Compression Neuropathies of the Upper Extremity

Lee Wang

Financial disclosures

- I’m broke.

Objectives

- Review pathophysiology of compression neuropathies
- Review anatomy and function of the nerves of the upper extremity
- Identify compression neuropathies of the upper extremity based on anatomical findings and syndromes

Introduction

- Compression neuropathies of the upper extremity are common
- Usually near joints, where the nerve passes through a fibro-osseous or fibro-muscular tunnel
- Lead to altered function, morbidity, irreversible damage

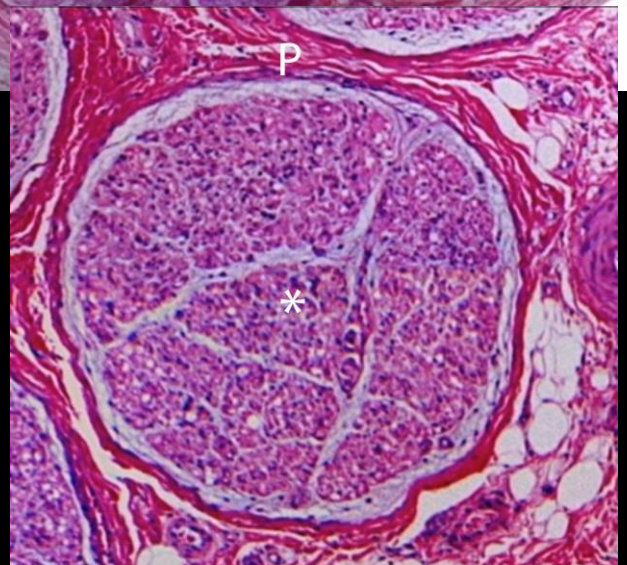
Introduction

- Andreisek et al. – 51 patients with ambiguous physical exam findings
  - MRI identified a cause in 93%
  - Affected clinical management in 86%
- Rewarding for radiologists and surgeons – identification and treatment can lead to dramatic improvements

Microanatomy

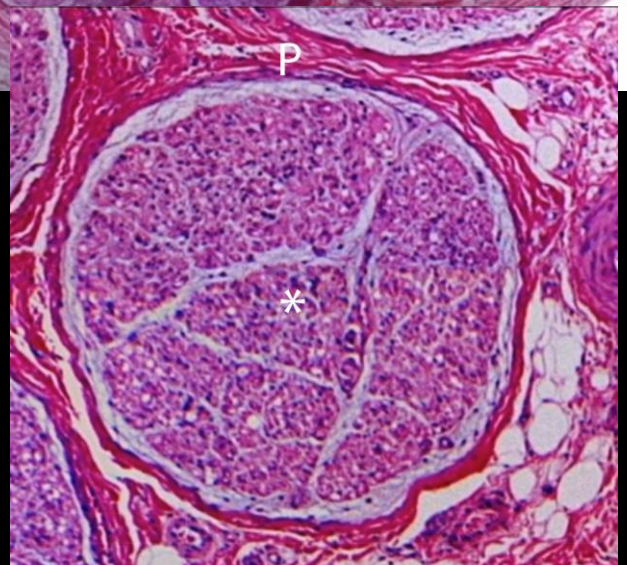
- Nerves are composed of neuroectodermal and mesodermal tissue

- E-epineurium
  A-adventitia
  F-fascicle
  P-perineurium
  *-axon with endoneurium



Pathophysiology

1. Compression
2. ↓lymphatic/venous drainage
3. Increased adventitial pressure and leakage of cytokines
4. Breakdown of blood-nerve barrier
5. Increased endoneurial pressure
6. ↓ axonal transport, demyelination, axonal injury/death, fibrosis

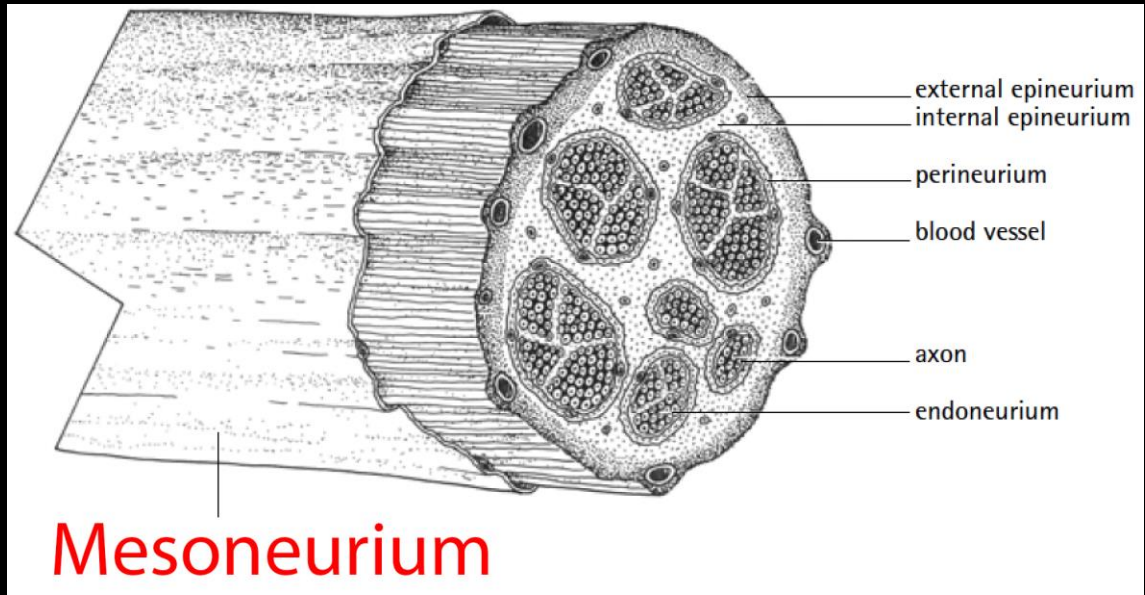


Pathophysiology

- Impaired venous drainage at 20 mmHg
- Delayed nerve injury at 30 mmHg for 2 hours
- Within 30 days - inflammatory reaction, fibrosis, demyelination, and axonal loss
- Injury follows a dose-response pattern

Nerve gliding

- Extraneural and intraneural nerve gliding are critical for nerve health
- Median and ulnar nerves can glide up to 7 and 10 mm at the elbow; 15 and 14 mm at the wrist
- Reduced gliding → ischemia

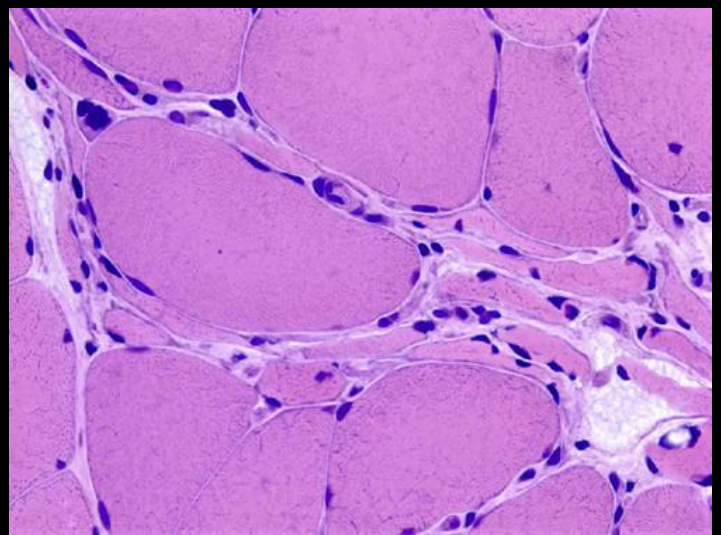


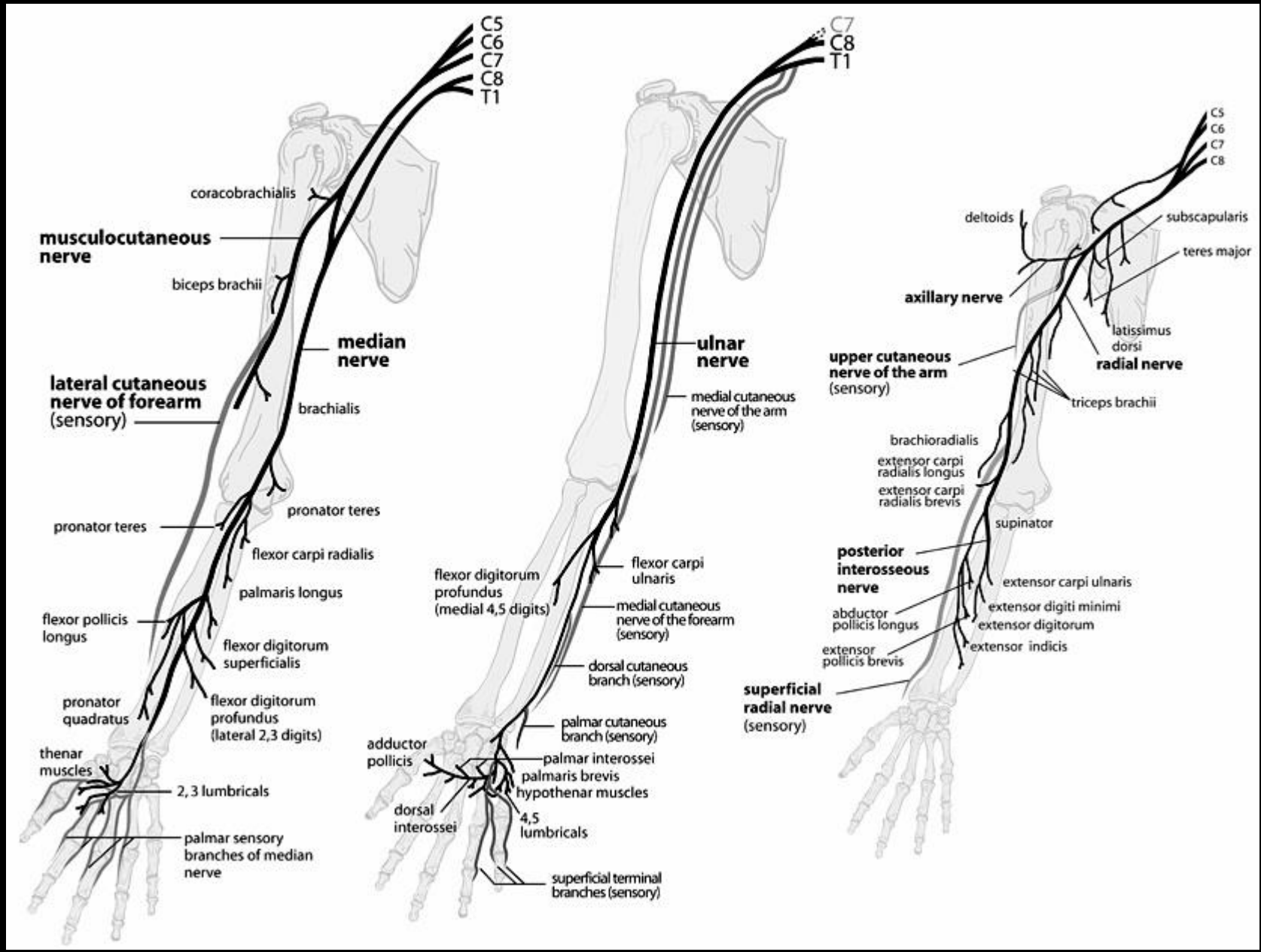
Imaging

- Focal flattening
- Nerve swelling
  - Hyperintensity on fluid-sensitive MRI
  - Hypoechogenicity on US
  - Predominantly proximal to site of compression
- Denervation myopathy

Denervation myopathy

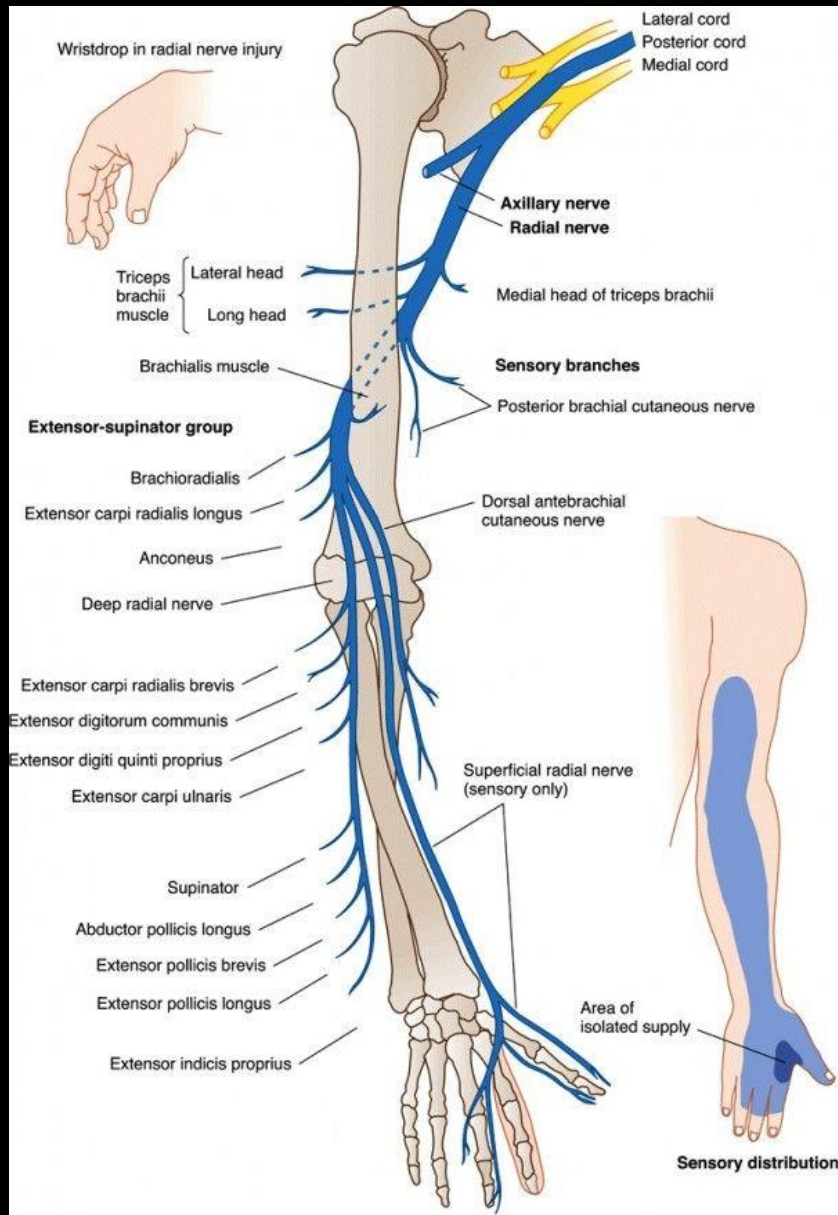
- Poorly understood
- Muscle edema seen typically in 2 to 4 weeks, but has been described as early as 4 days
- Motor neuron exerts trophic effects mediated by contraction and trophic factors
- Denervation → myocyte growth arrest → atrophy



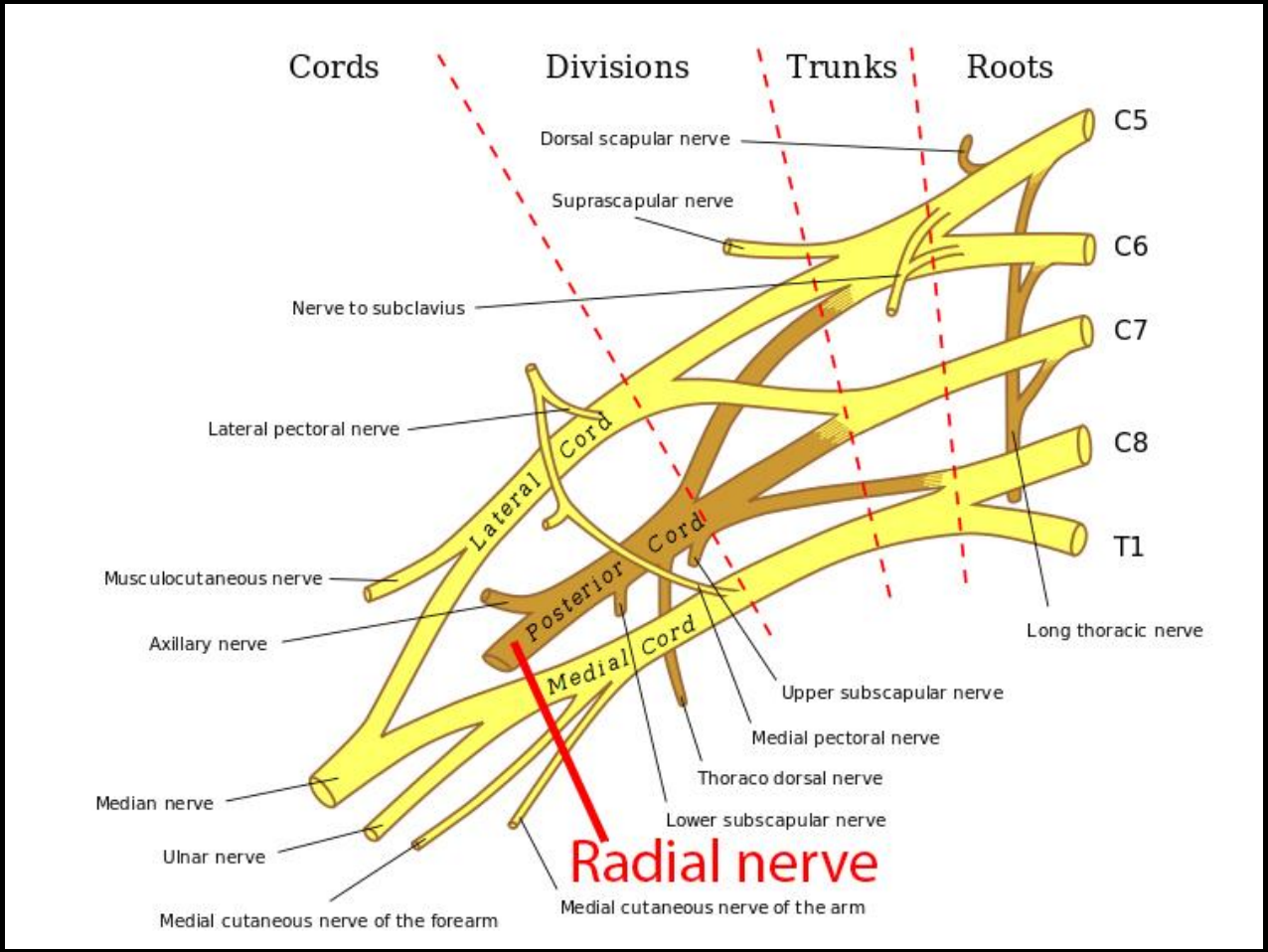

C5
C6
C7
C8
T1
coracobrachialis
musculocutaneous nerve
biceps brachii
median nerve
lateral cutaneous nerve of forearm (sensory)
brachialis
pronator teres
pronator teres
flexor carpi radialis
palmaris longus
flexor pollicis longus
flexor digitorum superficialis
pronator quadratus
flexor digitorum profundus (lateral 2,3 digits)
thenar muscles
2, 3 lumbricals
palmar sensory branches of median nerve
C7
C8
T1
ulnar nerve
medial cutaneous nerve of the arm (sensory)
flexor digitorum profundus (medial 4,5 digits)
flexor carpi ulnaris
medial cutaneous nerve of the forearm (sensory)
dorsal cutaneous branch (sensory)
palmar cutaneous branch (sensory)
adductor pollicis
palmar interossei
palmaris brevis
hypothenar muscles
dorsal interossei
4,5 lumbricals
superficial terminal branches (sensory)
C5
C6
C7
C8
deltoids
subscapularis
teres major
axillary nerve
latissimus dorsi
radial nerve
upper cutaneous nerve of the arm (sensory)
triceps brachii
brachioradialis
extensor carpi radialis longus
extensor carpi radialis brevis
supinator
posterior interosseous nerve
extensor carpi ulnaris
extensor digiti minimi
extensor digitorum
extensor indicis
abductor pollicis longus
extensor pollicis brevis
superficial radial nerve (sensory)

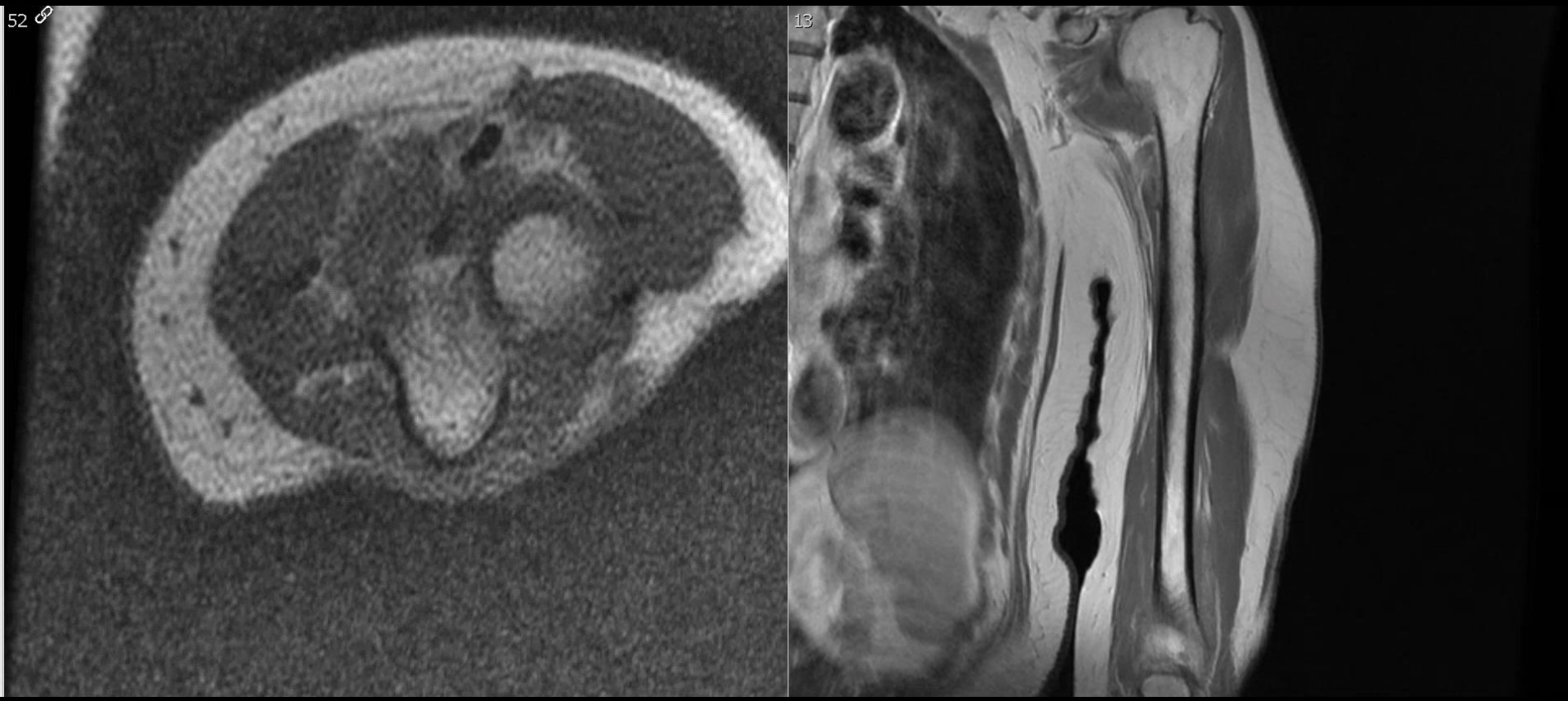
Radial nerve

- Sensory
  - posterior and lateral arm
  - posterior forearm
  - dorsal lateral palm and lateral three and a half digits.
- Motor
  - triceps brachii (except long head)
  - majority of the extensor muscles in the forearm.



