cubitus valgus deformity results in lateral deviation of the forearm to an angle of about 30 degrees

- Cubitus varus deformity is when the forearm deviates medially to below normal cubitus valgus (<15 degrees)



A. Normal Cubitus Valgus **B.** Abnormal Cubitus Valgus **C.** Cubitus Varus

Biomechanics of Elbow Complex

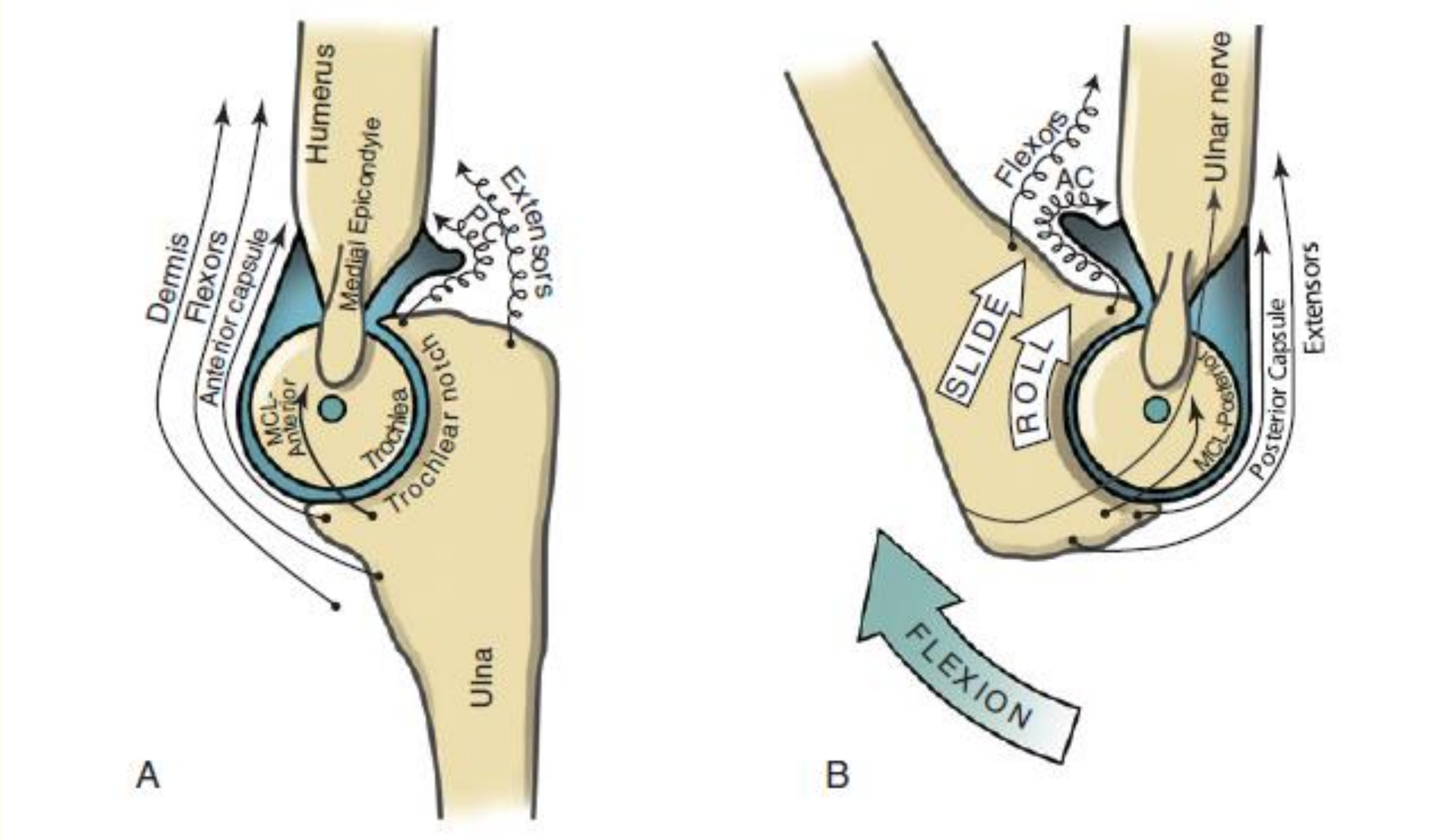
Osteokinematics

- The humeroulnar and humeroradial joints have 1 degree of freedom
- Flexion– extension occurs in the sagittal plane around a medial–lateral (coronal) axis
- During elbow flexion and extension, the axis of motion lies approximately through the center of the trochlea
- There is a slight amount of axial rotation and side-to-side motion of the ulnar during flexion and extension
- Thus, the term modified hinge is best used to describe the elbow joint

Biomechanics of Elbow Complex

Arthrokinematics

- At the humeroulnar joint
  - During flexion, the concave trochlear notch of ulna slides anteriorly along the humerus until the coronoid process of the ulna reaches the floor of the coronoid fossa of the humerus or until soft tissue in the anterior aspect of the elbow blocks further flexion
  - During extension, posterior sliding of the concave trochlear notch of the ulna on the convex trochlea of the humerus continues during extension until the ulnar olecranon process enters the humeral olecranon fossa
- At the humeroradial joint
  - During flexion, the concave radial head slides anteriorly until the rim of the radial head enters the radial fossa of the humerus
  - During extension the concave radial head slides posteriorly on the convex surface of the capitulum


Humerus
Medial Epicondyle
Dermis
Flexors
Anterior capsule
PC
Extensors
MCL-Anterior
Trochlea
Trochlear notch
Ulna
A
Flexors
AC
Ulnar nerve
SLIDE
ROLL
MCL-Posterior
Posterior Capsule
Extensors
FLEXION
B

Biomechanics of Elbow Complex

Muscles acting on the joint

- Flexion
  - ➢Biceps brachii
  - ➢Brachialis
  - ➢Brachioradialis

- Extension
  - ➢Triceps brachii muscle

Biomechanics of Elbow Complex

❖**Superior and Inferior radioulnar Articulations**

- Superior
  - ➢Between concave radial notch located on the lateral aspect of the proximal ulna and the convex head of the radius
- Inferior
  - ➢Between convex ulnar head and concave ulnar notch of the radius
- Interosseous membrane, a broad sheet of collagenous tissue linking the radius and ulna, provides stability for both joints

