Ultrasound of Compressive Neuropathies

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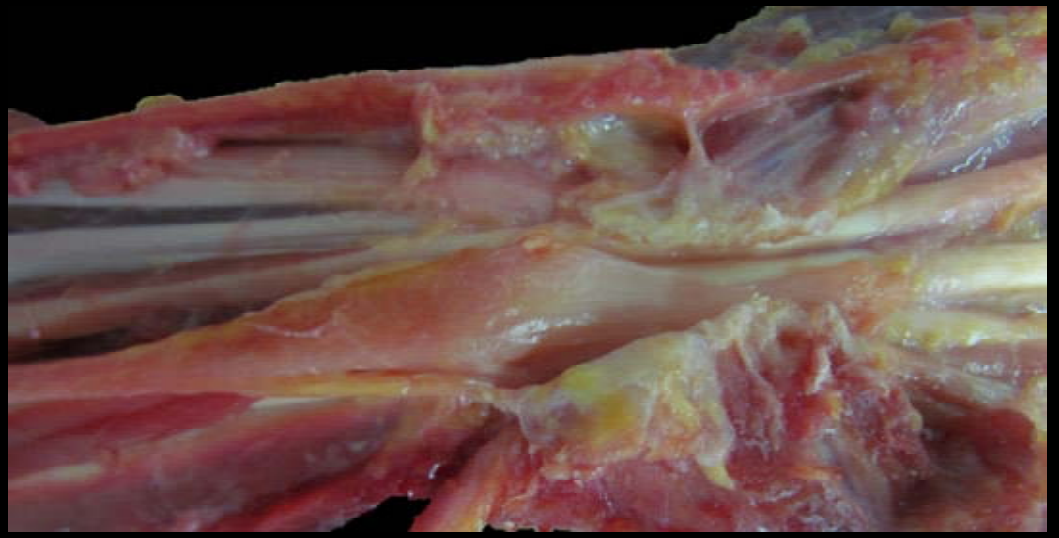
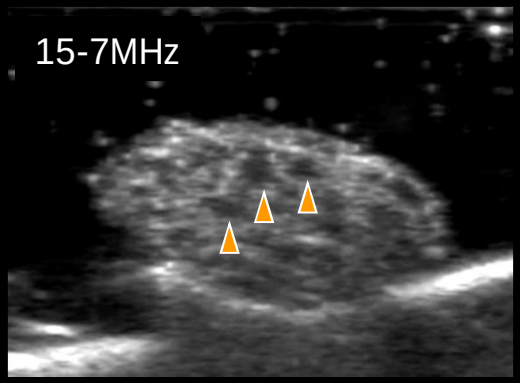


XXI World Congress of Neurology – WCN 2013
Vienna 21-26 September, 2013

Nerve Ultrasound – anatomy

Common Peroneal Nerve at the Knee

15-7MHz



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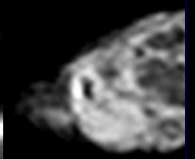
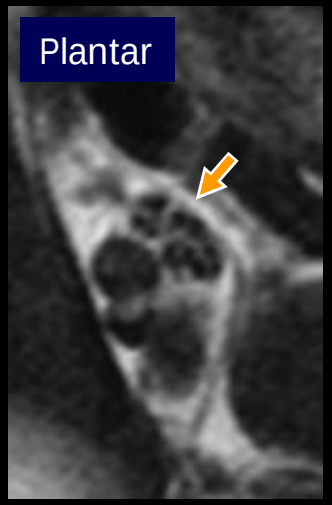
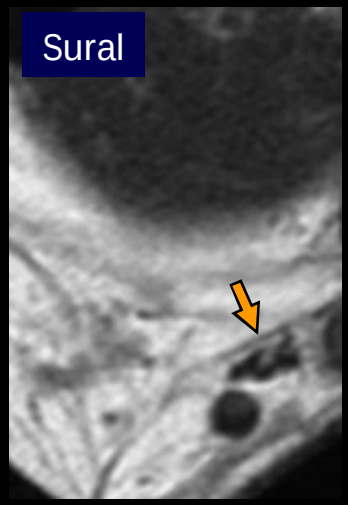


SHORT-AXIS PLANE

- Nerves have a honeycomb-like appearance with multiple rounded hypoechoic areas in homogeneous hyperechoic background

