Posterior (Extensor) Compartment of Forearm

Debra J. Hazen-Martin, PhD (Walton RS 811)
Professor, Dept of Pathology & Lab Medicine
Email: hazenmad@musc.edu

Lecture outline:

I. Introduction to arrangement of muscles
   A. Structural
   B. Functional

II. Superficial Group of Muscles
   A. Brachioradialis
   B. Extensor carpi radialis longus
   C. Extensor carpi radialis brevis
   D. Extensor digitorum
   E. Extensor digit minimi
   F. Extensor carpi ulnaris
   G. Anconeus

III. Clinical Considerations
   A. Extensor tendon insertion injuries
   B. Inflammation at common tendon of origin

IV. Deep Group of Muscles
   A. Supinator
   B. Abductor pollicis longus
   C. Extensor pollicis brevis
   D. Extensor pollicis longus
   E. Extensor indicis

V. Extensor Retinaculum
   A. Compartments
   B. Clinical Considerations

VI. Blood Supply

VII. Nerve Supply

VIII. Functional and Clinical Considerations

Readings: Gray's Anatomy for Students, Drake et al.: Online, Chapter 7,

Objectives:

On completion of study of texts, lecture material and related laboratory dissection you should be able to:

1) describe the muscles that occupy each of the compartments in the extensor region of the forearm.

2) describe the muscles that produce movement at only the elbow or wrist joint exclusively and which produce movement at both joints.

3) describe where/how the brachioradialis reflex is tested and which spinal cord level is assessed by this action.

4) describe which muscle(s) would be affected by inflammation of the common extensor tendon and what action would invoke pain at this site.

5) list which muscles would lose innervation if the radial nerve or its branches were severed in the following locations: radial groove, at the neck of the radius, or just proximal to the wrist joint.

6) describe the method of insertion of the parts of the extensor expansion hood relative to the MCP, PIP, and DIP joints.

7) describe the outcome of tearing of either the central or later bands of the extensor expansion.

8) explain how insertion of the interosseous and lumbrical muscles effects movement at the MCP, PIP, and DIP joints.

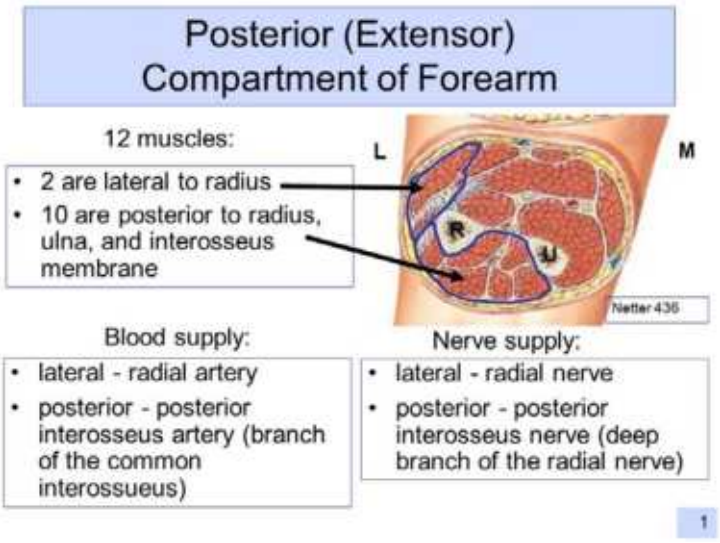
9) describe the relationship of tendons as they pass deep to the extensor retinaculum at the distal radius and ulna.

10) describe what is meant by “position of function” at the wrist, which muscles contribute to this position, and the functional significance.

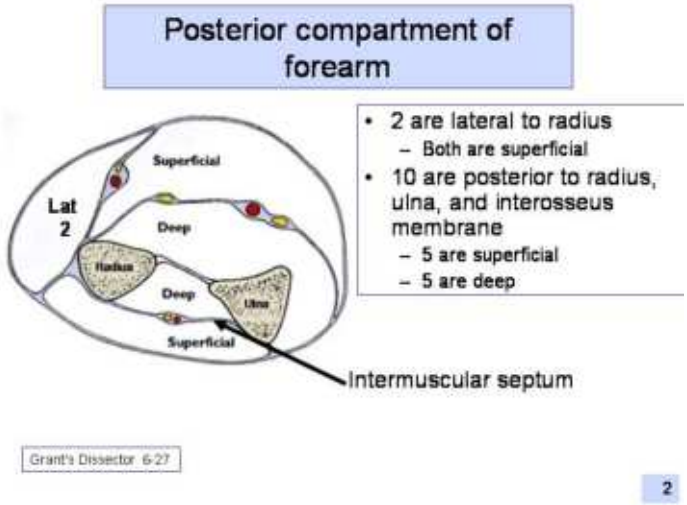
Illustrations are adapted from:

Posterior (Extensor) Compartment of the Forearm

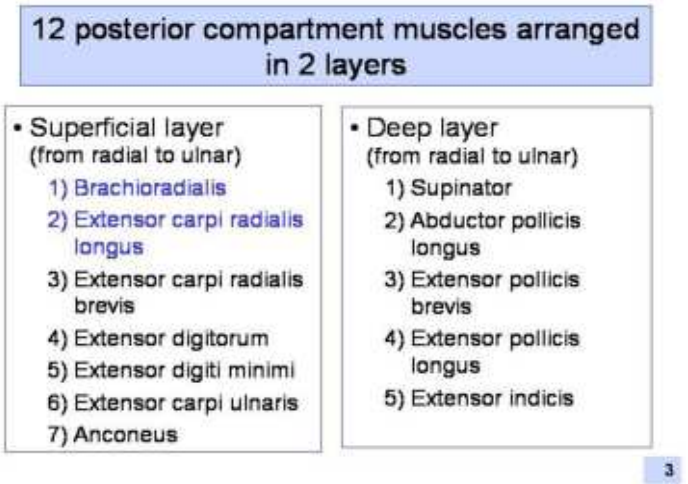
Debra Hazen-Martin, PhD
Department of Pathology and Laboratory Medicine
Medical University of South Carolina



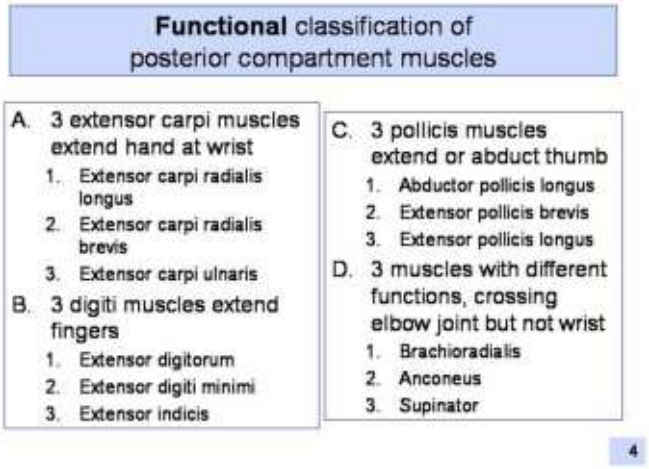
Slide #1: The posterior compartment of the forearm is posterior to the radius, ulna, and interosseus membrane. Some textbooks, include 2 muscles, brachioradialis and extensor carpi radialis longus in a lateral compartment. These two muscles are supplied by the radial artery rather than the posterior interosseous artery. In addition, they are supplied by the radial nerve rather than its deep branch (posterior interosseous nerve). Despite these differences, we will include the 2 muscles that are lateral to the radius in the superficial group of posterior compartment muscles. **(Netter 8th ed, 461)**



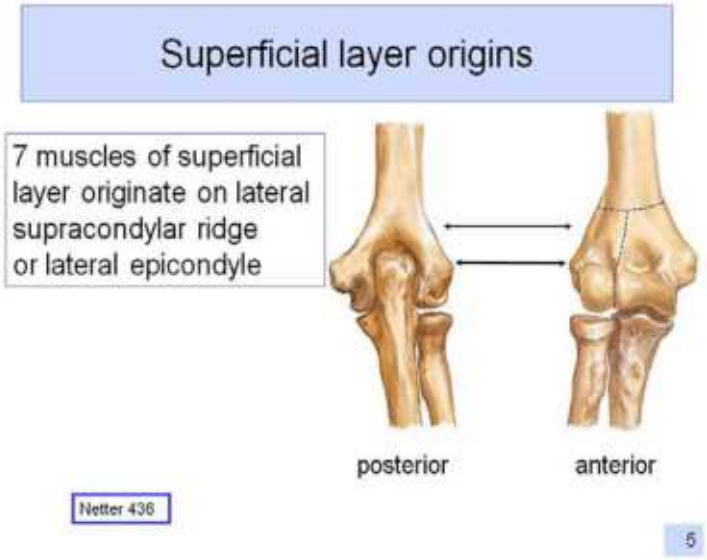
Slide #2:
There are 12 muscles in the posterior compartment. Seven of the muscles are in the superficial layer (the 2 lateral muscles and 5 from the posterior group). The remaining five muscles are in a deeper layer. An intermuscular septum separates the deep and superficial group.



