Muscles, Innervation and the Compartments of the Upper Limb

Organized in an Unintentionally Difficult Manner

Fascia and compartments of the shoulder

**PECTORALIS FASCIA**
- The only contents is Pectoralis Major;
- Pectoralis fascia continue inferiorly as fascia of the anterior abdominal wall
- It continues laterally-once it leaves the lateral edge of Pectoralis Major, it becomes AXILLARY FASCIA

**AXILLARY FASCIA**
- Continuous with the CLAVIPECTORAL FASCIA
- Forms the floor of the axilla

**CLAVIPECTORAL FASCIA**
- Deep to the Pectoralis major muscle, the CLAVIPECTORAL FASCIA invests the subclavius muscle and pectoralis minor.
- It forms the costocoracoid membrane above pectoralis minor, and the suspensory ligament of axilla below pectoralis minor. The suspensory ligament drags the axillary fascia upwards when the arm is raised, forming the actual “pit” of the armpit.

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**Supraspinous, Infraspinous and Subscapular fascia**
- The supraspinatus, infraspinatus and subscapularis muscles are contained in their own little fascial compartments

**Deltoid Fascia**
- The deltoid has its own fascia, continuous with the pectoral fascia and infraspinatus fascia
- It has numerous fascial septa which separate the fascicles of the deltoid
Anterior Axioappendicular Muscles of the Shoulder

There are 3 distinct groups of shoulder muscles:

ANTERIOR AXIOAPPENDICULAR MUSCLES – 4 muscles which move the pectoral girdle

POSTERIOR AXIOAPPENDICULAR MUSCLES – 4 muscles which attach the upper lumbar to the skeleton of the trunk

SCAPULOHUMERAL MUSCLES – 6 muscles which act on the glenohumeral joint

Anterior Axioappendicular muscles

All supplied by stupidly different nerves.
No pattern whatsoever.

Pectoralis Major

Two heads:
- **CLAVICULAR HEAD:** lateral pectoral nerve
  - Originates from the medial half of the anterior clavicle
- **STERNOCOSTAL HEAD:** medial pectoral nerve
  - Originates from the front surface of the sternum, and the first 6 costoclavicular cartilages
  - Also originates from the aponeurosis of the external oblique muscle of the abdomen
- Inserts into the lateral lip of the intertubercular groove of the humerus
- Its inferior border forms the anterior axillary fold
  - Abducts and medially rotates the humerus
  - Draws scapula anteriorly and inferiorly by pulling on the humerus
- The heads can act independently:
  - Clavicular head alone acts to flex the humerus
  - When flexed, the sternocostal head extends it from its flexed position.

Pectoralis Minor

- mediad pectoral nerve
- Originates at the 3rd, 4th and 5th ribs near the costal cartilages
- Inserts into the medial border and superior surface of the coracoid process of scapula
- Its job is to stabilize the scapula by pulling it anteriorly and inferiorly against the chest wall
- It also assists in elevating the ribs when breathing
- All the vessels and nerves to the arm travel under the pectoralis minor.

Subclavius

- nerve to subclavius
- Originates at the junction of the 1st rib and its costal cartilage
- Inserts into the “groove for subclavius” on the inferior surface of the middle third of the clavicle
- Depresses and anchors the clavicle
- Protects the subclavian vessels when the clavicle is fractured

Serratus anterior

- long thoracic nerve
- Originates from the lateral surfaces of the first 8 ribs
- Inserts into the medial border of scapula
- Protracts the scapula, holds it against the chest wall, and rotates it superiorly (eg when reaching for something up high).
  - **THE MAIN PROTRACTOR OF THE SCAPULA**
  - One of the most powerful muscles in the pectoral girdle.
  - Its paralysis causes a winged scapula. Also, the arm cannot be abducted past the horizontal position (the scapula doesn't rotate upwards anymore)
  - If you insert your chest drain BELOW the mid-axillary line, you will cause this sort of paralysis, which is embarrassing.
Posterior Axioappendicular Muscles of the Shoulder: the Extrinsic Group

There are 2 layers, the superficial and the deep.
The superficial group is trapezius and latissimus dorsi
The deep group is the levator scapulae and the rhomboids

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**Trapezius** ← spinal accessory nerve

- **Originates from**
  - The external occipital protuberance
  - Nuchal ligament
  - Medial third of superior nuchal line
  - Spine of scapula
- **Inserts into**
  - Lateral third of the clavicle
  - Acromion of scapula
  - Spine of scapula
- **Has 3 distinct parts:**
  - SUPERIOR (descending) part which elevates the scapula
  - MIDDLE part which retract the scapula
  - INFERIOR (ascending) part which depresses the scapula

All the parts together act to rotate the scapula superiorly, so the glenoid fossa faces up.