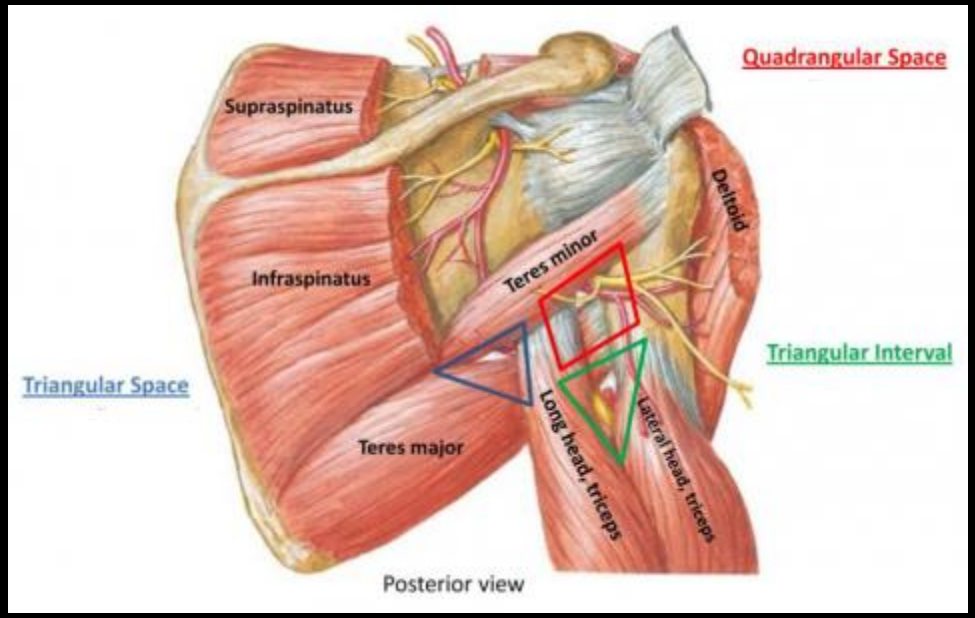
Radial nerve

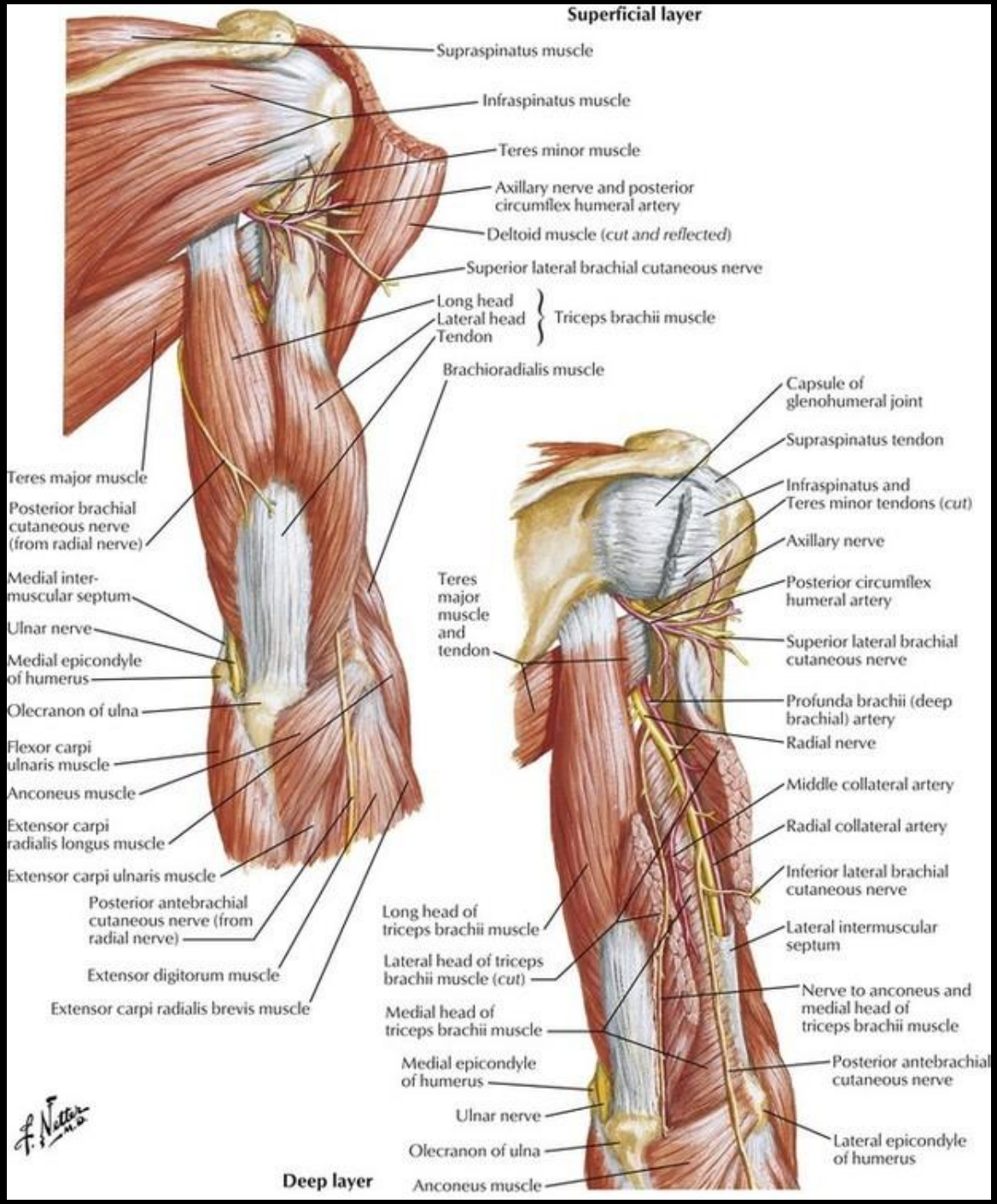



52
13

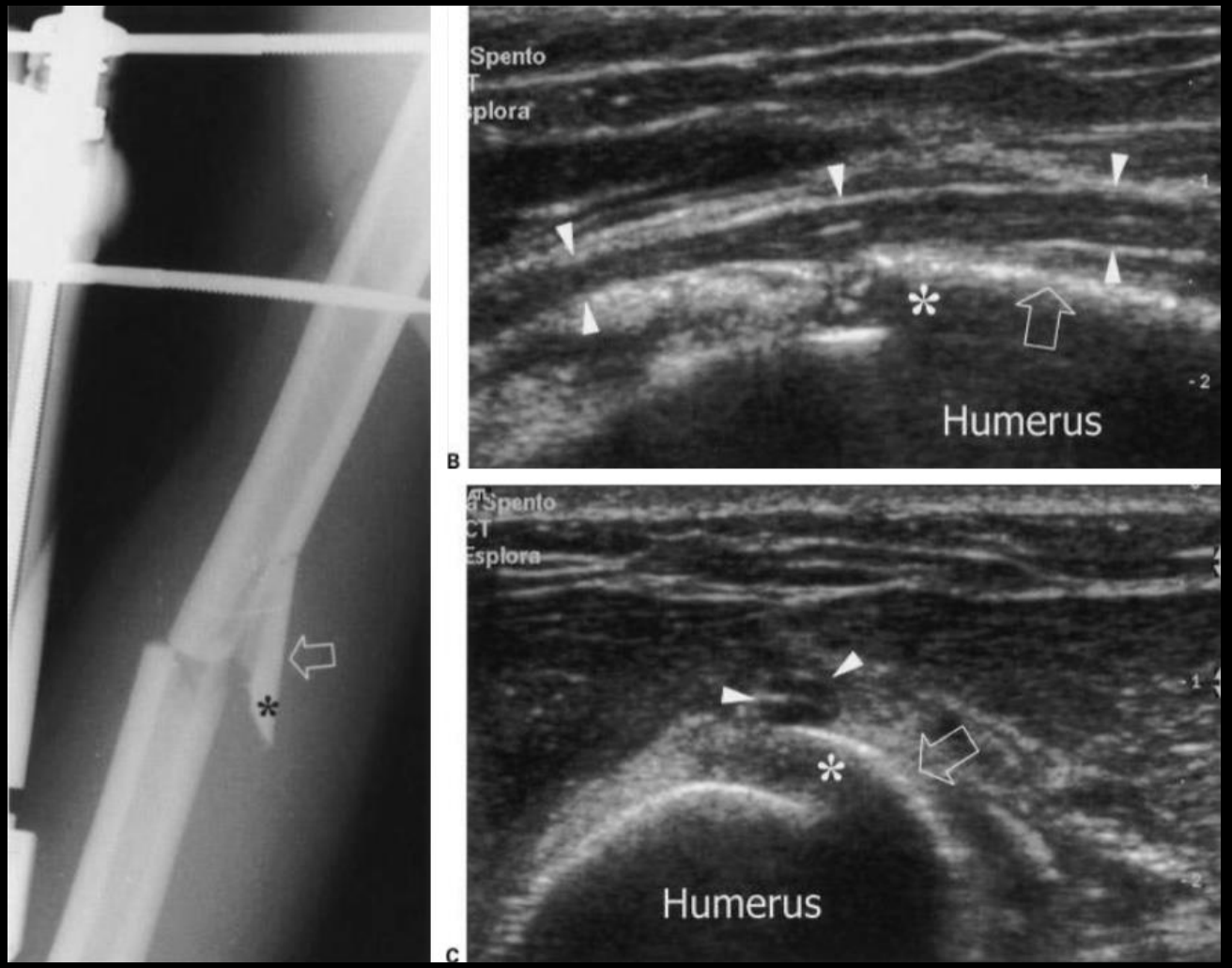
Triangular interval

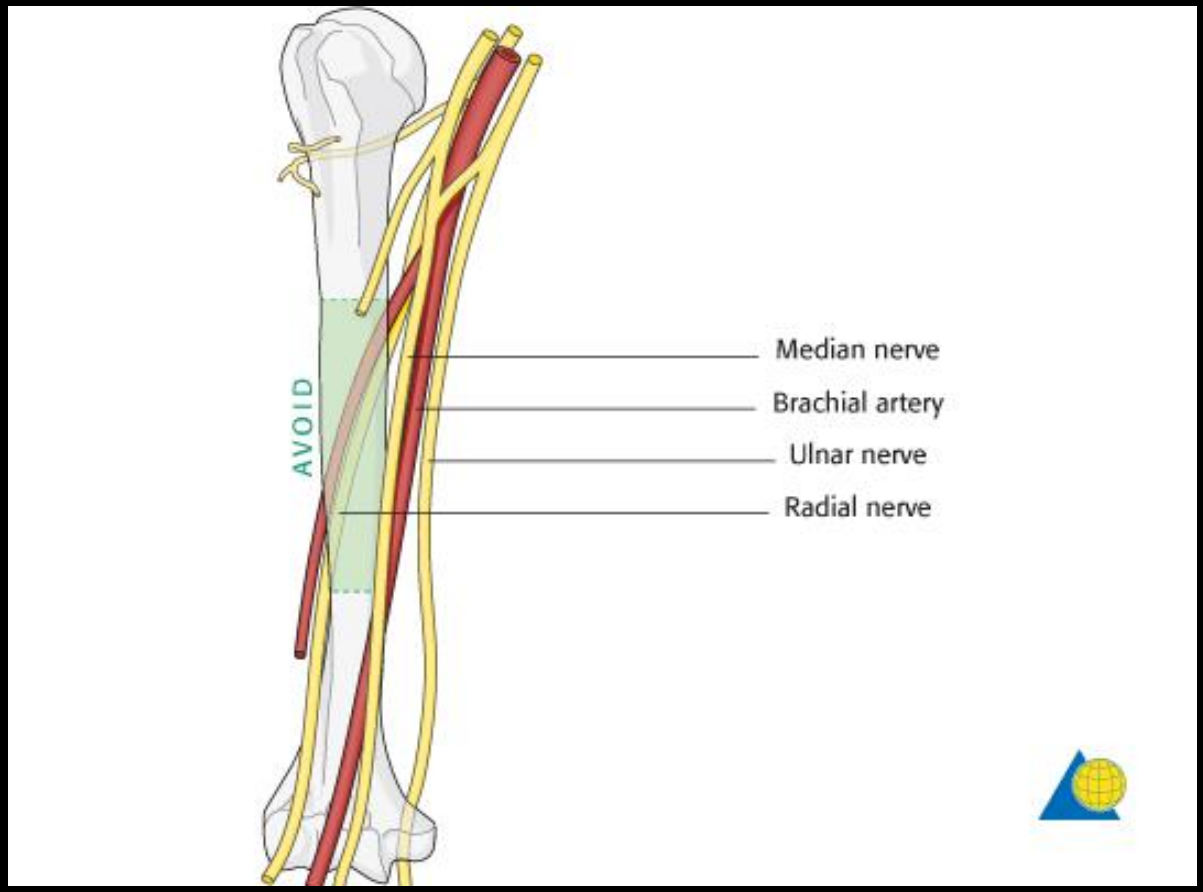
- Radial nerve enters the posterior compartment of the arm via the triangular interval

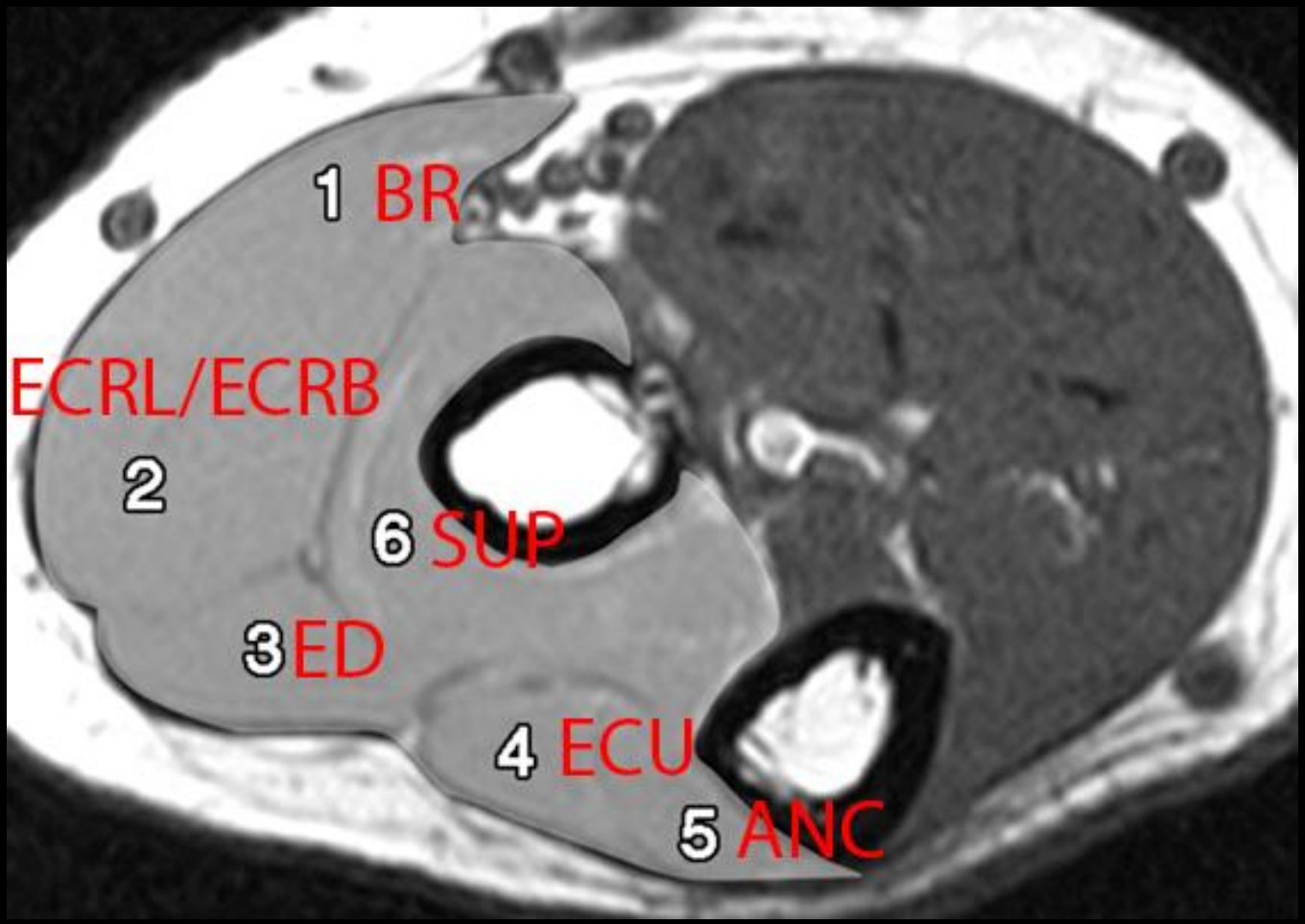


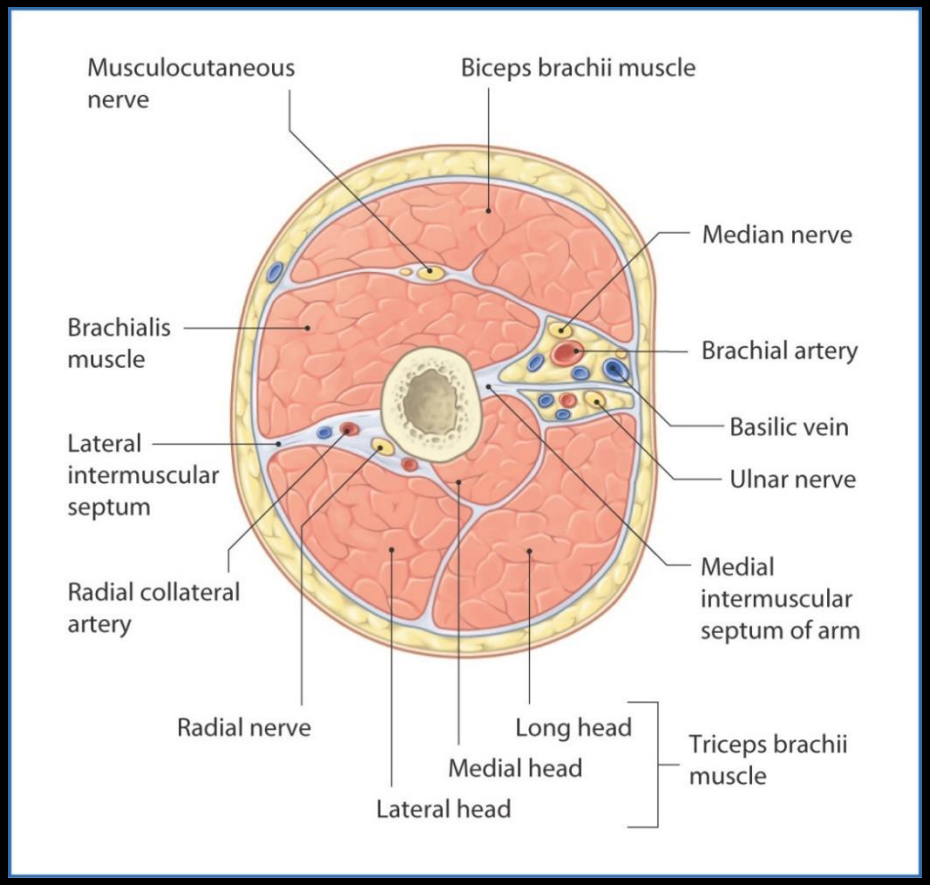

Superficial layer
Supraspinatus muscle
Infraspinatus muscle
Teres minor muscle
Axillary nerve and posterior circumflex humeral artery
Deltoid muscle (cut and reflected)
Superior lateral brachial cutaneous nerve
Long head
Lateral head
Tendon
Triceps brachii muscle
Brachioradialis muscle
Teres major muscle
Posterior brachial cutaneous nerve (from radial nerve)
Medial intermuscular septum
Ulnar nerve
Medial epicondyle of humerus
Olecranon of ulna
Flexor carpi ulnaris muscle
Anconeus muscle
Extensor carpi radialis longus muscle
Extensor carpi ulnaris muscle
Posterior antebrachial cutaneous nerve (from radial nerve)
Extensor digitorum muscle
Extensor carpi radialis brevis muscle
Capsule of glenohumeral joint
Supraspinatus tendon
Infraspinatus and Teres minor tendons (cut)
Axillary nerve
Posterior circumflex humeral artery
Teres major muscle and tendon
Superior lateral brachial cutaneous nerve
Profunda brachii (deep brachial) artery
Radial nerve
Middle collateral artery
Radial collateral artery
Inferior lateral brachial cutaneous nerve
Long head of triceps brachii muscle
Lateral intermuscular septum
Lateral head of triceps brachii muscle (cut)
Nerve to anconeus and medial head of triceps brachii muscle
Medial head of triceps brachii muscle
Medial epicondyle of humerus
Posterior antebrachial cutaneous nerve
Ulnar nerve
Olecranon of ulna
Lateral epicondyle of humerus
Anconeus muscle
Deep layer

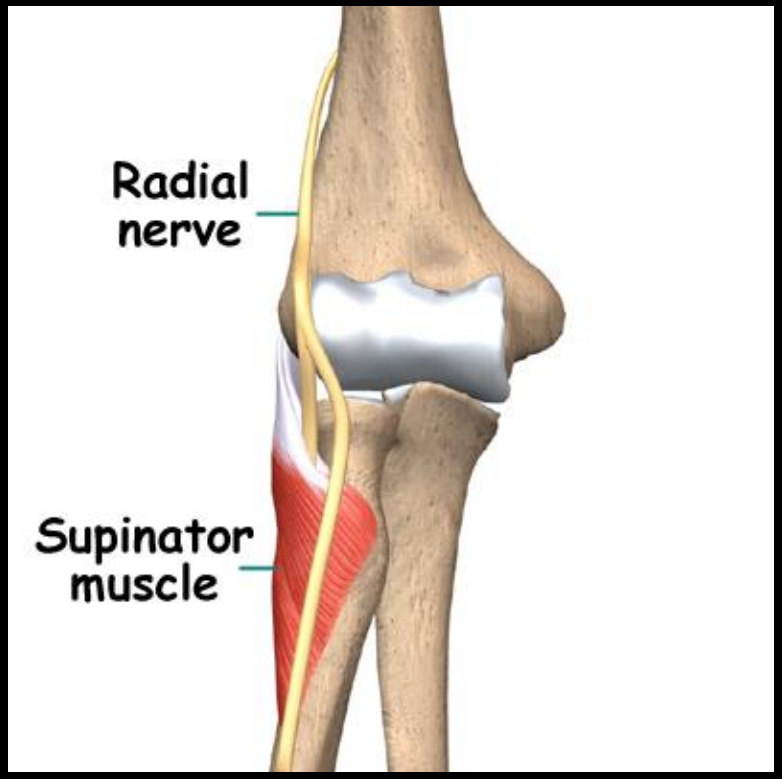
Spiral groove


Spento
Esplora
Humerus
B
Spento
Esplora
Humerus
C


AVOID
Median nerve
Brachial artery
Ulnar nerve
Radial nerve

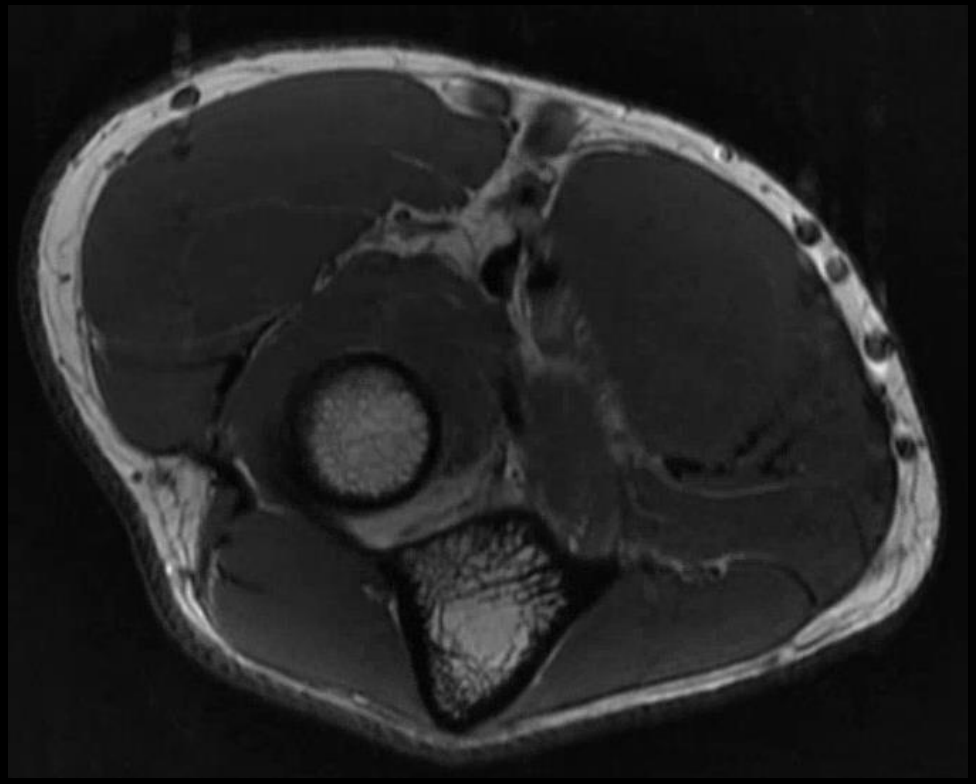

1 BR
ECRL/ECRB
2
6 SUP
3 ED
4 ECU
5 ANC


Musculocutaneous nerve
Biceps brachii muscle
Median nerve
Brachialis muscle
Brachial artery
Basilic vein
Lateral intermuscular septum
Ulnar nerve
Radial collateral artery
Medial intermuscular septum of arm
Radial nerve
Long head
Medial head
Lateral head
Triceps brachii muscle