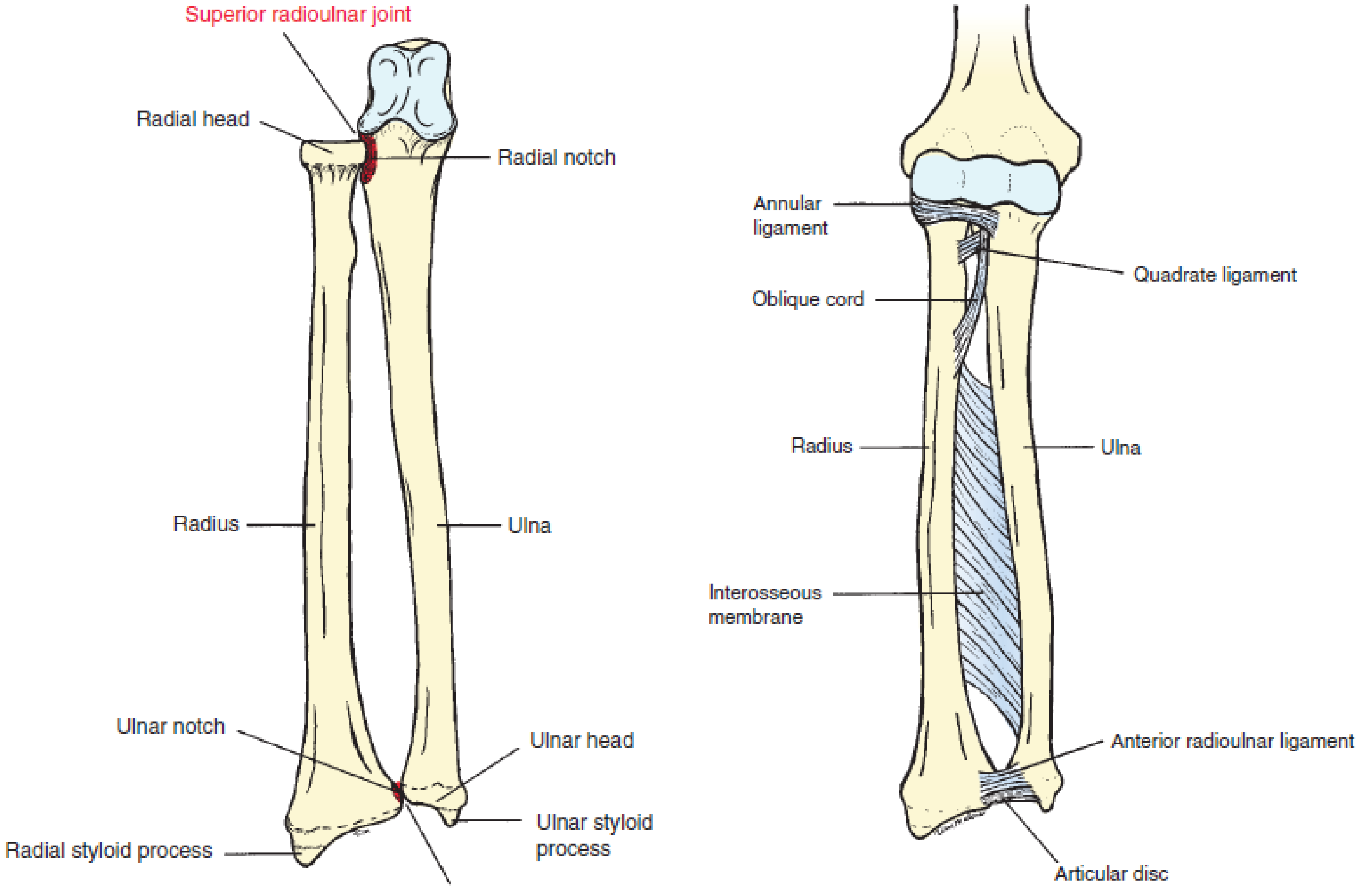


FIGURE 5.7 Anterior view of the superior and inferior

Biomechanics of Elbow Complex

Osteokinematics

- Superior and inferior radioulnar joints are mechanically linked
- Hence, motion at one joint is always accompanied by motion at the other joint
- The joints have 1 degree of freedom
- The joints permit the motions of pronation and supination in the transverse plane and a vertical axis