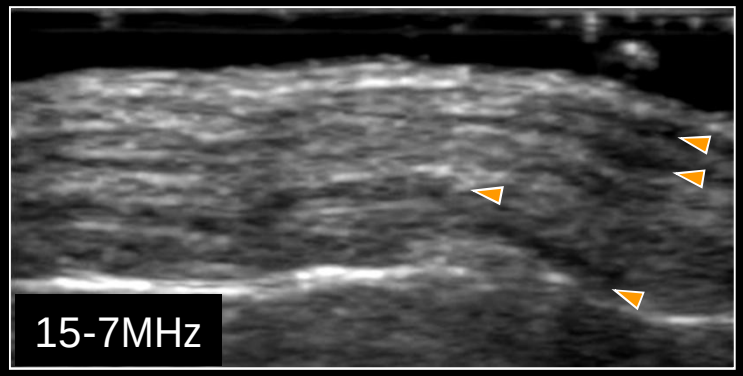


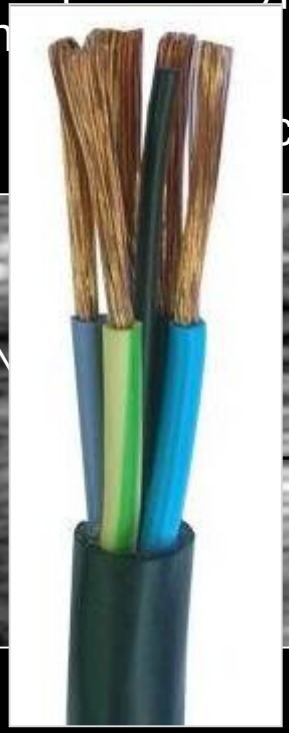


Nerve Ultrasound – anatomy

LONG-AXIS PLANE

- Nerve have a striated
  of multiple parallel hyp
  hyperech

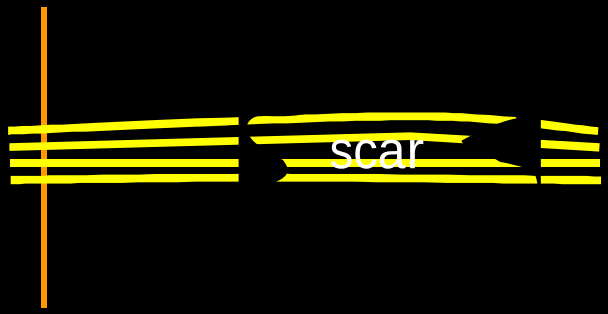


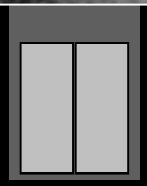


Ultrasound – scanning technique

- Systematic scanning on short-axis planes is essential to follow the nerves contiguously throughout the limbs

"Lift" technique

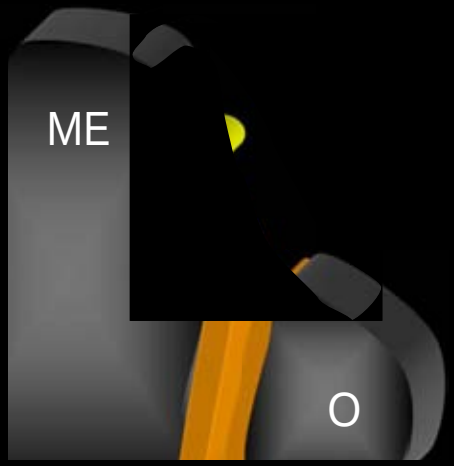




Wrist

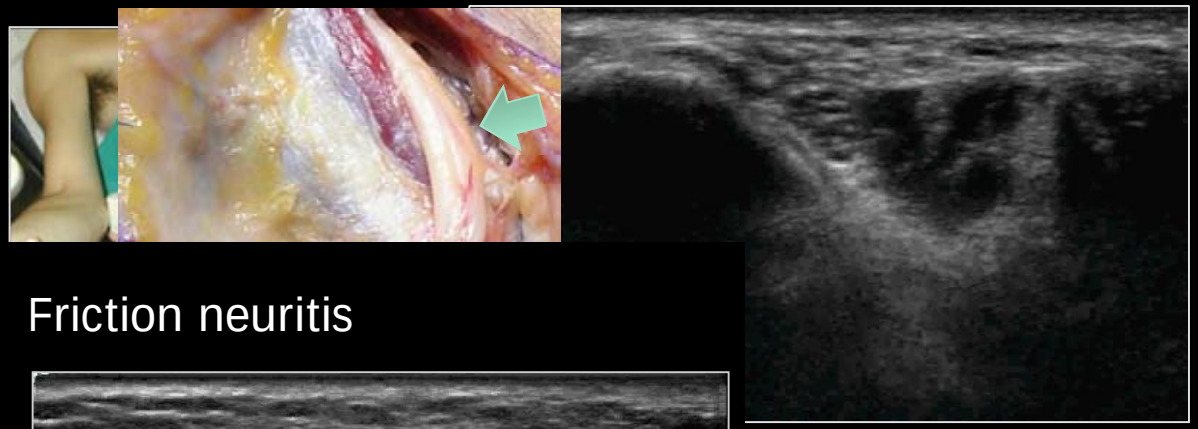
Nerve Instability

- The Osborne retinaculum retains the ulnar nerve posterior to the medial epicondyle during elbow flexion