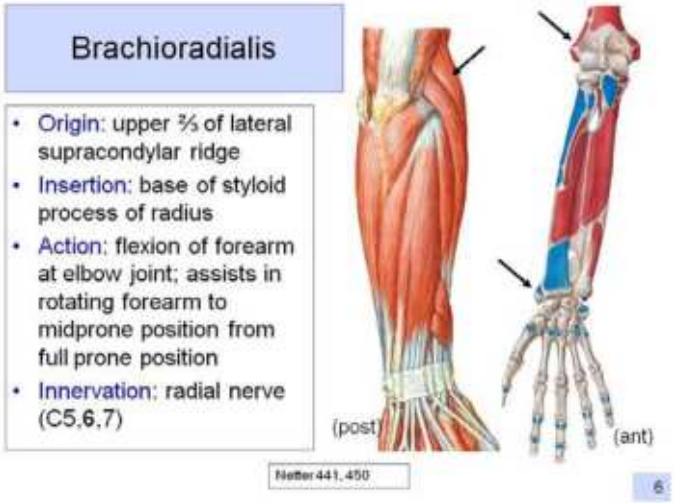
Slide #3:
The 12 muscles of the posterior forearm, grouped by their position, include the following:



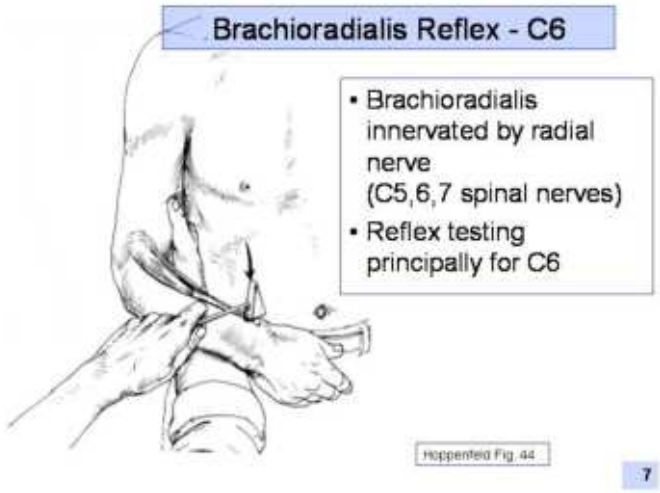
Slide #4:
The 12 muscles of the posterior forearm, can be grouped by their functions into four groups with three muscles in each group.



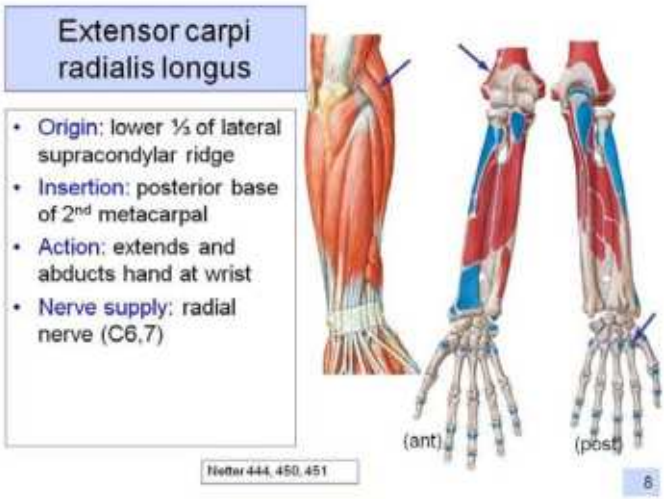
Slide #5: Remember that the superficial layer of muscles of the anterior (flexor) compartment of the forearm originates mainly from the medial epicondyle of the humerus. In a similar way, the superficial layer of muscles of the posterior (extensor) compartment originates from the **lateral** side of the humerus. Brachioradialis and extensor carpi radialis longus have origins on the upper ⅔ and lower ⅓ of the lateral supracondylar ridge. Four muscles (extensor carpi radialis brevis, extensor digitorum, extensor digiti minimi, and extensor carpi ulnaris) originate by a tendon of common origin on the lateral epicondyle (the common extensor tendon). **(Netter 8th ed. 446)**



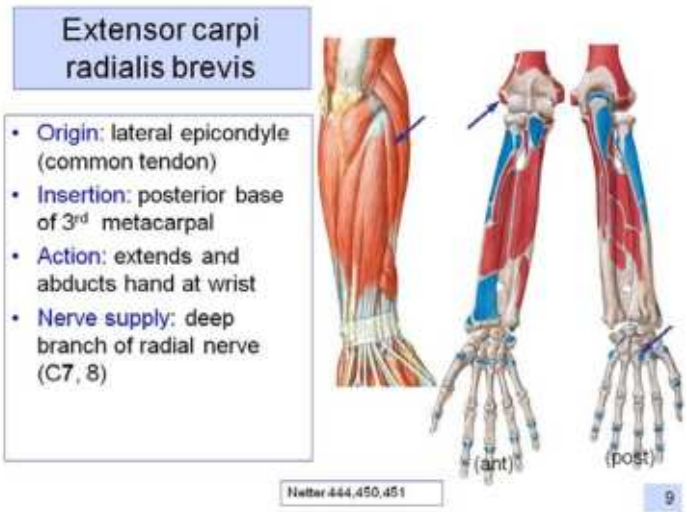
Slide #6:
The brachioradialis is named for its attachments. It originates from the upper ⅔ of the lateral supracondylar ridge of the humerus and inserts on the lateral side of the radius just proximal to the radial styloid process. This muscle does not cross the wrist joint, so it cannot move or provide stability to the wrist. The major action is **flexion** of the elbow joint. It is the only posterior compartment muscle innervated by the radial nerve that **does not** act as an extensor. Brachioradialis pronates the forearm from full supination and supinates from full pronation; thus, it rotates the forearm to bring the hand to the intermediate position in which it is usually carried. **(Netter 8th ed. 454)**



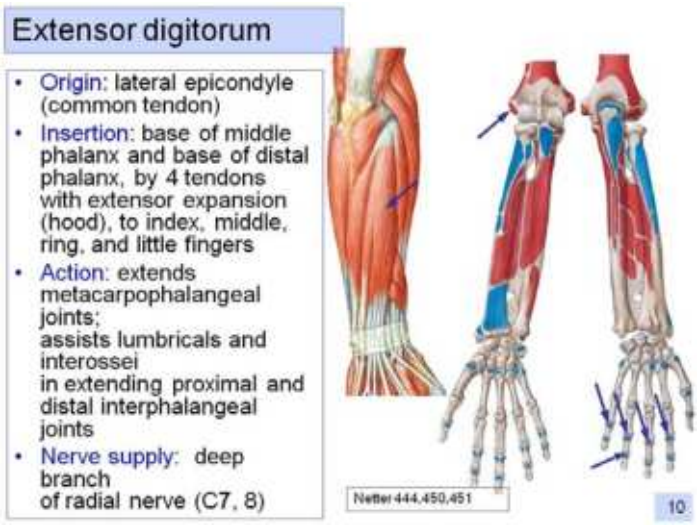
Slide #7:
Brachioradialis is effective in flexion of the forearm when the forearm is in the intermediate position between supination and pronation. The muscle can be palpated when the forearm is flexed in this mid-prone position. The **brachioradialis reflex** is a test of C6 motor innervation. This is tested by tapping the brachioradialis tendon with a hammer to elicit a muscular twitch or jerk.



