

THE UPPER EXTREMITY

- [Pectoral and Scapular Regions](#)
 - [The Arm](#)
 - [The Extensor Forearm](#)
 - [The Flexor Forearm](#)
 - [Joints of the Upper Extremity](#)
 - [The Hand](#)
 - [Fractures and Entrapment Neuropathies](#)
-

MOTOR UNIT: A motor (GSE) neuron, plus all of the muscles that neuron innervates.

- Fine Motor Control: Lots of motor neurons going to relatively few muscles.
 - Gross Motor Control: A few motor neurons going to lots of muscles.
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PECTORAL AND SCAPULAR REGIONS

THE SCAPULA:

- **Supraspinatus Fossa:** Depression in the scapula, above the scapular spine.
- **Infraspinatus Fossa:** Depression in the scapula, below the scapular spine.

TRAPEZIUS MUSCLE: It is innervated by the spinal accessory nerve. Hence with a cervical neck fracture, some people can still shrug their shoulders, even though they've lost upper-limb innervation, due to residual innervation from this nerve.

TRIANGLE OF AUSCULTATION (N399a): On the medial back, it is an area of little muscle and hence a good place to listen to the lungs.

- Medial Border: Trapezius muscle
- Lateral Border: Teres Major, laterally and deep.
- Inferior Border (base): Latissimus Dorsi

QUADRANGULAR SPACE (N401b): Just medial to the surgical neck of the humerus on the posterior side.

- Superior border: Teres Minor (posteriorly)
- Inferior border: Teres Major (anteriorly)
- Lateral border: Lateral head of the Triceps
- Medial border: Long head of the Triceps
- CONTENTS: These guys can be damaged with a fracture of the neck of the humerus.
 - **Axillary Nerve**
 - **Posterior Circumflex Humeral Artery**

TRIANGULAR SPACE (N401a, N401b): Anterior aspect, medial to the neck of the humerus.

- Lateral border: Long head of the triceps.
- Upper border: Teres Minor
- Lower border: Teres Major
- CONTENTS: **Circumflex Scapular Branch** of the subscapular artery.

TRIANGULAR INTERVAL (N401b): Between the two heads of the triceps muscle, inferior to the teres major.

- CONTENTS: **Deep Brachial Artery** and **Radial Nerve**, both of which continue along the radial groove of the humerus.

SCAPULA: The shoulder blade.

- From top to bottom, order of the Scapular Muscles (N401):
 - Supraspinatus
 - Infraspinatus
 - Teres Minor
 - Teres Major
- **WINGED SCAPULA:** Both the Serratus Anterior and Rhomboids insert on the medial aspect of the scapula. If you lose this insertion, you can get winged scapula, where the scapula does not stay in place and is raised a bit from the posterior wall.

Deltoid Muscle: It inserts on the Deltoid Tuberosity of the humerus and has multiple actions

- Anterior part flexes and medially rotates the arm.
- Posterior part extends and laterally rotates the arm.
- Lateral fibers abduct the arm.

Abduction of the Arm:

- STEP I: Movement of supraspinatus and deltoid muscles, until the angle is about 80 at which point the acromion and greater tubercle hit each other.
- STEP II: *Rotation of the Scapula*, to get the acromion process out of the way. The Serratus Anterior and Trapezius move the inferior border of the scapula laterally.

PECTORALIS MAJOR: Aids in both flexing and extending the arm, depending on part of muscle.

- **Clavicular Head:** It flexes the arm.
- **Sternocostal Head:** It extends the arm.

CLAVIPECTORAL FASCIA (N403): Fascia separating the pectoralis major from pectoralis minor, and overlying the pecs, the serratus anterior, and latissimus dorsi muscles. It goes from the pec-minor to the clavicle.

- Perforations:
 - The **Cephalic Vein** goes through the membrane to become the axillary vein.
 - The **Thoracoacromial Artery** comes from axillary artery and perfuses the deltoid and pec-minor muscles.
- The subclavius muscle is completely invested by the fascia, both anteriorly and posteriorly.
- **Costocoracoid Ligament** is the strongest part of the fascia, going from the 1st rib to the coracoid process. It travels along the lower border of the subclavius.

CEPHALIC VEIN CLINICAL: A surgeon may pass a fine tube through the Cephalic Vein -----> Axillary Vein -----> Subclavian -----> SVC -----> Heart to withdraw blood.

THE AXILLA (N404, N403b):

- Borders of the Axilla (N403b):
 - Anterior Border: The pectoralis major and minor, and the subclavius, plus investing fascia (Clavipectoral fascia).
 - Base of the Axilla: The skin of the armpit, superficial fascia.
 - Apex of the Axilla: The root of the neck, through which the brachial plexus of nerves and vessels travels.
 - Medial Border: Serratus Anterior and intercostal muscles.
 - Posterior Border: Subscapularis, Latissimus Dorsi, and Teres Minor.
- CONTENTS:
 - The axillary artery
 - The axillary vein

- The Brachial Plexus
- The Axillary group of lymph nodes

AXILLARY ARTERY (N402a): Branches of the Axillary Artery.