Biomechanics of Elbow Complex

Arthrokinematics

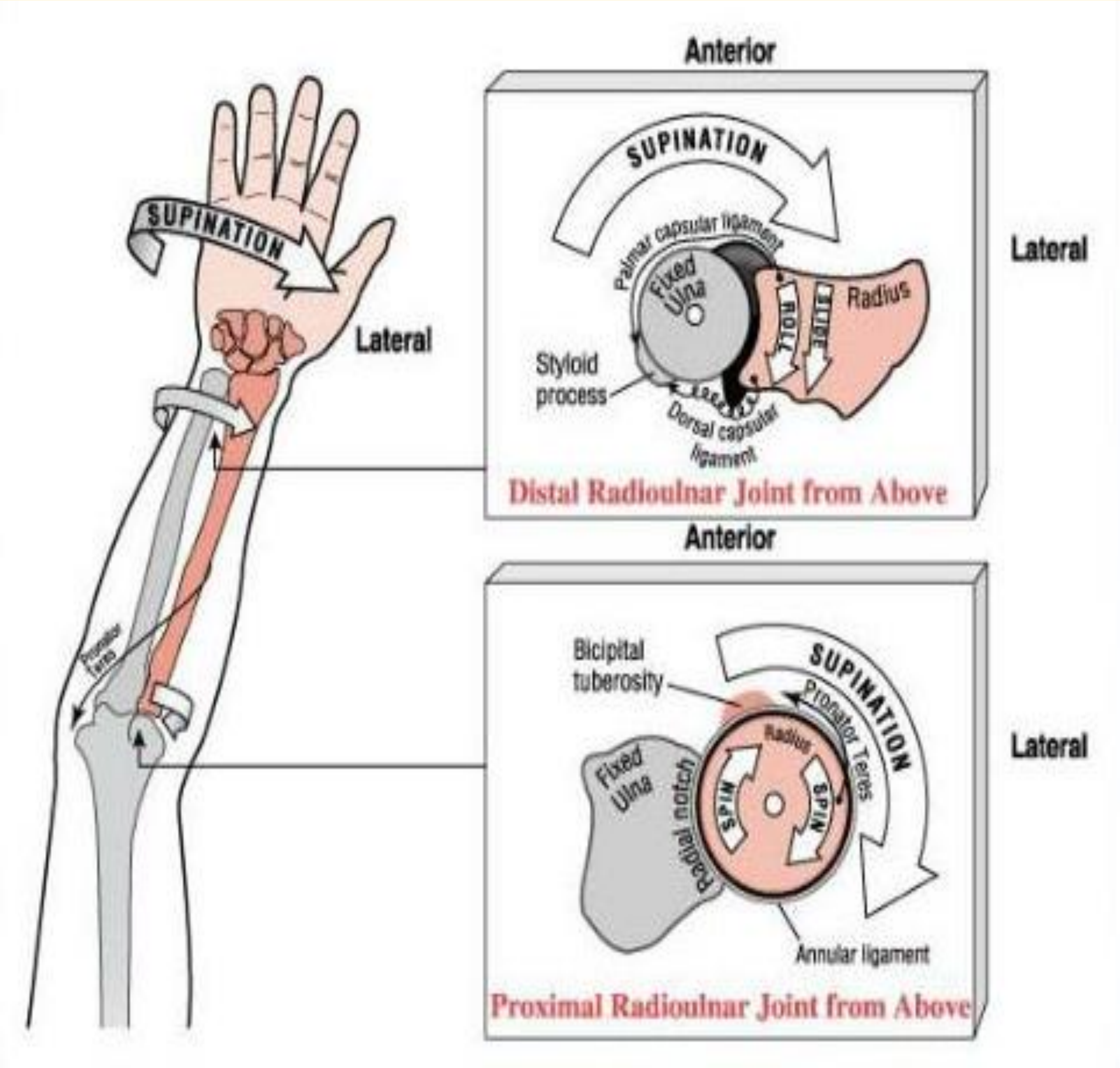
- At the superior radioulnar joint

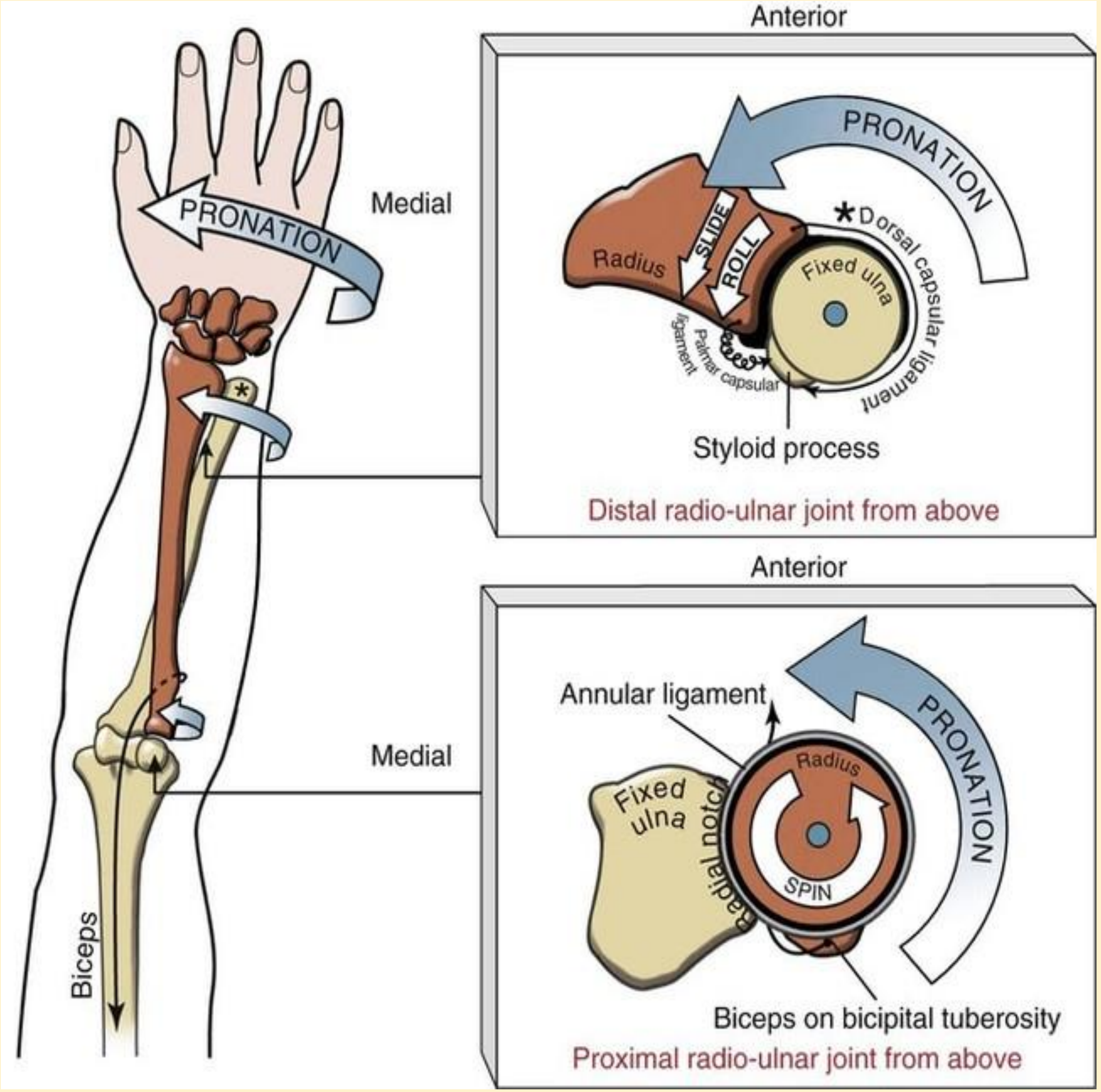
- Convex rim of the radial head spins within the annular ligament and the concave radial notch of the ulna during pronation and supination

- Articular surface on the radial head spins posteriorly during pronation and anteriorly during supination

Biomechanics of Elbow Complex

- At the inferior radioulnar joint
- Concave surface of the ulnar notch on the radius slides over the ulnar head
- Concave articular surface of the radius slides anteriorly during pronation and slides posteriorly during supination





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Biomechanics of Elbow Complex

- Muscles acting on the joint
- Pronation
  - ➢Pronator teres
  - ➢Pronator quadratus
  - ➢Brachioradialis