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**Latissimus dorsi** ← Thoracodorsal nerve

- **Originates from**
  - Inferior 6 thoracic vertebrae
  - Thoracolumbar fascia
  - Iliac crest
  - Inferior 3 or 4 ribs
- **Inserts into**
  - ANTERIOR surface of the humerus, at the floor of the intertubercular groove
  - Extends, adducts, medially rotates the humerus
  - Lifts the body up too the arms when climbing

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**Levator scapulae** ← dorsal scapular and cervical nerves

- **Originates at**
  - The posterior tubercles of the spinous processes of C1, 2, 3 and 4 vertebral bones
- **Inserts into**
  - The medial border of the scapula, superior to the spine
  - Elevates that corner of the scapula, rotating it so the glenoid cavity faces down
  - Extends the neck (when acting bilaterally) or flexes it laterally (when acting unilaterally)

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**Rhomboid Minor** ← dorsal scapular nerve

- **Originates from**
  - The nuchal ligament and the spinous processes of C7 and T1
- **Inserts into**
  - The medial border of the scapula, at the root of the scapular spine
  - Retracts the scapula
  - Rotates the scapula so the glenoid cavity faces down
  - Fixes the scapula to the thoracic wall

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**Rhomboid Major** ← dorsal scapular nerve

- **Originates from**
  - The spinous processes of T2, T3 and T4
- **Inserts into**
  - The medial border of the scapula, from the root of the spine down.
  - Retracts the scapula
  - Rotates the scapula so the glenoid cavity faces down
  - Fixes the scapula to the thoracic wall
Posterior Axioappendicular Muscles of the Shoulder: the Intrinsic Group with Rotator Cuff muscles
These are the deltoid and teres major; and the 4 rotator cuff muscles (teres minor, supraspinatus, infraspinatus and subscapularis)

Posterior Axioappendicular Intrinsic muscles
Again, supplied by totally different nerves.

Deltoid \(\leftarrow\) axillary nerve
- Originates from the lateral third of the clavicle, the acromion, and the lateral spine of scapula.
- Inserts into the deltoid tuberosity of humerus
- THREE PARTS:
  - Anterior part flexes and medially rotates the humerus
  - Middle part abducts the humerus
  - Posterior part extends and laterally rotates the arm
- The middle part is multipennate; the others are unipennate
- It cannot initiate abduction on its own when the arm is fully adducted—thus it needs supraspinatus to initiate the movement. It becomes effective after about 15 degrees of abduction.
- The deltoid’s anterior and posterior parts swing your arms while walking. It also helps to keep the humeral head in the glenoid fossa.

Teres major \(\leftarrow\) lower subscapular nerve
- Originates from the posterior surface of the inferior angle of scapula
- Inserts into the medial lip of the intertubercular groove of humerus
- Adducts and medially rotates the arm
- Also keeps the head of humerus in the socket

Rotator Cuff Muscles
Whatever other actions they may have, they all help hold the humeral head in the glenoid fossa

Supraspinatus \(\leftarrow\) suprascapular nerve
- Originates in the supraspinous fossa of the scapula
- Inserts into the superior facet of the greater tubercle of humerus
- Initiates abduction, and assists the deltoid with abduction of the arm; its the only one that doesn’t rotate the arm.

Infraspinatus \(\leftarrow\) suprascapular nerve
- Originates in the infraspinous fossa of the scapula
- Inserts into the middle facet of the greater tubercle of humerus
- Laterally rotates the arm

Teres Minor \(\leftarrow\) axillary nerve
- Originates from the middle of the lateral border of scapula
- Inserts into the inferior facet of the greater tubercle of humerus
- Laterally rotates the arm

Subscapularis \(\leftarrow\) upper and lower subscapular nerves
- Originates in the subscapular fossa
- Inserts into the lesser tubercle of humerus
- Medially rotates and abducts the arm
Muscles and Nerves involved in the movements of the shoulder joint

flexion:
- pectoralis major (clavicular head) – medial and lateral pectoral nerve
deltoid (anterior part) – axillary nerve
coracobrachialis – musculocutaneous nerve
biceps femoris – musculocutaneous nerve

extension:
deltoid (posterior part) – axillary nerve
teres major – lower subscapular nerve

abduction:
deltoid (central part) – axillary nerve
supraspinatus – suprascapular nerve

adduction:
- pectoralis major – medial and lateral pectoral nerve
latissimus dorsi – thoracodorsal nerve
subscapularis – upper and lower subscapular nerve
infra spinatus – suprascapular nerve
teres minor – axillary nerve

medial rotation:
- subscapularis
pectoralis major – medial and lateral pectoral nerve
deltoid (anterior part) – axillary nerve
latissimus dorsi – thoracodorsal nerve

lateral rotation:
infra spinatus – suprascapular nerve
long head of triceps – radial nerve
coracobrachialis – musculocutaneous nerve
short head of biceps – musculocutaneous nerve
Fascia and compartments of the proximal arm