- *1st Part of Axillary Artery:* Above the pectoralis minor. Has 1 branch.
 - **Superior Thoracic Artery**
- *2nd Part of Axillary Artery:* Directly deep to the Pectoralis Minor. Has 2 branches.
 - **Thoracoacromial Artery** (pierces clavipectoral fascia)
 - **Deltoid Branch of Thoracoacromial**
 - **Pectoralis Branch of Thoracoacromial.**
 - **Lateral Thoracic Artery** (aka External Mammary Artery) -- important source of blood for mammary glands.
- *3rd Part of Axillary Artery:* Below the pectoralis minor. Has 3 branches.
 - **Anterior Circumflex Humeral Artery**
 - **Posterior Circumflex Humeral Artery** -- passes through Quadrangular space along with the axillary nerve.
 - And anterior and posterior circumflex humerals anastomose with each other around the lateral neck of the humerus.
 - The posterior circumflex also anastomoses with the deep brachial artery.
 - **Subscapular Artery** -- largest branch which supplies muscles of posterior wall (scapula)
 - **Circumflex Scapular Artery** branches off and proceeds posteriorly through the *triangular space*.
 - **Thoracodorsal Artery** travels along with thoracodorsal nerve.

AXILLARY VEIN (N175): The union of the basilic and deep brachial veins. It then joins with the Cephalic Vein to become the Subclavian Vein.

- It travels along the *medial side* of the axillary artery.
- Commonly receives tributaries from the **Thoraco-Epigastric Veins**, an important collateral route for venous return, if the IVC becomes obstructed.

THYROCERVICAL TRUNK (N402a): An arterial branch that comes off the subclavian artery, before it turns into the Axillary Artery. It has the following branches:

- **Transverse Cervical Artery:** Turns into the Dorsal Scapular Artery.
 - **Dorsal Scapular Artery:** Branch on the posterior side, where it supplies the Levator Scapulae and Rhomboids, along with the Dorsal Scapular N.
- **The Suprascapular Artery:** Heads around the scapular notch and anastomoses with the *circumflex artery* to form one of the main collateral channels around the scapula.
 - Suprascapular N. follows the suprascapular artery to supply to the supraspinatus and infraspinatus.

AXILLARY LYMPH NODES (N456): The apical group is the most crucial for spreading of breast cancer. If it has gotten to the axillary group, you is in trouble.

- **Lateral Group:** Drains the upper limb. Located near brachial artery.
- **Subscapular Group:** Drains the scapular region and posterior thoracic wall.
- **Pectoral Group:** Drains the anterior thorax and some of mammary glands. Assoc. with lateral thoracic artery.
- **CENTRAL GROUP:** It receives the lymph from the previous three groups. It forms the largest group and is often palpable upon examination.
- **APICAL GROUP:** The only one above the pectoralis minor. It receives lymph from the central group as well as other locales, and dumps into the subclavian trunk.

THE BRACHIAL PLEXUS OF NERVES (N405):

- **CERVICAL ROOTS** of the Plexus:
 - **Dorsal Scapular (C5)**
 - **Long Thoracic Nerve (C5,C6,C7).**
 - Runs along the Serratus Anterior superficially. You gotta watch it during a mastectomy -- it could be cut accidentally.

- CLINICAL -- if the Long Thoracic is accidentally cut, You will get **Winged Scapula**. The long Thoracic will no longer hold the Scapula in place, via Rhomboids and Serratus Anterior.
- SUPERIOR TRUNK -- C5, C6, part of C4
 - Direct Branches
 - **Suprascapular Nerve (C5,C6)**
 - **Subclavius Nerve (C5,C6)**
 - ANTERIOR DIVISION -----> LATERAL CORD
 - POSTERIOR DIVISION -----> POSTERIOR CORD
- MIDDLE TRUNK -- C7
 - ANTERIOR DIVISION -----> LATERAL CORD
 - POSTERIOR DIVISION -----> POSTERIOR CORD
- INFERIOR TRUNK -- C8, L1
 - ANTERIOR DIVISION -----> MEDIAL CORD
 - POSTERIOR DIVISION -----> POSTERIOR CORD
- LATERAL CORD
 - Gives off the **Lateral Pectoral Nerve**. (mammary glands)
 - Becomes the **MUSCULOCUTANEOUS NERVE (C5,C6,C7)**.
 - Forms a branch with the medial cord, to form the Median Nerve.
- MEDIAL CORD
 - Gives off the Medial Pectoral, **Medial Brachio-cutaneous**, and **Medial Antebrachial Cutaneous** Nerves. (medial aspect of arm)
 - Forms a branch with the Lateral Cord, to form the Median Nerve.
 - Becomes the **ULNAR NERVE (C8,T1, some C7)**.
- POSTERIOR CORD
 - Gives off the Upper and Lower Subscapular Nerves, and the **Thoracodorsal Nerve**.
 - Forms the **AXILLARY NERVE (C5,C6)**.
 - Becomes the **RADIAL NERVE (C5,C6,C7,C8)**

MEDIAN NERVE: Formed by the union of the anterior divisions of the lateral and medial cords. It is the bottom-middle part of the "M"

DUCHENNE-ERB PARALYSIS: Damage to the Upper Trunk of the Brachial Plexus

- Excessive downward traction of the arm during birth, which can tear the upper trunk at its root.
- This cuts off the suprascapular and subclavius completely, as well as most of axillary nerve. You lose shoulder movement.
- Symptom: The arm just droops there, medially rotated, elbow extended, shoulder adducted, forearm pronated. **Waiter's Tip Position**.
- **Erb's Point:** The location of the superior trunk, where C5 and C6 unite, and where the Suprascapular and Subclavius are given off.

KLUMPKE'S PARALYSIS: Damage to the lower trunk (C8-T1).

- Loss of most of median and especially *ulnar* nerves.
- Symptoms:
 - Clawed hands due to loss of innervation of intrinsic muscles (T1) of the hand.
 - Loss of sensation on medial aspect of arm, forearm, and hand (due to loss of ulnar nerve).
- **Horner's Syndrome:** Associated problem; cervical sympathetic paralysis, resulting in:
 - Constriction of pupils.
 - Enophthalmos -- apparent recession of eyeballs.