Elbow extension

Elbow flexion



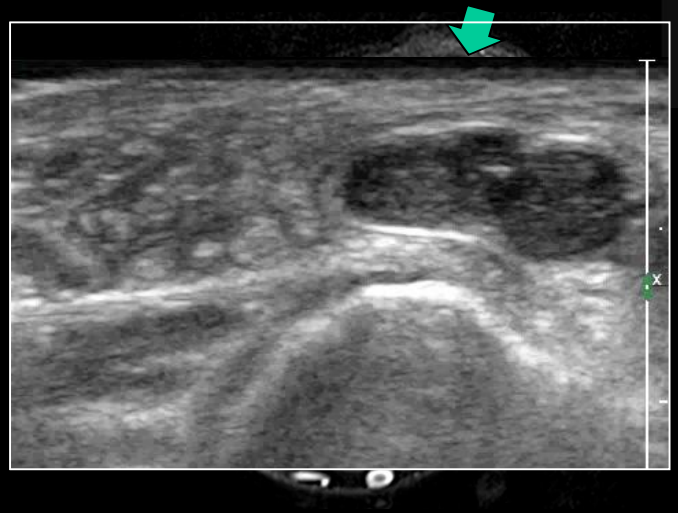
Friction neuritis

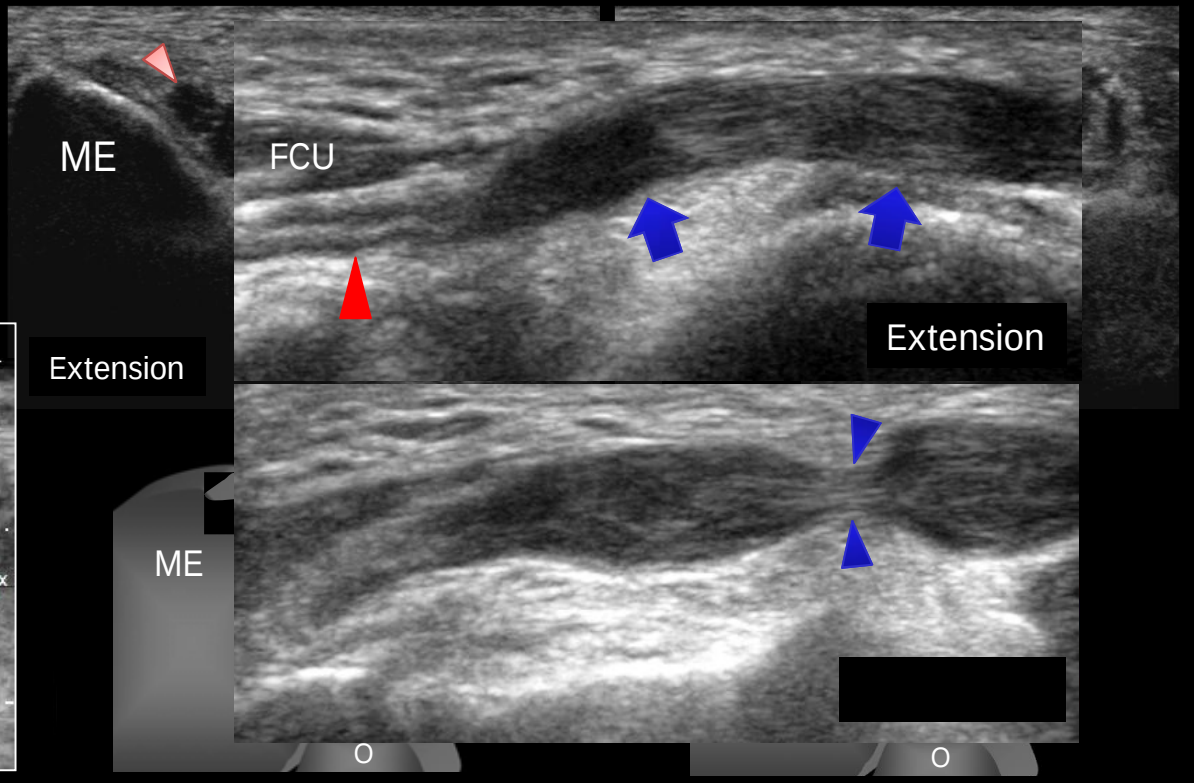
Cubital Tunnel Syndrome

ADVANTAGES OF DYNAMIC IMAGING

- triceps medial head compression (condylar groove)
- impingement by FCU tendinous bands (cubital tunnel)
- ulnar nerve instability
- snapping triceps syndrome

FULL ELBOW FLEXION

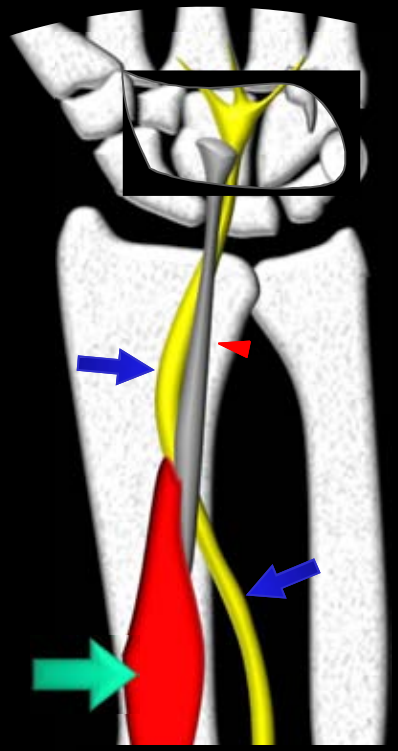


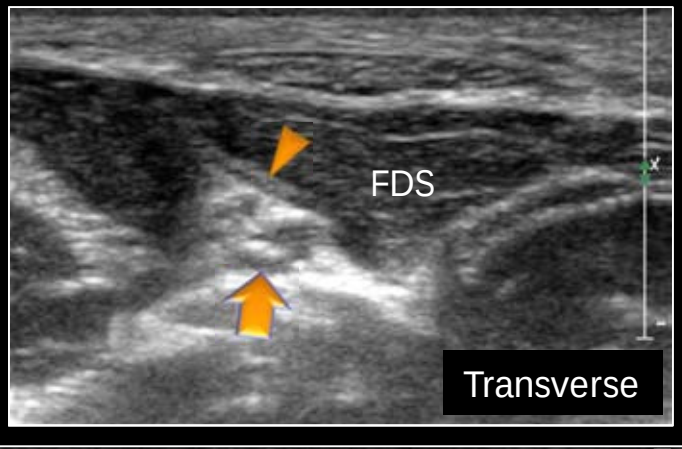


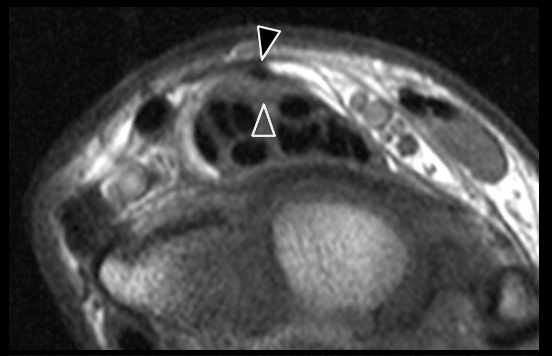
Palmaris Profundus

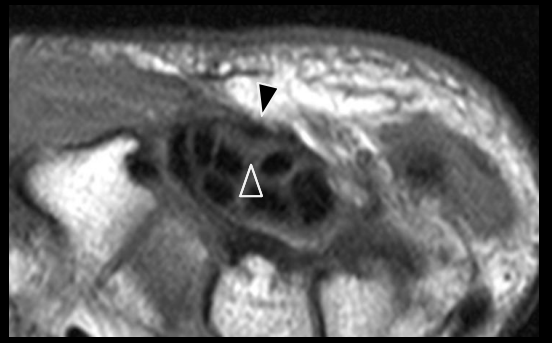
MUSCULUS CONCOMITANS NERVI MEDIANI

- gives off a distal tendon which passes beneath the flexor retinaculum and after traversing the carpal tunnel, it fans out attaching into the deep surface of the distal retinaculum or the palmar aponeurosis