Section at a level just short of half-way along the humerus

Brachial Fascia
- Encloses the upper arm like a sleeve
- Superiorly, it is continuous with the deltoid fascia, infraspinatus fascia and pectoralis fascia
- Inferiorly, it is attached to the epicondyles of the humerus and the olecranon of ulna
- It is continuous with the antebrachial fascia – the fascia of the forearm
  - It contains two SEPTA: the MEDIAL and LATERAL INTERMUSCULAR SEPTA.
  - The septa are attached to the supracondylar ridges and to the shaft of humerus
  - They separate the arm into the ANTERIOR COMPARTMENT and the POSTERIOR COMPARTMENT

Anterior Compartment: FLEXORS
- Biceps Brachii
- Brachialis
- Coracobrachialis
- Median nerve
- Musculocutaneous nerve
  - The medial cutaneous nerve of forearm is not inside the fascial sheath, but is still important enough to warrant a brief mention.
  - The Basilic vein and the Cephalic vein are usually superficial to the fascial planes

Supplied by the MUSCULOCUTANEOUS NERVE

Posterior Compartment: EXTENSORS
- Triceps Brachii
- Anconeus
- Radial nerve
- Deep artery of the arm (profunda brachii)
  (A branch of the brachial artery)
- Superior ulnar collateral artery
- Ulnar nerve

Supplied by the RADIAL NERVE

Deltoid:
Not actually a part of the anterior compartment, as it has its own fascial compartment.
The innervation and mechanics of the flexor and extensor muscle compartments of the arm

**Anterior Compartment: FLEXORS**

All supplied by the MUSCULOCUTANEOUS NERVE

**Biceps Brachii**

Two heads:
- **SHORT HEAD:**
  - The medial head.
  - Originates from the tip of the coracoid process
- **LONG HEAD:**
  - The lateral head.
  - Originates from the supraglenoid tubercle of the glenoid fossa
- The biceps inserts into the tuberosity of radius; and it also inserts into the antebrachial fascia by virtue of the bicipital aponeurosis.
- It does very different things depending on what position the arm is in:
  - It supinates the forearm by pulling on the aponeurosis, when the arm is pronated; it is the MOST POWERFUL SUPINATOR of the forearm
  - when the forearm is supine if FLEXES the elbow joint by pulling on the attachment to the radial tuberosity.
  - It is useless as a flexor when the forearm is pronated.
- The short head resists dislocation of the shoulder

**Coracobrachialis**

- Originates at the tip of the coracoid process of scapula
- Inserts into the middle third of the medial humerus
- Helps flex and adduct the arm
- Resists dislocation of the shoulder: it’s a SHUNT muscle, it resists the downward dislocation of the humeral head
- Stabilizes the glenohumeral joint
- A landmark – it is pierced by the musculocutaneous nerve

**Brachialis**

- Originates from the distal half of the anterior humerus
- Inserts into the tuberosity of the ulna, and the coronoid process
- Flexes the forearm in all positions – it’s the PRIMARY FLEXOR

**Posterior Compartment: EXTENSORS**

All supplied by the RADIAL NERVE

**Triceps Brachii**

- **LONG HEAD:**
  - Originates from the infraglenoid tubercle
- **LATERAL HEAD:**
  - Originates from the proximal humerus, more proximal than the radial groove
- **MEDIAL HEAD:**
  - Originates from the posterior surface of the humerus, distal to the radial groove

The united triceps inserts into the olecranon of ulna
- It is the chief extensor of the arm.
- The long head resists dislocation of the head of humerus, especially during abduction

**Anconeus**

- Originates from the posterior lateral epicondyle of humerus
- Inserts into the lateral surface of olecranon
- Assists the triceps in flexing the forearm, and stabilizes the elbow joint. It also pulls the joint capsule out of the way of the olecranon upon extension; otherwise it would get pinched in the olecranon fossa. Many anatomists believe it to be a vestigial and forgotten 4th head of the triceps.
Fascia and compartments of the distal arm

Section at the junction of distal third and proximal two thirds of the humerus

- Superior ulnar collateral artery
- Ulnar nerve
- Deep artery of the arm
- Radial nerve
- Triceps brachii
- Long head
- Medial head
- Lateral head
- Cephalic vein
- Biceps brachii
- Musculocutaneous nerve
- Coracobrachialis
- Brachial artery
- Median nerve
- Basilic vein
- Brachialis
- Medial cutaneous nerve of forearm which arises from the MEDIAL CORD of the brachial plexus
- Posterior cutaneous nerve of forearm which has just branched off from the RADIAL nerve
- Lateral cutaneous nerve of forearm which has just branched off from the MUSCULOCUTANEOUS nerve

Section at the level of the humeral epicondyles

- Radial nerve which has pierced the lateral intermuscular septum a little while ago, and now travels between brachialis and brachioradialis
- Brachioradialis which is important for a number of reasons:
  - Forms the lateral border of the cubital fossa
  - Innervated by the RADIAL NERVE
  - Flexes the forearm, unlike the rest of the forearm extensor compartment
  - Together with the Supinator, they are the only extensor compartment muscles which do not cross the wrist and cause no movement there

- Anconeus
  Which is unimportant, and arguably useless. In fact some anatomists believe it to a rudimentary 4th triceps head. If it were missing, you would likely not notice.
**Fascia and compartments around the cubital fossa and distal forearm**

**Section at the level of the neck of radius**

**Antebrachial Fascia**
- Extension of the brachial fascia
- Also envelopes the forearm like a sleeve
- There are no “intermuscular” septa per se; the muscles are all invested in their own fascia; however there are still two recognisable compartments: the FLEXOR compartment and the EXTENSOR compartment.