THE ARM

THE HUMERUS (N396, N397)

- **Radial Groove:** The region of the humerus along which the radial nerve travels, just posteroinferior to the Deltoid Tuberosity.
 - CLINICAL: Thus a fracture in the middle of the radius could easily damage the radial nerve.
 - CONTENTS of Radial Groove:
 - **Radial Nerve**
 - **Deep Brachial Artery**
- **Surgical Neck of the Humerus:** The **Axillary Nerve** wraps around the surgical neck of the humerus. Thus injuries to the neck can damage that nerve.

Cutaneous Innervation of the Arm (N454):

- **Axillary Nerve:** Supplies the skin over the deltoid muscle.
- **Radial Nerve:** Posterior of arm and forearm.
 - The lateral dorsal aspect of the hand (posterior of thumb and index finger up to the DIP joint).
- **Medial Antebrachial Cutaneous Nerve:** Supplies much of the anterior skin of arm.

BRACHIAL ARTERY (N409): Supplies the arm.

- The **Deep Brachial Artery** comes off the brachial artery to curl around the back of the humerus, along the radial groove, to supply to the Triceps.
 - **Posterior Circumflex Humeral:** Deep Brachial gives off this branch, which goes back up arm to the Quadrangular space.
 - **Radial Collateral** and **Middle Collateral Arteries** which join up with Radial Recurrent to form elbow anastomoses.

MUSCULOCUTANEOUS NERVE: The major innervator of the arm.

- It goes straight through the coracobrachialis muscle to innervate the anterior aspect of the brachialis.
- **Lateral Antebrachial Cutaneous Nerve:** After innervating the brachialis, it goes to the anterior arm to innervate the skin of the anterior arm.

Intermuscular Septa: Fibrous sheath that separates the anterior and posterior compartments of the forearm.

- CONTENTS OF INTERMUSCULAR SEPTUM:
 - Deep Brachial Artery
 - Radial Nerve
 - Basilic Vein
 - Ulnar Nerve
 - Median Nerve

ARTERIAL ANASTOMOSES AROUND ELBOW (N409):

- Collateral Branches off the Ulnar Artery
 - **Posterior Ulnar Recurrent Artery:** Medial anastomoses with Inferior Ulnar Collateral.
 - **Anterior Ulnar Recurrent Artery:** Medial anastomoses with Superior Ulnar Collateral.
- Collateral Branches off the Radial Artery
 - **Radial Recurrent Artery:** Lateral anastomoses with Radial Collateral
- Collateral Branches off the Brachial Artery:
 - **Inferior Ulnar Collateral:** (Ulnar Recurrent)
 - **Superior Ulnar Collateral:** (Ulnar Recurrent)
- Collateral Branches off the Deep Brachial Artery:
 - **Radial Collateral Artery:** (Radial Recurrent)
 - **Middle Collateral Artery:** Anastomoses with Interosseus Recurrent, but there is variety.

ULNAR ARTERY (N409, N422): One of the terminal branches of the Brachial Artery.

- Gives off the **Common Interosseus Artery**, a short stub which divides into two parts:
 - **Anterior Interosseus Artery:** Supplies the deep muscles of the flexor forearm.
 - **Posterior Interosseus Artery:** Supplies the entire extensor forearm.

THE EXTENSOR FOREARM

BRACHIORADIALIS: CLINICAL -- it may become damaged during a distal radial fracture, because it inserts on the styloid process of the radius.

COMMON EXTENSOR TENDON: The origin of the *superficial* extensor forearm muscles. It hooks onto the *lateral epicondyle* and *supracondylar ridge* of the humerus.

POSTERIOR INTEROSSEUS NERVE: The Deep Branch of the Radial Nerve. It innervates most muscles of the extensor forearm.

- (N419) It pierces the supinator muscle to come into the posterior forearm.
- It travels between the superficial and deep groups of muscles in the posterior forearm.

POSTERIOR INTEROSSEUS ARTERY: Supplies the extensor forearm muscles and travels with the Posterior Interosseus Nerve. It is a branch of the Common Interosseus Artery, which comes from the Ulnar Artery.

EXTENSOR RETINACULUM (N443): The sheath that covers all of the extensor tendons going into the wrist.

- ORDER OF EXTENSOR TENDONS GOING INTO THE WRIST
 - Extensor Pollicis Brevis
 - Extensor Pollicis Longus
 - Extensor Carpi Radialis Longus
 - Extensor Carpi Radialis Brevis
 - (Extensor Indices, concurrent with and deep to Extensor Digitorum)
 - Extensor Digitorum
 - Extensor Digiti Minimi

EXTENSOR DIGITORUM: These tendons cross over the MCP, PIP, and DIP joints -- one tendon going over all joints. This is different than the flexor digitorum.

ANATOMICAL SNUFFBOX: In between the *Extensor Pollicis Longus* and *Extensor Pollicis Brevis*. The *Abductor Pollicis Longus* is directly lateral to it.

- The **Radial Nerve** runs over the superficial part of the anatomical snuffbox, to innervate the lateral cutaneous hand.
- The **Radial Artery** is the "floor" of the snuffbox, snugged right on top of the Scaphoid bone.
 - You can take a pulse in anatomical snuffbox, by palpating the radial artery against the Scaphoid bone.

THE FLEXOR FOREARM

MEDIAN NERVE (N448): Lies in between the *flexor digitorum superficialis* and *flexor digitorum profundus* in the forearm.