Radial nerve
Supinator muscle

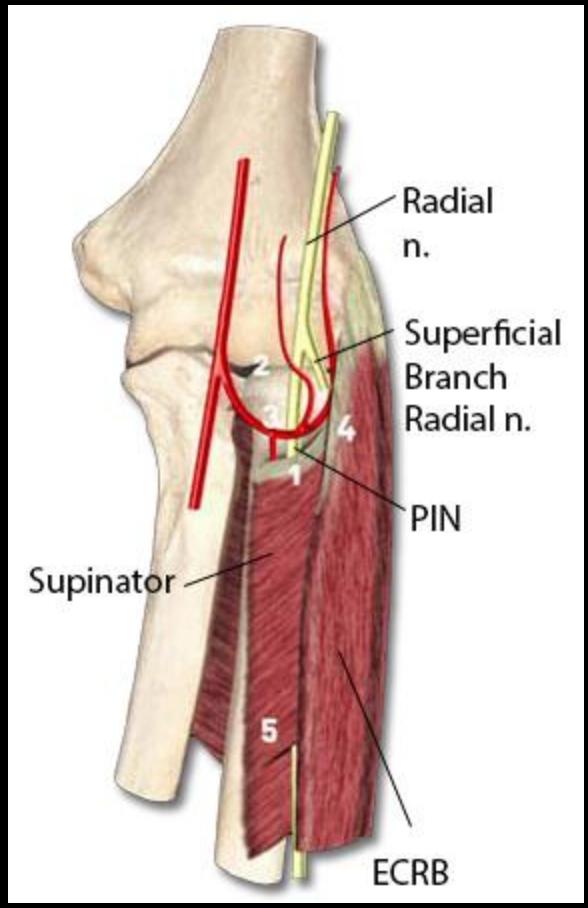
Radial tunnel syndrome

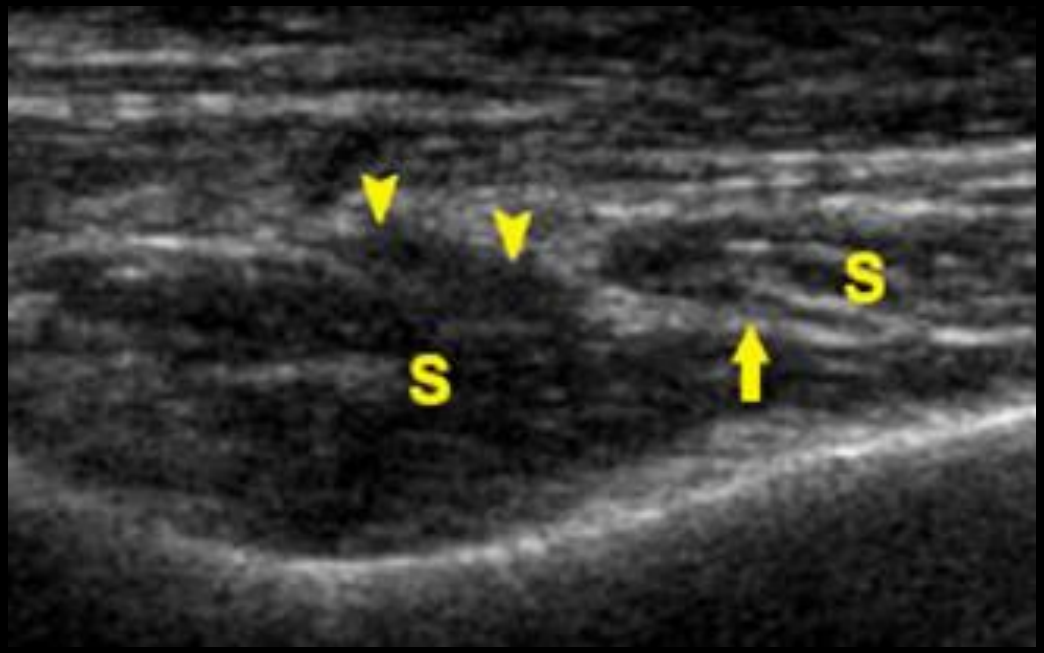
- 1 case for every 100 case of CTS
- Radial tunnel is bounded by:
  - Supinator
  - Brachioradialis
    + ECRL/ECRB
  - Biceps tendon



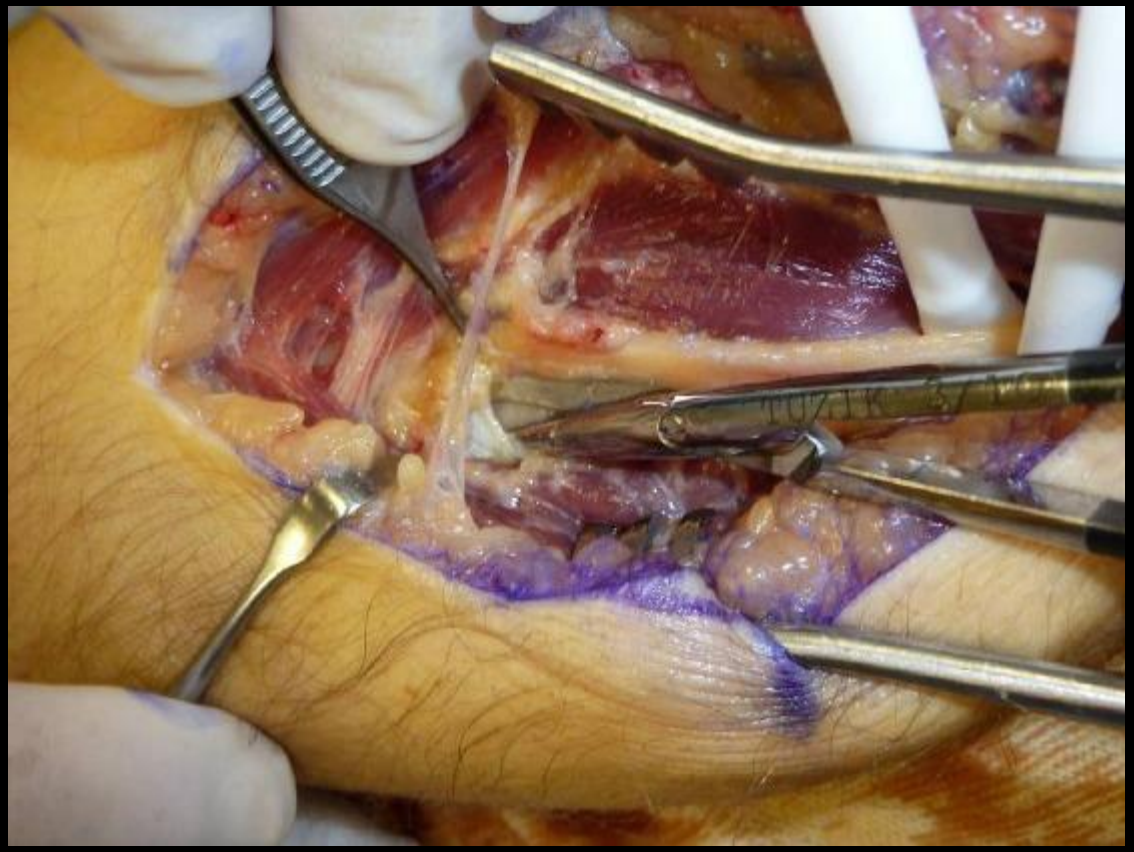
Sites of compression

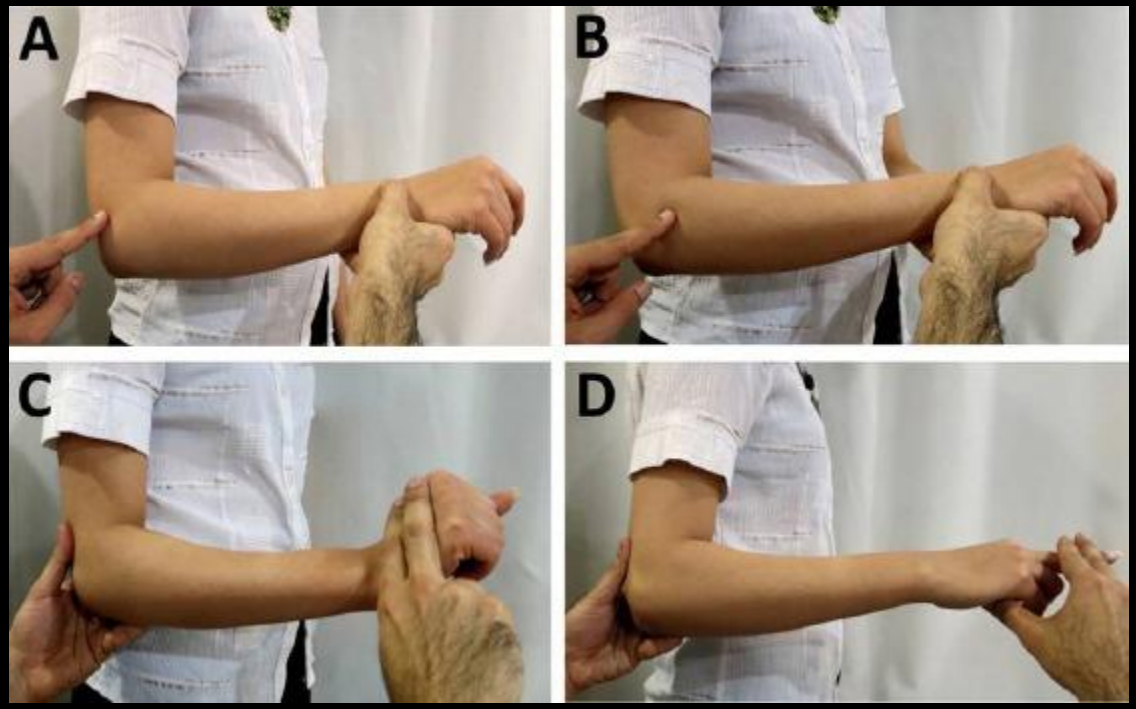
- Fibrous bands between the brachialis and brachioradialis
- Recurrent radial vessels (leash of Henry)
- Medial edge of the ECRB
- Arcade of Fröhse
- Distal edge of supinator




S
S

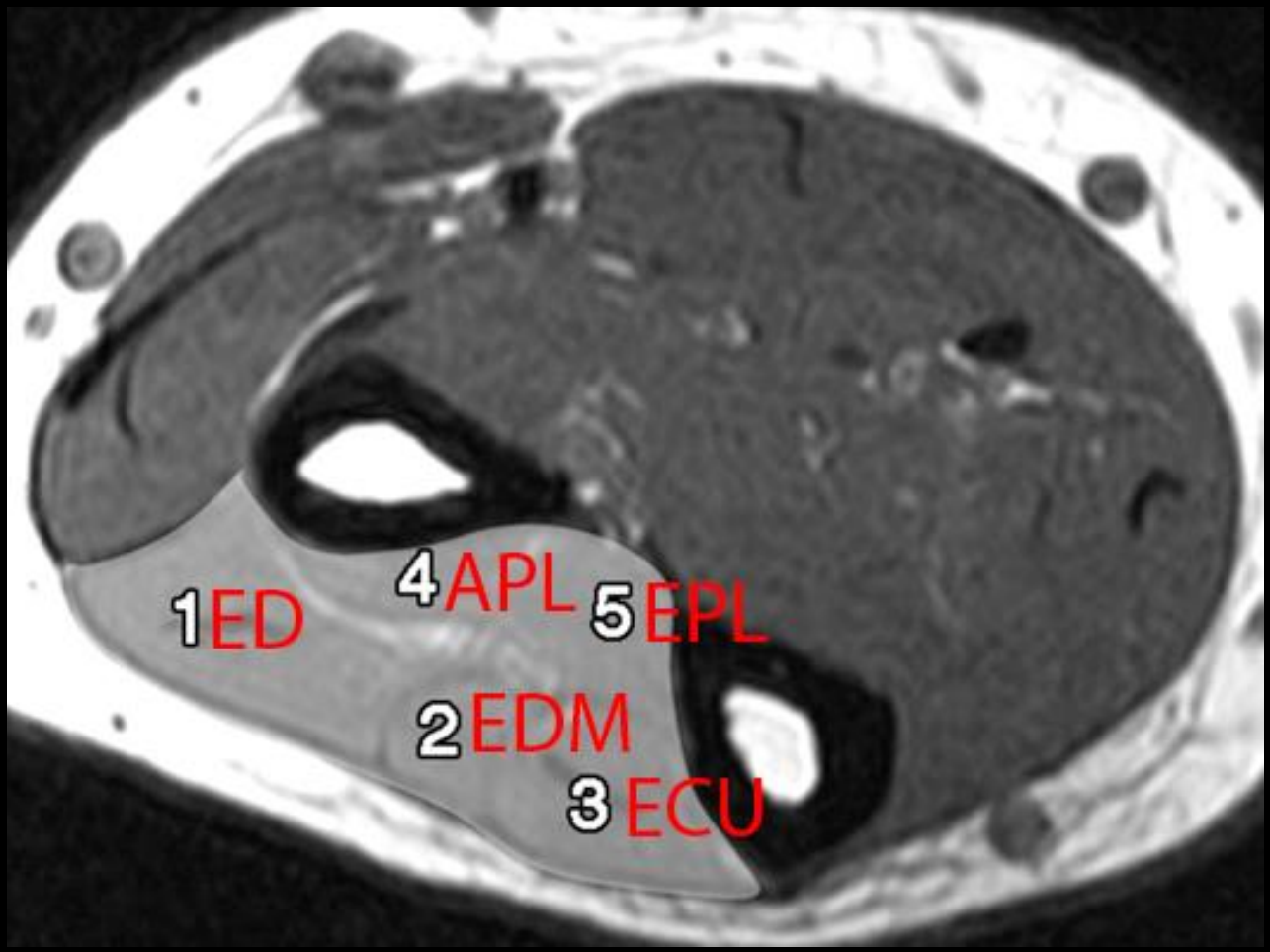

S
R

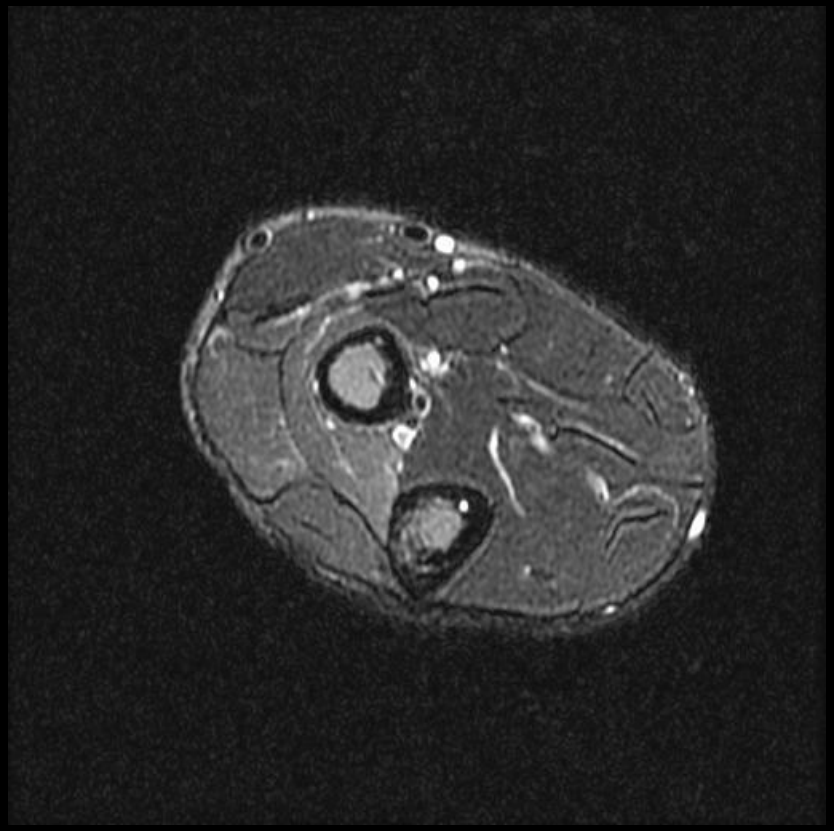



A
B
C
D

Posterior interosseous nerve syndrome vs Radial tunnel syndrome

- Posterior interosseous nerve syndrome:
  - Inability to extend fingers and thumb
  - ECRL function intact—the wrist extends and radially deviates
- Radial tunnel syndrome:
  - Pain distal to lateral epicondyle
  - Pain worsened by extending the elbow, pronating the forearm and flexing the wrist
  - Pain with resisted active supination or wrist extension
  - Pain with resisted middle finger extension at the MCP joint
  - No motor deficit


1ED
4APL
5EPL
2EDM
3ECU

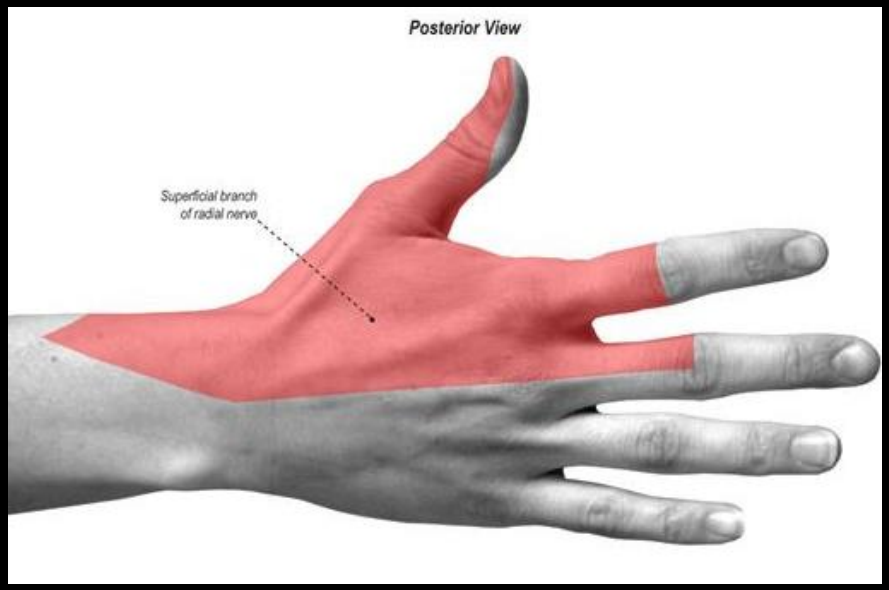


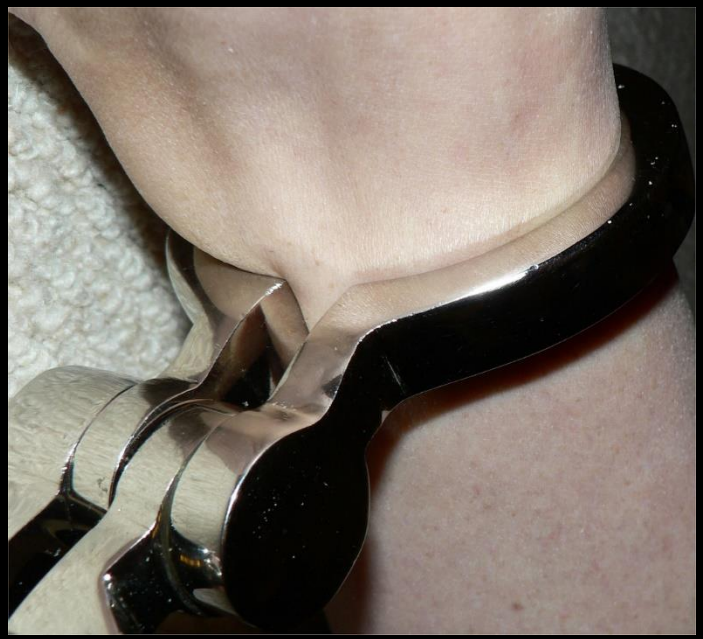
Courtesy of Dr. Fliszar

- Superficial branch of the radial nerves gives sensory to the dorsoradial hand

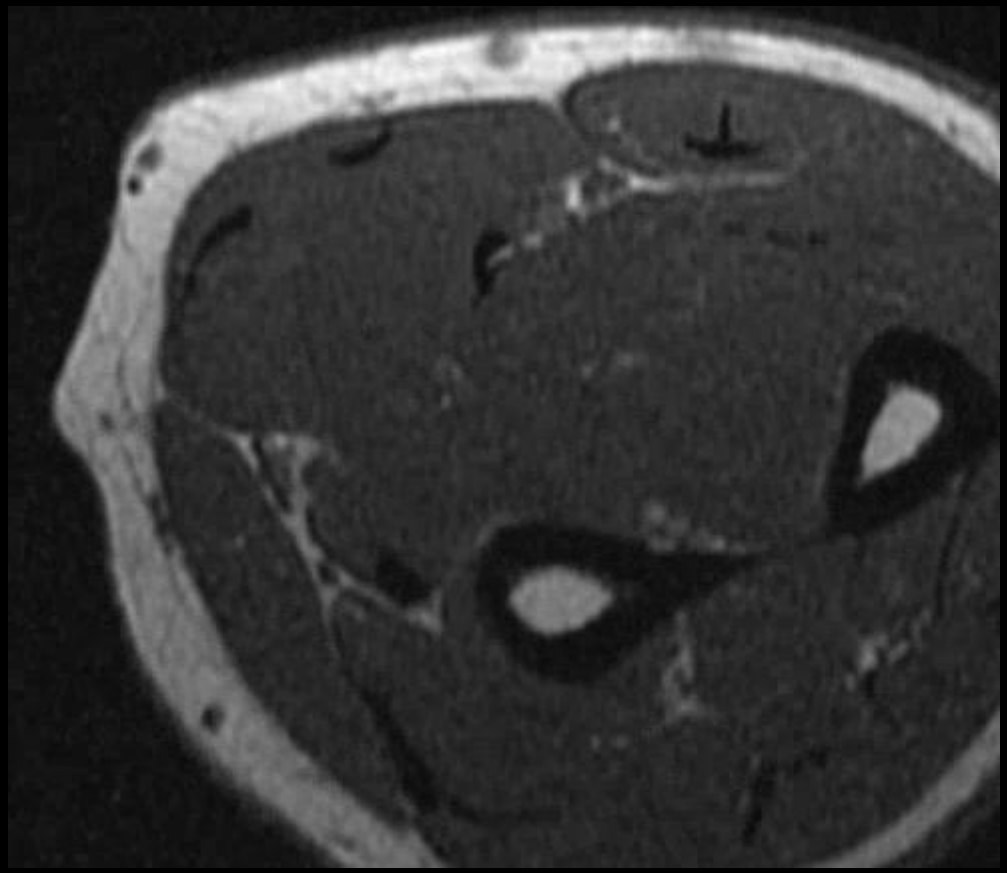
Wartenberg syndrome

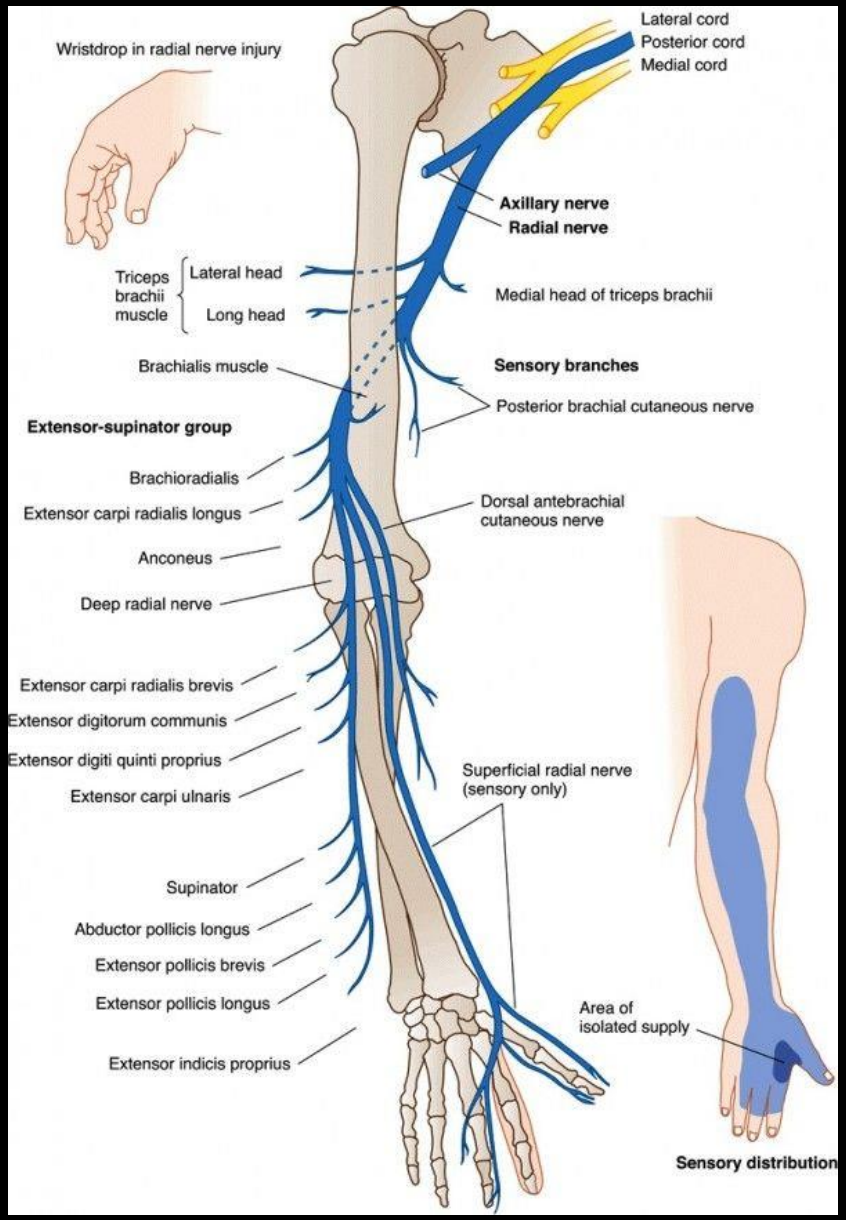
- AKA cheiralgia parasthetica - pain radial 3.5 fingers
- Very rare compression of the superficial branch of the radial nerve