**THERE ARE 17 MUSCLES CROSSING THE ELBOW JOINT.**

**COMPARTMENTS IN THIS SECTION** are not clear-cut or sensible.
- This is an intersection of several compartments. The EXTENSOR compartment of the forearm is anterolateral, represented by brachioradialis, extensor carpi radialis longus and brevis, and extensor digitorum. The FLEXOR compartment is posteromedial and represented by pronator teres, palmaris longus, flexor carpi ulnaris, and flexor digitorum profundus and superficialis. The ANTERIOR compartment of the arm is represented by the biceps tendon, and by brachialis.
- Anconeus is a lonely representative of the POSTERIOR compartment.
Fascia and compartments of the middle forearm

Section at the level of the mid-forearm

Boundaries of the compartments:
- Lateral border: radial artery
- Interosseous membrane
- Medial border: subcutaneous ulna

FLEXOR COMPARTMENT
This is the beefier compartment; twice as fat as the extensor compartment

4 layers of muscles:

- LAYER 1: pronator teres (not shown, too proximal)
  - Flexor carpi radialis
  - Palmaris longus
  - Flexor carpi ulnaris

- LAYER 2: Flexor digitorum superficialis

- LAYER 3: Flexor pollicis longus
  - Flexor digitorum profundus

- LAYER 4: Pronator Quadratus (not shown, too distal)

 Half of the Flexor Digitorum Profundus which is innervated by the ulnar nerve, unlike the rest of the flexors (which are all supplied by the Median nerve)

EXTENSOR COMPARTMENT

- Lateral cutaneous nerve of the forearm
- Brachioradialis
- Radial artery
- Superficial branch of the radial nerve

- Supinator
- Extensor pollicis Brevis
- Abductor pollicis longus
- Extensor pollicis Longus
- Extensor carpi ulnaris
- Extensor carpi radialis brevis
- Posterior interosseous nerve
- Posterior interosseous artery
- Extensor indices

Muscles of a similar purpose are grouped together in compartments. The EXTENSORS are posteromedial, and the FLEXORS are anterolateral. They spiral round the arm and eventually the flexors become truly anterior and the extensors become truly posterior.

Functionally, the forearm includes the distal humerus because the muscles that attach at the supracondylar ridges and the epicondyles stretch along the forearm to move the wrist and fingers.

BOUNDARIES OF THE COMPARTMENTS

POSTERIORLY (proximal forearm) and MEDIALLY (distal forearm), the subcutaneous border of the ulna

ANTERIORLY (proximal forearm) and then LATERALLY (distal forearm), the radial artery

Because neither of these boundaries is crossed by motor nerves they are used for surgical incisions
The Flexor Compartment of the Forearm

The flexor compartment has 4 discrete layers:

**LAYER 1:**
- **PRONATOR TERES**
  - Forms the medial border of the cubital fossa; it’s the most lateral of the first layer of muscles
  - Has an ulnar head and a humeral head
  - The humeral head originates from the COMMON FLEXOR ORIGIN
  - The ulnar head originates from the coronoid process
  - Pronates and flexes the elbow

- **FLEXOR CARPI RADIALIS**
  - Originates from the COMMON FLEXOR ORIGIN
  - Inserts into the base of the 2nd metacarpal
  - Flexes and abducts the wrist
  - About half-way down the forearm, its belly is replaced by a flat tendon which becomes cord-like at the wrist
  - It travels in the lateral carpal tunnel inside its own synovial sheath (it doesn’t share)
  - The radial artery is just lateral to this tendon

- **PALMARIS LONGUS**
  - Originates from the COMMON FLEXOR ORIGIN
  - Inserts into the distal flexor retinaculum, and palmar aponeurosis.
  - Flexes and abducts the wrist, tenses the palmar aponeurosis
  - Its actually absent in 14% of people (usually on the left side). Those people don’t miss it being gone.
  - The tendon of palmaris longus is a marker for where the median nerve is – the tendon passes medially to it, and then deep to it in the flexor retinaculum

- **FLEXOR CARPI ULNARIS**
  - Has an ulnar and a humeral head
  - Humeral head originates from the COMMON FLEXOR ORIGIN; Ulnar head originates from the olecranon, and posterior border of ulna
  - Inserts into the pisiform, hook of hamate and the 5th metacarpal.
  - Flexes and abducts the wrist; has its own synovial sheath
  - The tendon of flexor carpi ulnaris is a marker for the ulnar artery, which passes laterally to it at the wrist