- Travels into the hand deep to the *palmaris longus* (right in the middle, anterior surface), traveling through the carpal tunnel.
- Supplies all of flexor forearm EXCEPT the *Flexor Carpi Ulnaris* and the medial half of the *Flexor Digitorum Profundus*.

- INJURY: Can be injured in wrist slashing and carpal tunnel syndrome.
 - Lost sensation to area supplied by median nerve in hand.
 - Paralysis of long flexors of wrist (except the two ulnar flexors)
 - Thenar muscles atrophy, with the result that opposition of thumb is lost.
 - Loss of pronation, depending on where the severance occurs (wrist or elbow)
- SUMMARY OF INJURY: Very crippling: loss of action of thumb and cutaneous sensation on palm of hand.

ULNAR NERVE (N449):

- In the forearm, it supplies the *Flexor Carpi Ulnaris* and the medial half of the *Flexor Digitorum Profundus*.
- It passes *superficial* to the flexor retinaculum.
- INJURY: Commonly injured around the posterior of the medial epicondyle -- right where the funny bone is.
 - **Claw-Hand:** Paralysis of small muscles of hand supplied by Ulnar Nerve. This is the result of loss of control over intrinsic hand muscles, which supply the "balance" between the long flexor and extensor tendons. Result is over-flexion of distal phalanges and extension of proximal phalanges.

RADIAL NERVE (N450, N451): Enters the forearm by traveling over the lateral epicondyle. Splits into two branches.

- **Superficial Branch of the Radial Nerve:** Travels *deep to the brachioradialis* to go to the hand.
- **Deep Branch of the Radial Nerve --** Goes deep back to posterior compartment, where it is the **Posterior Interosseus Nerve**.
- INJURY: **Wrist-Drop** is the sign of radial nerve injury.
 - It is the most frequently injured, due to breaks in the middle of the humerus.
 - Paralysis of the long extensors of the fingers.
 - Lateral (radial deviation) of hand is difficult.
 - Movement (extension and abduction) of thumb is difficult.

T1: INTRINSIC MUSCLES -- All intrinsic muscles of the hand are supplied by T1 fibers, whether from the Ulnar or Radial nerves.

LATERAL ANTEBRACHIAL CUTANEOUS NERVE: From the Musculocutaneous Nerve, it innervates the lateral part of the anterior forearm.

MEDIAL ANTEBRACHIAL CUTANEOUS NERVE: From the medial cord of the brachial plexus, it innervates the medial part of the cutaneous flexor forearm.

RADIAL ARTERY (N409, N422): One of the terminal branches of the Brachial Artery.

- Gives off the Deep Palmar Arch.
- Gives off the Dorsalis Pollicis and Dorsalis Indices Arteries.
- CLINICAL -- **RADIAL PULSE:** On the palmar lateral wrist, at the location of the **Radial Trio**, you can feel the pulse.
 - The Radial Artery is found lateral to the **Flexor Carpi Radialis** and **Flexor Pollicis Longus** tendons at this location in the wrist. Those are the components of the radial trio.
- PATH: Then the radial artery goes to the floor of the anatomical snuffbox -----> through the adductor pollicis and dorsal interosseus muscles -----> deep palmar arch.

ULNAR ARTERY (N409, N422): One of the terminal branches of the Brachial Artery.

- *Does not* pass through the Flexor Retinaculum.
- Gives off the Superficial Palmar Arch.

FLEXOR RETINACULUM (N433b, N434a): The sheath that contains the flexor tendons on the anterior wrist.

- Goes from the Trapezium to the Scaphoid.
- **CARPAL TUNNEL SYNDROME:** The *Median Nerve* passes deep to the flexor retinaculum. If it is entrapped, carpal tunnel syndrome results.
 - Causes numbness and tingling in the lateral part of the hand supplied by the median nerve, and some motor dysfunction.

- Treatment: Cut the flexor retinaculum and relieve the pressure.

MOBILE WAD: The lateral compartment of the flexor forearm, which is more loosely connected than the other compartments. It contains two muscles:

- **Brachioradialis**
- **Extensor Carpi Radialis Longus**

PALMARIS LONGUS MUSCLE: Absent in about 30% of people, and a good candidate for surgical **tendon transfers** when it is present.

FLEXOR DIGITORUM: Acts differently than the extensor digitorum.

- **Superficial Flexor Digitorum:** Inserts on the distal phalanx and crosses over the DIP joint.
- **Profunda Flexor Digitorum:** Inserts on the proximal phalanx and crosses over the PIP joint.

SPACE OF PARONA: The potential space between the superficial and deep groups of anterior muscles -- essentially between the Flexor Digitorum Superficialis and Flexor Digitorum Profundus.

FASCIA ANTEBRACHIALIS: Thick fascial plane over the anterior forearm.

INTEROSSEUS MEMBRANE: Between the radius and ulna, the posterior limit to the anterior compartment. The Anterior Interosseus Nerve and Artery, and the Flexor Digitorum Profundus, are directly superficial to it.

JOINTS OF THE UPPER EXTREMITY

Types of Joints: Joints are structures that connects bones together.