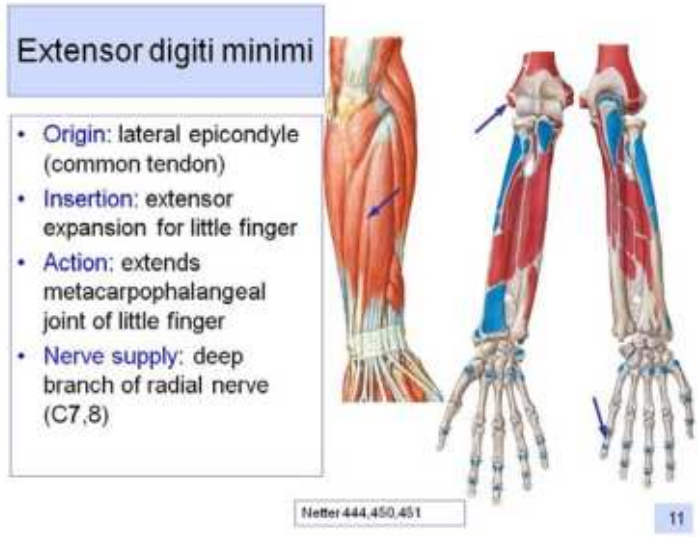
Slide #8:
The extensor carpi radialis longus muscle originates from the lower ⅓ of the supracondylar ridge of the humerus It inserts on the posterior side of the base of the 2nd metacarpal bone. ECRL is involved in extension and abduction (or radial deviation) of the hand at the wrist joint. Like the brachioradialis, the ECRL is innervated by the radial nerve. **(Netter 8th ed. 454, 459, 460)**



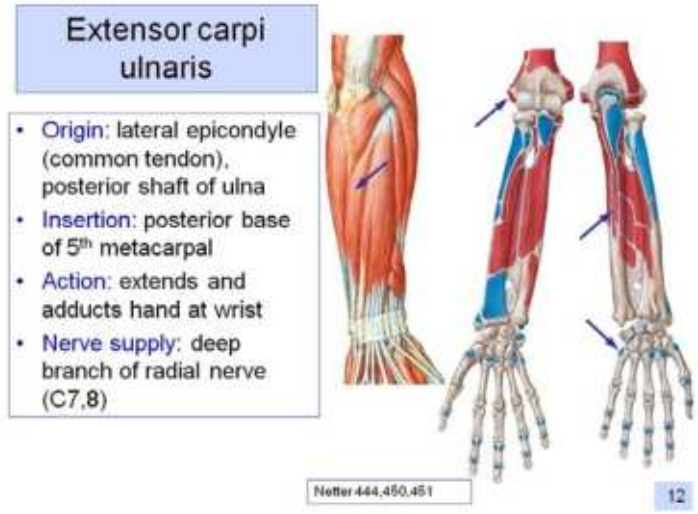
Slide #9:
The extensor carpi radialis brevis muscle originates from the lateral epicondyle by the common extensor tendon with three other muscles (below). It inserts on the posterior side of the base of the 3rd metacarpal bone. ECRB extends and abducts (radially deviates) the hand at the wrist. Its innervation is different from that of ECRL, but the same as the other three muscles of the common extensor tendon: the deep branch of the radial nerve. We will see the location and branching of that nerve in a later slide. **(Netter 8th ed. 454, 459, 460)**



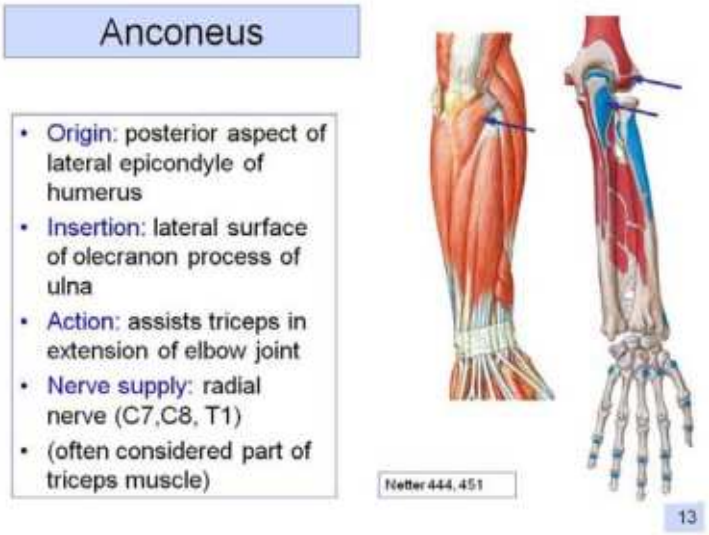
Slide #10:
The extensor digitorum muscle originates from the common tendon and it inserts by 4 tendons on the bases of the middle and distal phalanges of the index, middle, ring, and little fingers. It is Innervated by the deep branch of the radial nerve and both extends the joints between the metacarpals and the proximal phalanges and assists the lumbricals and interossei in extending the proximal and distal interphalangeal joints. The extensor digitorum cannot easily extend single fingers independently due to "intertendinous connections". The connections prevent the retraction of any individual tendon that might be cut in an injury, unlike what might be seen with the long digital flexor tendons. (Netter 8th ed. 454, 459, 460)



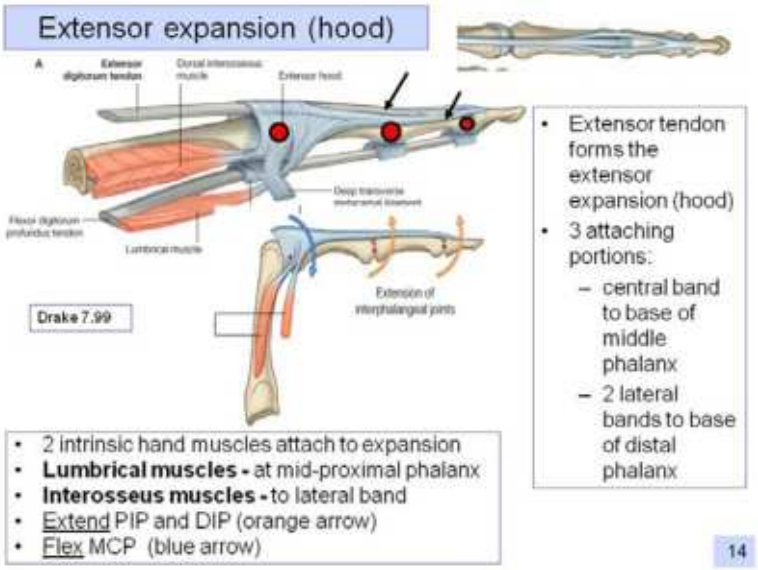
Slide #11:
The extensor digiti minimi is a thin muscle on the ulnar side of the extensor digitorum. It inserts (usually by two slips of tendons) by contributing with the fourth tendon of extensor digitorum to the extensor expansion complex for the little finger. The extensor digiti minimi can extend the MCP joint of the little finger independently from the other long extensor tendons to the fingers. The nerve supply of this muscle is from the deep branch of the radial nerve, as the other three muscles originating from the common extensor tendon on the lateral epicondyle. **(Netter 8th ed. 454, 459, 460)**



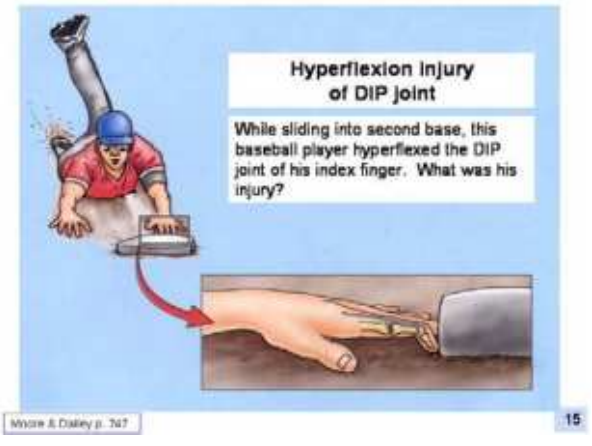
Slide #12:
On the medial side, the extensor carpi ulnaris is another muscle of this group originating from the common extensor tendon on the lateral epicondyle. The tendon passes in a groove between the head and the styloid process of the ulna and inserts on the posterior side of the base of the 5th metacarpal. It extends and adducts the hand at the wrist. The innervation for ECU is from the deep branch of the radial nerve. **(Netter 8th ed. 454, 459, 460)**



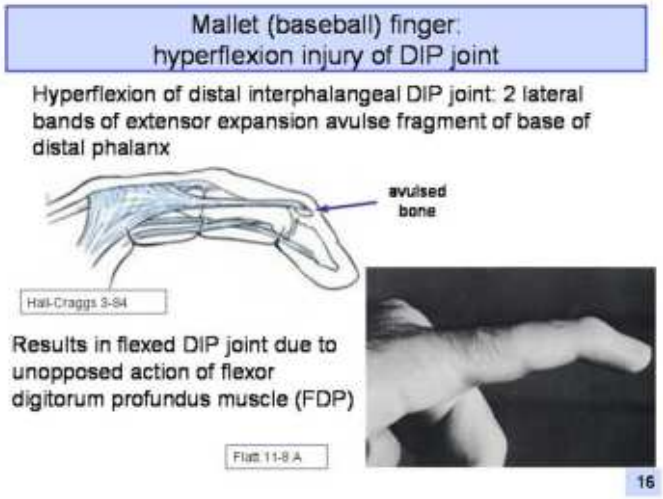
Slide #13:
The anconeus muscle is a small triangular-shaped muscle with origin from the lateral epicondyle of the humerus (but not from the common extensor tendon). It inserts into the lateral surface of the olecranon process of the ulna. Its function is to assist the triceps in extension of the forearm at the elbow joint. It is often considered part of the triceps muscle (also innervated by C7, C**8**), and is classified by some textbooks as a muscle of the arm rather than the forearm. **(Netter 8th ed. 454, 459, 460)**