**LAYER 2**
- **FLEXOR DIGITORUM SUPERFICIALIS**
  - The fast flexor of the fingers. Has two heads: humeroulnar and radial head
  - The humeroulnar head originates FROM BOTH THE COMMON FLEXOR ORIGIN and the coronoid process of ulna; the radial head originates the proximal half of the radius
  - It inserts into shafts of the middle phalanges
  - It flexes the metacarpophalangeal joints and the proximal interphalangeal joints; it can flex each joint independently of the others.
  - Its tendons are enclosed in the COMMON FLEXOR SHEATH together with the tendons of flexor digitorum profundus

- **FLEXOR DIGITORUM PROFUNDUS**
  - The slow flexor of the fingers
  - Originates from the interosseous membrane, and from the proximal three quarters of the anterior surface of the ulna. It has two parts: medial and lateral parts;
  - The medial part is innervated by the ulnar nerve
  - The medial part flexes the distal interphalangeal joints of the 4th and 5th digits
  - The lateral part flexes the distal interphalangeal joints of the 2nd and 3rd digits
  - All parts can flex the wrist joint as well as the fingers
  - The lateral part is innervated by the ANTERIOR INTEROSSEOUS NERVE (a branch of the median nerve).
  - The tendon to the index finger tends to separate early; it’s the only one which can operate independently. Unlike the flexor digitorum superficialis, the profundus flexes all the DIPs together.

**LAYER 3**
- **FLEXOR POLLICIS LONGUS**
  - Originates from the anterior surface of the radius and the nearby interosseous membrane
  - Inserts into the base of the distal phalanx of thumb. It has its own synovial sheal in the carpal tunnel
  - Also innervated by the ANTERIOR INTEROSSEOUS NERVE
  - It flexes the phalanges of the thumb; mainly the distal interphalangeal joint (it’s the only muscle that flexes the DIP of the thumb)

**LAYER 4**
- **PRONATOR QUADRATUS**
  - Originates from the flexor carpi ulnaris, and inserts into the flexor retinaculum. It can flex the ulnar head of the radius
  - It is innervated by the ANTERIOR INTEROSSEOUS NERVE
  - It pronates the forearm (it’s the PRIMARY PRONATOR of the forearm) and its fibers hold the radius and ulna together. When speed is needed, it is assisted by the Pronator Teres.

All supplied by the MEDIAN NERVE, ...except:
- **Flexor Digitorum Profundus, ulnar half**
- **Flexor Carpi Ulnaris, whole**
### Extensor Compartment of the Forearm: Superficial layer

All extend the forearm, wrist or fingers – EXCEPT BRACHIORADIALIS

Brachioradialis is the solitary exception:
  - it is in the extensor compartment, but it flexes the forearm.
  - It is the only flexor innervated by the radial nerve.

All supplied by the RADIAL NERVE, or some branch thereof.

Two originate from the supracondylar ridge as well as the adjacent intermuscular septum:

- **Brachioradialis**
  - Radial nerve
  - Inserts at the lateral surface of the distal end of the radius
  - Flexes the forearm, in a feeble way, and mostly when the forearm is pronated; it also acts as a shunt muscle to prevent subluxation of the head of radius. Its most active in quick movements, and in movement against resistance.
  - Forms the lateral border of the cubital fossa
  - Under it run the radial nerve and the radial artery
  - Distally, its tendon is covered by the tendons of Abductor Pollicis Longus and Extensor Pollicis Brevis.

- **Extensor Carpi Radialis Longus**
  - Radial nerve
  - Inserts at the dorsum of the 2nd metacarpal, at the base
  - Extends and abducts the hand at the wrist
  - It is covered by the Extensor Carpi Radialis Longus
  - They also share the same extensor tendon sheath at the wrist
  - The brevis is more involved in extension than the longus

- **Extensor Carpi Radialis Brevis**
  - Deep branch of radial nerve
  - Inserts into the dorsum of the 3rd metacarpal at the base
  - Extends and abducts the hand at the wrist
  - It is covered by the Extensor Carpi Radialis Longus
  - They also share the same extensor tendon sheath at the wrist
  - The brevis is more involved in extension than the longus

- **Extensor Digits**
  - Posterior interosseous nerve which is really the continuation of the deep branch of the radial nerve
  - Inserts at the extensor expansions of the fingers
  - THE EXTENSOR EXPANSIONS are triangular aponeuroses which wrap around the metacarpal head, and the proximal phalanx. They are united with the insertions of the lumbricals and the interosseous muscles.
  - The tendons thus divide into a median band which passes to the base of the middle phalanx, and two lateral bands which insert at the base of the distal phalanx.
  - Extends the fingers, primarily at the metacarpophalangeal joint; secondarily at the distal interphalangeal joint.
  - Occupies a lot of space in the extensor compartment
  - Shares an extensor tendon sheath with the Extensor Indicis... etc.
  - Just proximally to the metacarpophalangeal joints, the tendons are linked by intertendinous connections which prevent the fingers from being independently extended; thus you can never fully extend a finger while the others remain flexed. This is most true of the ring finger.