- **Fibrous Joints:** Collagen joints.
 - Suture of the skull.
 - The *interosseus membrane* between the radius and ulna. This is a type of **syndesmosis** -- i.e. a sheet of fibrous tissue.
- **Cartilaginous Joints:**
 - Examples:
 - Epiphyseal Plates
 - Costochondral Joints
 - Intervertebral Disc
 - Pubic Symphysis
 - *Primary Cartilaginous Joints:* **Synchondroses** -- hyaline cartilage.
 - *Secondary Cartilaginous Joints:* **Symphysis** -- hyaline cartilage along with fibrous tissue or fibrous cartilage.
- **Synovial Joints:**
 - Characterized by four things.
 - A *joint cavity*, filled with a viscous lubricant substance -- synovial fluid.
 - A *synovial membrane*, which produces the synovial fluid to fill the joint cavity.
 - *Articular cartilage*
 - *Fibrous Capsule*
 - Types of Synovial Joints
 - *Plane Joint* -- moveable only in one axis, in one plane.
 - *Hinge Joint* -- moveable only in one axis -- i.e. flexion and extension.
 - *Pivot Joint* -- moveable only in one axis -- i.e. rotation.
 - *Condylloid Joint* -- moveable in two axes -- i.e. flexion-extension, or abduction-adduction.
 - It is usually ellipsoid in shape.
 - *Saddle Joint* -- two axes.
 - *Ball and Socket Joint* -- Multi-axis movement.

Hilton's Law: The nerves supplying a joint also supply the muscles moving that joint and the skin covering those muscles.

DEGREE'S OF FREEDOM: *The more mobile a joint (i.e. the more degrees of freedom), the less stable it is.*

- First degree of freedom: Flexion and Extension.
- Second degree of freedom: Abduction and Adduction
 - The First plus Second degree of freedom results in the ability to **circumduct** the joint, or flex/extend + abduct/adduct at the same time.
- Third degree of freedom: Rotation.

CLINICAL -- Injuries / Diseases of the Joints:

- **Dislocation:** Complete loss of apposition between two articular surfaces.
- **Subluxation:** Partial dislocation; partial loss of apposition between two articular surfaces.
- **Osteoarthritis:** Degeneration of articular cartilage and/or surfaces in weight-bearing joints, resulting from age and/or trauma.
- **Rheumatoid Arthritis:** Connective tissue disorder affecting the whole body, mainly affecting the small joints in terms of joints.
- **Gout:** Painful inflammation of the joint from excess uric acid, resulting sodium biurate deposits in joints.

CONJUNCT ROTATION: Instinctive or automatic rotation of the forearm, as demonstrated by Codman's paradox, where you hold your palm to your side, abduct it, rotate it anteriorly, and bring it back to your body, to discover that it is now facing the other way.

ADJUNCT ROTATION: Deliberate rotation of the joint, such as when you point your hands laterally and then try to abduct your arm.

GLENOHUMERAL JOINT:

- **ROTATOR CUFF** (N398): The tendons of the muscles surrounding the shoulder joint. They rotate the shoulder.
 - Anterior Border: Subscapularis
 - Superolateral Border: Head of the biceps
 - Posterior Border: Infraspinatus and Teres Minor
 - Superior Border: Supraspinatus
- CLINICAL (N401b): The joint is covered on all sides except inferiorly. Hence shoulder dislocations tend to occur inferiorly.
 - In this case you have to watch for damage to the **axillary nerve** and **Posterior Circumflex Humeral Artery**, both of which are directly inferior, in the Quadrangular Space, because this is straight below the shoulder joint.
 - TEST for Axillary Nerve damage: Cutaneous sensation in the Deltoid region (N454)
- THREE DEGREES OF FREEDOM: Circumduction + Rotation. Hence it is a mobile but unstable joint.
 - The glenohumeral joint is an *incongruent* joint -- note that the head of the humerus does not fit in perfectly with the Glenoid Cavity of the Scapula.
- STABILIZING MUSCLES: The *deltoid* and *biceps* help stabilize the shoulder, due to the incongruence of the joint.

ULNOHUMERAL JOINT (ELBOW) (N412):

- Has higher stability and lower mobility: only one degree of freedom (flexion / extension).
- *The Humerus articulates only with the Ulna -- the radius has nothing to do with it!*
- **Radial Collateral Ligament** -- Lateral ligament support.
- **Ulnar Collateral Ligament** -- Medial ligament support.
- CONGRUENCE: The Olecranon of the Ulna fits much better into the Olecranon Fossa of the Humerus, as compared to the shoulder joint.
- Posterior Elbow: The joint capsule is lax on the posterior, so that the elbow can flex and extend.

ULNORADIAL JOINT (ELBOW) (N413):

- Proximal Ulnoradial Joint: **Annular Ligament** holds the Radial Head in place in the Radial Notch of the Ulna.
- Intermediate Ulnoradial Joint: **Interosseus Membrane** holds them together along the shafts of both bones.

- Distal Ulnoradial Joint: **Anterior** and **Posterior Ulnoradial Ligaments**.

RADIOCARPAL JOINT (WRIST) (N429): *The Radius articulates with the Carpal Bones -- not the Ulna at all!*

- TWO DEGREES OF FREEDOM: We can circumduct the wrist.
- Much of flexion (especially) and extension actually occurs at the **Intercarpal Joints** between the two rows of Carpal Bones.

Joint of Knuckles and Fingers:

- **Carpometacarpal Joints:** Joints between distal row of carpal bones and metacarpals.
 - **Metacarpophalangeal (MCP) Joints:** The knuckles, between the metacarpals and proximal phalanges.
 - **Proximal Interphalangeal (PIP) Joints:** Between the proximal and middle phalanges.
 - **Distal Interphalangeal (DIP) Joints:** Between the middle and distal phalanges (not present in thumb).
 - **THUMB** -- NOT A STABLE JOINT compared to the other fingers. The thumb has more mobility, too, to allow opposition.