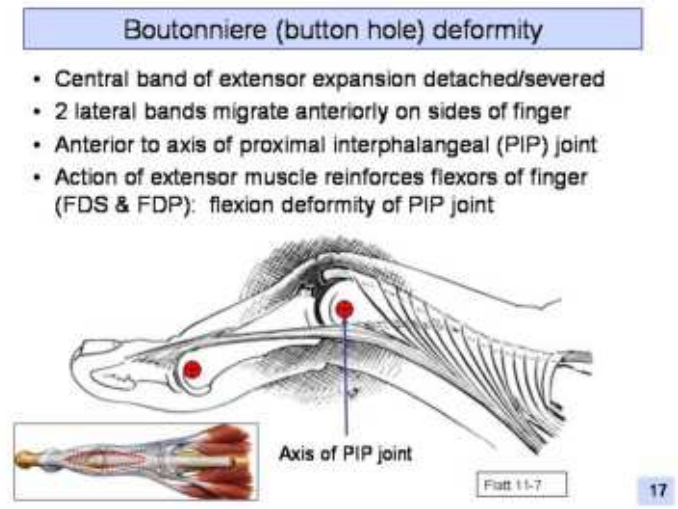
Slide #14:
Consider the tendons of the extensor digitorum and the way in which they insert: These tendons form an expansion sometimes called a hood. 2 groups of intrinsic hand muscles, the interossei and lumbricals, insert into the hood. The hood, extends over the MCP joint and around on either side to attach to the palmar ligament on the anterior side of the joint, serving to prevent lateral and medial displacement of the extensor tendon. On the dorsal surface of the proximal phalanx, the extensor expansion divides into three slips: a central band, which inserts on the base of the middle phalanx and two lateral bands, which join to form a common insertion on the base of the distal phalanx. The insertion of the lumbricals and interossei muscles into the extensor expansion provides a line of pull for these muscles that is anterior to the axis of the MCP joint and posterior to the PIP and DIP joints. Thus, they flex the MCP and at the same time, extend the PIP and DIP joints.



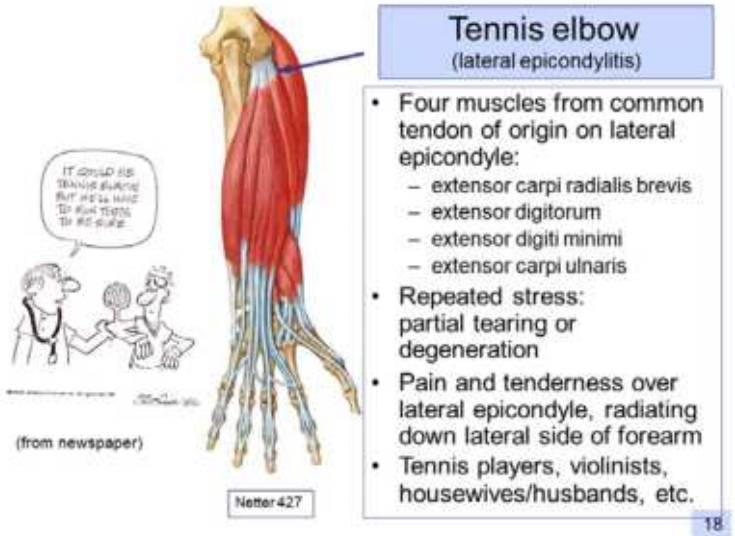
Slide #15:
This baseball player was sliding into second base. He jammed his index finger against the base, causing hyperflexion of the distal interphalangeal joint.
What was his injury?



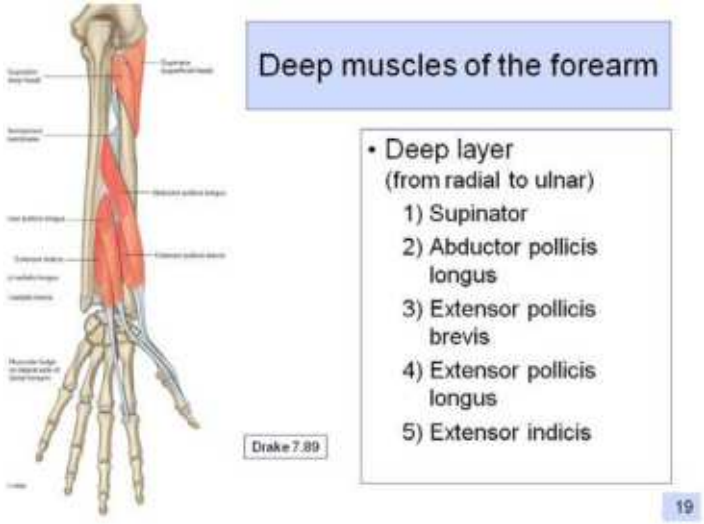
Slide #16:
With hyperflexion of the DIP joint, the lateral 2 bands of the extensor expansion at their single insertion on the base of the distal phalanx pulled a small fragment of the bone away from the rest of the distal phalanx (avulsion injury). It is surprising that the tendons are often stronger than the bones at their attachment sites. At lower right is a photograph of the baseball player's finger shows the resultant deformity of this injury. The DIP joint is flexed due to unopposed action of the flexor digitorum profundus muscle.



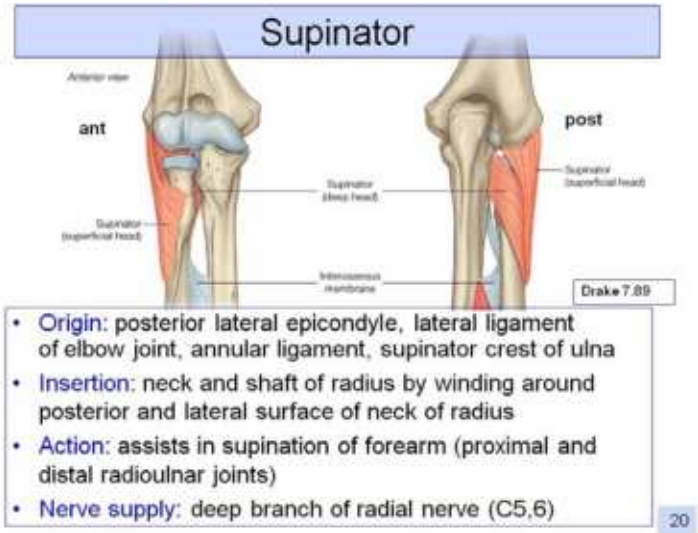
Slide #17:
A different injury occurs when the central band, rather than the lateral bands, of the extensor expansion, is torn. In this case, the lateral bands will move anteriorly along the sides of the finger to lie anterior to the axis of rotation of the PIP joint. The result is that the lateral slips will reinforce the action of the flexors of the finger producing this flexion deformity of the PIP joint. The name, boutonniere, or button hole, deformity refers to the shape of the defect in the extensor expansion, with the "button" being the PIP joint, protruding through the "button hole" defect formed by the lateral bands on each side.



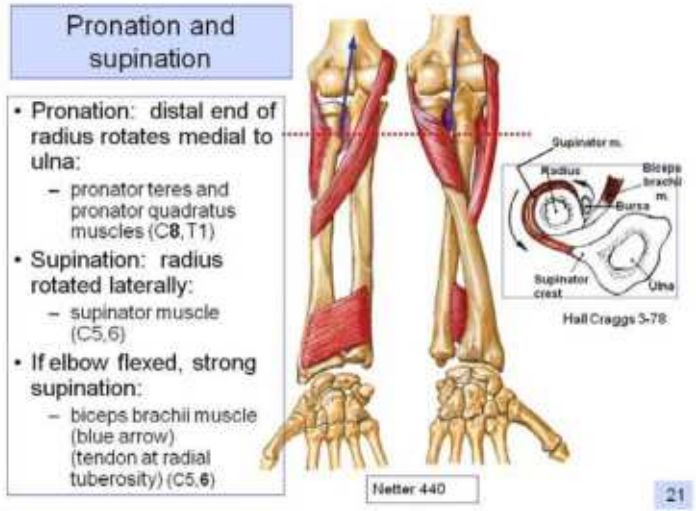
Slide #18
Repeated strenuous contraction of the extensor muscles can lead to degeneration of the common extensor tendon and inflammation of the lateral epicondyle and surrounding tissues. This condition, lateral epicondylitis, is commonly known as "tennis elbow" because it is aggravated by activities such as repeated dorsiflexion of the hand during a tennis backhand stroke. (Netter 8th ed. 451)



Slide #19:
The deep layer of 5 extensor muscles include one responsible for supination, 3 which act on the thumb (pollicis) and an extender of the index finger.