- Supination
  - ➢Supinator
  - ➢Biceps brachii

Biomechanics of Wrist Joints

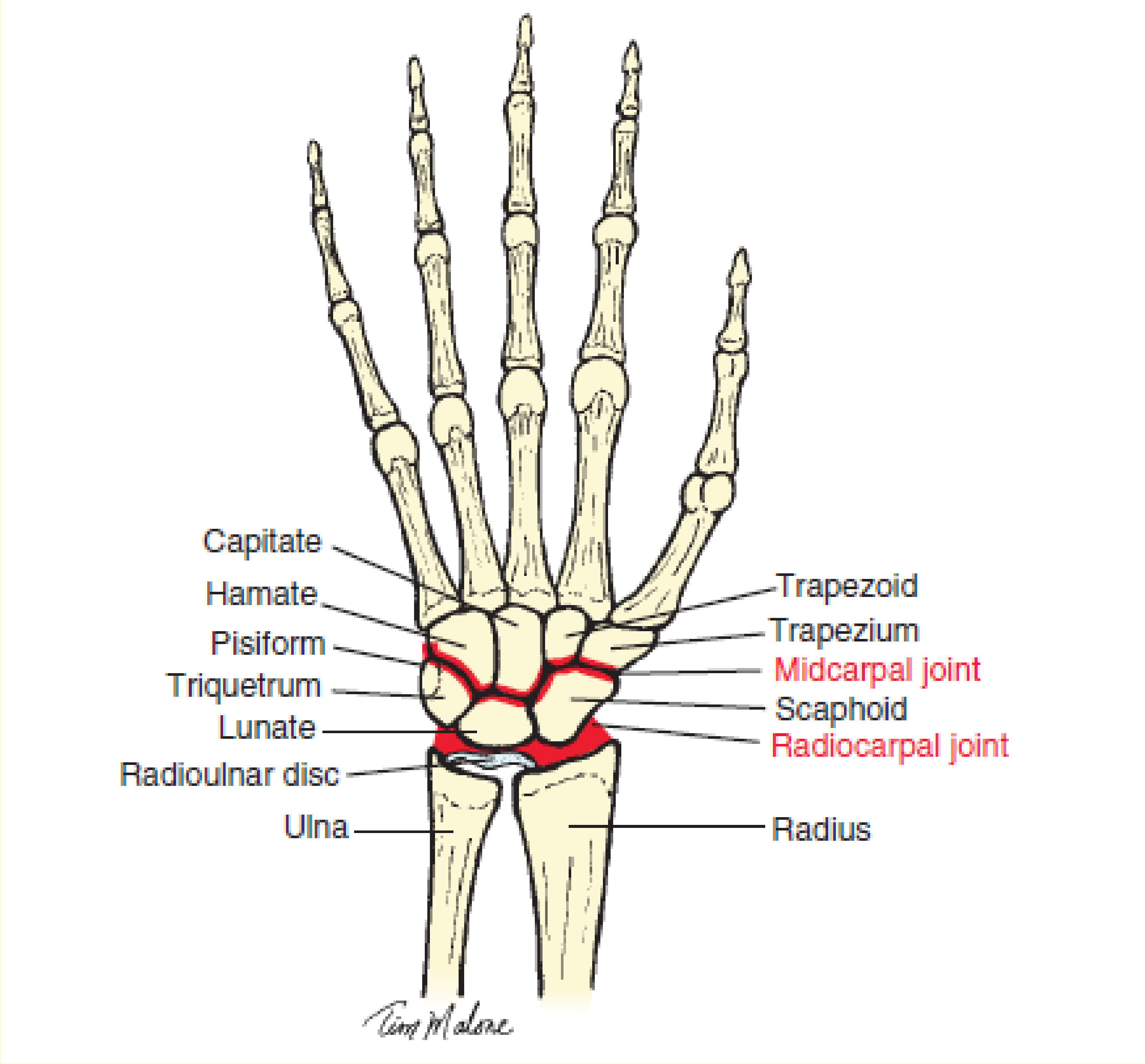
- Wrist is composed of two joints:
  - ➢Radiocarpal
  - ➢Midcarpal joints

❖Radiocarpal and Midcarpal joints

Articulations

- Radiocarpal: Between concave surfaces of distal radius and radioulnar articular disc and convex surfaces of scaphoid, lunate, and triquetrum

- Midcarpal: Between concave surfaces of the scaphoid, lunate, and triquetrum proximally and the convex surfaces of the capitate and hamate distally


Capitate
Hamate
Pisiform
Triquetrum
Lunate
Radioulnar disc
Ulna
Trapezoid
Trapezium
Midcarpal joint
Scaphoid
Radiocarpal joint
Radius
Tim Malone

Biomechanics of Wrist Joints

Osteokinematics

- Radiocarpal and midcarpal joints are of the condyloid type, with 2 degrees of freedom

- Wrist complex (radiocarpal and midcarpal joints) permits the following motions:

  - Flexion–extension in the sagittal plane around a medial–lateral axis

  - Radial–ulnar deviation in the frontal plane around an anterior–posterior axis

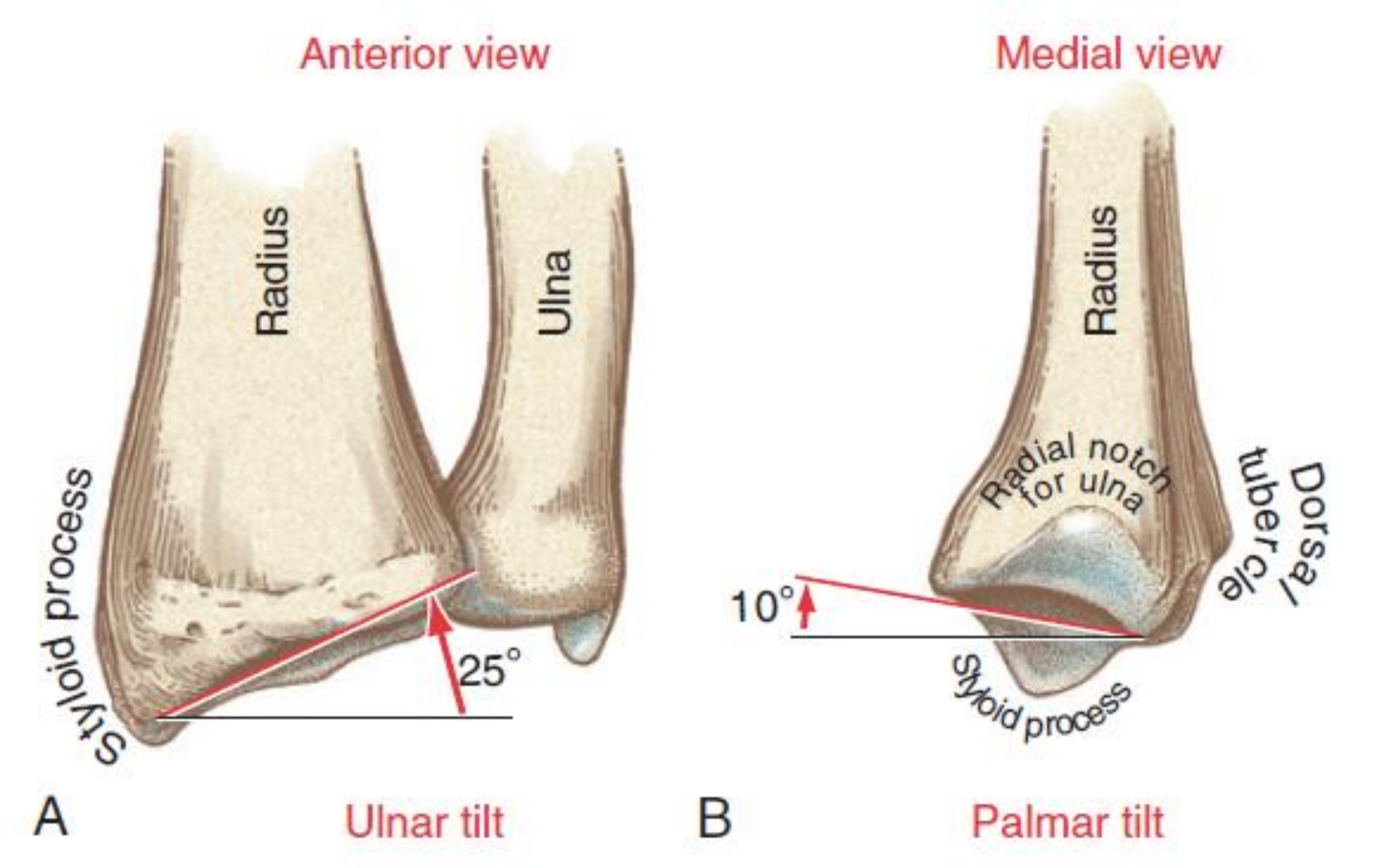
Biomechanics of Wrist Joints

- Distal end of the radius is angled about 25 degrees toward the ulnar and results in more range of motion (ROM) in ulnar deviation than radial deviation