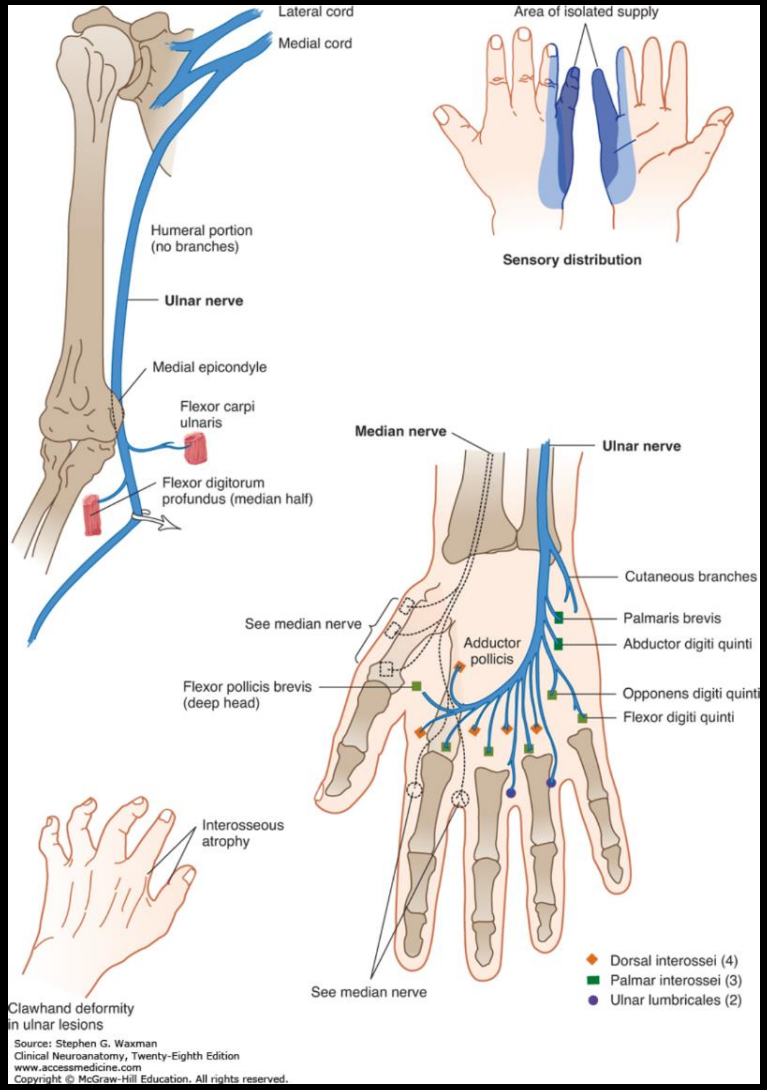
Can occur where the nerve transitions from deep to superficial between the ECRL and brachioradialis

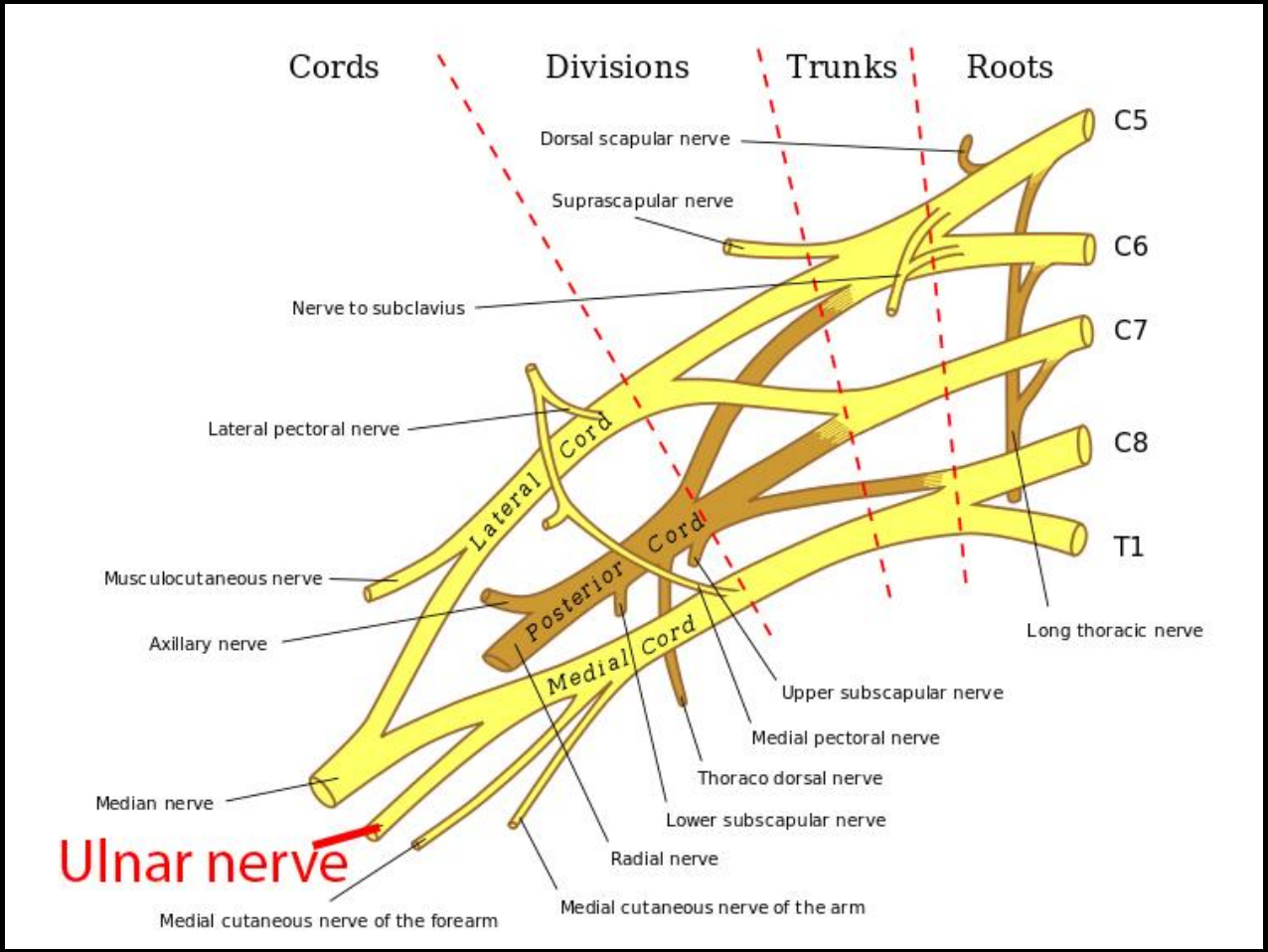


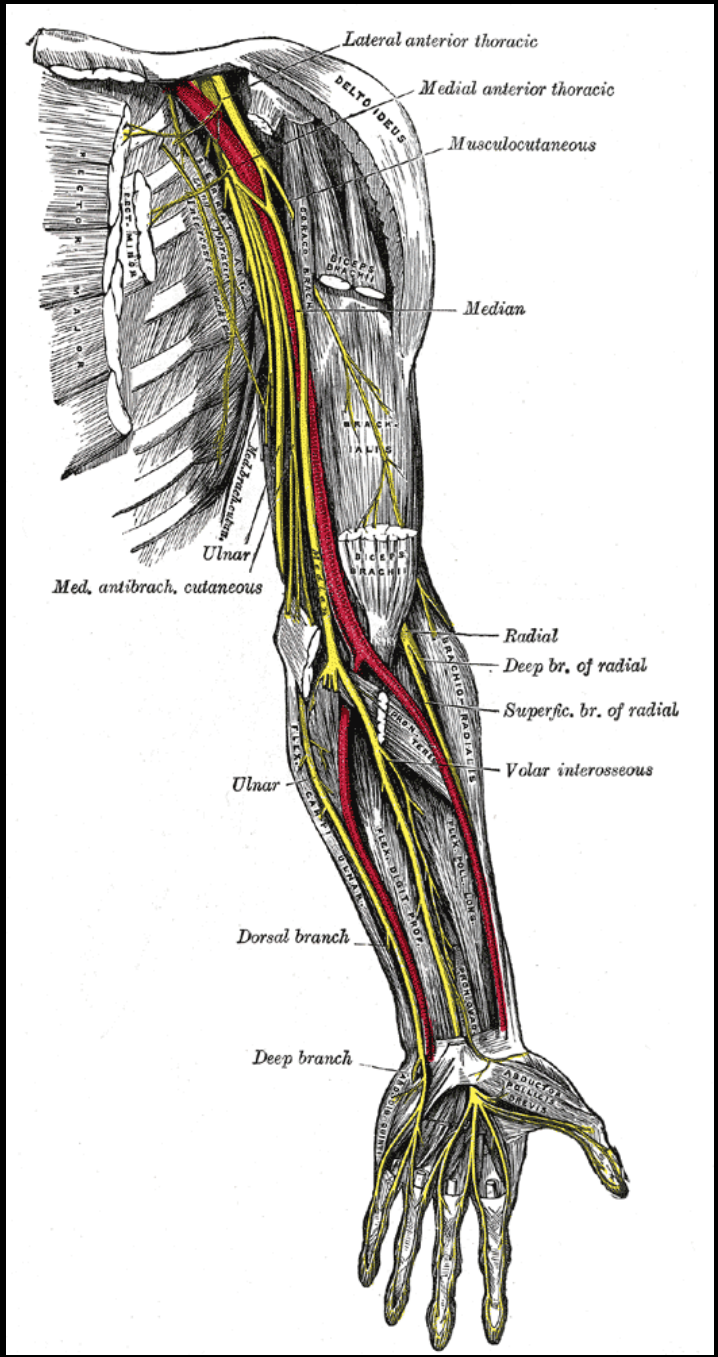

Wristdrop in radial nerve injury
Lateral cord
Posterior cord
Medial cord
Axillary nerve
Radial nerve
Triceps brachii muscle
Lateral head
Long head
Medial head of triceps brachii
Brachialis muscle
Sensory branches
Posterior brachial cutaneous nerve
Extensor-supinator group
Brachioradialis
Extensor carpi radialis longus
Dorsal antebrachial cutaneous nerve
Anconeus
Deep radial nerve
Extensor carpi radialis brevis
Extensor digitorum communis
Extensor digiti quinti proprius
Extensor carpi ulnaris
Superficial radial nerve (sensory only)
Supinator
Abductor pollicis longus
Extensor pollicis brevis
Extensor pollicis longus
Area of isolated supply
Extensor indicis proprius
Sensory distribution

Ulnar nerve

- sensory
  - articular innervation to elbow, wrist and hand
  - ulnar aspect of the hand, 5th finger, ulnar aspect of 4th finger
- motor
  - flexor carpi ulnaris, flexor digitorum profundus (medial half)
  - hypothenar muscles
  - 3rd and 4th lumbricals, interossei muscles, flexor pollicis brevis (deep head), adductor pollicis

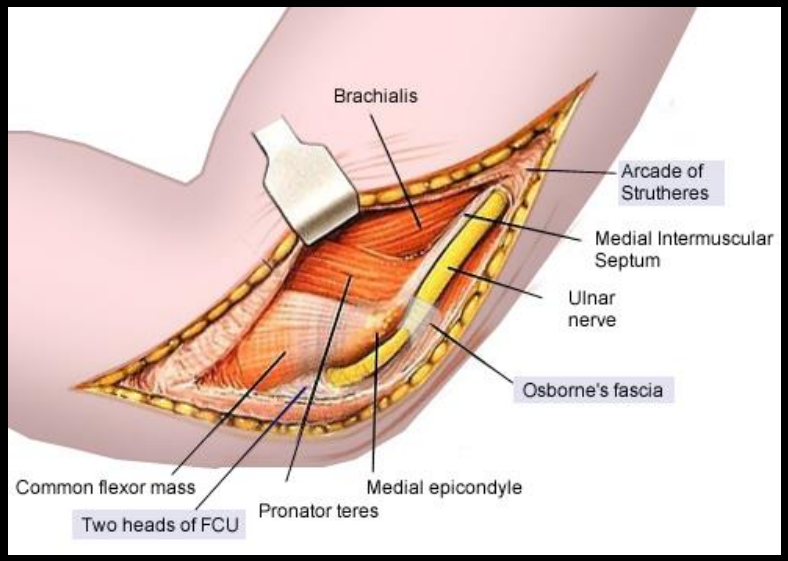


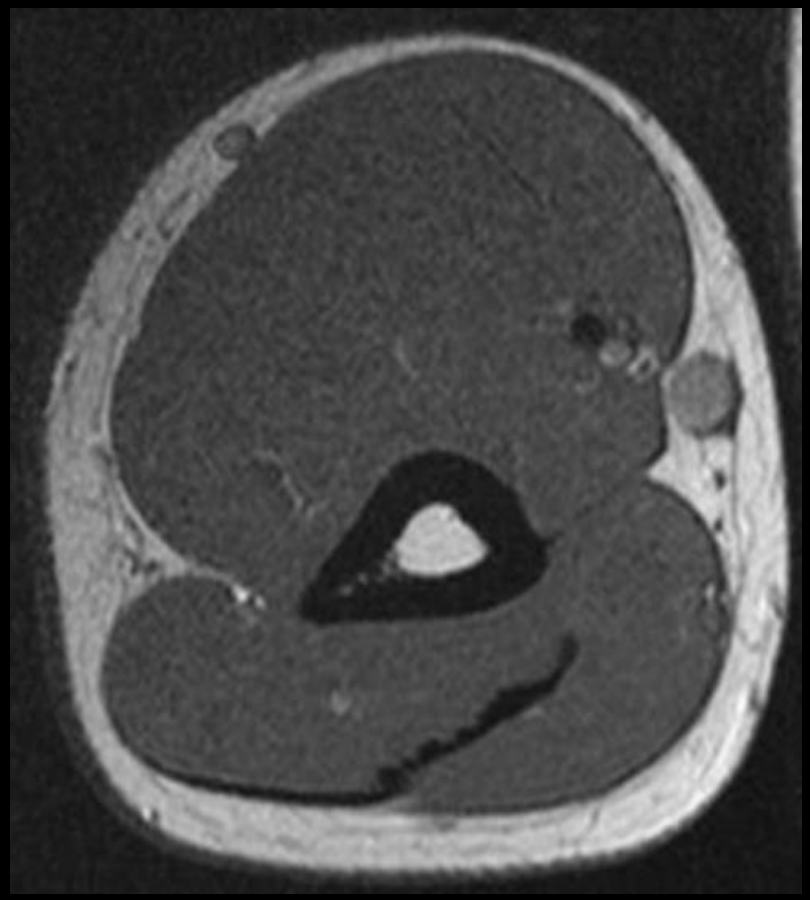

Cords
Divisions
Trunks
Roots
C5
C6
C7
C8
T1
Dorsal scapular nerve
Suprascapular nerve
Nerve to subclavius
Lateral pectoral nerve
Lateral Cord
Posterior Cord
Medial Cord
Musculocutaneous nerve
Axillary nerve
Median nerve
Ulnar nerve
Medial cutaneous nerve of the forearm
Radial nerve
Medial cutaneous nerve of the arm
Lower subscapular nerve
Thoraco dorsal nerve
Medial pectoral nerve
Upper subscapular nerve
Long thoracic nerve


Lateral anterior thoracic
Medial anterior thoracic
Musculocutaneous
Median
Ulnar
Med. antibrach. cutaneous
Radial
Deep br. of radial
Superfic. br. of radial
Volar interosseous
Ulnar
Dorsal branch
Deep branch
DELTOIDEUS
PECTORALIS MAJOR
PECT. MINOR
BICEPS BRACHII
BRACHIALIS
BRACHIO-RADIALIS
FLEX. CARP. ULNARIS
FLEX. DIGIT. PROF.
PRONATOR QUADRATUS
ABDUCTOR POLLICIS BREVIS

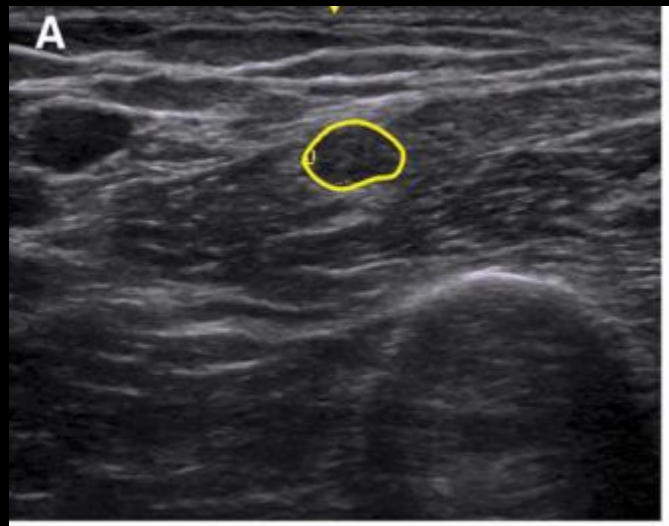
Arcade of Struthers

- Aponeurotic band from the medial head of the triceps to the intermuscular septum, 8 cm proximal to the medial epicondyle
- Ulnar nerve passes under the arcade in 80% of individuals

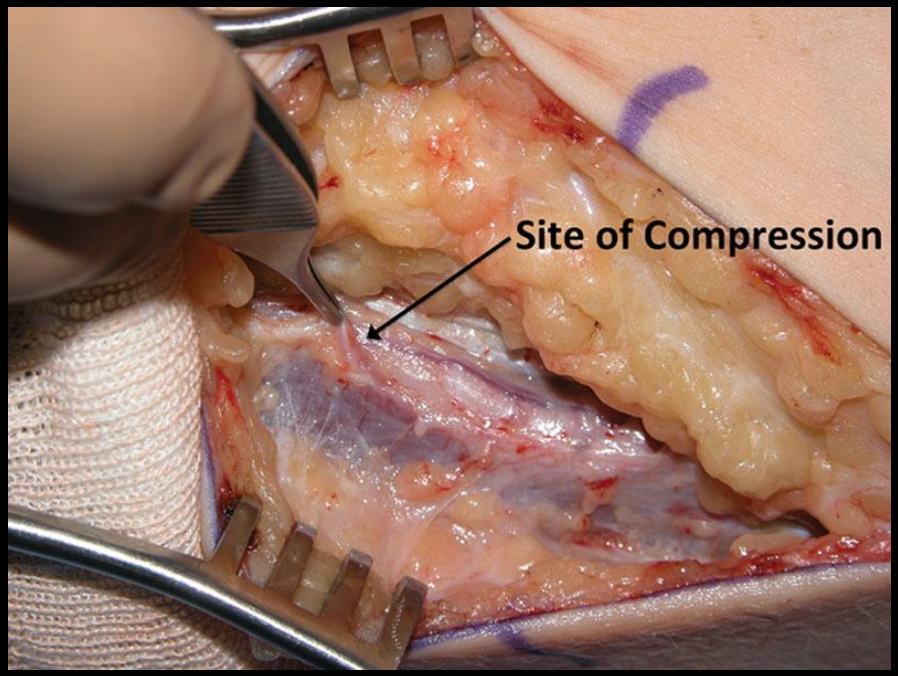


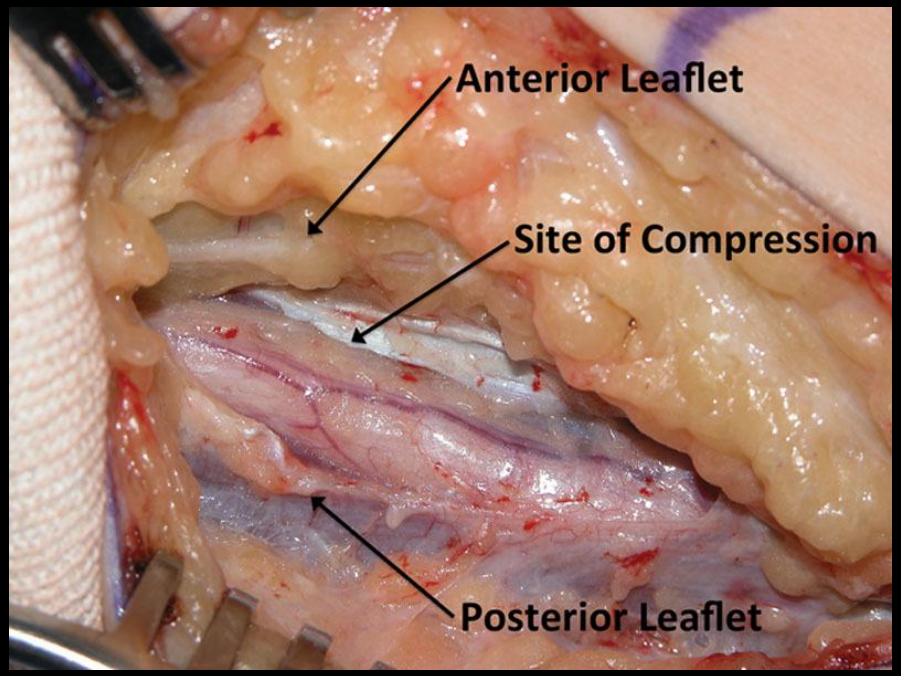


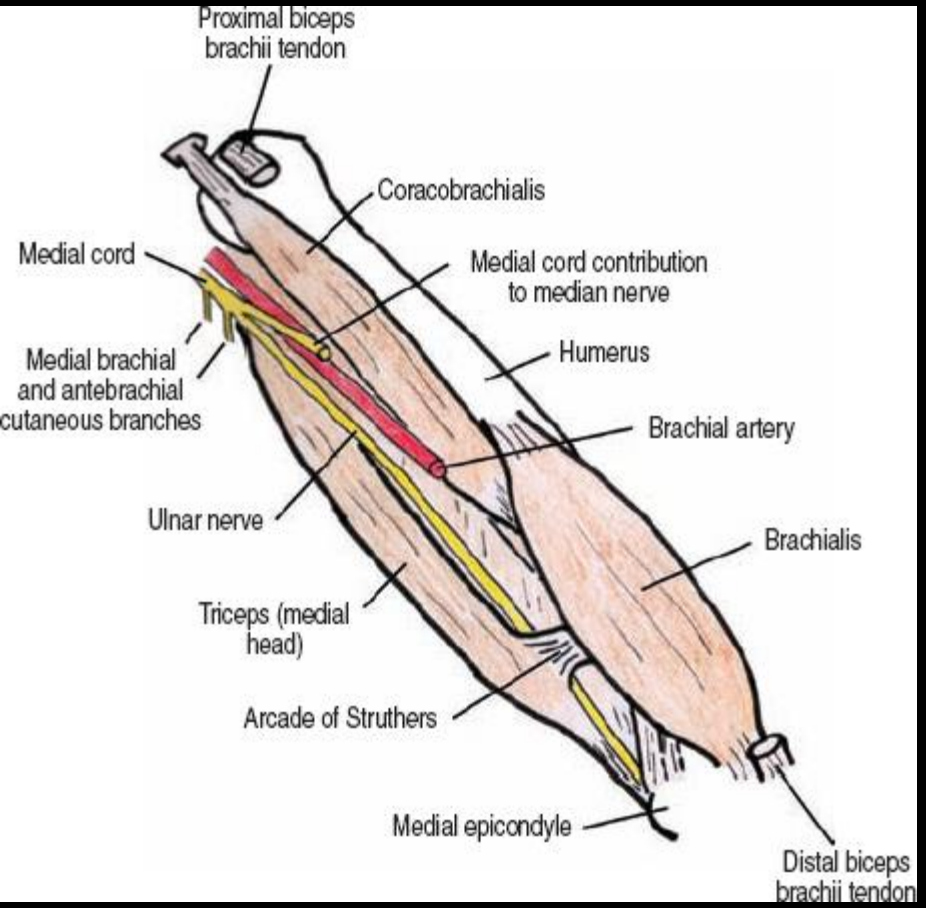
Ulnar nerve entrapment at the Arcade of Struthers