THE HAND

Movements of the Fingers:

- Flexion and Extension of Fingers: Uses the fingernails as a fan.
- Abduction and Adduction of Fingers: Uses the fingernails to slice through the air, centered around the middle finger.
- THUMB: Same goes for thumb -- flexion, extension, abduction, and adduction are based on the position of the thumb-nail.
- **Circumduction:** The combination action of flexion, extension, abduction, and adduction. Moving around in a circle, as you can do with your fingers, wrist, and shoulder.

Force Transduction through the Hand and Arm:

- Weight-bearing on the hand can be transmitted as follows:
 - SCAPHOID -----> RadioCarpal joints -----> RADIUS -----> Interosseus Membrane -----> ULNA -----> Olecranon -----> HUMERUS -----> Glenohumeral Joint -----> SCAPULA -----> Coracoclavicular Ligaments -----> CLAVICLE
- ***The clavicle is the only bony articulation between the upper limb and trunk.***
- Most common points of fracture in a fall:
 - The surgical neck of the humerus
 - The middle of the clavicle

Common Wrist Fractures:

- **Colles Fracture:** Fracture of the distal radius.
- **Scaphoid Fractures:** Fracture of the scaphoid bone.

Extrinsic Muscles of the Hands: Mostly concerned with grip.

Intrinsic Muscles of the Hands: Concerned with manipulation of the digits. All of them are basically innervated by T1.

PALMAR APONEUROSIS: Deep to the skin and fascia. It holds it down, so that the skin on the palm is tight and hairless.

CLINICAL -- DUPUYTREN'S CONTRACTURE: Flexion of the 4th and 5th digits, resulting from progressive shortening of the palmar aponeuroses, from hypertrophy and hyperplasia. Unknown cause.

FIBROUS FLEXOR SHEATHS (N435): Strong sheath covering the long tendons going into the hand, distal to the flexor retinaculum.

- The fibrous sheaths of the fingers contain two tendons: The tendons of the *Flexor Digitorum Superficialis* and the *Flexor Digitorum Profundus*.
- The fibrous sheath of the thumb contains one tendon: The *Flexor Pollicis Longus*.

SYNOVIAL FLEXOR SHEATHS (N435): The fibrous sheaths are enclosed in synovial sheaths in areas where there is friction. Primarily:

- Deep to the flexor retinaculum.
- Within the digits.
- There are NO SYNOVIAL SHEATHS in the central palm of the hand.

RADIAL BURSA (N435, N436):

- Contains the Pollicis Longus tendon.
- Communicates with Ulnar Bursa in 50% of people.

ULNAR BURSA (N435, N436):

- Contains the Flexor Digitorum Superficialis and Profundus tendons.
- Communicates with Radial Bursa in 50% of people.

CLINICAL -- HORSESHOE INFECTION: Infection spreading from little finger to thumb or vice versa, as a consequence of the communication between the radial and ulnar bursae.

CLINICAL: DORSAL SUBCUTANEOUS SPACE will receive lymph from the palmar aspect of the hand. Thus a hand-infection can easily result in swelling on posterior aspect of the hand, in which case it would be lymph -- not pus -- so don't incise it.

SUPERFICIAL PALMAR ARCH (N439a): Main arterial supply to the hand.

Literally it is formed by a continuation of the artery, and it anastomoses with the Superficial Palmar Branch of the Radial Artery.

It gives off **Common Palmar Digital Arteries** -----> **Proper Palmar Digital Arteries**

DEEP PALMAR ARCH (N439b): Lies deep to the flexor retinaculum.

This is formed by the radial artery, and it anastomoses with the terminal ulnar artery.

It gives off the **Palmar Metacarpal Arteries** -----> **Proper Palmar Digital Arteries**

DORSAL CARPAL ARCH: From the dorsal carpal branches of the Radial and Ulnar arteries.

It gives off the **Dorsal Metacarpal Arteries** -----> **Dorsal Digital Arteries.**

THENAR SPACE: The area deep to the 1st lumbrical muscle and the 2nd flexor tendon, in the palm of the hand.

MIDPALMAR SPACE: The medial part of the deep palm of the hand, deep to the rest of the flexor tendons. It is next to the Thenar Space.

A SEPTUM separates the Thenar from MidPalmar spaces.

CUTANEOUS INNERVATION OF HAND, FOREARM, ARM (N454, N445):

- Axillary N:
 - Shoulder and Deltoid regions
- Musculocutaneous N / Lateral Antebrachial Cutaneous N:
 - Lateral forearm (both posterior and anterior)
- Medial Antebrachial Cutaneous N:
 - Medial Forearm (both posterior and anterior)
- Radial N:
 - Central posterior arm and forearm
 - Lateral 2/3 of posterior hand (up to middle of 4th digit or so) -- EXCEPT the finger tips!!
 - Lateral part of the thumb
- Median N:
 - Lateral two thirds of anterior hand
 - Fingertips of lateral 2/3 of posterior hand
- Ulnar N:
 - Medial third of the hand, both anterior and posterior.

LUMBRICALS: They provide stability to the digits.

- They are *anterior* to the Metacarpophalangeal (MCP) joints (knuckles).
 - So they *flex* the knuckles.
- They are *posterior* to the proximal and distal interphalangeal (PIP and DIP) joints.
 - So they *extend* the distal phalanges.
- They originate from the tendon of the flexor digitorum Profundus.
- FUNCTION OF LUMBRICALS: They are rich in **neuromuscular spindle organs**, and they are thought to give you **proprioception** (spatial orientation) and **kinesthesia** (sense of motion) of the digits, due to the tension placed on them by the digital tendons.
 - In other words, they allow you to know where your finger is and where it is going.