Slide #20:
The supinator muscle is the most proximal and lateral of the 5 muscles in the deep layer. It is hidden by more superficial muscles. The supinator originates from the posterior side of the lateral epicondyle, the lateral and annular ligaments, and the supinator crest of the ulna. It inserts on the neck and shaft of the radius, by winding around the posterior and lateral surface of the neck of the radius. Innervation is from the deep branch of the radial nerve, which passes through the muscle after branching from the radial nerve on the anterior side. It supinates the forearm.

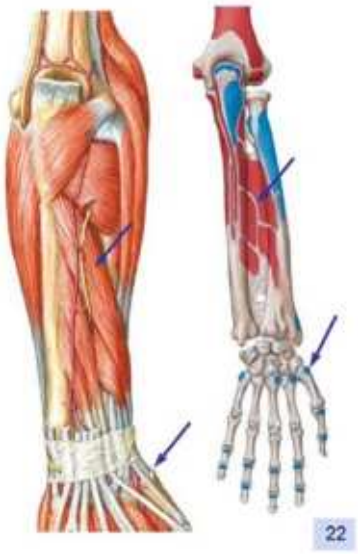


Slide #21:
Pronation of the forearm turns the palm posteriorly. The radius rotates around its long axis by the action of the pronator teres and pronator quadratus muscles. A section through the forearm at the level of the supinator muscle (dotted line) demonstrates that during pronation, the supinator is “wrapped around” the radius as it rotates along its long axis. The tendon of the biceps brachii is also pulled down between the radius and ulna. Supination is the opposite movement, which is accomplished by the supinator when the forearm is in extension. When the elbow is flexed, the biceps brachii muscle provides a strong supination force via its tendon on the radial tuberosity. As the supinator and biceps brachii muscles contract, they “unwrap” the radius in the direction of the arrows, which accomplishes the supination motion. **(Netter 8th ed. 450)**

Abductor pollicis longus

- Origin: shaft of ulna, radius and interosseus membrane
- Insertion: posterior base of 1st metacarpal
- Action: abducts and extends thumb at carpometacarpal joint
- Nerve supply: deep branch of radial nerve (post. Interosseous n.) (C7,**8**)

Netter 431,438

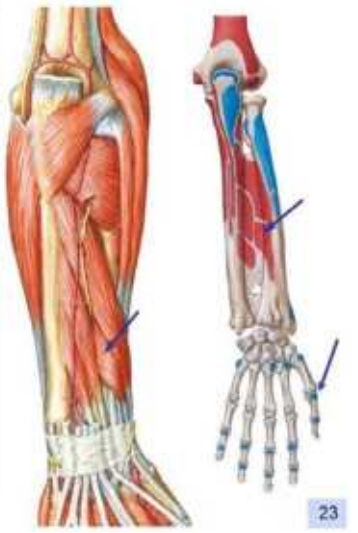


Slide #22:
Three muscles with long tendons in the deep group have actions on the thumb. The abductor pollicis longus originates along the middle of the posterior side of the shafts of the ulna and radius and the interosseus membrane between these areas. Its insertion is on the posterior of the base of the 1st metacarpal. The action of this muscle is to abduct and extend the thumb at the carpometacarpal joint (at the trapezium). The nerve supply to this muscle is from the deep branch of the radial nerve. **(Netter 8th ed. 455, 460)**

Extensor pollicis brevis

- Origin: posterior radius and adjacent interosseus membrane
- Insertion: posterior base of proximal phalanx of thumb
- Action: extends metacarpophalangeal joint of thumb
- Nerve supply: deep branch of radial nerve (post. Interosseous n.) (C7,**8**)

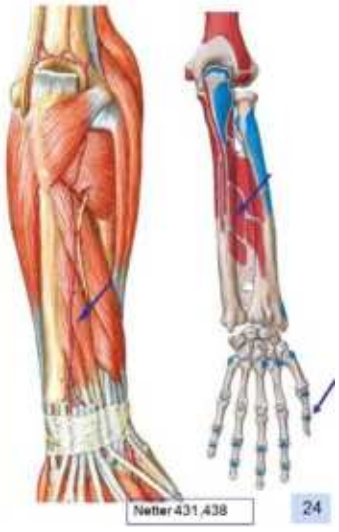
Netter 431,438



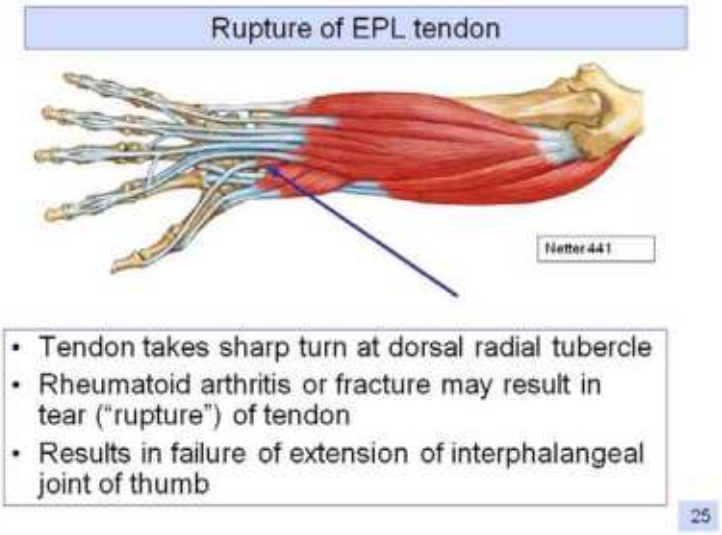
Slide #23:
The extensor pollicis brevis originates on the posterior of the radius and the adjacent part of the interosseus membrane. Its insertion is on the posterior of the base of the proximal phalanx of the thumb. It extends the metacarpophalangeal joint of the thumb. The nerve supply is from the deep branch of the radial nerve. **(Netter 8th ed. 455, 460)**

Extensor pollicis longus

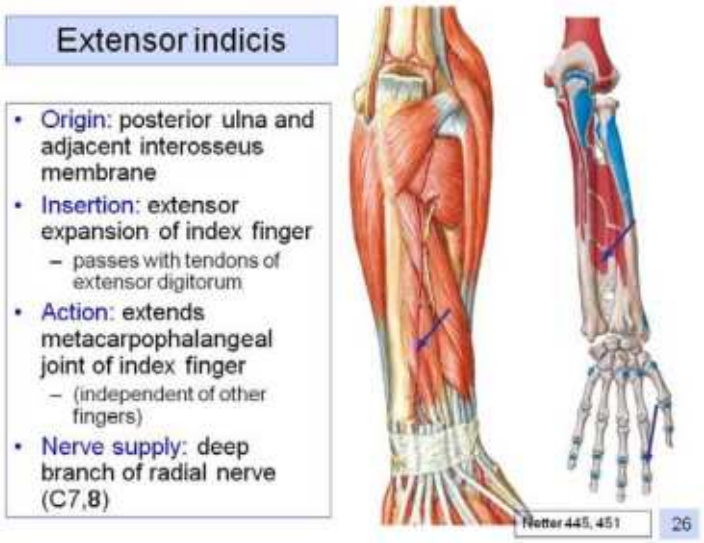
- Origin: posterior ulna and adjacent interosseus membrane
- Insertion: posterior base of distal phalanx of thumb
  - tendon passes medial to and around dorsal tubercle of radius
- Action: extends distal phalanx of thumb
- Nerve supply: deep branch of radial nerve (post. Interosseous n.) (C7,**8**)



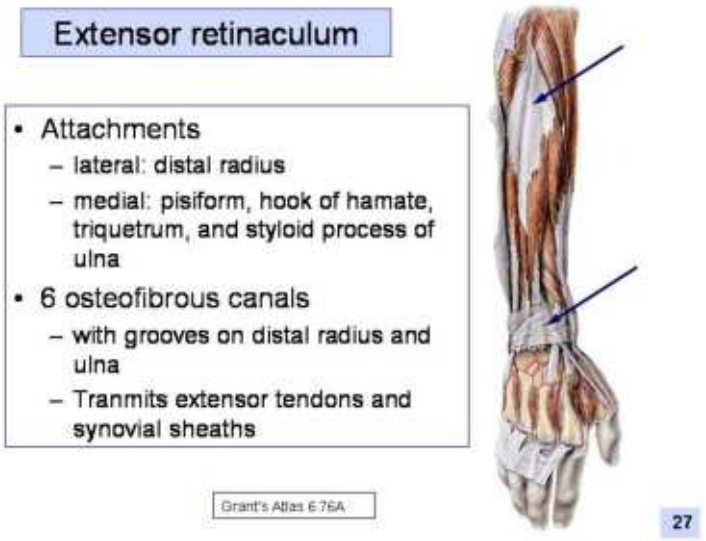
Slide #24:
The extensor pollicis longus muscle originates at the posterior side of the ulna and the interosseus membrane adjacent to this area. It inserts on the posterior base of the distal phalanx of the thumb. The long tendon passes medial to (i.e., on the ulnar side of) the dorsal radial tubercle (of Lister), giving the muscle an added degree of mechanical advantage around this "pulley". The action of the muscle is to extend the distal phalanx of the thumb. The nerve supply is from the deep branch of the radial nerve. **(Netter 8th ed. 455, 460)**