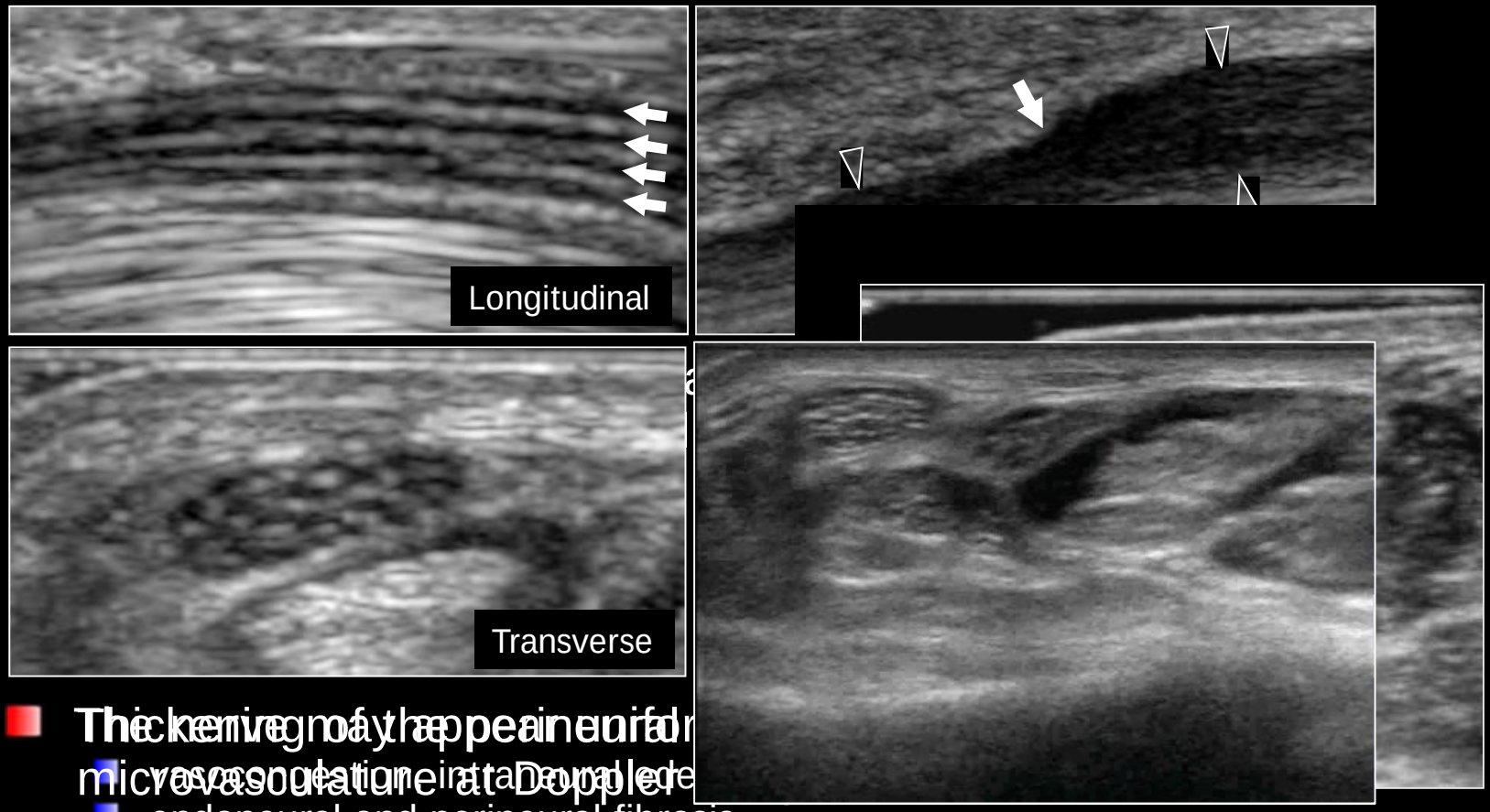




Entrapment Syndromes

Normal nerve

Compressed nerve



- The nerve may appear unaffected
  - increased microvasculature at Doppler
  - endoneural and perineural fibrosis

Quantitative Studies

- Nerve swelling (CSA)
  - Which is the method to measure the CSA?
    - Æ indirect by calipers
    - Æ direct by manual tracing and automated calculation

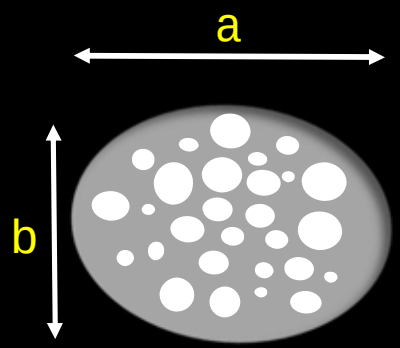
p >.05

Duncan et al. 99
Yelsildag et al. 04

  - Use the ellipse formula (equipment software)
    - Æ high reproducibility between experienced and inexperienced observers