- **Extensor Digiti Minimi**
  - Posterior interosseous nerve
  - Divides into two tendons- the lateral one joins the pinky tendon of the extensor digitorum, and then together with the medial one all three insert into the extensor expansion of the pinky finger.
  - Extends the pinky, primarily at the metacarpophalangeal joint; secondarily at the distal interphalangeal joint.
  - This is really just a detached part of the extensor digitorum
  - However, it has its own tendon sheath

- **Extensor Carpi Ulnaris**
  - Posterior interosseous nerve
  - Yes it does originate at the common extensor origin; that’s the humeral head. There is also an ulnar head, which originates at the ulnar border posteriorly, via an aponeurosis. This origin is also shared with the Flexor Digitorum profundus and the Flexor Carpi Ulnaris.
  - Inserts at the dorsum of the base of 5th metacarpal
  - Extends the hand at the wrist joint, and abducts it
  - It has its own tendinous sheath at the wrist
  - It is also crucial to the formation of the closed fist

### Tendon sheaths:

- Extensor carpi ulnaris has its own; and so does extensor digiti minimi. The extensor digitorum shares a sheath with the tendon of Extensor Indicis
- The common tendon sheath of the extensors radialis: both travel within the same sheath
- The Insertions of the Extensors Carpi Radialis tendons:
  1. Bases of the metacarpals
  2. Longus inserts into the 2nd
  3. Brevis inserts into the 3rd

### Intertendinosus connections

- which unite the extensor digitorum tendons and prevent the digits from extending independently
Extensor Compartment of the Forearm: Deep layer

DEEP LAYER OF EXTENSORS

"true" deep layer

- **Supinator**
  - deep branch of radial nerve which pierces it on its way to transforming into the posterior interosseous nerve
  - originates from everywhere... the lateral humeral epicondyle, the radial collateral ligament, the annular ligament, the supinator fossa and the crest of ulna
  - inserts into the lateral posterior and anterior surfaces of the proximal third of radius
  - it supinates the forearm, turning the arm to face anteriorly and superiorly when the forearm is flexed. It is the PRIME MOVER for slow unopposed suination
  - The supinator forms the floor of the cubital fossa together with brachialis. It is a sheet-like muscle, and it envelops the radius.

"outcropping" deep layer

these originate from the proximal, middle and distal thirds of the ulna (as a generalization). They emerge in the surface in the furrow that forms in the extensor compartment

- **Extensor Indicis**
  - Posterior interosseous nerve
  - originates from the posterior surface of the distal third of the ulna, and the interosseous membrane
  - inserts into the extensor expansion of the index finger
  - helps extend the hand at the wrist

- **Abductor Pollicis Brevis**
  - Posterior interosseous nerve
  - originates from the posterior surface of the distal third of the ulna, and the interosseous membrane
  - inserts into the dorsum of the base of the proximal phalanx of the thumb
  - extends the proximal phalanx of the thumb at the metacarpophalangeal joint; also extends the carpometacarpal joint of the thumb.
  - partly covered by the abductor pollicis longus
  - its tendon is immediately medial to the APL
  - these two tendons form the anterior boundary of the anatomical snuffbox.

- **Extensor Pollicis Longus**
  - Posterior interosseous nerve
  - originates from the posterior surface of the middle third of the ulna, and the interosseous membrane
  - inserts into the dorsum of the base of the distal phalanx of the thumb
  - extends the distal phalanx of the thumb; also extends the metacarpophalangeal and the carpometacarpal joints of the thumb. It also rotates the thumb laterally.
  - It enjoys its own tendon sheath at the wrist; it passes medially over the dorsal tubercle of radius, using it as a pulley.
  - the EPL forms the posterior border of the anatomical snuffbox

APL inserts into the base of 1st metacarpal
EPB inserts into the base of proximal phalanx
EPL inserts into the base of distal phalanx
The Extensor Retinaculum

- Attaches to the lateral border of the radius
- Does NOT attach to the border of the ulna, because the ulna moves too much.
- Instead, attaches to the pisiform and the triquetrum
- Also attaches to the ridges of the radius, thus forming osseofibrous tunnels for the above tendons to run through
- There are 6 tunnels in total:
  1. One for abductor pollicis longus and extensor pollicis brevis
  2. One for extensor carpi radialis longus and extensor carpi radialis brevis
  3. One for extensor pollicis longus
  4. One for extensor digitorum and extensor indices
  5. One for extensor digiti minimi
  6. One for extensor carpi ulnaris
The Flexor retinaculum is stretched between four bony posts:

1) Hook of hamate
2) Pisiform bone
3) Tuberosity of scaphoid
4) Tuberosity of trapezium

The Carpal Tunnel and its Contents

This is a narrow enclosed space. Needless to say, if anything in here swells, the median nerve will get compressed. It is the most sensitive structure in the carpal tunnel.