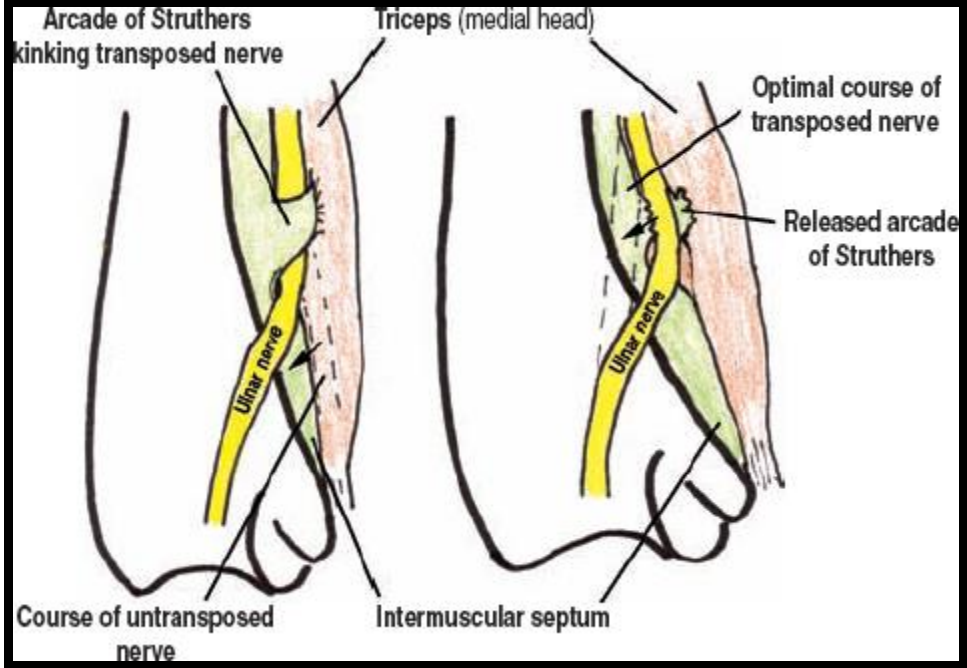


Level	Nerve area (mm^2)
(A) Above elbow	14.89
(B) At elbow	8.07
(C) Below elbow	4.98


Site of Compression

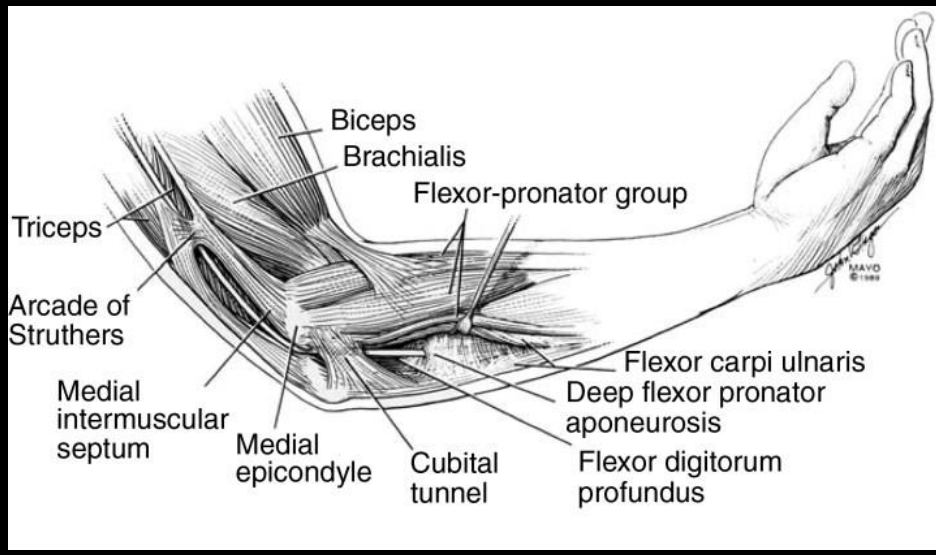

Anterior Leaflet
Site of Compression
Posterior Leaflet


Proximal biceps brachii tendon
Coracobrachialis
Medial cord
Medial cord contribution to median nerve
Humerus
Medial brachial and antebrachial cutaneous branches
Brachial artery
Ulnar nerve
Brachialis
Triceps (medial head)
Arcade of Struthers
Medial epicondyle
Distal biceps brachii tendon


Arcade of Struthers kinking transposed nerve
Triceps (medial head)
Optimal course of transposed nerve
Released arcade of Struthers
Ulnar nerve
Ulnar nerve
Course of untransposed nerve
Intermuscular septum

Cubital tunnel syndrome

- Second most common compression neuropathy in the upper extremity
- Sites:
  - Cubital tunnel
  - Arcade of Struthers
  - Medial intermuscular septum
  - Medial epicondyle
  - Deep flexor pronator aponeurosis

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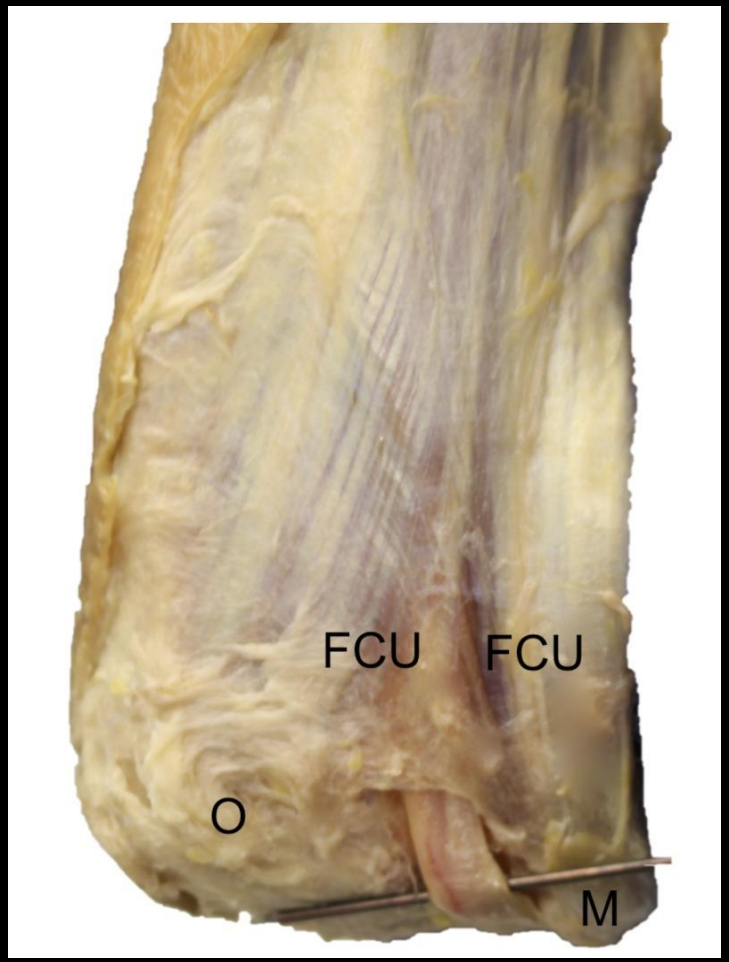
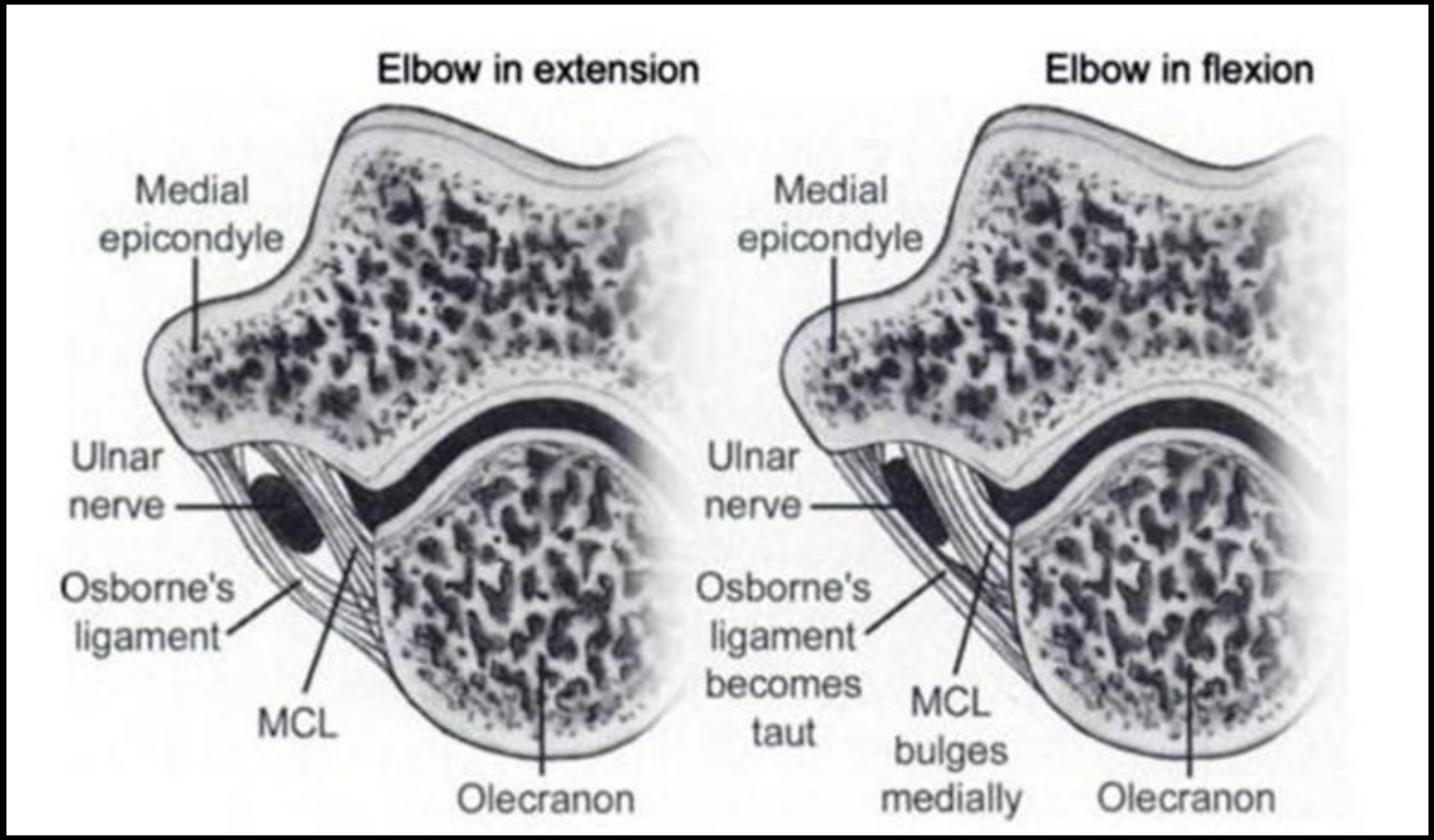
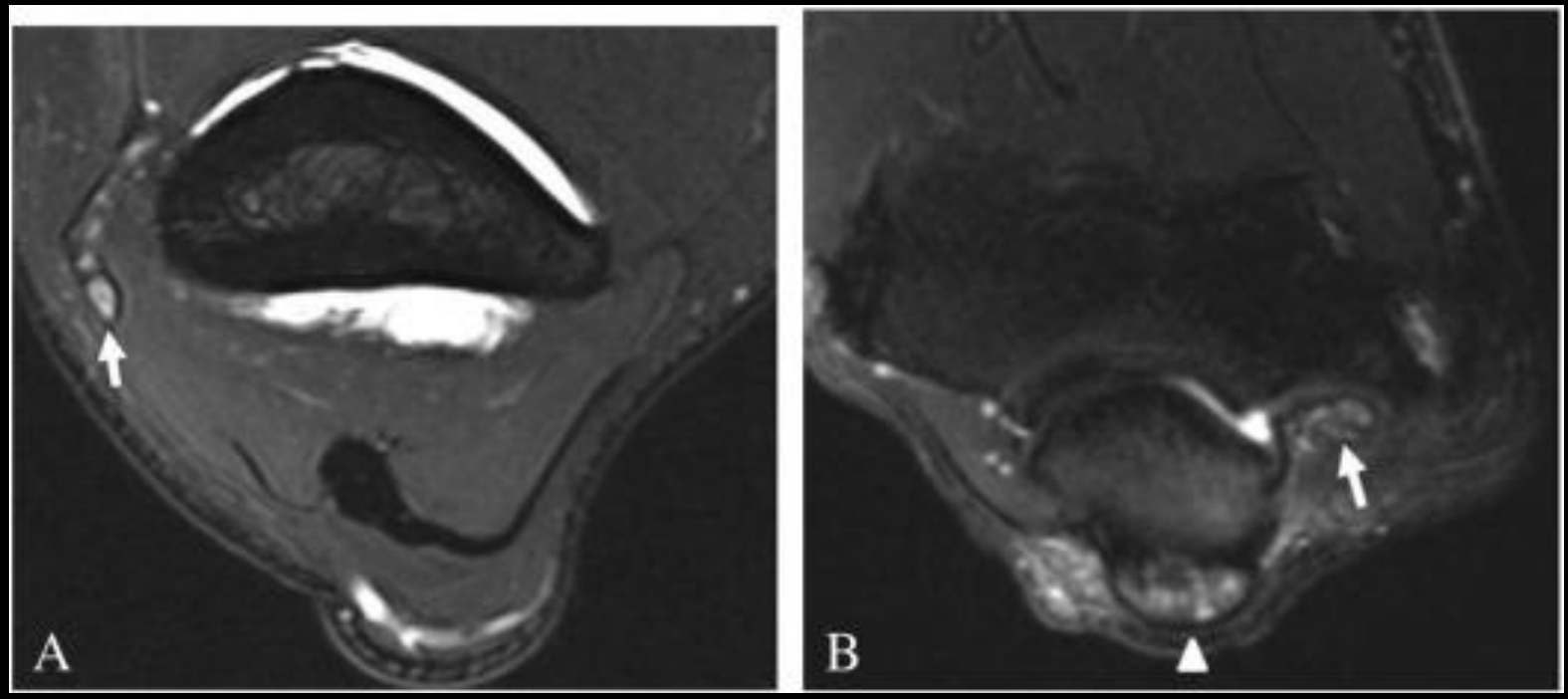
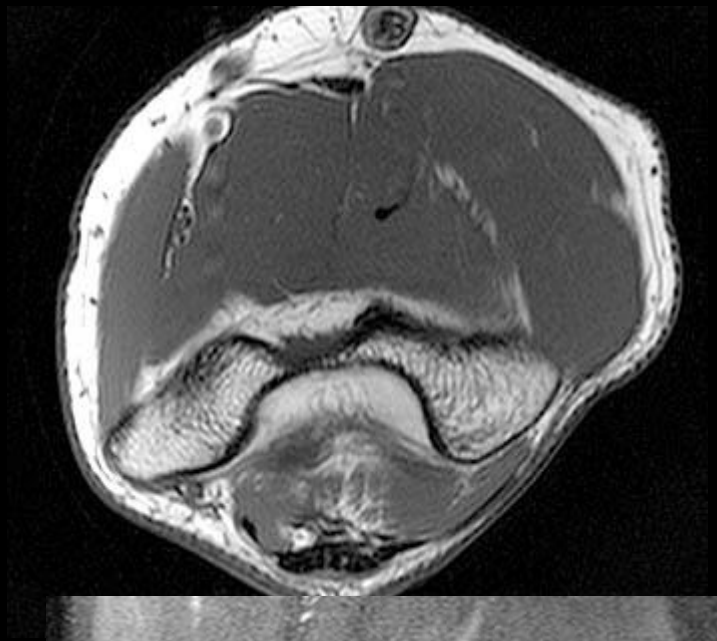
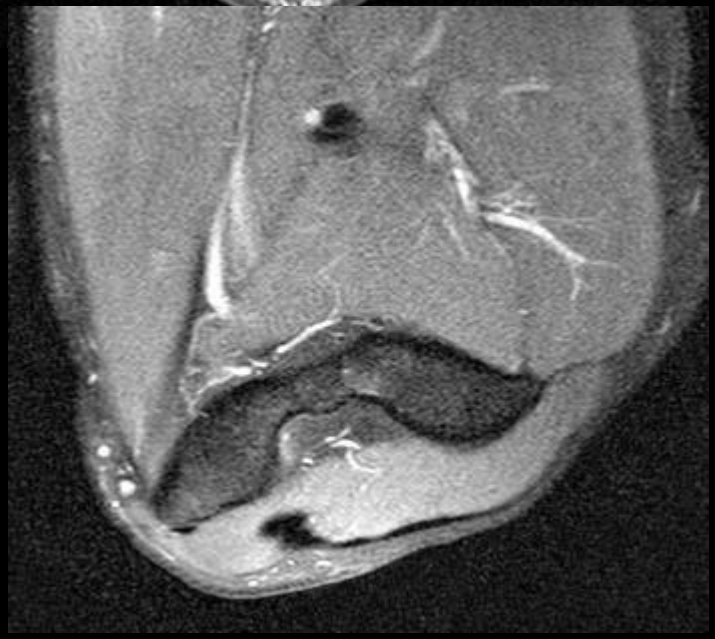
F
B

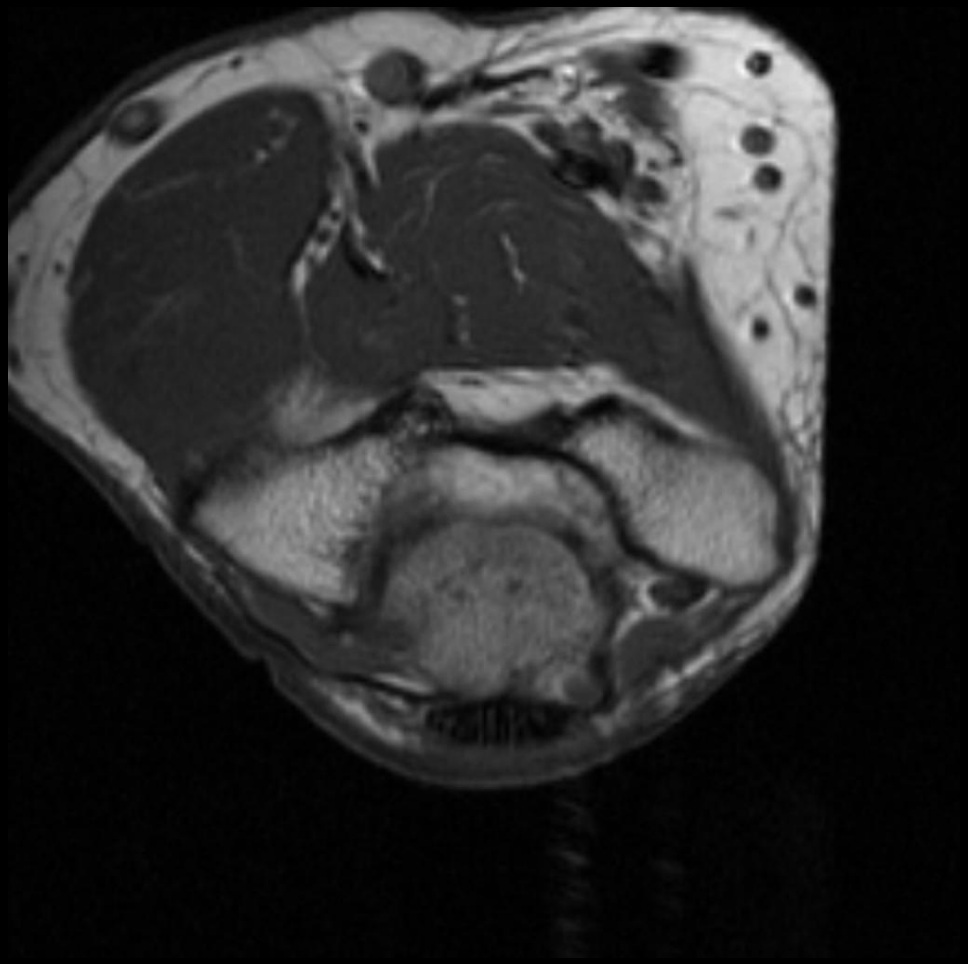

FCU
FCU
O
M

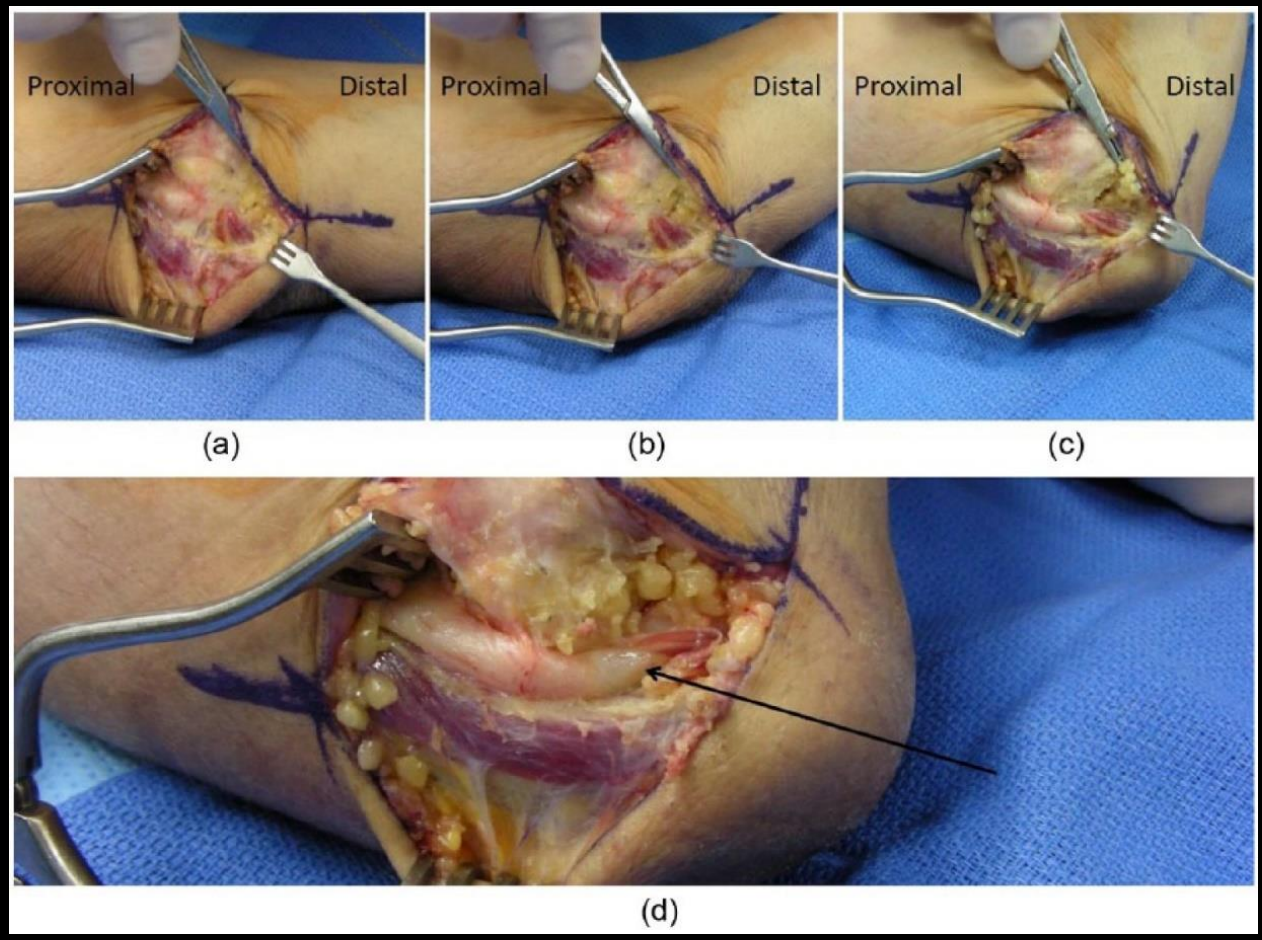

Elbow in extension
Medial epicondyle
Ulnar nerve
Osborne's ligament
MCL
Olecranon
Elbow in flexion
Medial epicondyle
Ulnar nerve
Osborne's ligament becomes taut
MCL bulges medially
Olecranon

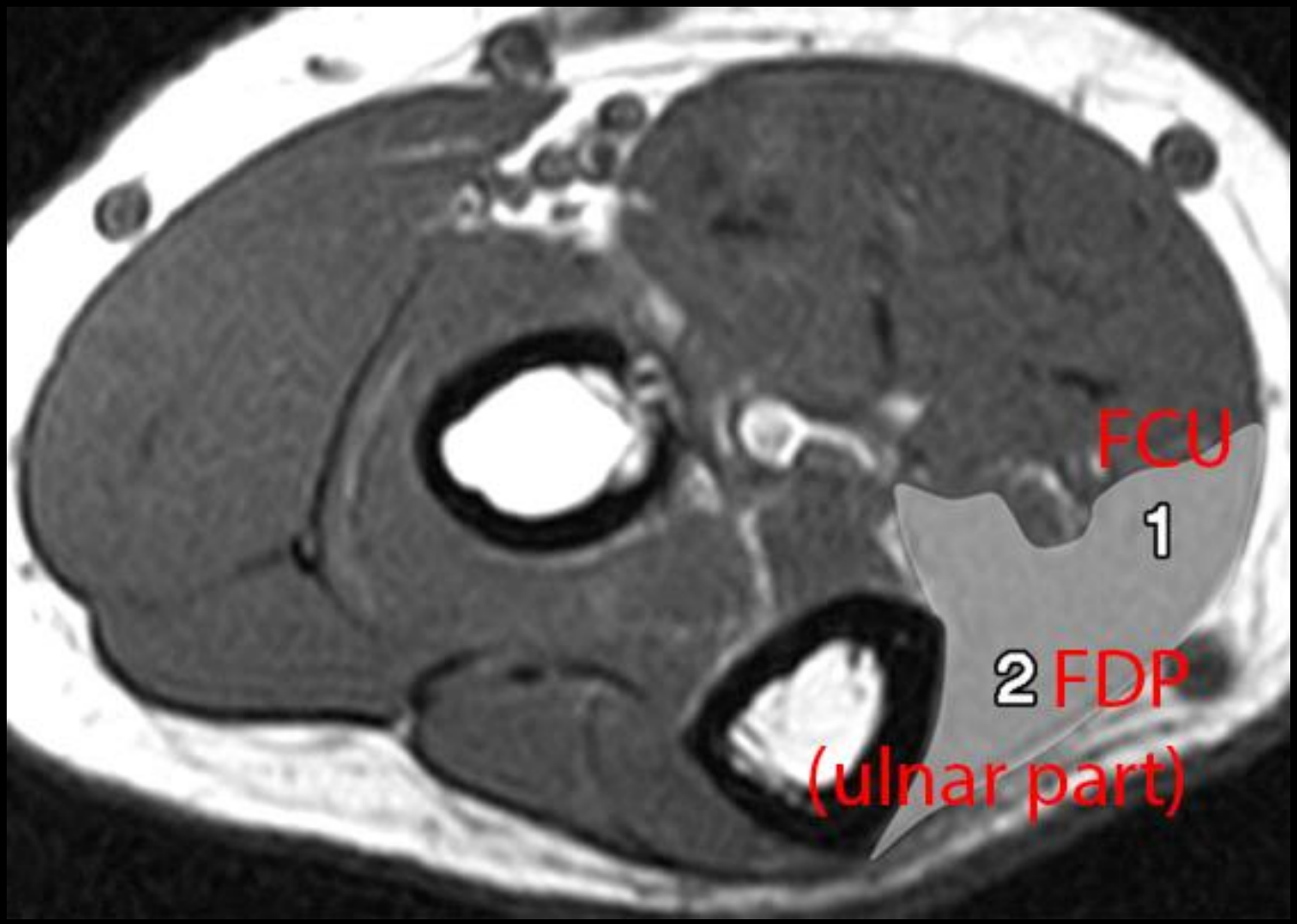

A
B








Proximal
Distal
Proximal
Distal
Proximal
Distal
(a)
(b)
(c)
(d)