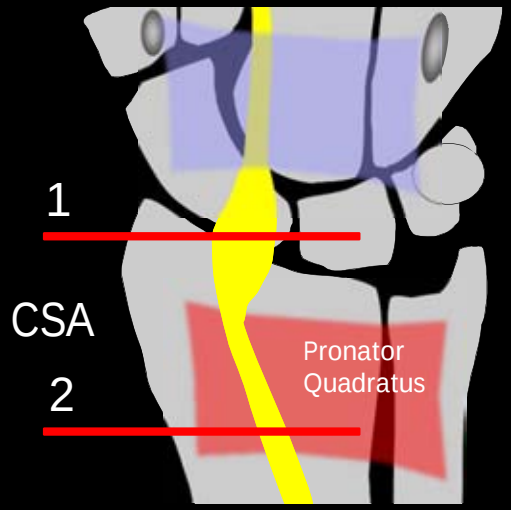
Aleman et al. 08

  - Where is the level of nerve measurement?
    - Æ where the nerve is maximally enlarged
  - Which is the threshold value?
    - Æ median nerve [≥9mm^2; ≥10mm^2; ≥15mm^2...]
  - Potential confounding factors ....
    - Æ gender, weight, BMI, race



Cross-sectional area: $\pi ab/4$

Quantitative Studies



- wrist-to-forearm comparison of median nerve CSA
  - pronator quadratus
  - CSA ?ç2mm^2 è 99% sensitivity, 100% specificity

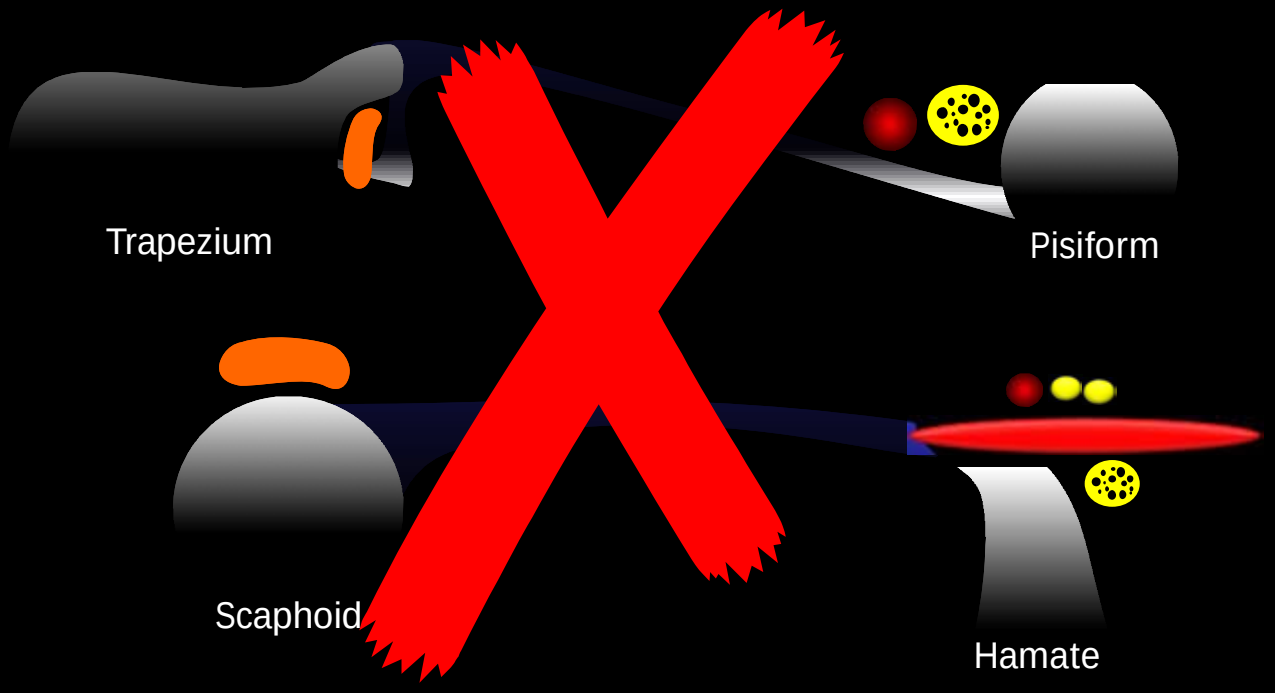
    Klauser et al., 2008
- wrist-to-forearm ratio of median nerve CSA
  - 12cm proximal in the forearm
  - 1.4 è 100% sensitivity with no false positives