- Also, the distal end of the radius is angled about 10 degrees in the palmar direction contributing to a slightly greater range of wrist flexion than extension

- Small amount of supination–pronation occurs at the wrist complex

- Circumduction, a combination of flexion, extension, and radial and ulnar deviation in an egg-shaped asymmetrical pattern, is also possible

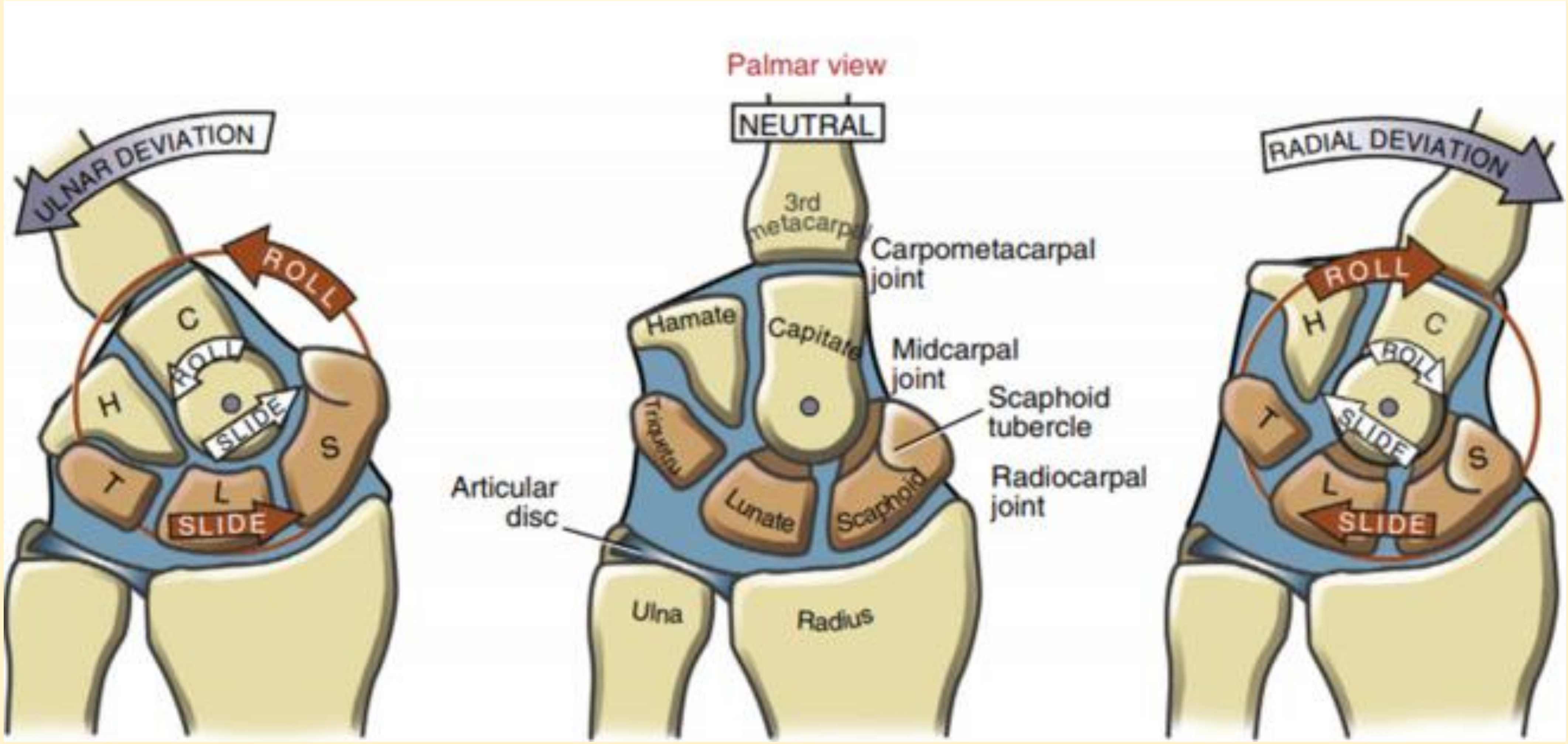


A. Anterior view of the distal radius showing an ulnar tilt of about 25 degrees
B. Medial view of the distal radius showing a palmar tilt of about 10 degrees

Biomechanics of Wrist Joints

Arthrokinematics

- Convex surfaces of the proximal row of carpals roll and slide on the concave surfaces of the radius and radioulnar disc
- Proximal row of carpals rolls in the same direction but slides in the opposite direction to movement of the hand
- Distal row of carpals rolls and slides on the proximal row of carpals.
- Similarly, the distal joint surface of the midcarpal joint is predominantly convex and rolls in the same direction and slides in the opposite direction to the osteokinematic movements of the wrist



Osteo and arthrokinematics of the wrist complex

Biomechanics of Wrist Joints

Muscles acting on the joint

- *Flexion* – Produced mainly by the flexor carpi ulnaris, flexor carpi radialis, with assistance from the flexor digitorum superficialis

- *Extension* – Produced mainly by the extensor carpi radialis longus and brevis, and extensor carpi ulnaris, with assistance from the extensor digitorum comunis

- *Adduction* – Produced by the extensor carpi ulnaris and flexor carpi ulnaris

- *Abduction* – Produced by the abductor pollicis longus, flexor carpi radialis, extensor carpi radialis longus and brevis