FCU
1
2 FDP
(ulnar part)

Physical exam

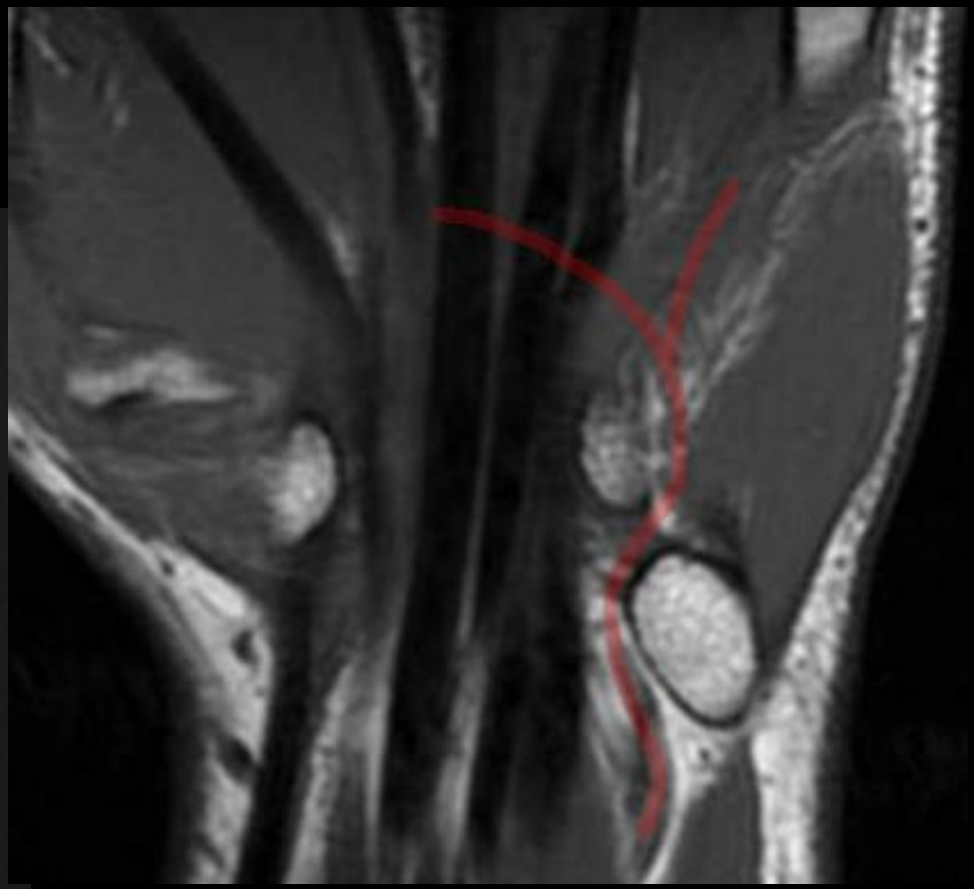
- Tinel's test along the course of the ulnar nerve
- Elbow flexion test.
- Pressure provocation test

Treatment

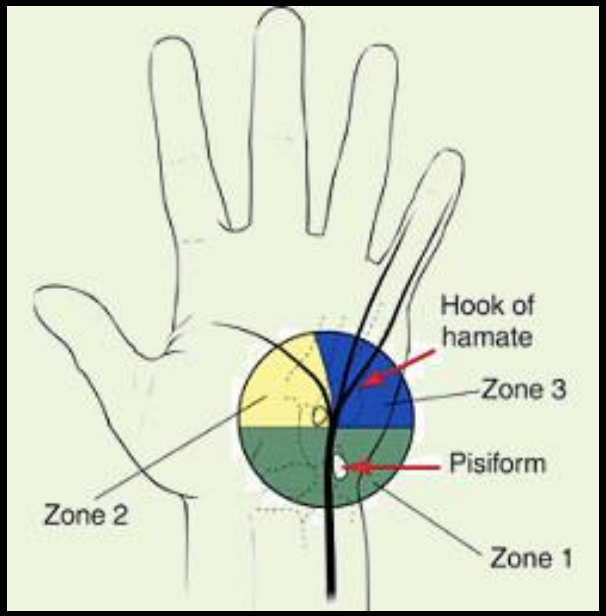
- In situ decompression
- Subcutaneous transposition
- Intramuscular transposition
- Submuscular transposition
- Medial epicondylectomy.

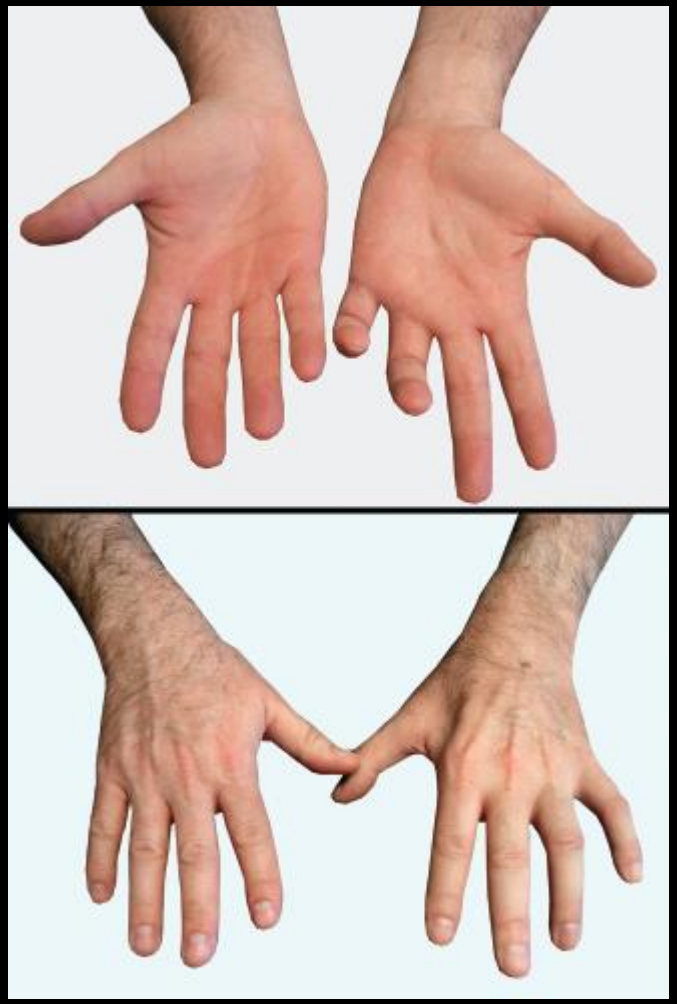
Ulnar tunnel syndrome

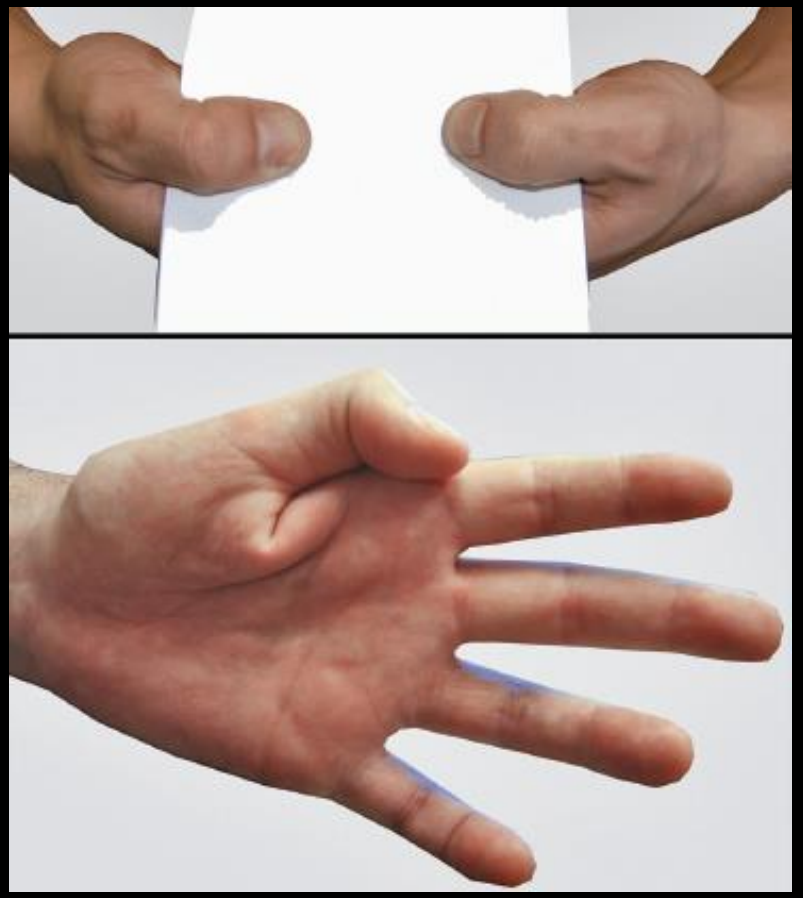
- Ulnar tunnel aka Guyon's canal is bounded by:
  - Transverse carpal ligament
  - Volar carpal ligament
  - Pisiform and piso-hamate ligament
  - Hook of hamate

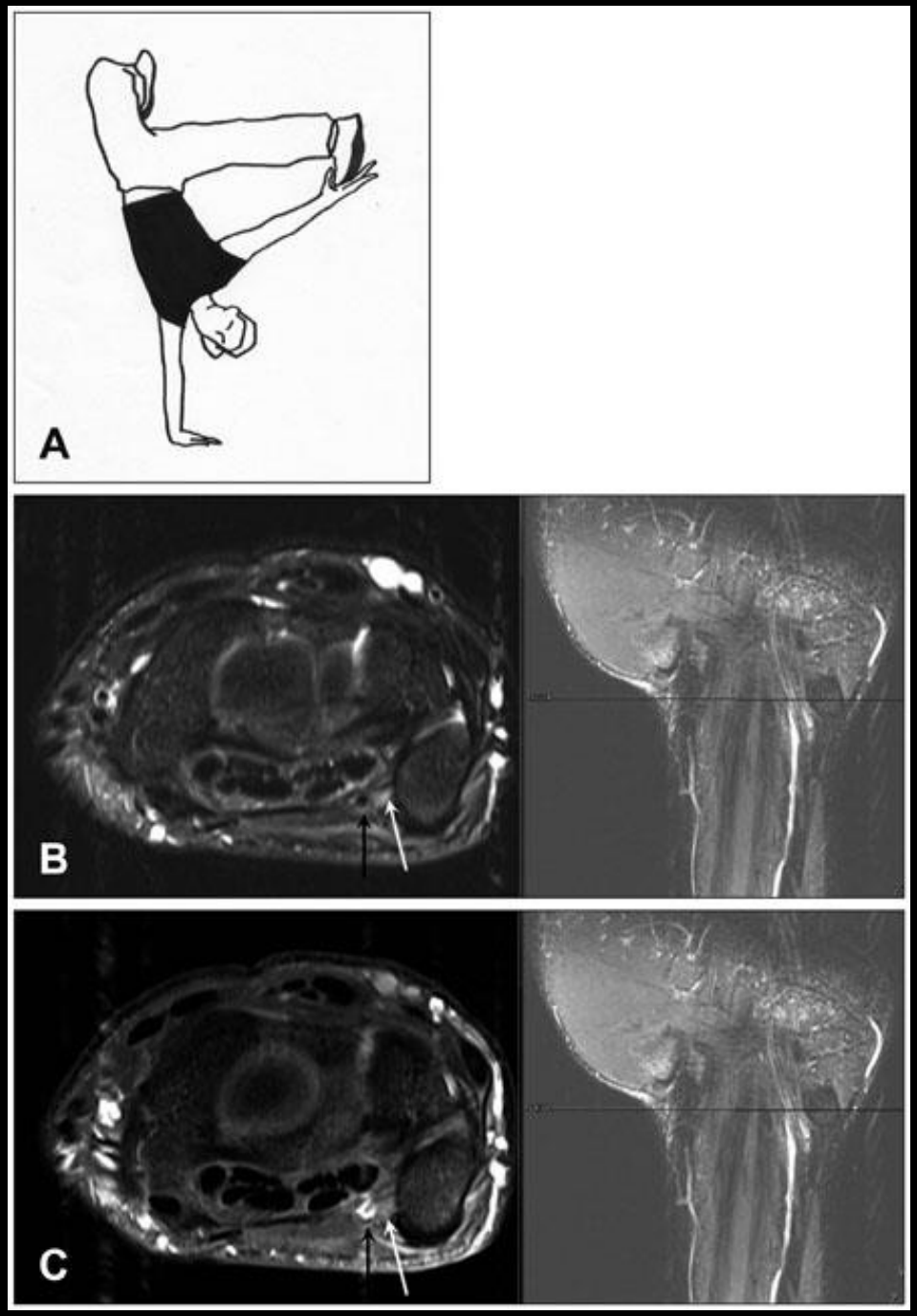


- Lesions in zone 1 cause both motor and sensory symptoms.
  Lesions in zone 2 cause motor deficits.
  Lesions in zone 3 create sensory deficits.





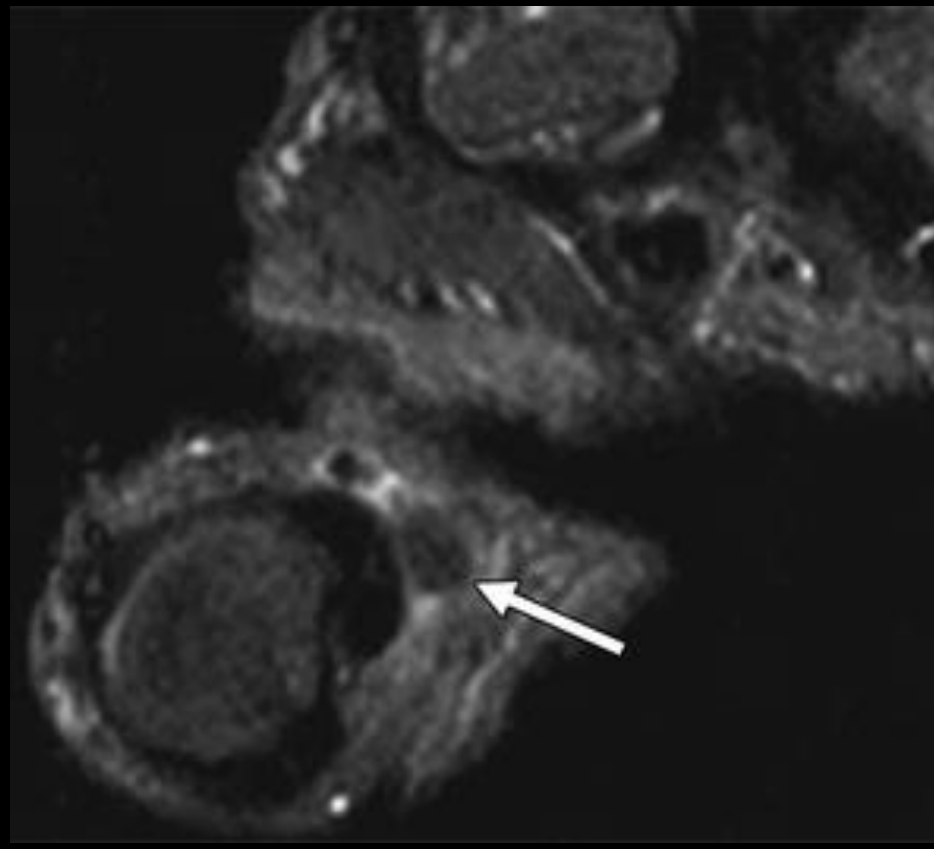



A
B
C

What happens after noon…

Bowler's thumb

- Traumatic neuropathy of the digital nerve on the ulnar side of the thumb
- Perineural fibrosis as nerve crosses over the sesamoid
- Parasthesias in thumb

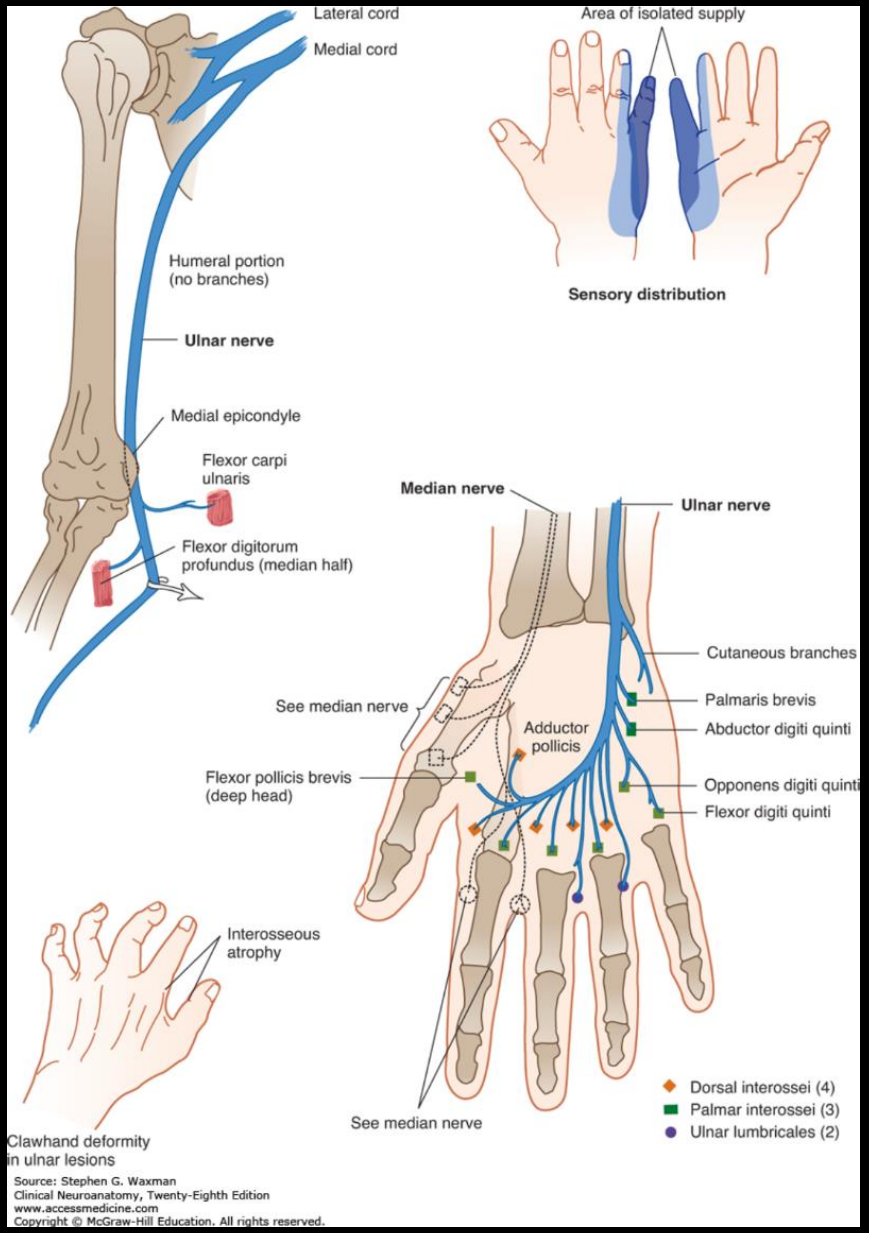


THE STAR

Sports

Will bowling be an Olympic sport in 2020?

Tokyo organizers selected a shortlist of eight sports from a list of 26 that had applied for inclusion.