    Hobson-Webb et al. 2008
- left-to-right comparison

  Thoirs et al. 2008

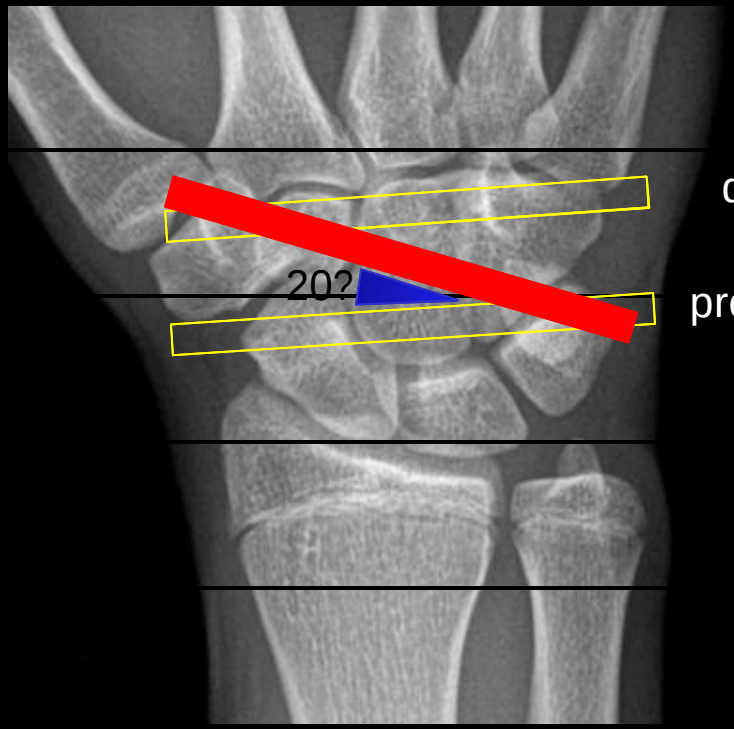
Scanning Technique - probe positioning

- Use carpal bones as landmarks to align the probe correctly



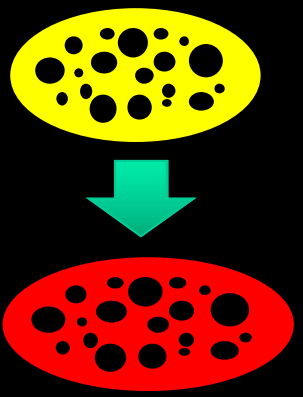
Scanning Technique - CSA measurement

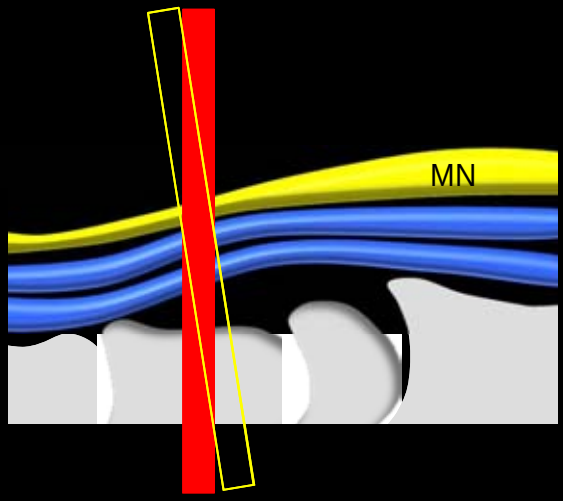
- Use true short-axis scans



distal

proximal



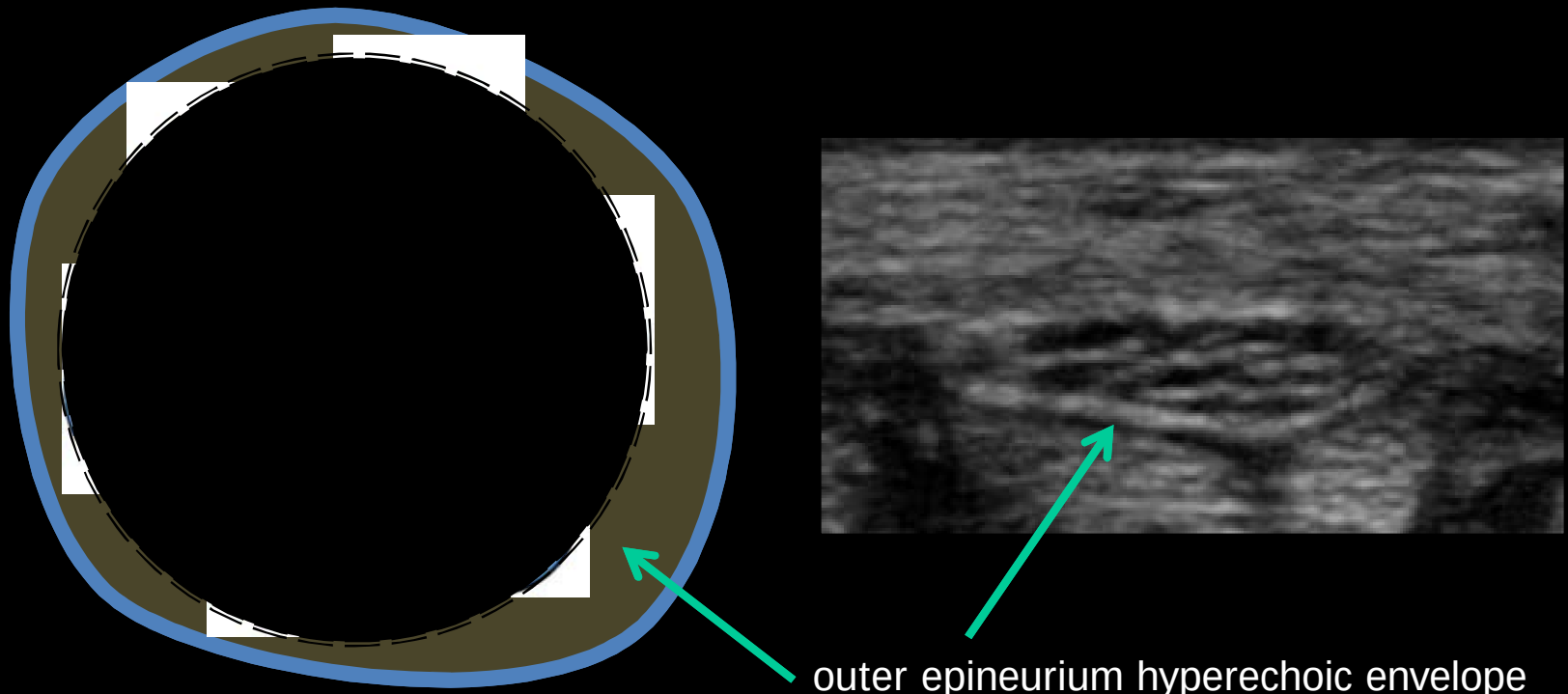


correct probe aligment may avoid CSA overestimation

Scanning Technique - CSA measurement

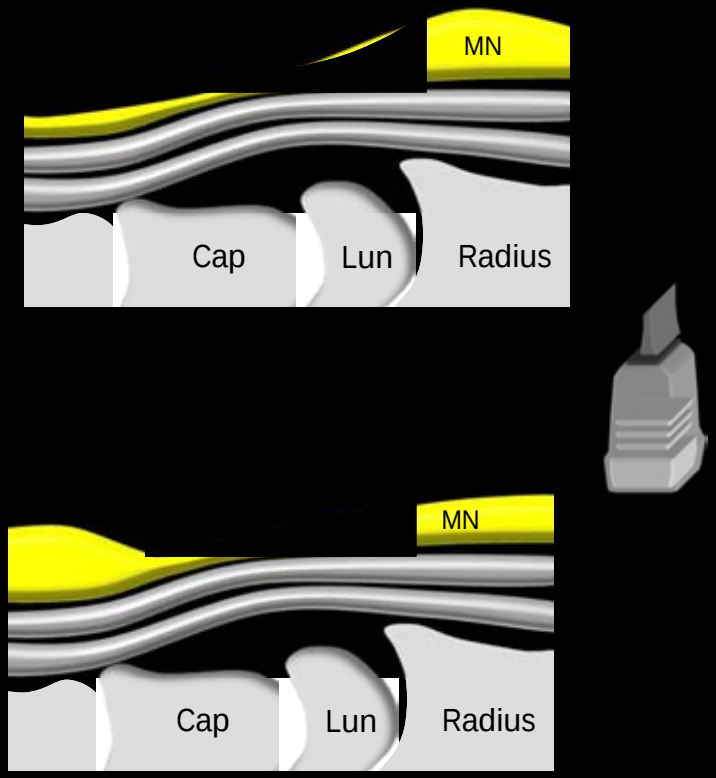