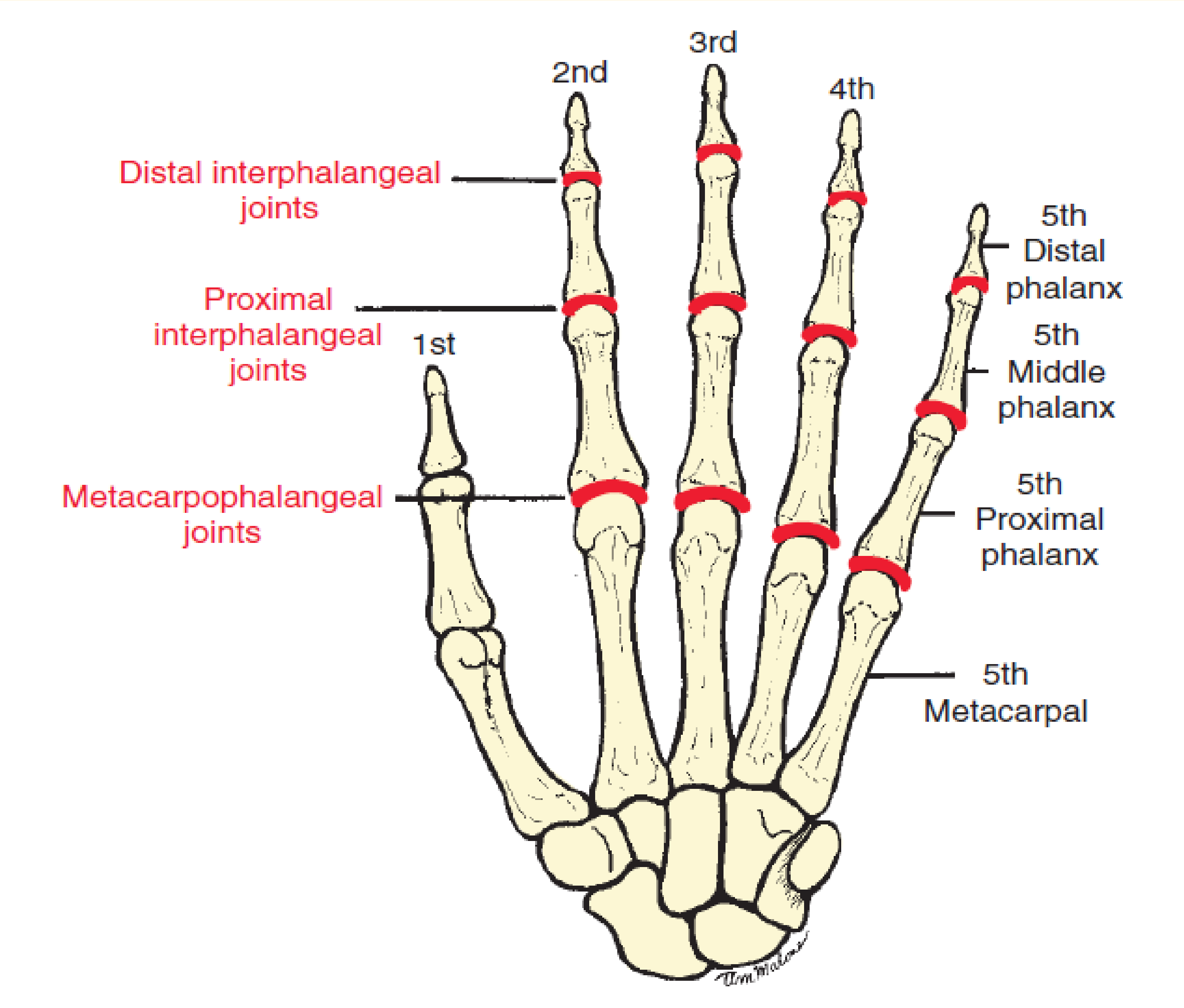
Biomechanics of Hand Joints

- Hand consists of the following joints
  - ➢Metacarpophalangeal (MCP)
  - ➢Interphalangeal (IP)

Articulation

- MCP joints of the fingers are composed of the convex distal end of each metacarpal and the concave base of each proximal phalanx

- IP joints composed of a convex head and concave base of more proximal and more distal phalanx



Hand articulations

Biomechanics of Hand Joints

Osteokinematics

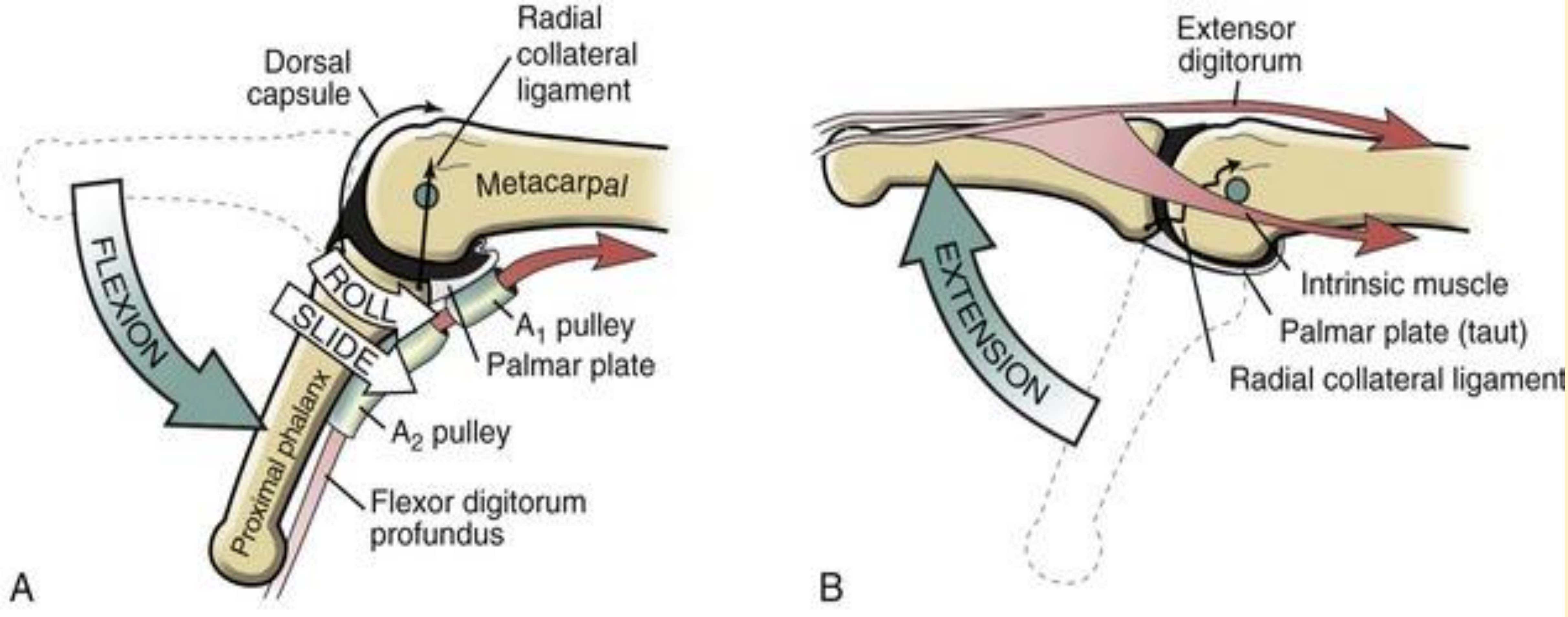
- MCP joints are biaxial condyloid joints that have 2 degrees of freedom, allowing flexion–extension in the sagittal plane and abduction–adduction in the frontal plane