Source: Stephen G. Waxman
Clinical Neuroanatomy, Twenty-Eighth Edition
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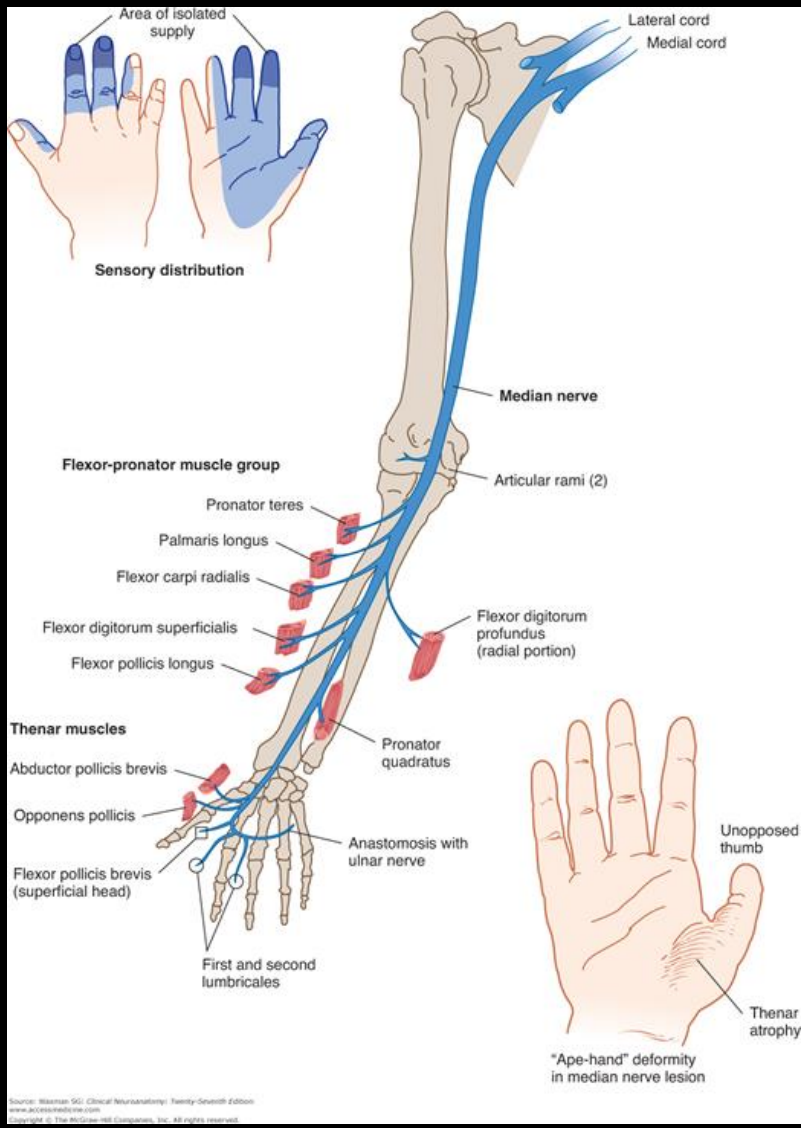
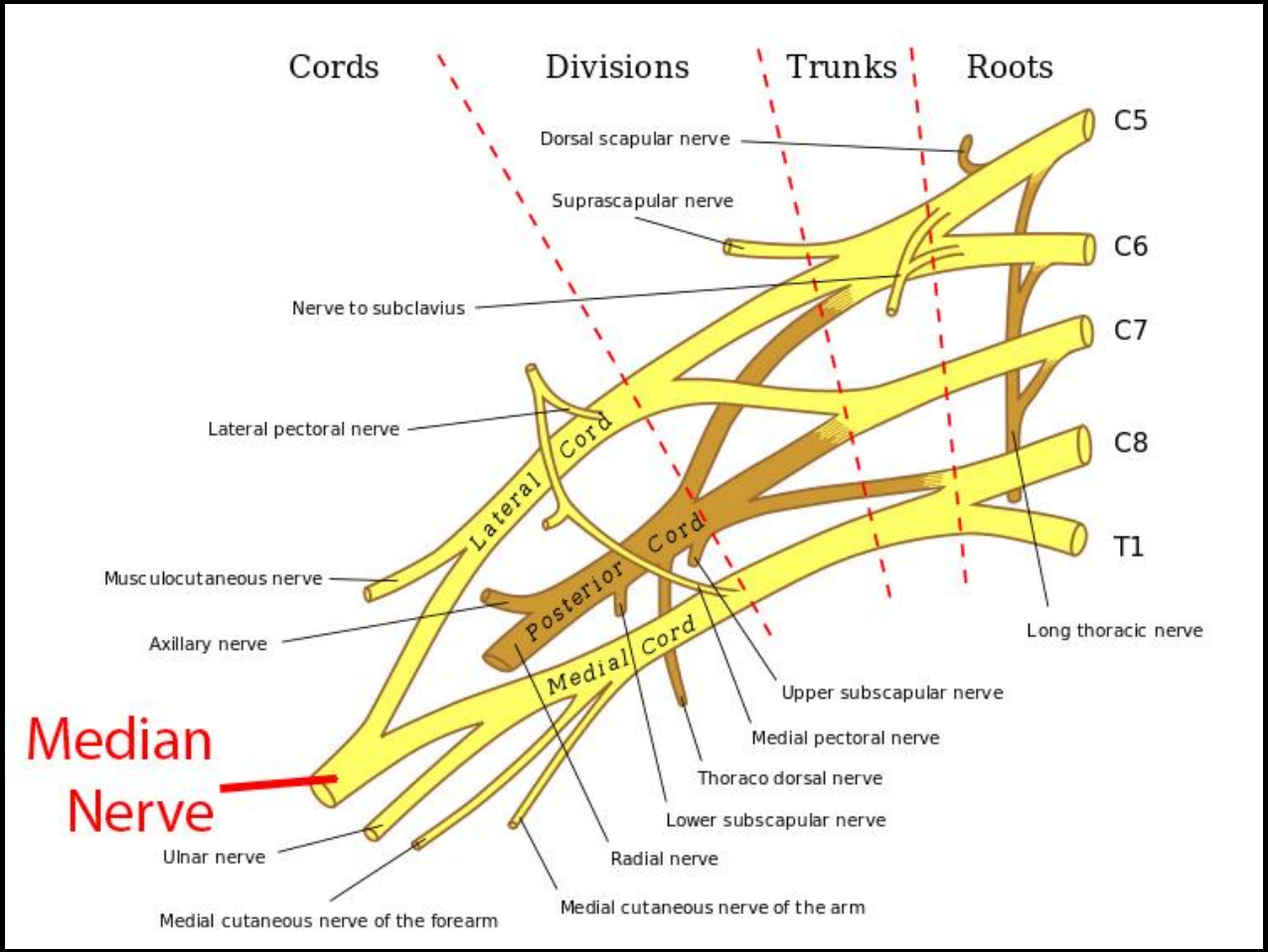
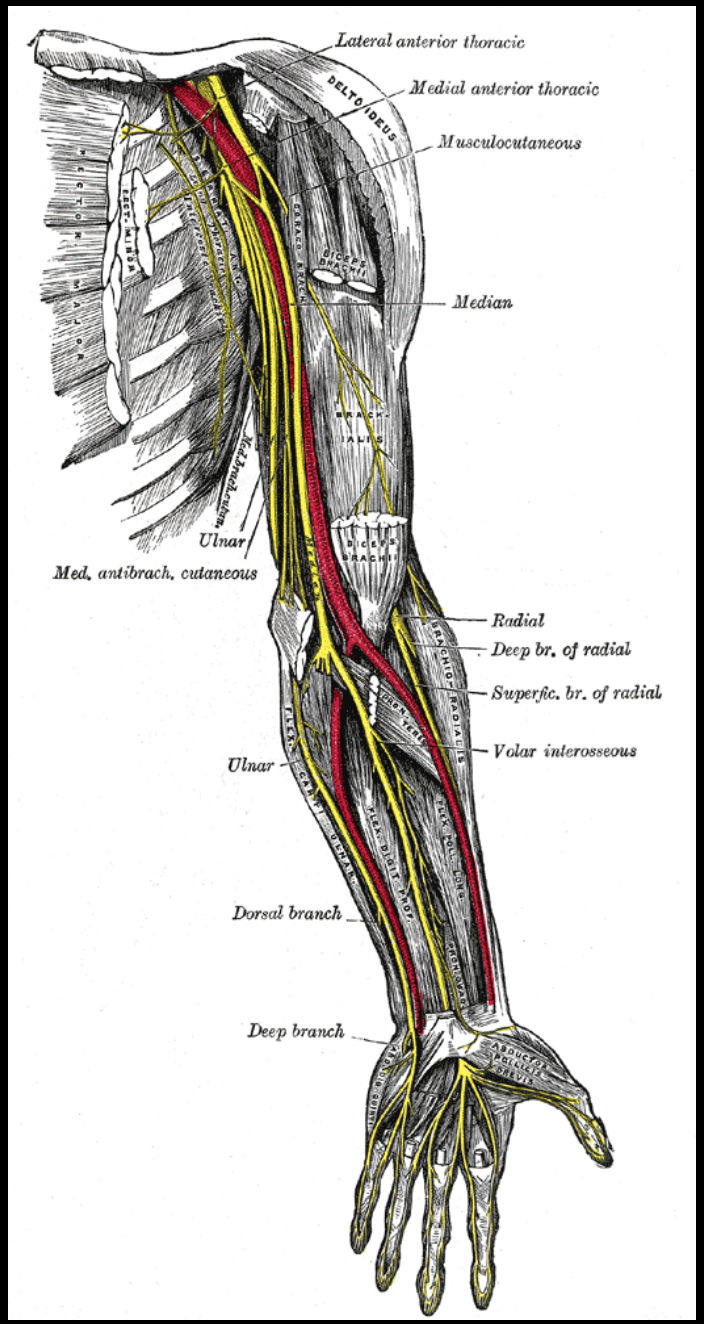
Median nerve

- sensory:
  - radial aspect of the palm
  - palmar aspect of the thumb, index, middle finger and radial half of the ring finger
- motor:
  - flexor compartment of the forearm
  - thenar muscles and first and second lumbricals

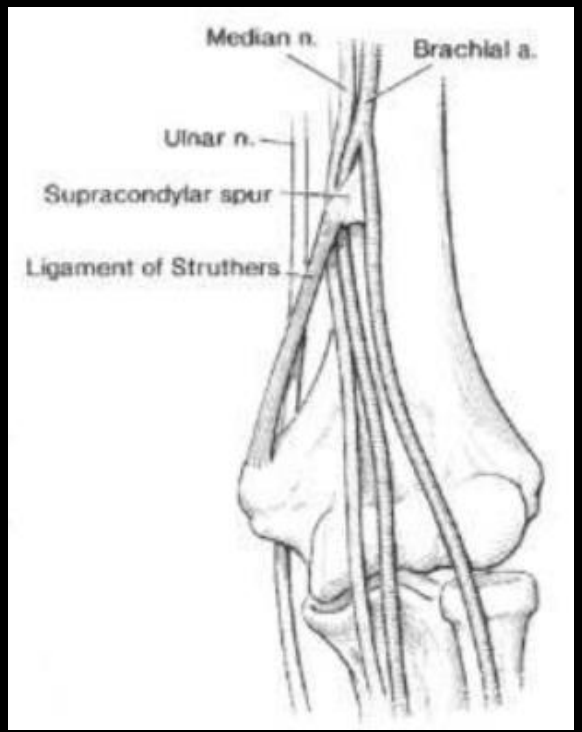


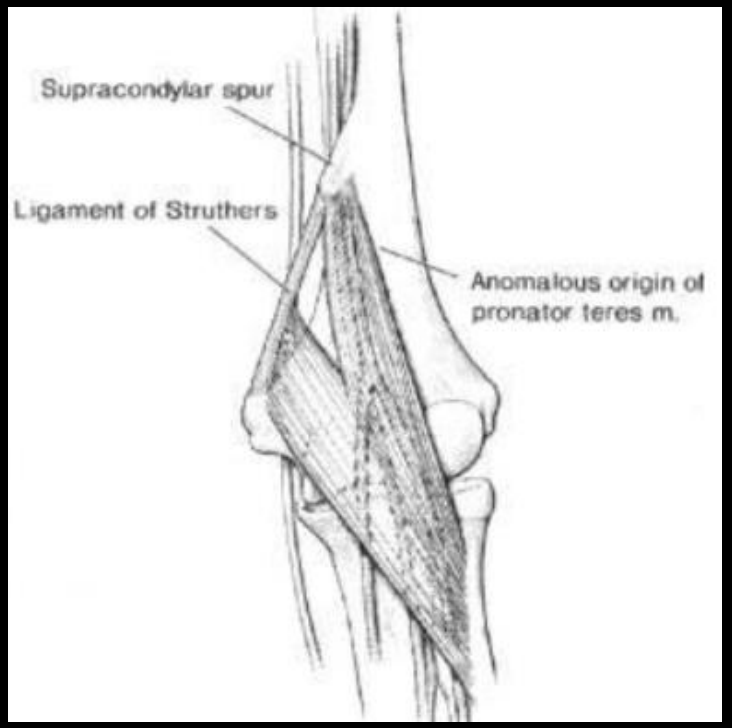

Cords
Divisions
Trunks
Roots
C5
C6
C7
C8
T1
Dorsal scapular nerve
Suprascapular nerve
Nerve to subclavius
Lateral pectoral nerve
Lateral Cord
Posterior Cord
Medial Cord
Musculocutaneous nerve
Axillary nerve
Long thoracic nerve
Upper subscapular nerve
Medial pectoral nerve
Thoraco dorsal nerve
Lower subscapular nerve
Radial nerve
Medial cutaneous nerve of the arm
Ulnar nerve
Medial cutaneous nerve of the forearm
Median Nerve


Lateral anterior thoracic
Medial anterior thoracic
Musculocutaneous
Median
Ulnar
Med. antibrach. cutaneous
Radial
Deep br. of radial
Superfic. br. of radial
Volar interosseous
Ulnar
Dorsal branch
Deep branch

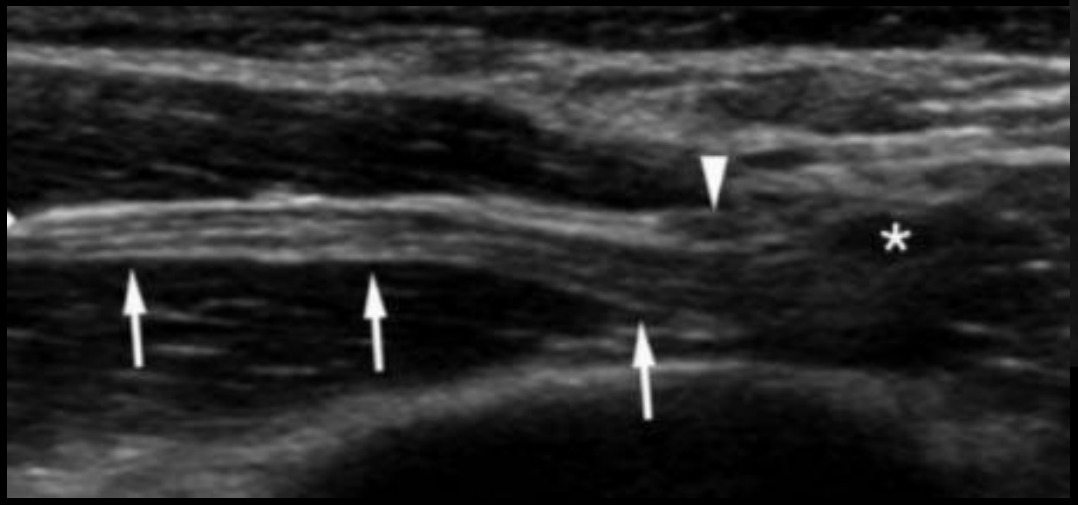
Supracondylar humeral spur and Struther's ligament

- Present in 1-2%
- Possible contents: median nerve, ulnar artery, pronator teres m.






*
PROC SUPRACONDYL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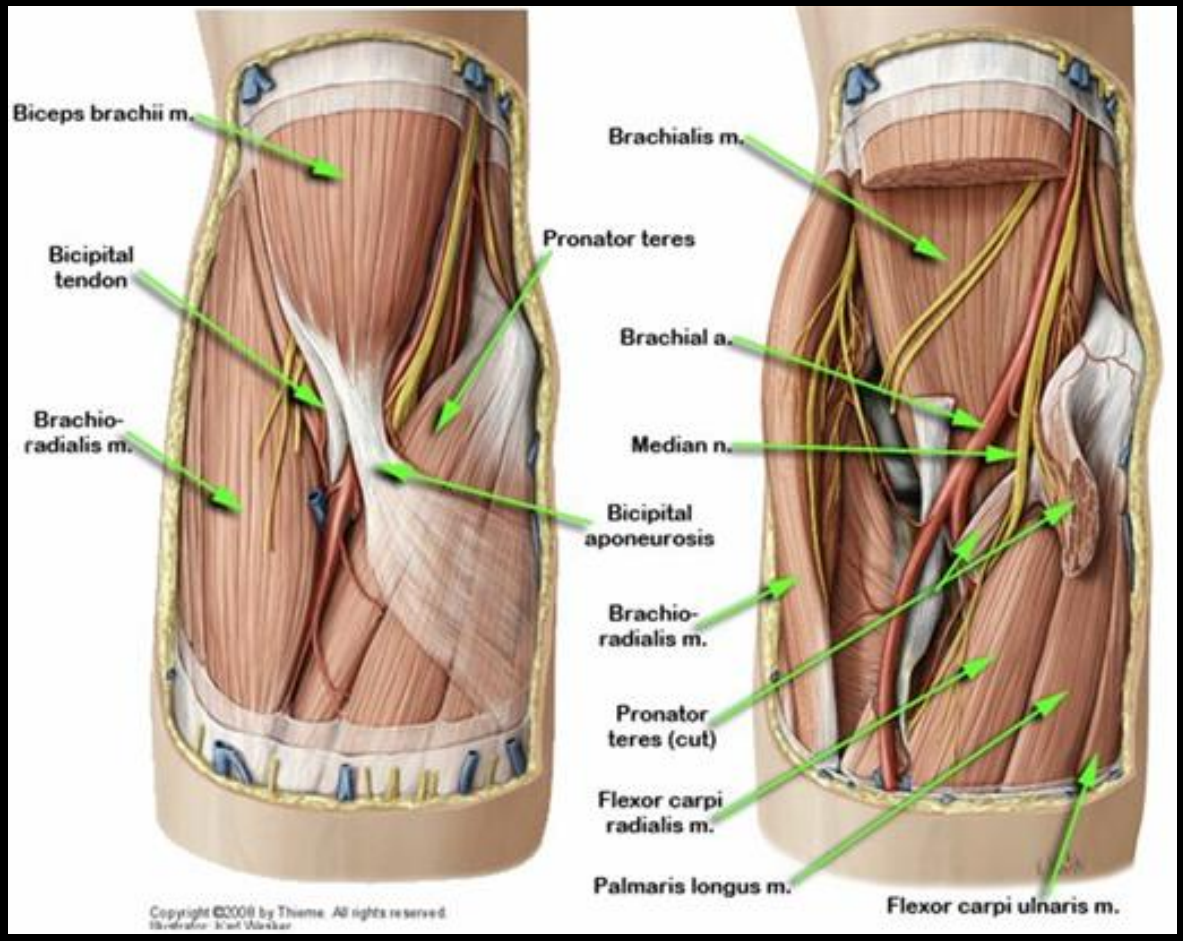
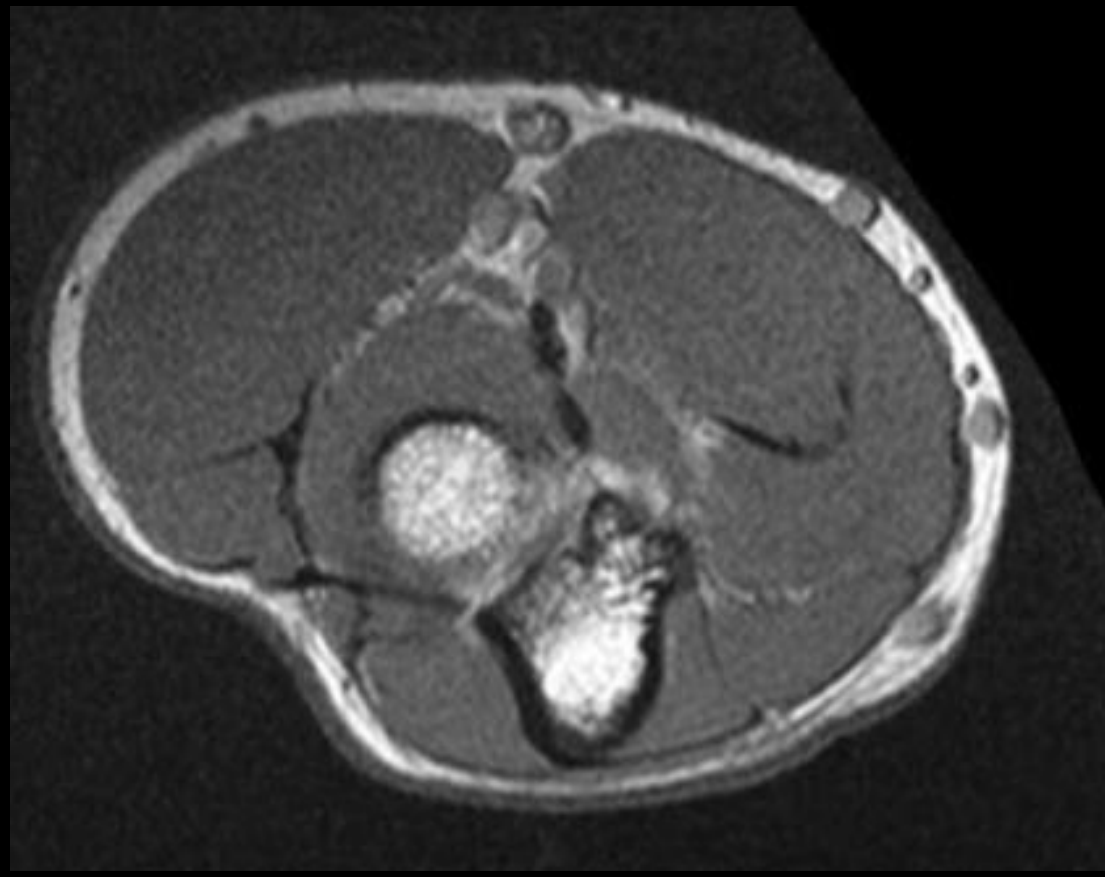
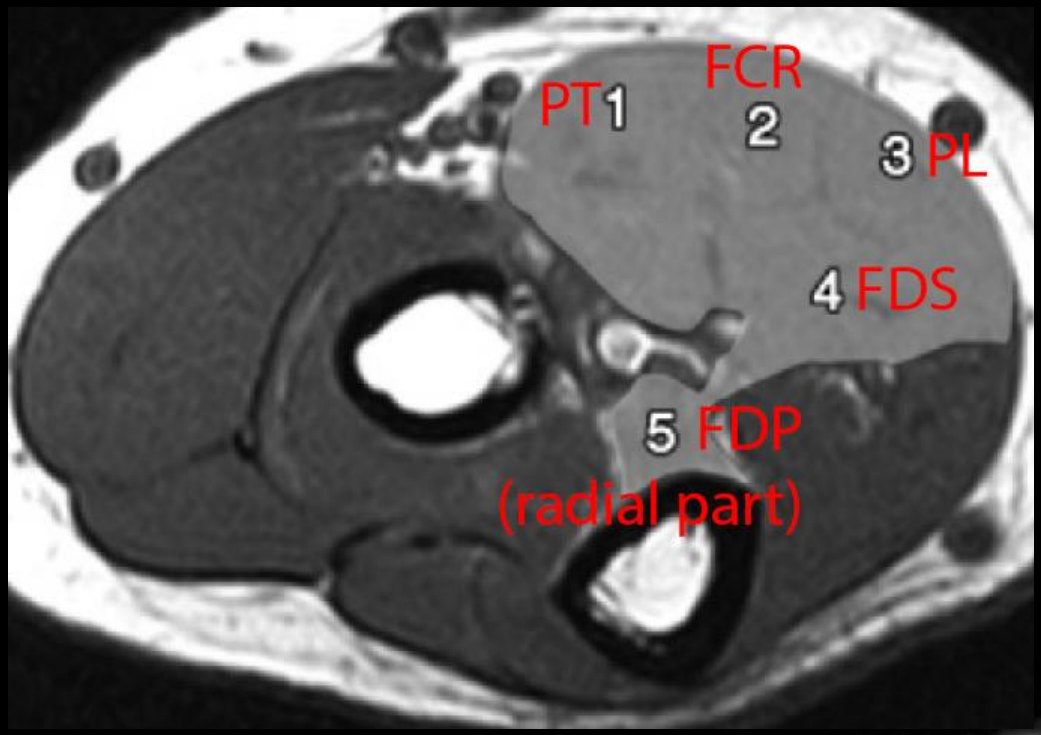
Cubital fossa



Pronator syndrome

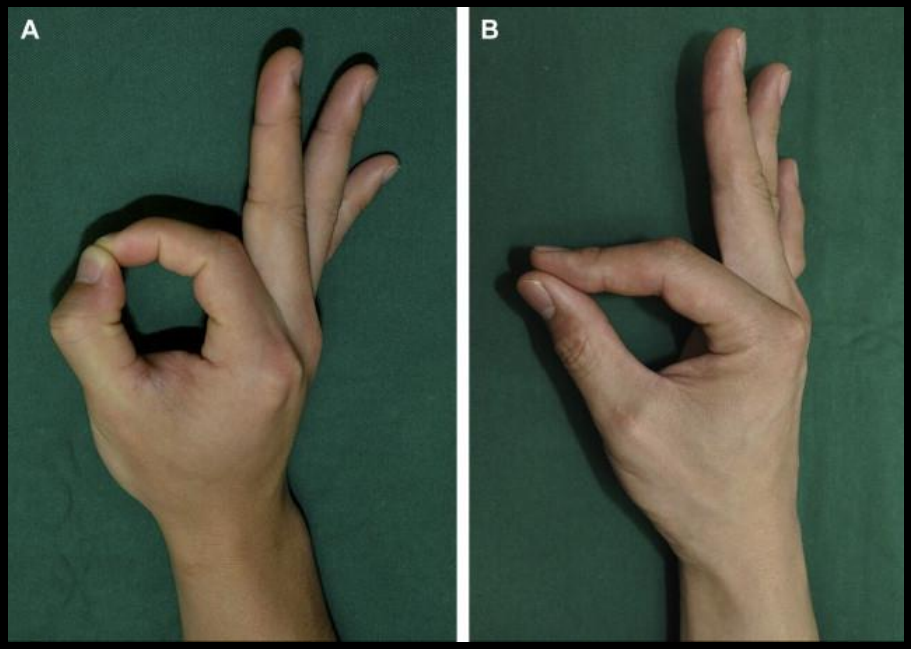
- Compression of median nerve as it passes between the two heads of the pronator teres muscle or proximal edge of the FDS arch
- Aching pain in the proximal, volar forearm
- Paresthesias radiating into the median innervated fingers
- Pain on resisted pronation