- The lateral three and a half digits will get diminished sensation
- Sensation on the thenar eminence will be spared because the palmar cutaneous branch splits from the median nerve long before the flexor retinaculum
- The movement of the thenar muscles is controlled by a terminal motor branch of the median nerve, and so the thenar muscles will atrophy in carpal tunnel syndrome
A Summary of the Innervation of the Extensors and Flexors of the Forearm

**Extensors**

All innervated by branches of the RADIAL NERVE

Radial nerve itself: innervates muscles with attachments proximal to the cubital fossa
- Brachioradialis
- Extensor Carpi Radialis Longus
- Both of these originate at the supracondylar ridge

Deep branch of the radial nerve: a branch which splits off from the radial nerve at the level of the humeral condyle in the cubital fossa; it pierces the supinator muscle, and becomes the posterior interosseous nerve
- Extensor Carpi Radialis Brevis
- Supinator

Posterior interosseous nerve: travels along the posterior aspect of the interosseous membrane; innervates most of the extensor muscles
- Extensor digitorum
- Extensor Indicis
- Extensor Digiti minimi
- Extensor Carpi Ulnaris
- Extensor Pollicis Longus
- Extensor Pollicis Brevis
- Abductor Pollicis Longus

**Flexors**

Innervated by either the ULNAR or the MEDIAN nerves

Median nerve itself:
- Pronator Teres
- Palmaris Longus
- Flexor carpi Radialis
- Flexor Digitorum Superficialis

Anterior interosseous nerve, a branch of the median nerve:
- Flexor Digitorum Profundus - lateral half
- Flexor Pollicis Longus
- Pronator Quadratus

Ulnar nerve:
- Flexor Digitorum profundus, only the medial half
- Flexor Carpi Ulnaris

*Radial nerve is in red*

*Deep branch of the radial nerve is in pink*

*Posterior interosseous nerve is in green*

*Ulnar nerve:*
Innervates the muscles directly adjacent to it along its course down the arm

*Median nerve:*
Innervates mainly the 1st and 2nd layer of flexors

*Anterior interosseous nerve:*
Innervates the 3 deepest muscles
Fascia, Septa, Tendon Sheaths and the Potential Spaces of the Hand

These fascial layers are continuous with the fascial sleeve of the forearm. Centrally the fascia of the palm thickens in the centre, where the palmaris longs tendon attaches to it, which is also where it merges with the flexor retinaculum. This whole thickened area is called the palmar aponeurosis. Distally, the palmar aponeurosis divides into four bands which attach to the bases of the proximal phalanges, and there it becomes a part of the digital sheaths.

**The Midpalmar Space**
Unlike the thenar space, this one is continuous with the anterior compartment of the forearm - it communicates with it via the carpal tunnel.

**The Thenar Space**

**Palmar Aponeurosis**
so thick and tough that any infections in the palmar spaces will actually cause the weaker DORSAL fascia to bulge out.

*In Dupuytren’s contracture*, the palmar aponeurosis becomes nodular, fibrosed, and thickened.

**Digital Synovial Sheaths**

**Lateral fibrous septum of the palm**
which stretches from the palmar aponeurosis to the 5th metacarpal

**Medial fibrous septum of the palm**
which stretches from the palmar aponeurosis to the 5th metacarpal

Of the two septa, the LATERAL is the strongest
Compartments of the palm and their contents

**Thenar compartment**
Contains the thenar muscles

**Adductor compartment**
Contains only Adductor Pollicis

**Central compartment**
Contains the flexor tendons and their sheaths, the lumbricals, the superficial arterial palmar arch, and the digital vessels and nerves

**Hypothenar compartment**
Contains the hypothenar muscles

**Interosseous compartments**
Contains the interossei muscles

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**Thenar Compartment**

- **Flexor Pollicis Brevis**: Superficial head which is innervated by the MEDIAN NERVE
- **Deep Head**: which is innervated by the DEEP BRANCH OF THE ULNAR NERVE

**Central Compartment**

- **1st and 2nd Lumbricals**: which are unipennate and which are innervated by the MEDIAN NERVE
- **3rd and 4th Lumbricals**: which are bipennate and which are innervated by the DEEP BRANCH OF THE ULNAR NERVE

**Hypothenar Compartment**

- **Abductor Digitii Minimi**
- **Opponens Digiti Minimi**

**Interosseous Compartment**

- **1st Dorsal Interossei**
- **1st Palmar Interossei**
- **2nd Dorsal Interossei**
- **2nd Palmar Interossei**
- **3rd Dorsal Interossei**
- **3rd Palmar Interossei**
- **4th Dorsal Interossei**
There are 3 Thenar muscles, 3 Hypothenar muscles, 1 Adductor muscle, 4 Lumbricals, 4 dorsal interossei and 3 palmar interossei

**Thenar and Hypothenar muscles**

- **Opponens digitii minimi**
  - deep branch of ULNAR NERVE
  - originates from hook of hamate and the flexor retinaculum
  - inserts into the medial border of the 5th metacarpal
  - abducts the 5th digit and assists in its flexion
  - it is the most superficial of the three hypothenar muscles

- **Flexor digiti minimi brevis**
  - deep branch of ULNAR NERVE
  - originates from hook of hamate and the flexor retinaculum
  - inserts into the medial side of the base of the 5th proximal phalanx
  - flexes the proximal phalanx of the 5th digit

- **Abductor digiti minimi**
  - deep branch of ULNAR NERVE
  - originates from pisiform
  - inserts into the medial surface of the base of the 5th proximal phalanx
  - abducts the 5th digit and assists in its flexion
  - it is the most superficial of the three hypothenar muscles

There is also **Palmaris brevis**; a useless little muscle which wrinkles the skin of the palm; it originates at the flexor retinaculum and inserts into the skin. The ulnar nerve innervates it.