- IP joints of the fingers are classified as synovial hinge joints with 1 degree of freedom: flexion–extension in the sagittal plane

Arthrokinematics

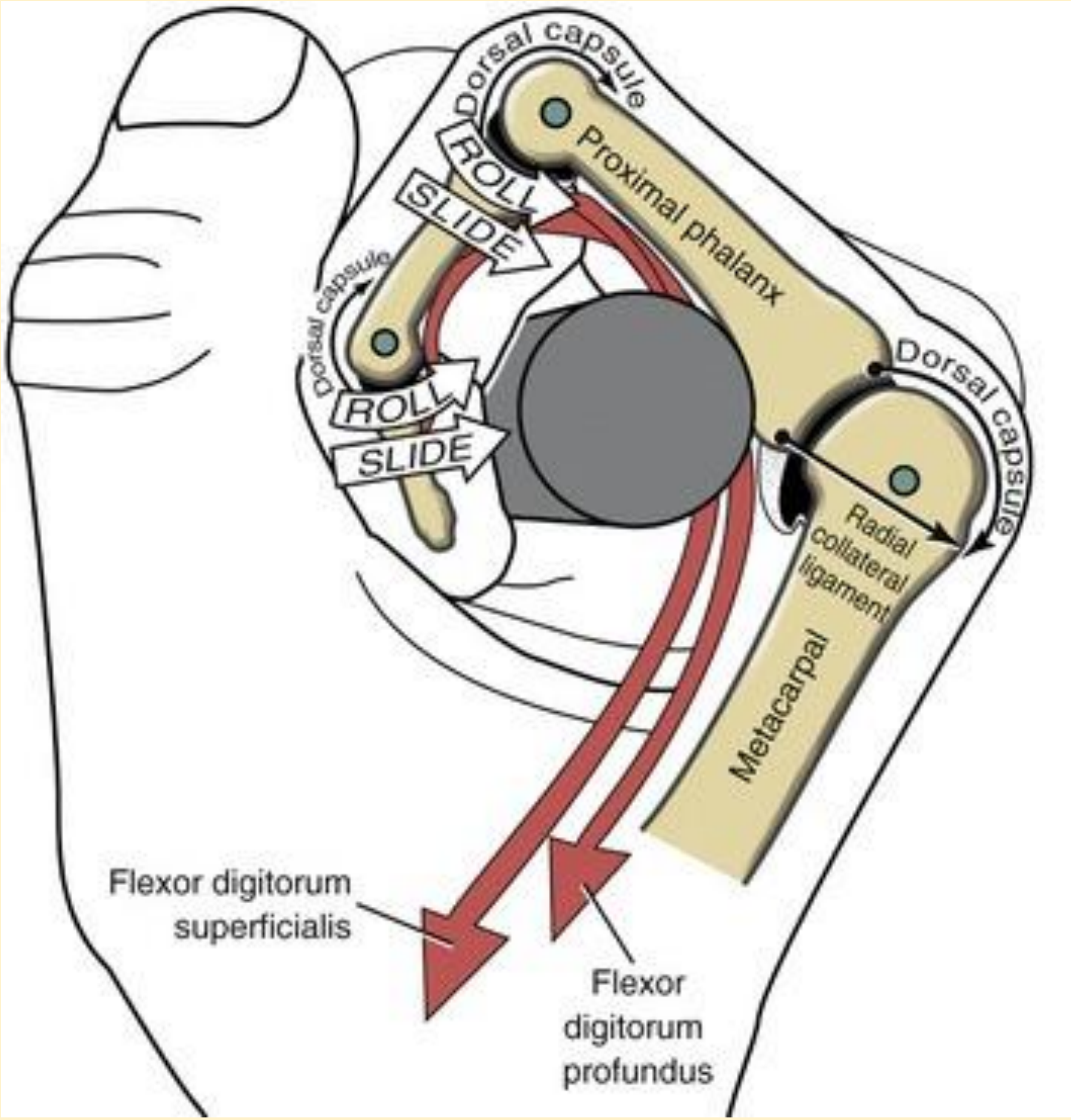
- MCP: concave base of the phalanx slides and rolls on the convex head of the metacarpal in the same direction as movement of the shaft of the phalanx

- IP: Sliding and rolling of the base of the moving phalanx occurs in the same direction as the movement of the shaft