Slide #25:
The extensor pollicis longus tendon runs separately from the other two long tendons to the thumb. As it passes around the dorsal radial tubercle, it is in jeopardy of tearing (or rupture) due to rheumatoid arthritis or injury. A torn tendon of extensor pollicis longus would result in inability to extend the interphalangeal joint of the thumb. **(Netter 8th ed. 451)**

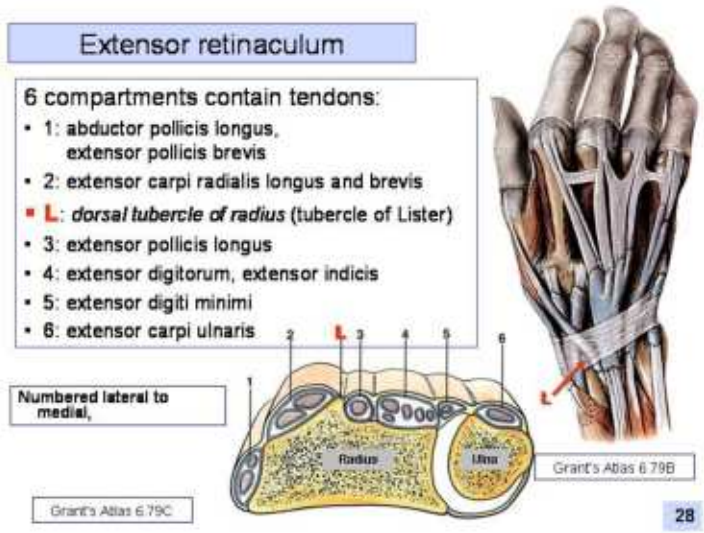


Slide #26:
The most distal and medial (ulnar) of the deep muscles is the extensor indicis muscle. This muscle is located deep to the extensor digitorum. Its origin is on the posterior ulna and the adjacent interosseus membrane. The tendon joins the tendon of the extensor digitorum for the index finger. Together, they insert into the extensor expansion of the index finger. The extensor indicis can extend the index finger independent of the other extensor tendons (similar to the action of the extensor digiti minimi muscle on the little finger). **(Netter 8th ed. 455, 460)**

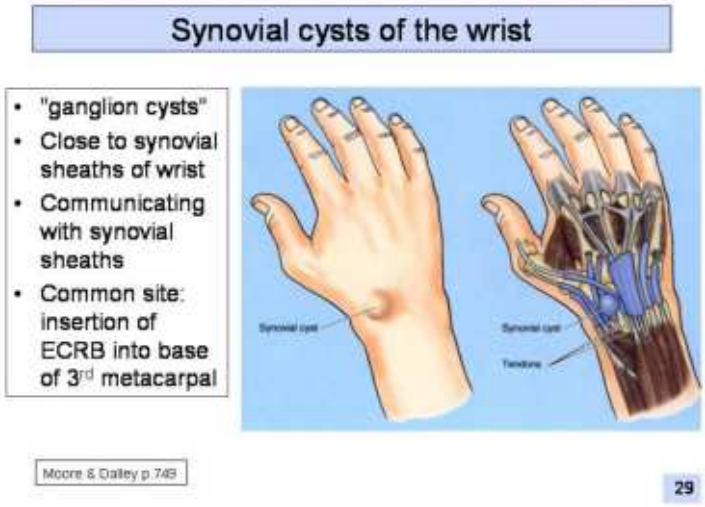


Slide #27:
The deep fascia of the forearm (antebrachial) is thickened in two places, as an aponeurosis for muscle origins and near the wrist, as the extensor retinaculum. This complex fibrous band holds the long extensor tendons in position. The extensor retinaculum is attached to the distal end of the radius and to the pisiform and the hook of the hamate. There are also fibers attached to the triquetrum and to the styloid process of the ulna. The extensor retinaculum has septa, which form 6 osteofibrous canals with

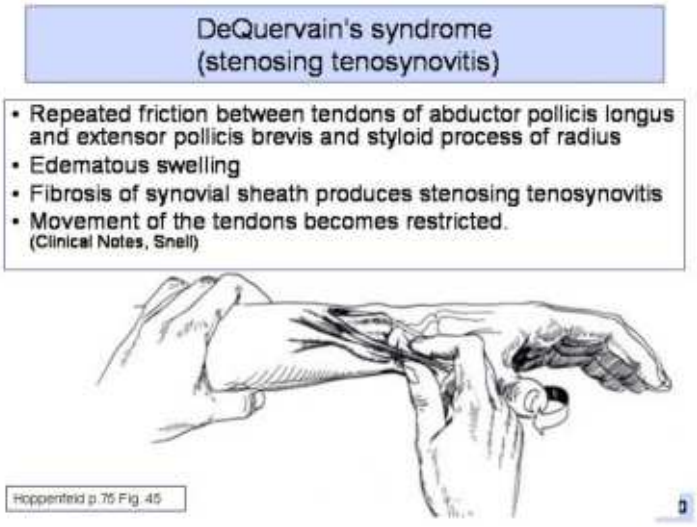
the groves on the distal portions of the radius and ulna. These are lined with synovial sheaths for the long tendons passing the dorsum of the wrist and on into the hand.



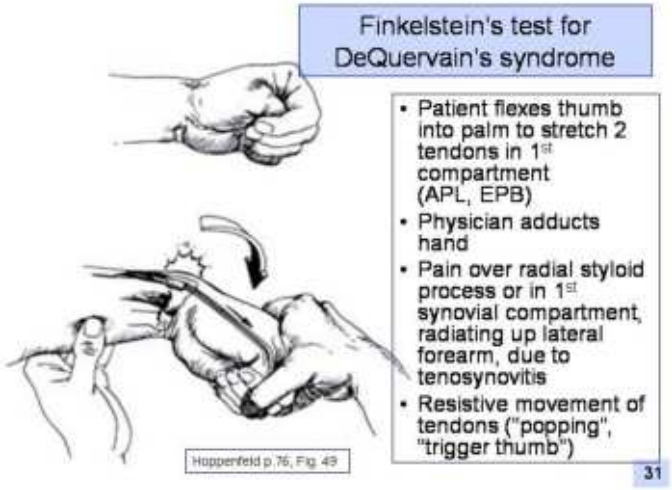
Slide #28:
The 6 compartments of the extensor retinaculum are demonstrated in these figures, with a list of tendons which pass through each compartment. Note that the numbering of the compartments is from lateral to medial, rather than the medial to lateral description found in the Snell text. Note that the tendons in compartments 1 and 3 extend the thumb; the tendons in 2 and 6 extend the wrist, the tendons in 4 and 5 extend the digits. Note the position of the extensor pollicis longus tendon in compartment 3, as it passes around the dorsal radial tubercle (of Lister).



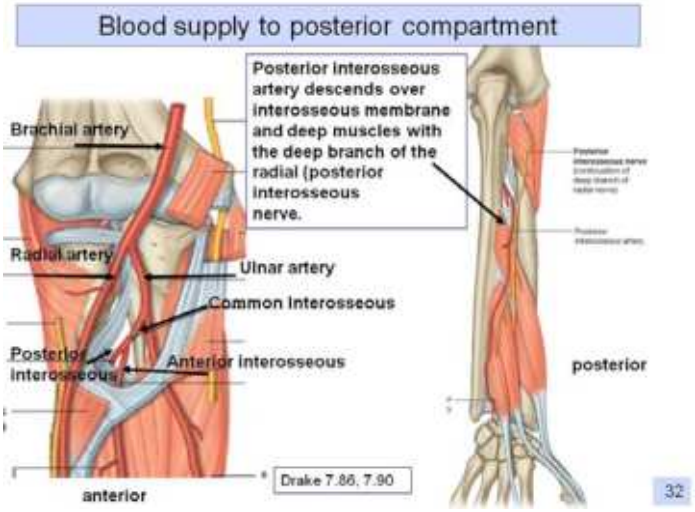
Slide #29:
A common clinical problem is synovial cysts of the wrist, in communication with synovial sheaths of the long tendons. These are often called ganglion cysts by clinicians. The site of insertion of the extensor carpi radialis brevis at the base of the 3rd metacarpal is a common location for a synovial cyst.