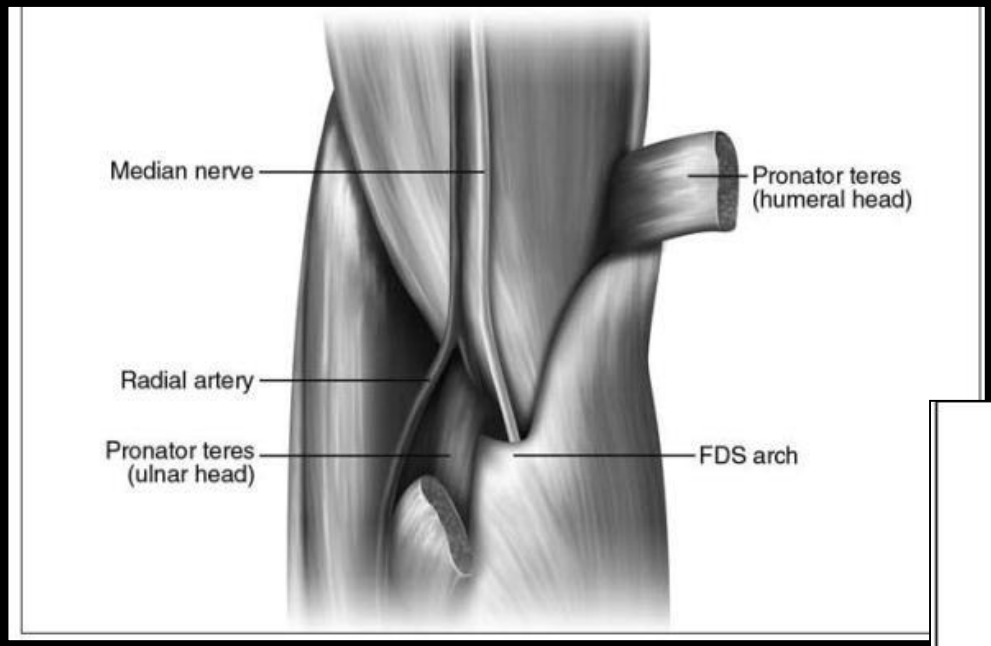


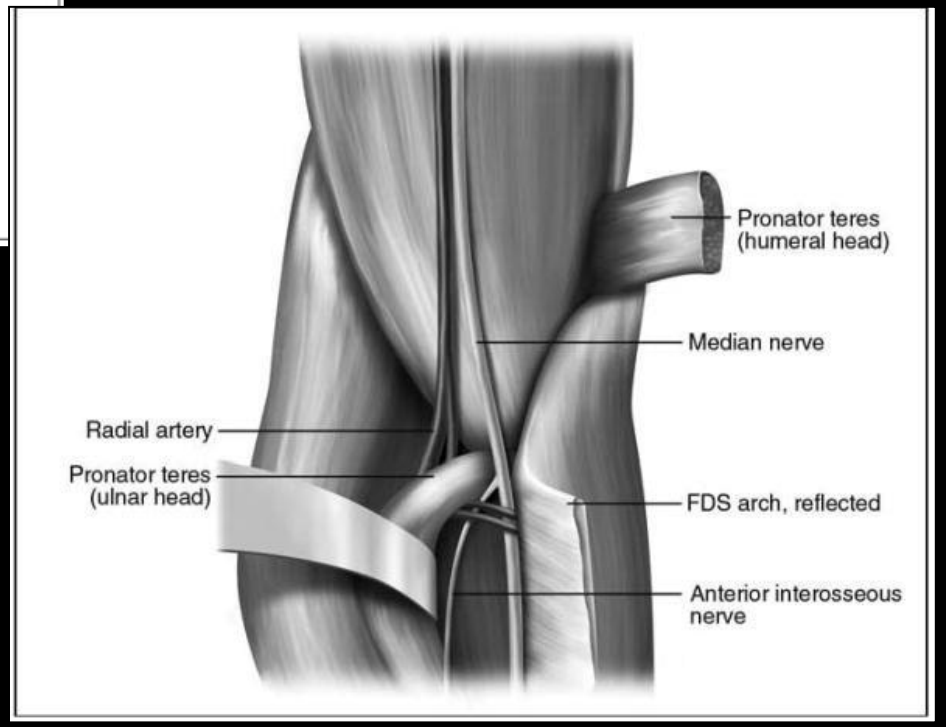

PT 1
FCR
2
3 PL
4 FDS
5 FDP
(radial part)

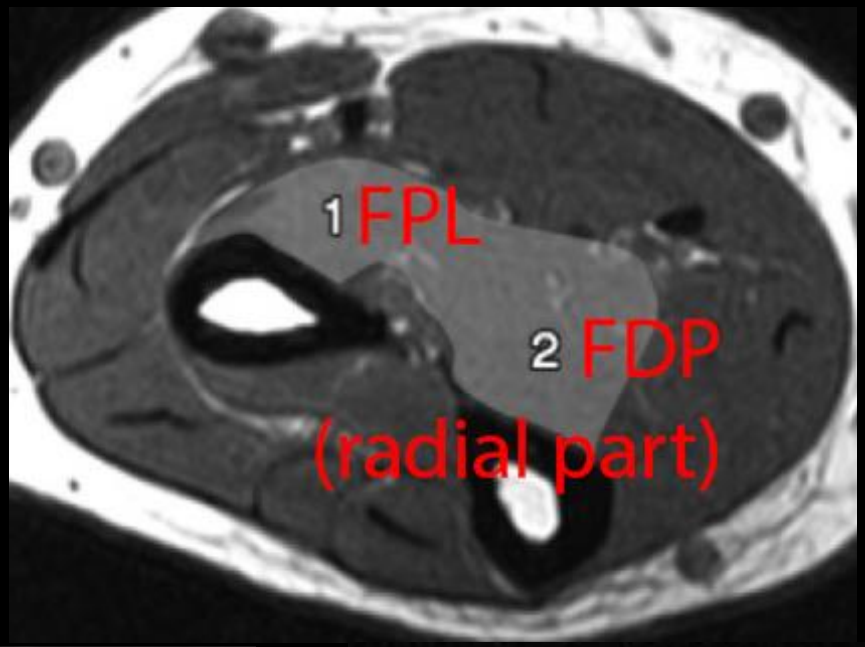
Anterior interosseous nerve syndrome

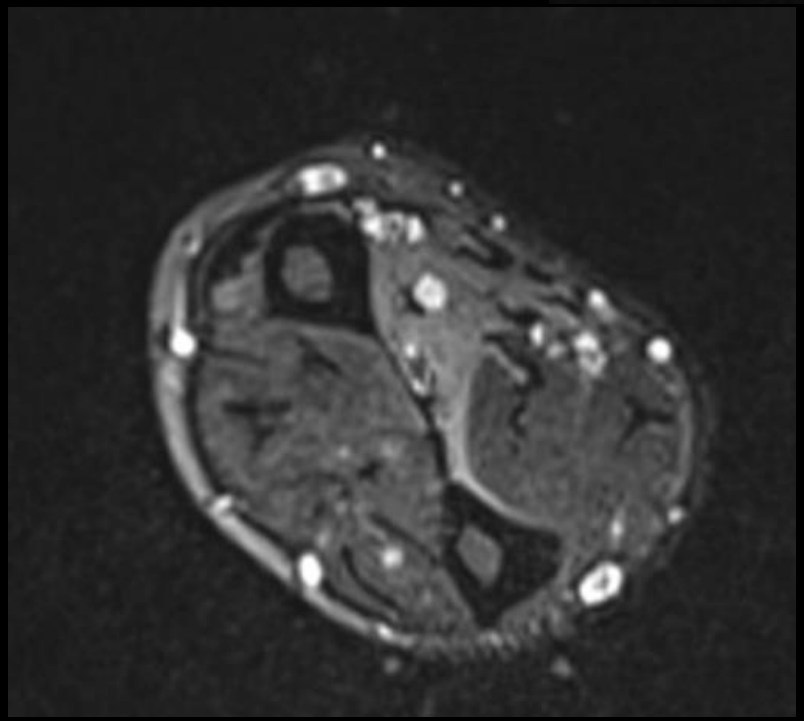
- AIN arises from the median nerve as it courses beneath the flexor digitorum superficialis m.
- Innervates the deep muscles of the forearm (FPL, radial part of FDP, and pronator quadratus)
- Inability to make an “OK” sign

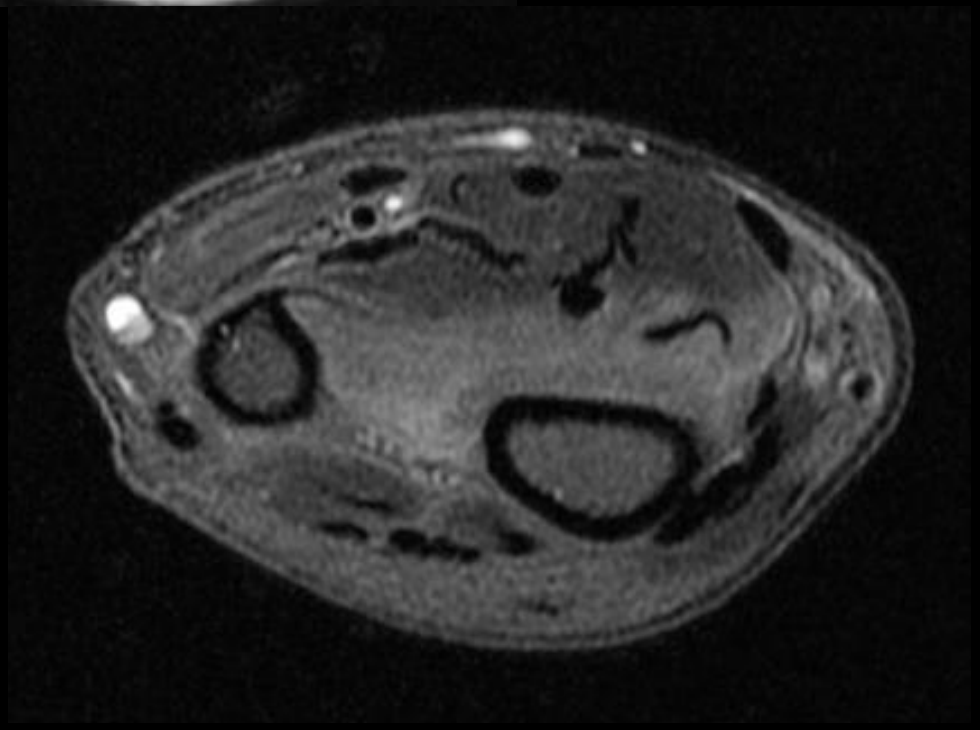



Median nerve
Pronator teres (humeral head)
Radial artery
Pronator teres (ulnar head)
FDS arch


Pronator teres (humeral head)
Median nerve
Radial artery
Pronator teres (ulnar head)
FDS arch, reflected
Anterior interosseous nerve







Courtesy of Dr. Fliszar

Carpal tunnel syndrome

- Most common compression neuropathy of the upper extremity
- 1-5% of individuals in the US
- Carpal tunnel is bounded by:
  - carpal bones and transverse carpal ligament
- Palmar cutaneous nerve branches 5 cm proximal to the tunnel
- Median nerve branches into sensory and motor branches after the tunnel
- CTS is bilateral in half of cases

Causes

- Primary CTS – women aged 30-50 years
- Hypothyroidism
- Rheumatoid arthritis
- Distal radius fracture
- Pregnancy
- Repetitive strain
- Workers using vibratory tools

Symptoms

- Numbness and tingling in the median nerve distribution
- Nocturnal numbness
- Weakness and/or atrophy of the thenar musculature
- Tinel sign
- Phalen's test
- Loss of 2-point discrimination

Diagnosis

- Median nerve
- Secondary causes
- Quantitative:
  - Cross sectional area (CSA) of nerve
  - Swelling ratio (CSA at radius : CSA at pisiform)
  - Palmar bowing

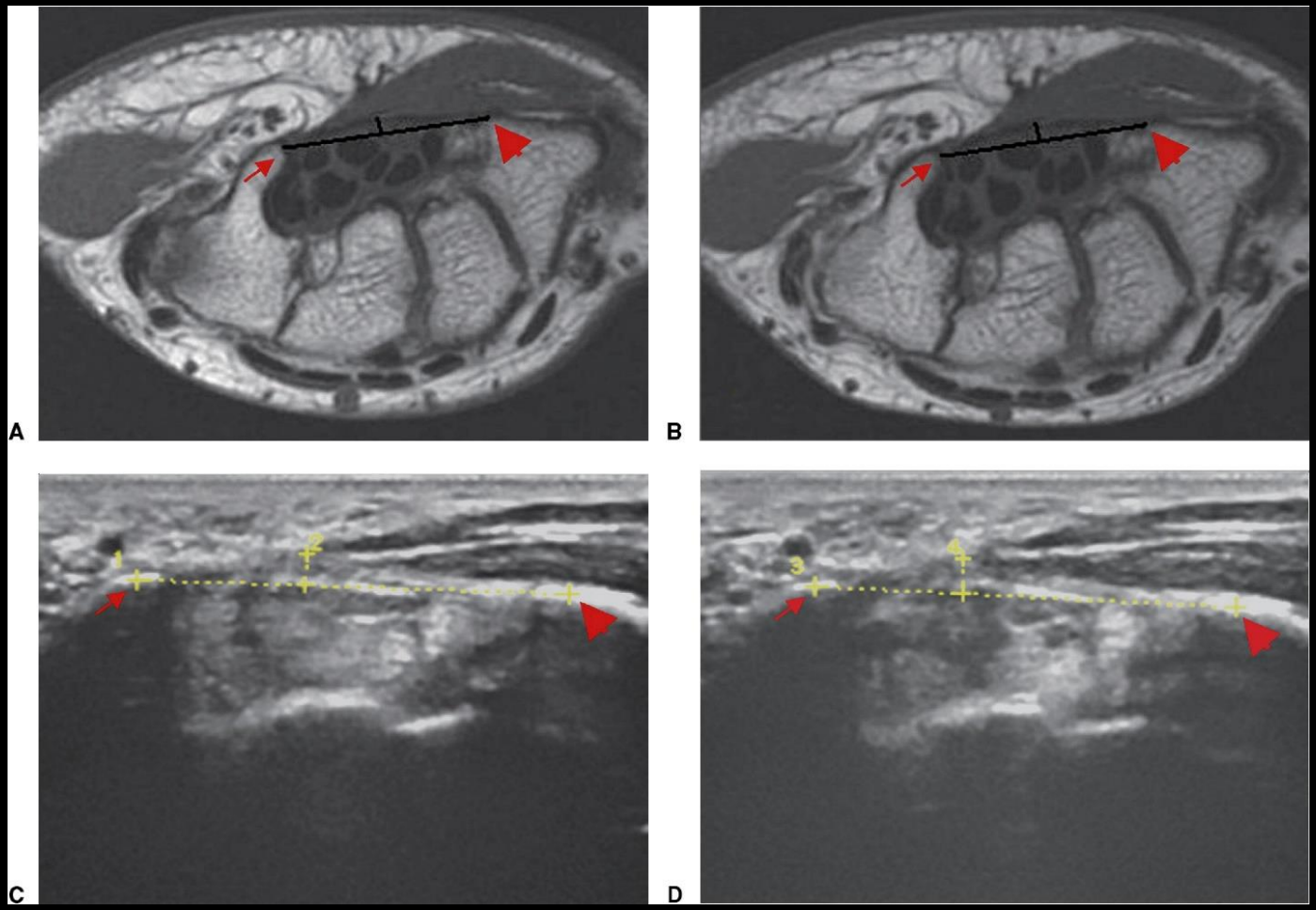
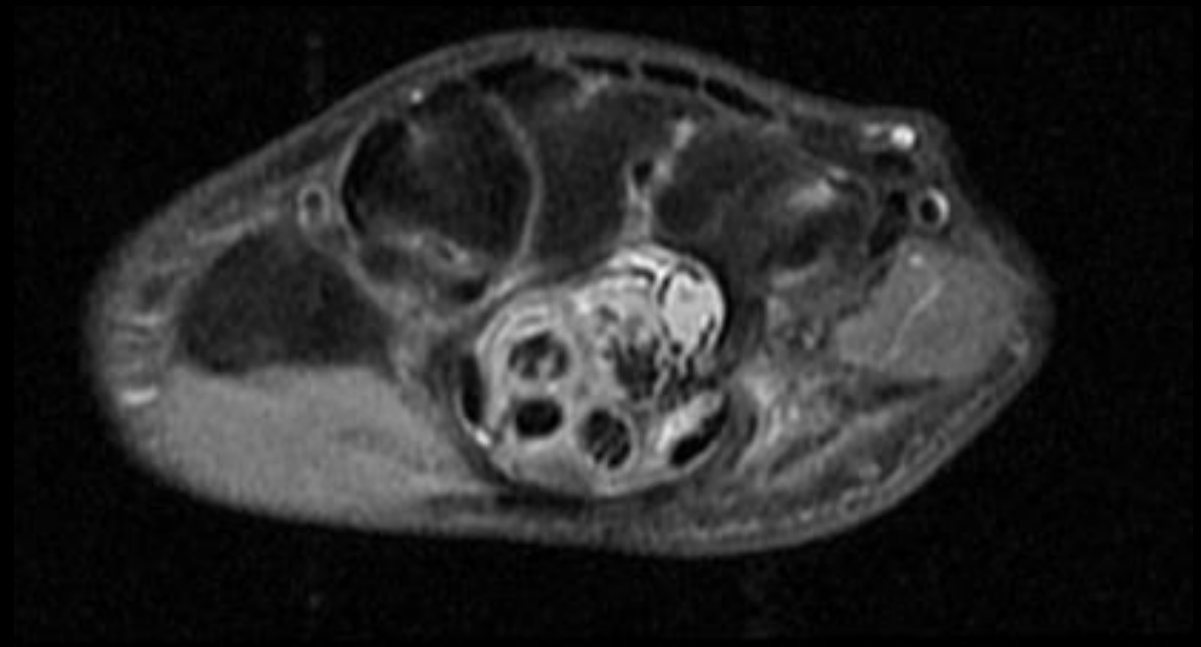

A
B
C
1
2
D
3
4

TABLE 3. Sensitivity, Specificity and Area Under the Curve in Receiver Operating Characteristics Analysis Using Single or Combined Criteria in Magnetic Resonance Imaging and Sonography

	MRI				Sonography			
	Sen	Spe	AUC (95% CI)	Cut-Point	Sen	Spe	AUC (95% CI)	Cut-Point
CSAp (mm^2), rest	0.74	0.88	0.84 (0.78–0.90)	10.9	0.63	0.86	0.80 (0.73–0.86)	10.0
Grasp*	0.74	0.86	0.84 (0.78–0.90)	10.3	0.53	0.88	0.76 (0.69–0.83)	9.8
Swelling ratio, rest*	0.80	0.59	0.76 (0.67–0.83)	1.3	0.72	0.49	0.61 (0.53–0.69)	1.3
Grasp*	0.76	0.63	0.73 (0.65–0.80)	1.3	0.26	0.84	0.55 (0.47–0.64)	1.5
Bowing of FR (mm), rest*	0.91	0.59	0.83 (0.77–0.89)	1.8	0.51	0.75	0.64 (0.56–0.72)	2.3
Grasp*	0.88	0.69	0.84 (0.78–0.90)	2.0	0.89	0.49	0.73 (0.66–0.80)	2.1
Flattening ratio, rest	0.60	0.69	0.65 (0.57–0.73)	2.2	0.58	0.58	0.56 (0.48–0.65)	2.4
Grasp	0.68	0.53	0.62 (0.54–0.71)	2.0	0.35	0.80	0.56 (0.48–0.65)	2.2
CSAp in rest and bowing of FR in grasp position	0.78	0.86	0.88 (0.82–0.93)		0.67	0.84	0.83 (0.77–0.89)	

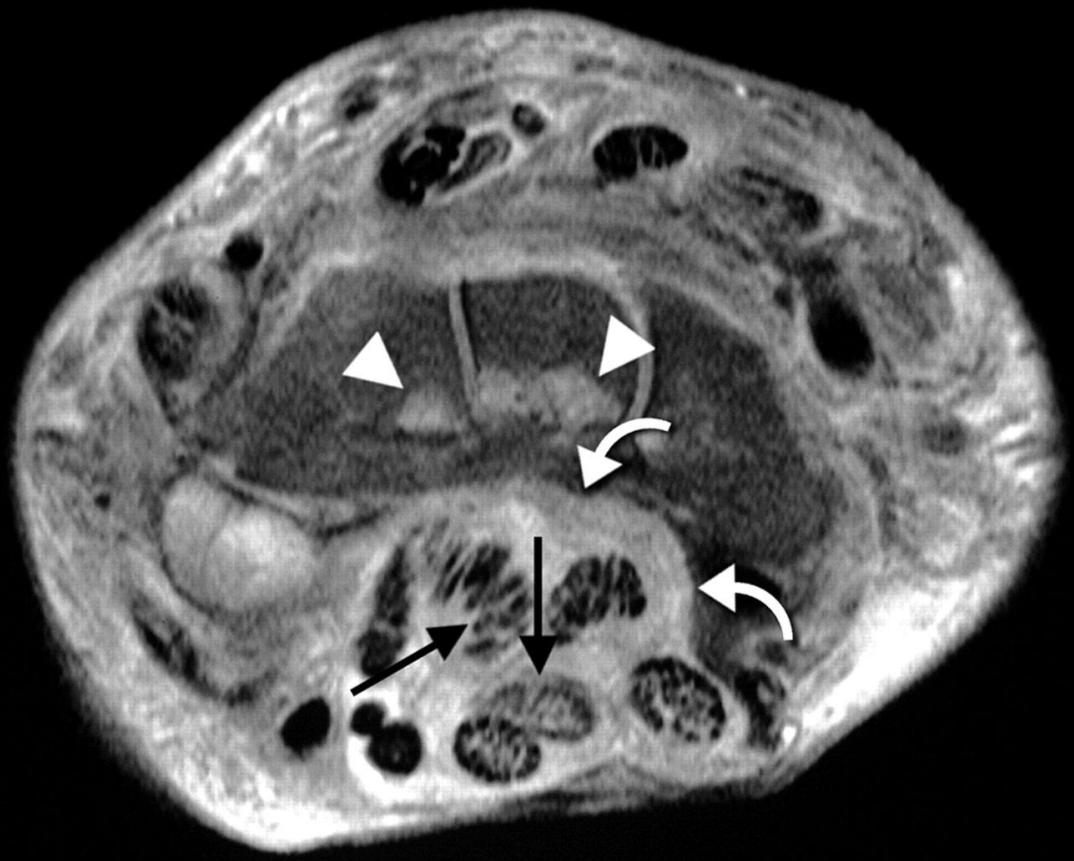
CI, confidence interval; FR, flexor retinaculum; Sen, sensitivity; Spe, specificity.
*$P < .05$, comparison of the AUC between the MRI and sonography.

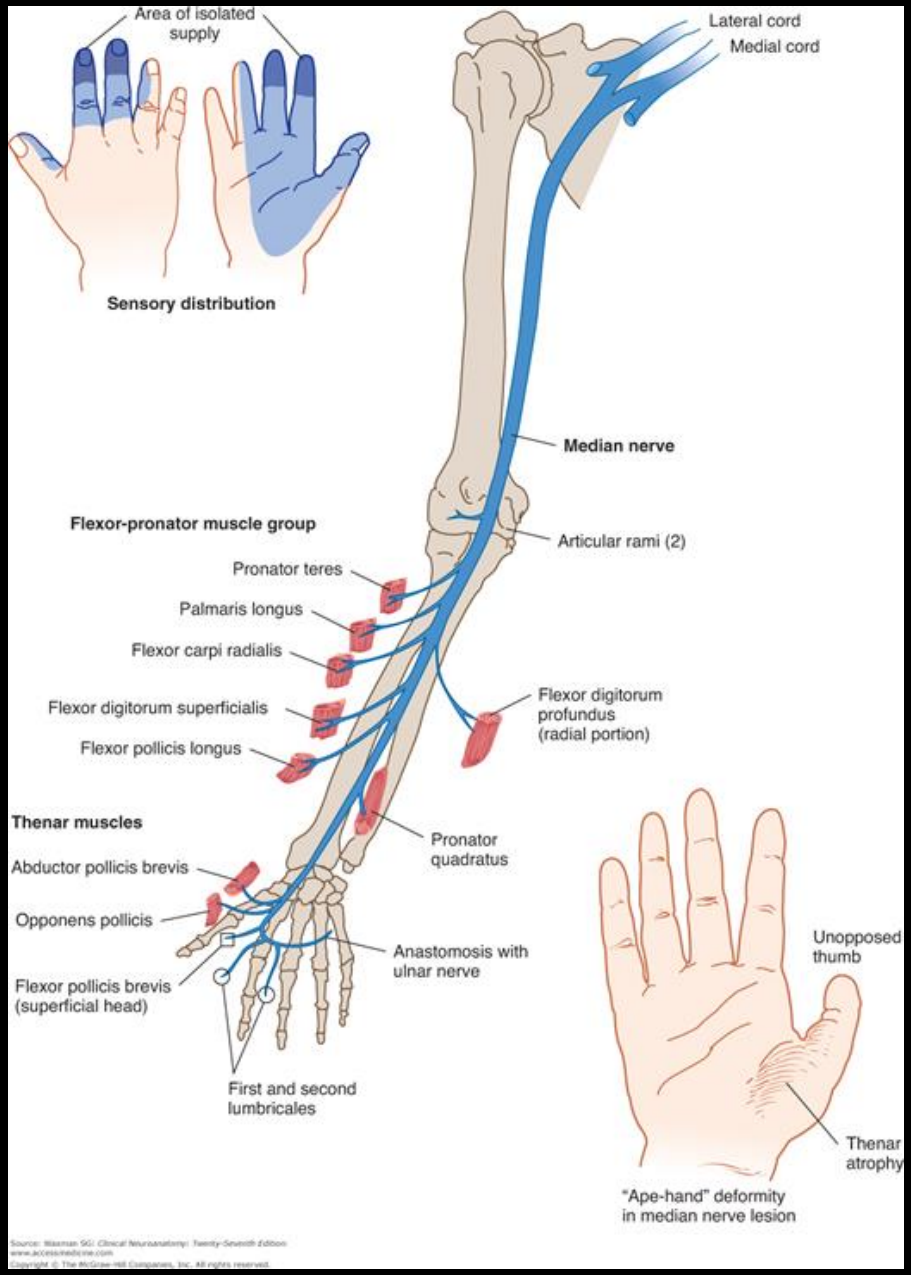
Rheumatoid Arthritis



Courtesy of Dr. Fliszar

Amyloidosis





Source: Waxman SG: Clinical Neuroanatomy: Twenty-Seventh Edition
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Conclusion

- Radiologists play an important role in the diagnosis and management of a small but significant subset of patients with compression neuropathies
- Anatomy is key to diagnosing compression neuropathies
- Secondary signs including denervation myopathy and clinical syndromes are useful

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