CLINICAL STUFF: FRACTURES AND ENTRAPMENT NEUROPATHIES

SPACE OF PARONA COMPRESSION: Veins are subject to compression when swelling or fluid buildup occurs in any potential space. This causes blood to backflow, which causes the following course of events.

- **Ischemia -----> Necrosis -----> Fibrosis**

FASCIOTOMY: Cutting through the fascia which is causing the compartment syndrome, thereby relieving the pressure and hopefully the compartment syndrome.

SATURDAY NIGHT SYNDROME: Drunk person falling asleep on elbow and hence on ulnar nerve. Wake up the next morning and the ulnar nerve is dead.

CORACOBRACHIALIS SYNDROME (N447): Loss of the **Musculocutaneous Nerve** where it runs through the **Coracobrachialis Muscle**. If the muscle dies, then nerve dies with it.

- YOU ALSO LOSE: *Biceps, Brachialis, and Lateral Antebrachial Cutaneous Nerve.*
- LOST FUNCTION:
 - Lost flexion at elbow.
 - Weak supination due to supinator muscle.
 - Lost sensation over lateral aspect of forearm (cutaneous innervation of medial antebrachial cutaneous N.)

SUPINATOR CHANNEL SYNDROME (N419): Compression of the **Deep Branch of the Radial Nerve** between the *Superficial and Deep Heads of the Supinator, and the Lateral Epicondyle.*

- This occurs right at the **lateral epicondyle**, where the Radial Nerve gives off two branches (Deep and Superficial) to innervate the forearm.
- **Arcade of Frohn:** Occurs in 20%-30% of population, where one head of the Supinator is actually a sharp tendon inserting on the lateral epicondyle. This can also lead to Radial N. damage.

SUPRACONDYLAR SYNDROME: Entrapment of the **Median N.** beneath the **Ligament of Struthers**, which connects the *Supracondylar Process* to the *Medial Epicondyle.*

- The Supracondylar Process is a bit of bone sticking out the medial aspect of the humerus. It is only present in a small fraction of population.
- **LOSS OF FUNCTION AND SENSATION:** Anywhere the median N. innervates.
 - Lateral 2/3 of palm of hand, lost cutaneous sensation.
 - Lose motor to the palmar thenar muscles.
 - Lose motor to the first two lumbricals.

PRONATOR TERES SYNDROME (N420): Entrapment of **Median N.** passing between the Deep and Superficial Heads of the Pronator Teres.

- The Median N. also passes deep to the Flexor Digitorum Superficialis tendon, right after it gets past the Pronator Teres. This can also cause trouble.
- **LOSS OF FUNCTION and SENSATION:** Again, whatever would happen if you lose the Median N. See above.

MARTIN-GRUBER ANASTOMOSIS: Connection between the Median and Ulnar nerves in the palm of the hand, in about 30% of population. When the connection is there, it is mainly a motor connection.

- Result = people with Ulnar N. damage may still have cutaneous anesthesia, but they may keep some motor function in the hand.

CARPAL TUNNEL SYNDROME: The *Median Nerve* passes deep to the flexor retinaculum. If it is entrapped, carpal tunnel syndrome results.

- Carpus is actually U-Shaped.
- **LOSS OF FUNCTION:**
 - Causes numbness and tingling in the lateral part of the hand supplied by the median nerve.
 - Weakening and wasting of the Thenar muscles.
- **TREATMENT:** Cut the flexor retinaculum and relieve the pressure.
- **Superficial Palmar Branch of Median N** *does not go through the Carpal Tunnel.* It results in an area of skin in the middle of the palm that is not affected by Carpal Tunnel Syndrome.

CUBITAL TUNNEL SYNDROME: Compression of the **Ulnar Nerve** between the two heads of origin of the *Flexor Carpi Ulnaris.*

- The **Pisiform bone**, distally, acts as a lever in allow the flexor carpi ulnaris to flex the fingers more strongly.
- **LOSS OF FUNCTION:** Medial two heads of the flexor digitorum profundus and most of the intrinsic muscles of the hand.

GUYON'S CANAL SYNDROME (N432): Compression of the **Ulnar Nerve** in *Guyon's Canal*, between the *Volar Carpal Ligament* and the *Flexor Retinaculum.*

- **Volar Carpal Ligament:** Is superficial to the flexor retinaculum. The ulnar artery and nerve pass superficial to the flexor retinaculum but deep to the volar carpal ligament.
- **CUBITAL TUNNEL -VS- GUYON'S CANAL:** In Guyon's Canal, only the intrinsic muscles of the hand are lost, whereas in Cubital Tunnel Syndrome you also lose the innervation of the medial half of the flexor digitorum profundus.

DUPUYTREN'S CONTRACTURE: Progressive shortening of the palmar aponeuroses, from hypertrophy and hyperplasia. Unknown cause.

- Found esp. in those who have done a lot of manual labor.
- **SYMPTOM:** Tends to bring the medial two fingers in toward the palm and flex them downward a bit.
- **LOSS OF FUNCTION:** Blood vessels that reach the skin through the palmar aponeurosis are compromised!!!
- **TREATMENT:** If caught early enough, incise the aponeurosis.

TENOSYNOVITIS: Not to be messed with. Inflammation of the tendons in the synovial joints, which can spread proximally all the way to the elbow.

- **INFECTION CAN SPREAD** from the **Ulnar Bursa** -----> **Carpal Tunnel** (with secondary carpal tunnel syndrome) -----> **Space of Parona** -----> **Cubital Fossa**.
- Tenosynovitis in the index finger flexor tendon can rupture and get into the **Thenar Space**, causing a compartment syndrome there as well.