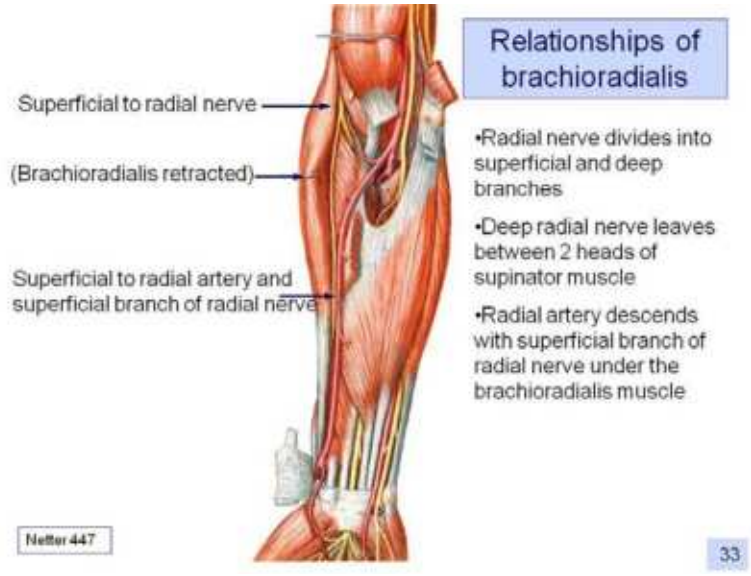
Slide #30:
An important clinical problem can result from repetitive movements of the thumb. This can result in friction of the tendons of abductor pollicis longus and extensor pollicis brevis along the styloid process of the radius, resulting in inflammation and edema. Fibrosis may develop in the synovial sheath, which could lead to a stenosing tenosynovitis, known as DeQuervain's syndrome, in which the movement of the two tendons in this first compartment of the extensor retinaculum becomes restricted.



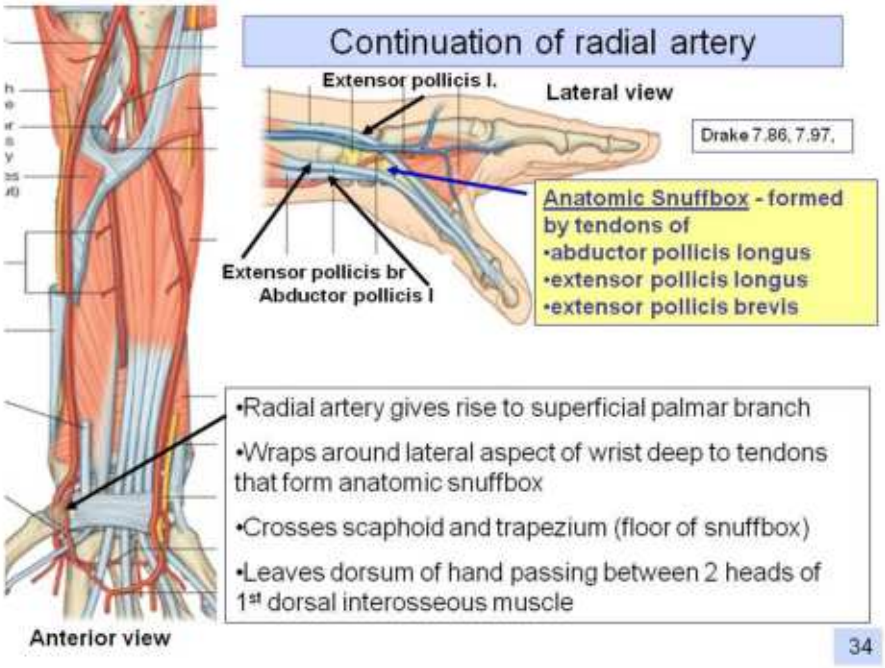
Slide #31:
A test for DeQuervain's syndrome is described in this slide. The pain due to the tenosynovitis elicited by this test manipulation will be located at the radial styloid process, but may radiate up the lateral forearm. There may also be an initial resistance to the adduction motion, with sudden release, as in a "trigger finger"-type response (in this case, "trigger thumb").



Slide #32:
The posterior interosseus artery is the blood supply to the posterior compartment. The brachial artery branches to the radial and ulnar arteries at the cubital fossa. The radial artery continues down the forearm, deep to the brachioradialis muscle. The ulnar artery branches just after it enters the forearm to the common interosseus artery and then continues in relation to the flexor carpi ulnaris muscle. The common interosseus then provides the anterior interosseus artery, supplying the deep structures in the anterior compartment. The common interosseus artery continues over the interosseus membrane into the posterior compartment, emerging between the supinator and the abductor pollicis longus muscles. It then gives rise to the posterior interosseus artery.

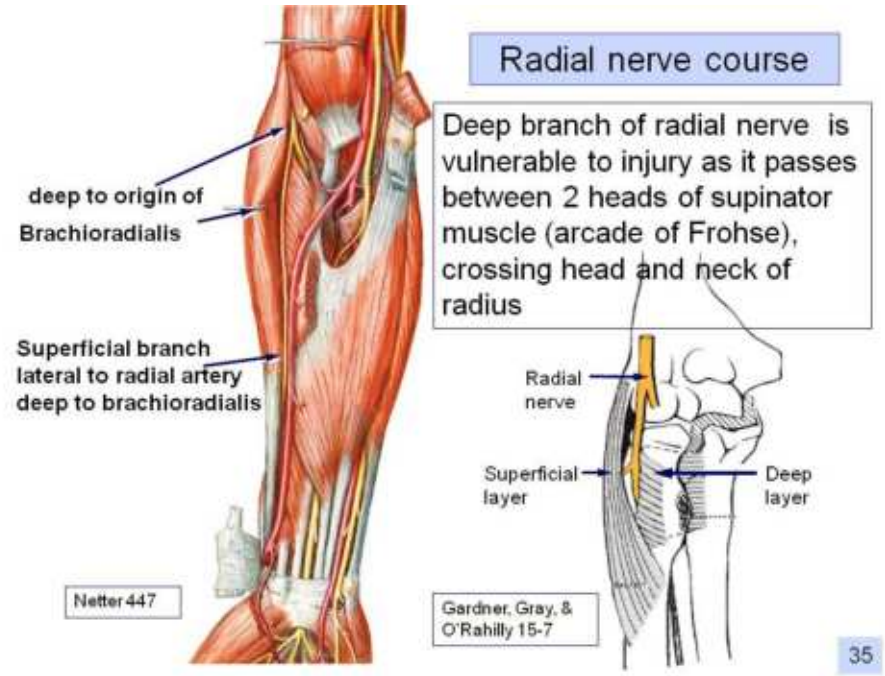


Slide #33:
From the anterior side of the forearm, we see the course of the radial artery adjacent to the brachioradialis. The earliest part of the branching of the ulnar artery can be seen just distal to the cubital fossa. **(Netter 8th ed. 457)**



Slide #34:

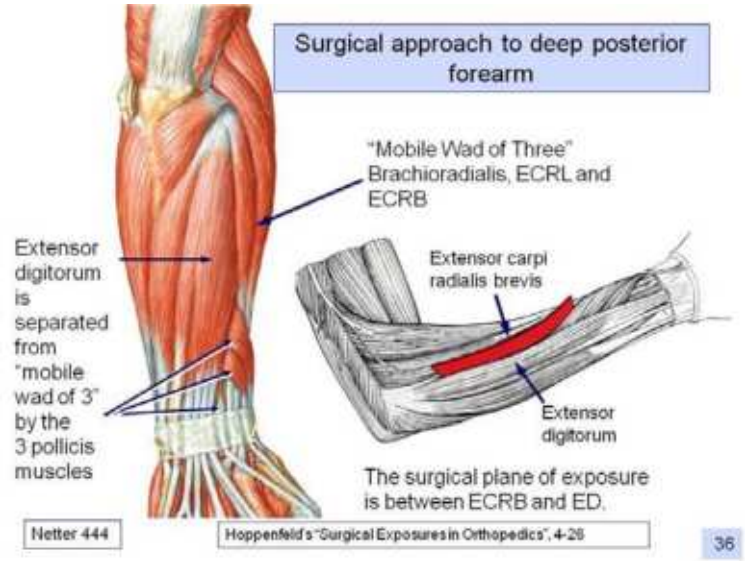
This slide shows the radial artery at the wrist and hand as it continues through a region commonly called the "anatomic snuff box". The extensor pollicis brevis tendon defines a "V"-shaped area with the extensor pollicis longus tendon. The radial artery continues around the wrist, deep to the tendons of abductor pollicis longus and extensor pollicis brevis, and can be located in this space, as passes over floor of the anatomic snuff box, consisting of the trapezium and scaphoid bones. The artery then courses deep to the extensor pollicis longus tendon and into the palm through the two heads of the first dorsal interosseus muscle. The radial pulse can be felt here, against the scaphoid and trapezium, and the artery is accessible for drawing arterial blood (e.g., for blood gas measurements).