CSA measured from the inner border of echogenic epineurium surrounding the fascicles

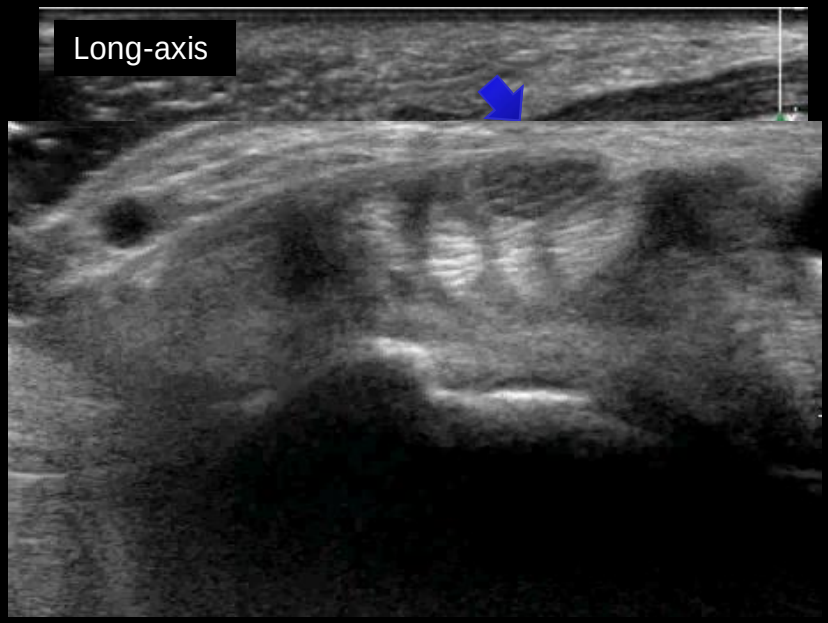
- outer epineurium excluded



Scanning Technique – where to start where to end

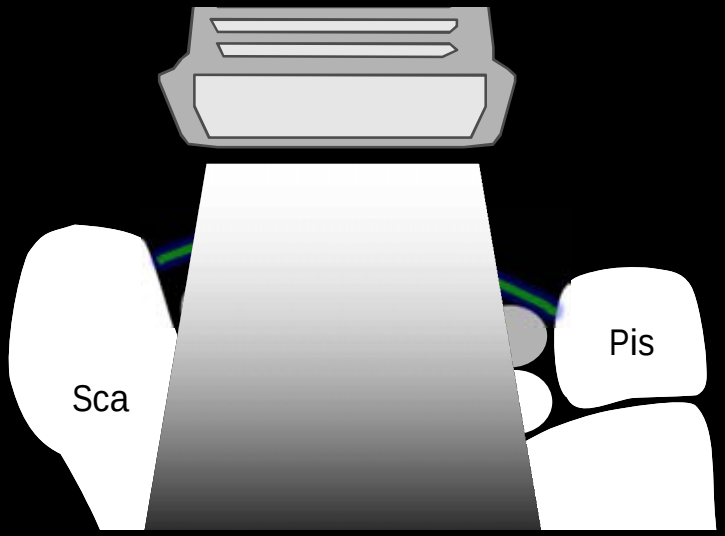
- Compression may occur at a distal site, where the nerve passes below the distal edge of the retinaculum è INVERTED NOTCH SIGN





Scanning Technique – pitfalls

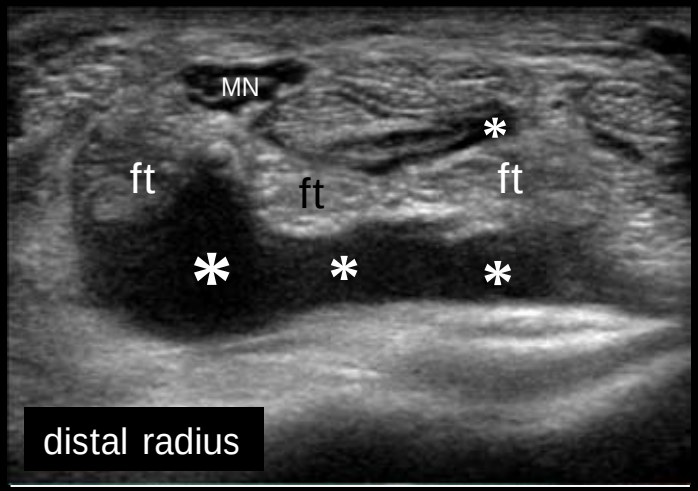
- Don't examine the carpal tunnel with too magnified settings
- The bony floor of the tunnel should be always included in the FOV