DEQUERVAIN'S DISEASE: A specific tenosynovitis of the first extensor compartment, which transmits the Extensor Pollicis Longus and Brevis.

- Found in people who use their thumb a lot and are not used to it.
- **SYMPTOM:** Dull pain around wrist and lack of desire to move the fingers.
- **Dequervain's test:** Make a fist like a child with the thumb inside, and then ulnar deviate (adduct) the wrist. It hurts even without the disease!

SCAPHOID FRACTURE: If the scaphoid is fractured, there is potential for avascular necrosis in 1/3 of all people, because blood comes from only one place -- the distal end.

- This will result in demineralization of the Scaphoid from lack of use, and it will appear dark on the X-Ray as a result.
- When the fracture occurs in the *neck* of the Scaphoid, blood supply is cut off to the proximal part.

TRIGGER FINGER: Swelling of the fibrous sheaths going around the tendons, such that, when the tendon is on one side of the swelling, such that the finger is flexed, it will stay that way and you can't extend it. Then you can pull real hard to get the tendon past the "bottleneck" to the other side of the swelling, such that the finger extends, and then you can't flex it again!

RAYNAUD'S DISEASE: Vascular problem of too high of sympathetic tone, which can cause complications in the hand.

- Spasmodic vasoconstriction at the wrist will cause one or two fingers to become cyanotic and ischemic.
- You could cut the sympathetic nerves at the neck to try and treat it.
- It is a very serious disease.

VARUS: A bone-fracture that creates angulation *toward the midline of the body*.

VALGUS: A bone-fracture that creates angulation *away from the midline of the body*.

UPPER LIMB CASE I: HUMERAL SHAFT FRACTURE WITH RADIAL NERVE PALSY

- ORIGINAL QUESTIONS
 - What arteries and/or nerves are associated with the upper, mid, and distal humerus?
 - *Upper-Humerus: Radial N. in the Radial Groove*
 - *Mid-Humerus: Radial N. and possibly Musculocutaneous N.*
 - *Distal Humerus: Ulnar N. in Medial Epicondylar space, Radial N. in lateral space*
 - Where would you normally test for functional cutaneous innervation of:
 - Radial N? *Dorsal web-space of 1st digit*
 - Ulnar N? *Palmar aspect of 5th distal phalanx.*

- Musculocutaneous N? *Lateral part of mid forearm*
 - Median N? *Palmar aspect of 2nd distal phalanx.*
- What muscles insert on mid-humerus and distal humerus which could affect the angulation/displacement of the proximal and distal humeral segments as a result of this fracture?
- If the radial nerve was completely transected, can you think of an alternative way to get extension of wrist and fingers?
- **Wrist-Drop:** Radial Nerve injury should also show an inability to extend the wrist or finger at the MCP joints, aka "Wrist-drop."
- RARITY: Permanent radial nerve damage is actually a rare circumstance with fractures at the head of the radius. Usually the nerve will resume function because it was only stretched or scarred.
- ANGULATION / DISPLACEMENT: Very important consideration in any fracture.

TYPES OF FRACTURES:

- Transverse
- Oblique
- Spiral
- Longitudinal
- **Segmental Fracture:** Broken bone in two or more places, creating pieces of bone between the fractures.
- **Open Fracture** -- fracture within an exposed wound and hence vulnerable to infection.
- **Close Fracture** -- not exposed by a wound and hence not susceptible to infection.

REASONS FOR PERFORMING SURGERY ON A FRACTURE:

- Open fracture
- Vascular injury -- no blood supply to distal segment causing threat of AVN.
- Satisfactory alignment not being achieved.

UPPER LIMB CASE II: DISTAL RADIAL (COLLES) FRACTURE

- ORIGINAL QUESTIONS:
 - What are the loci where force transduction from a fall might cause injury?
 - From the physical exam findings, are there any indications of a Scaphoid fracture?
 - What muscles insert on the distal radius? If muscles pull on the distal fragment, how would that affect the angulation/displacement of that portion of radius?
 - What nerves and/or arteries traverse the region fractured? What is their location relative to the fracture site? Could these structures have been injured?
- **Colles Fork Deformity:** Characteristics
 - The wrist is moved dorsally a few centimeters
 - No tenderness anywhere else in the upper extremity, and no lacerations.
 - A closed fracture
 - There is *pain associated with thumb movement.*
- HOW IT HAPPENS: It usually happens from falling on outstretched hands.
- SECONDARY CONSEQUENCES OF FRACTURE:
 - **Tendon of Extensor Pollicis Longus** goes over the dorsal tubercle of the distal radius. This tendon can get pinched between the carpal bones and the radial tubercle as the patient falls on his/her hands.
 - The **Median Nerve** can get damaged with this fracture, where it passes through the Carpal Tunnel, because the Carpal Tunnel can swell up, i.e. **Carpal Tunnel Syndrome** is a possible secondary complication.
 - **Scaphoid Fracture** may also happen secondarily. This may not show up on X-Ray, but look for *tenderness in the anatomical snuff-box* to verify such an injury. Make sure and check some time after the initial injury.
- EXTERNAL FIXATOR: Was used to keep her arm in a sling and sustain the injury. It keeps the bone straight over *two joints* -- both the elbow joint and wrist.
 - That is, there is a long cast that goes clear from the arm to the hand.
 - Pins are put in the wrist-region to stabilize the joint.
- ANGULATION IS IMPORTANT: If the inclination, angulation, and *radial length* are not right, long-term arthritis can result.
 - The angle is the articulation of the radius with the lunate and scaphoid bones.