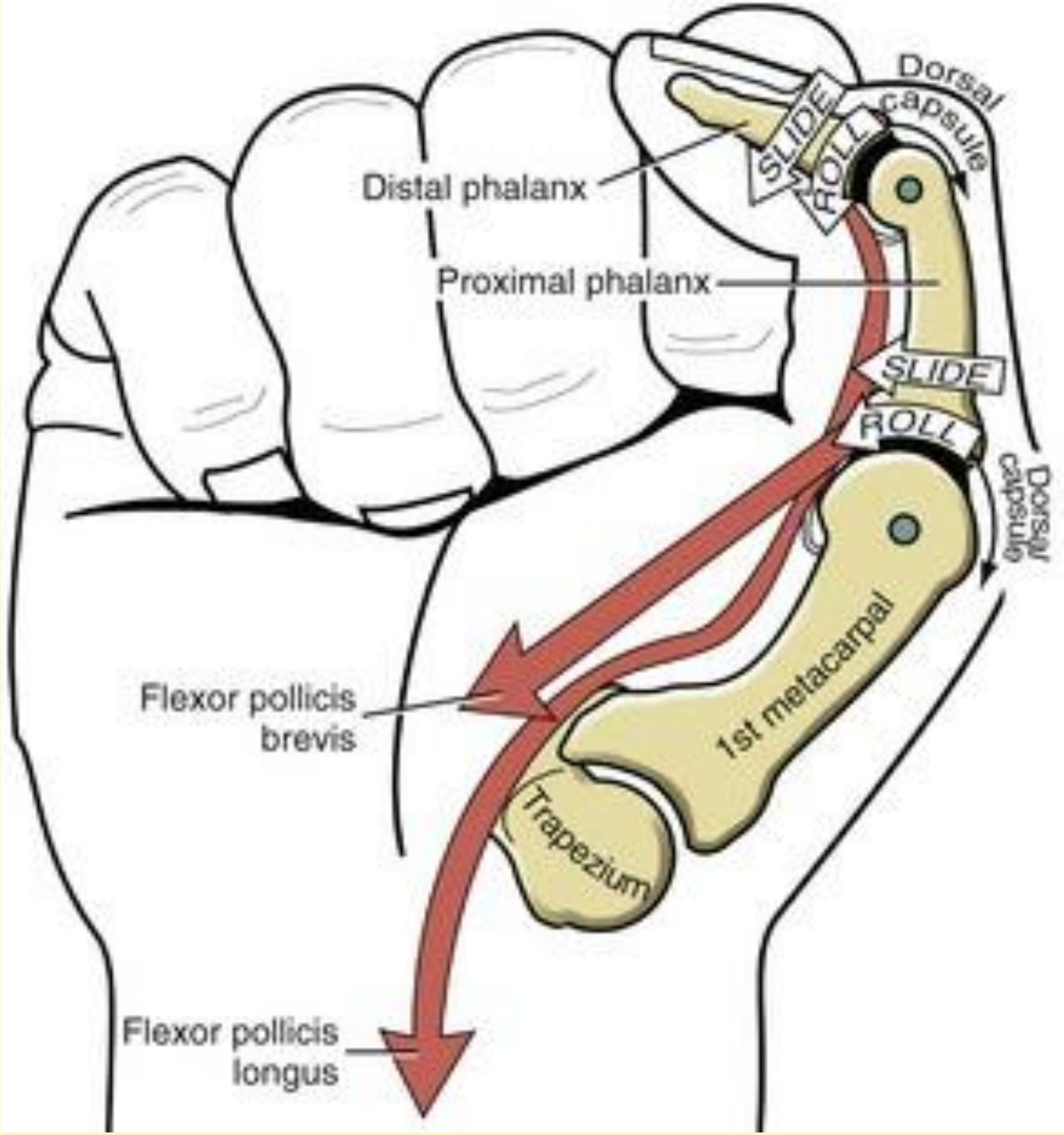


Joint kinematics at MCP Joint

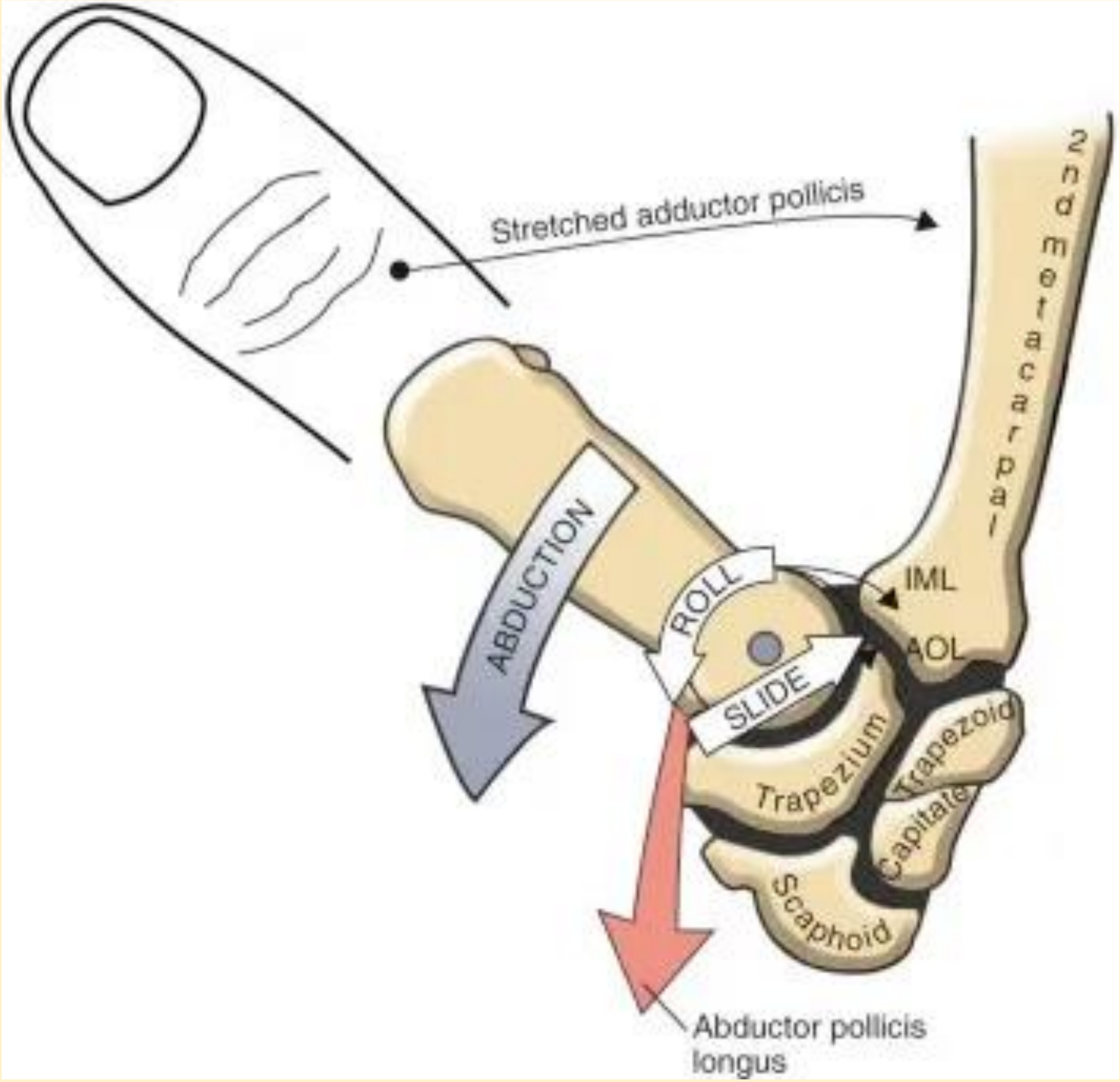
Joint kinematics at MCP and IP Joints



Joint kinematics at MCP and IP Joints



Joint kinematics at MCP Joint of the Thumb



Biomechanics of Hand Joints

Muscles acting at the joints

- Flexion of the thumb is mainly produced by flexor pollicis brevis, aided by flexor pollicis longus muscle.

- Flexion of digits 2 to 5 are produced by flexor digitorum superficialis, flexor digitorum profundus, lumbricals, and flexor digiti minimi brevis (fifth digit)

- Extension of the thumb (from the flexed position) is mainly produced by the extensor pollicis brevis, with some help from extensor pollicis longus muscle.

- Extension of digits 2 to 5 are produced by extensor digitorum, extensor indicis (second digit) and extensor digiti minimi (fifth digit).

Biomechanics of Hand Joints

- Adduction of the thumb is produced by the adductor pollicis
- Adduction of the other four digits is produced by palmar interossei muscles
- Abduction of the thumb is produced by the abductor pollicis longus and abductor pollicis brevis
- Abduction of the fifth digit is produced by the abductor digiti minimi
- Abduction of fingers 2-5 is produced by the dorsal interossei muscles
- Axial rotation is produced actively by the co-contraction of flexor pollicis brevis and abductor pollicis brevis

Summary Points

- Upper limb is the most mobile segment of the body
- Shoulder complex, elbow complex, wrist complex, and joints of the hand provide the needed fulcrum for the upper limb to perform its tasks
- Stability is partly compromised in some joints to attain high mobility
- Abnormal joint alignment could lead to pathomechanics around the joint

Contributions and Questions

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