**IT IS NOT PART OF THE HYPOTHENAR COMPARTMENT**

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**Hypotenar Muscles**

In the HYPOTHENAR compartment

- **Opponens digiti minimi**
  - deep branch of ULNAR NERVE
  - originates from hook of hamate and the flexor retinaculum
  - inserts into the medial border of the 5th metacarpal
  - abducts the 5th metacarpal anteriorly, and rotates the 5th digit so it can participate in opposition with the thumb
  - acts exclusively at the MCP joint

- **Flexor digiti minimi brevis**
  - deep branch of ULNAR NERVE
  - originates from hook of hamate and the flexor retinaculum
  - inserts into the medial side of the base of the 5th proximal phalanx
  - flexes the proximal phalanx of the 5th digit

- **Abductor digiti minimi**
  - deep branch of ULNAR NERVE
  - originates from pisiform
  - inserts into the medial surface of the base of the 5th proximal phalanx
  - abducts the 5th digit and assists in its flexion
  - it is the most superficial of the three hypothenar muscles

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**Thenar Muscles**

In the ADDUCTOR compartment

- **Adductor pollicis**
  - deep branch of the ulnar nerve
    - TRANSVERSE HEAD originates from the anterior surface of the 3rd metacarpal
    - OBLIQUE HEAD originates from the bases of the 2nd and 3rd metacarpals, from the capitate bone, and from any carpal bones around the capitate.
    - inserts into the medial side of the base of the proximal phalanx of thumb.
    - There tends to be a sesamoid bone at the site of insertion.
    - adducts the thumb towards the lateral border of the palm (presses it against the palm)

- **Flexor pollicis brevis**
  - deep branch of ULNAR NERVE
  - originates from the flexor retinaculum and the tubercles of scaphoid and trapezium; they both insert into the lateral aspect of the base of the proximal phalanx of the thumb.
  - act exclusively at the MCP joint

- **Opponens pollicis brevis**
  - Recurrent branch of MEDIAN NERVE
  - originates from the flexor retinaculum and the tubercles of scaphoid and trapezium; inserts into the lateral side of the 1st metacarpal.
  - opposes the thumb: medially rotates and the pulls medially the 1st metacarpal. Acts exclusively at the MCP joint
Short muscles of the Hand

- There are 4 lumbricals, 4 dorsal interossei, and 3 palmar interossei; you count them starting at the thumb.

The LUMBRICALS
- Originate from the tendons of the FLEXOR DIGITORUM PROFUNDIS
- Sit in the central compartment of the palm
- From the palm, cross over to the dorsum of the hand
- Insert into the extensor expansions on the dorsum of the proximal phalanges
- The first and second lumbricals are innervated by the median nerve. All other short muscles are innervated by the deep branch of the ulnar nerve.
- The third and fourth lumbricals are bipennate; the other two are unipennate.
- Flex the metacarpophalangeal joints
- Extend the proximal interphalangeal joints

Together the short muscles all produce the “Z” movement of the fingers; the MCPs are flexed, and the PIPs extended. This is the opposite of what happens in ulnar nerve palsy (“claw hand”) when the MCPs are extended and the PIPs are flexed.

The DORSAL INTEROSSEI
- Originate from the sides of two metacarpals (all of them are bipennate)
- Sit in their own INTEROSSEOUS compartment of the hand
- Insert into the bases of the proximal phalanges and into the extensor expansions
- ABDUCT the hand away from the axis of the middle finger (the axis as shown) - hence “DAB” (“Dorsal Interossei ABDuct”)
- Also help the lumbricals flex the MCPs and extend the PIPs
- When the thumb is flexed, the first dorsal interossei can be seen as the lump that appears on the dorsum of the hand.

The Interossei all live inside the INTEROSSEOUS compartment. The Palmar interossei occupy the anterior (palmar) part of it, and the dorsal interossei are more properly between the metacarpals.

The PALMAR INTEROSSEI
- Originate from the palmar surfaces of the metacarpals
- Sit in the anterior part of the INTEROSSEOUS compartment of the hand
- Insert into the bases of the proximal phalanges and into the extensor expansions
- ADDUCT the fingers towards the middle phalanx, hence “PAD” - Palmar Interossei ADDUCT
- There are only 3 palmar interossei; the deep part of the Flexor Pollicis Brevis can be described as the 4th, because it does much the same thing as the rest, and is innervated by the same nerve.

References: Moore’s Clinically Oriented Anatomy 5th edition