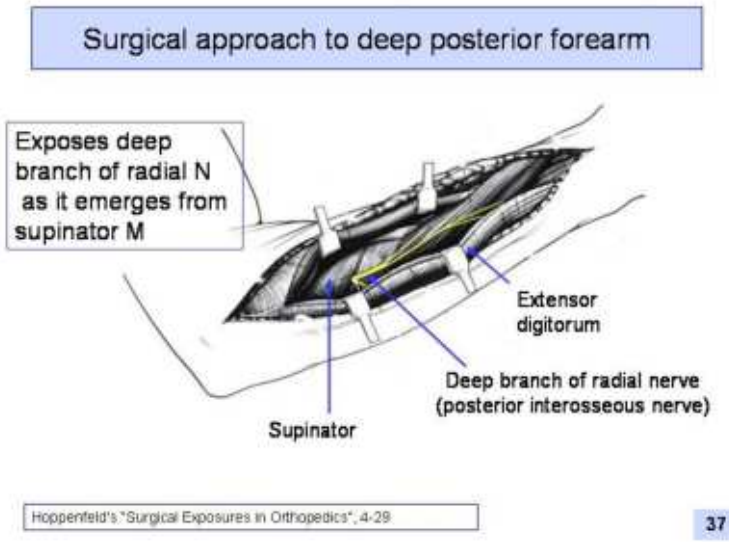
Slide #35:

The radial nerve divides to its superficial and deep branches deep to the proximal part of the brachioradialis, adjacent to the lateral epicondyle. The superficial branch continues under the brachioradialis, becoming cutaneous just before it reaches the wrist and providing cutaneous innervation over the dorsum of the thumb and hand. The deep branch passes between two layers of the supinator muscle (arcade of Frohse) to pass into the posterior compartment of the forearm. The deep branch of the radial nerve is vulnerable to injury here from fractures to

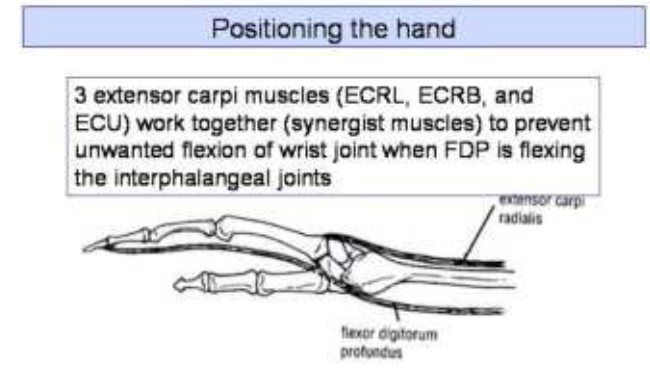
the head and neck of the radius or during surgery in this area. The supinator gets its supply from the deep branch as it passes though the muscle. **(Netter 8th ed. 457)**



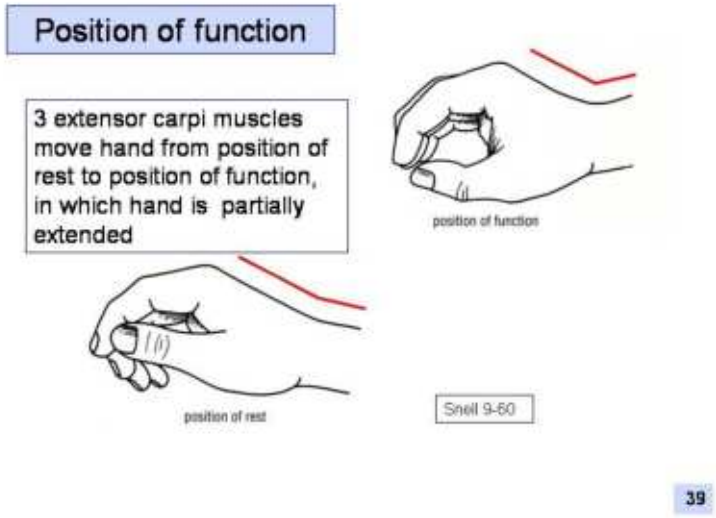
Slide #36:
A common surgical approach to the deep part of the posterior compartment is marked by the plane passing between the extensor carpi radialis brevis muscle and the radial side of the extensor digitorum muscle. The 3 muscles that act on the thumb (abductor pollicis longus, extensor pollicis brevis and extensor pollicis longus) separate these two muscles distally. Orthopedic surgeons call the 3 muscles on the radial side of this dividing plane (brachioradialis, extensor carpi radialis longus and extensor carpi radialis brevis) the **"mobile wad of three"** because they are easily displaced in surgical approaches to the radius. These 3 muscles are related to the lateral, rather than the posterior surface of the radius. **(Netter 8th ed. 454)**



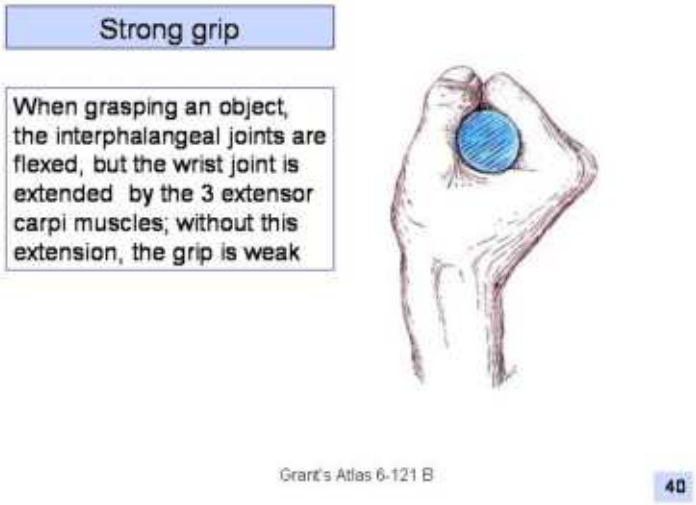
Slide #37:
This slide gives you another view, as it might appear during surgery to access the deep posterior forearm and the radius. Note that you can see the deep branch of the radial nerve as it emerges through the supinator muscle. This nerve is also called the posterior interosseus nerve.



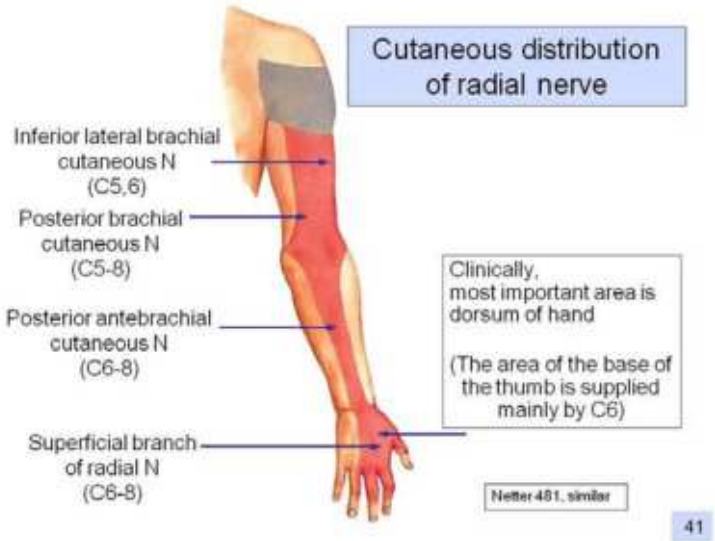
Slide #38:
The 3 extensor carpi muscles extend the wrist and also function as synergists for the flexors of the digits. The long flexor tendons pass anteriorly to the wrist joint on their way to the interphalangeal joints. The three extensor carpi muscles contract to prevent flexion of the wrist and thus permit the long flexors to perform their intended flexion of the interphalangeal joints.



Slide #39:
In much the same way, the 3 extensor carpi muscles help serve to “fine tune” the position of the hand. The hand is partially extended at the wrist as it is changed from the neutral “position of rest” to the active “position of function”, for example, when about to grasp an object between thumb and index finger.



Slide #40:
The importance of the synergistic action of the three extensor carpi muscles can be demonstrated by attempting to make a “tight strong fist”. This so-called “power grip” is difficult to achieve when the wrist is flexed, but with wrist extension, the grip formed by flexion of the interphalangeal joints is strengthened.
Thus, the three extensor carpi muscles are very important for full and proper function of the hand, especially as a user of tools and manipulator of the environment.



Slide #41:
The distribution is important for potential testing of the nerve in a clinical exam. Realize that the most important area of the cutaneous supply of this nerve is over the dorsum of the hand, especially on the more radial side. This is the area of distribution of the superficial branch of the radial nerve. **(Netter 8th ed. 423)**