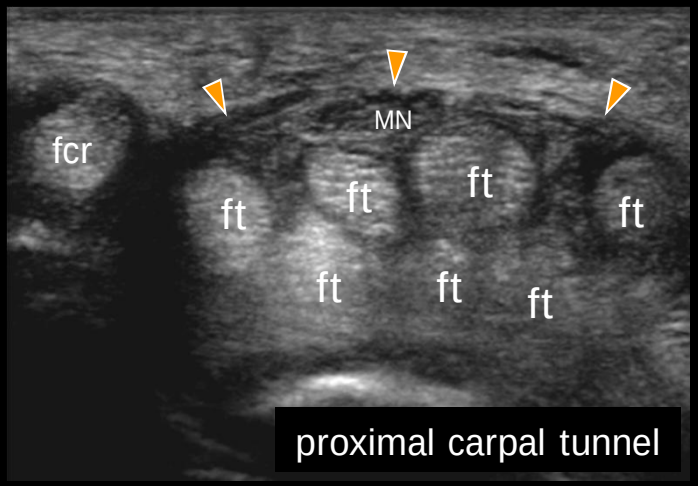


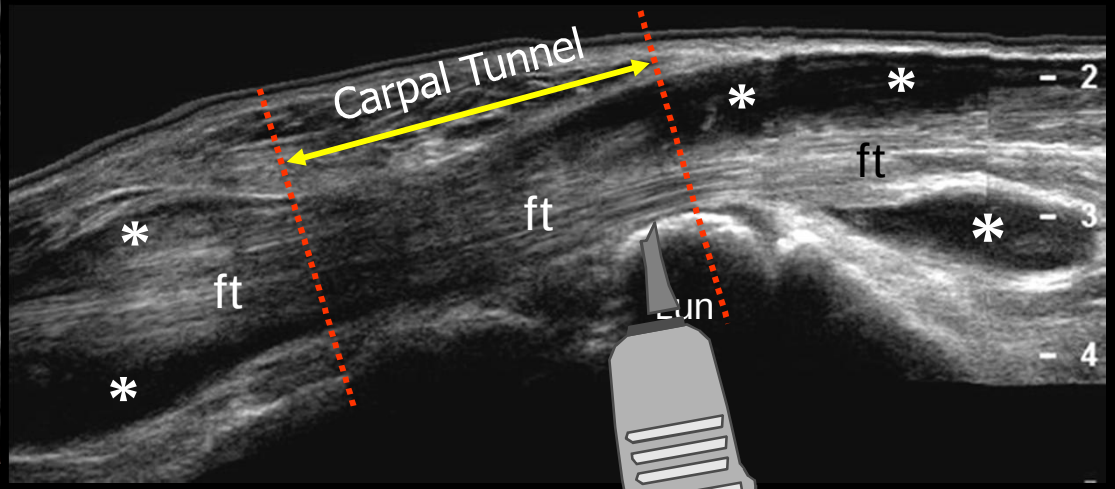
Ganglion Cyst

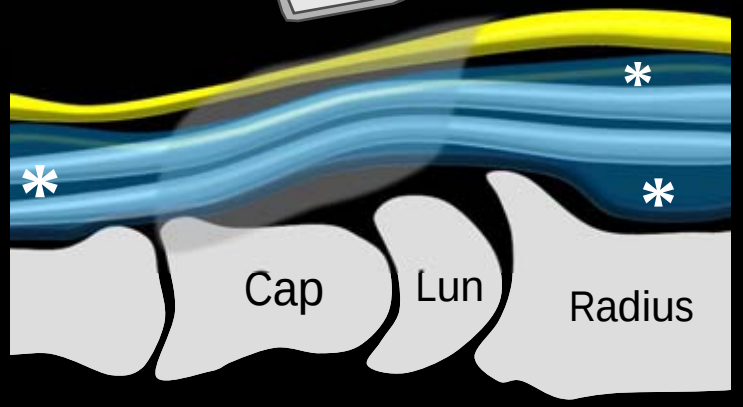
Scanning Technique – where to start where to end

Tenosynovitis of Flexor Tendons







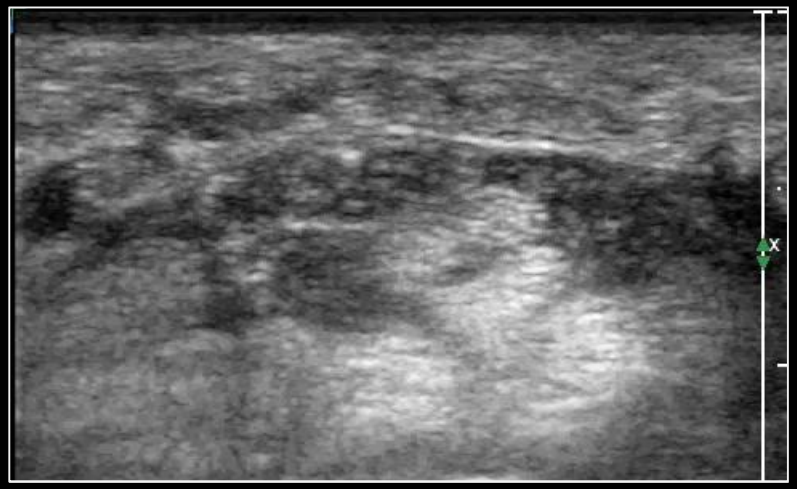


Scanning Technique – flexor tenosynovitis

Tilt the probe to make tendons hyperechoic

- to better distinguish the median nerve from adjacent tendons
- in normal states, flexor tendons are closely packed with absent/minimal hypoechoic rim

Tips & Tricks



Dynamic scanning during finger (index, middle) flexion/extension

- to better distinguish tenosynovitis from muscle extensions onto the tunnel

Nerve Ultrasound

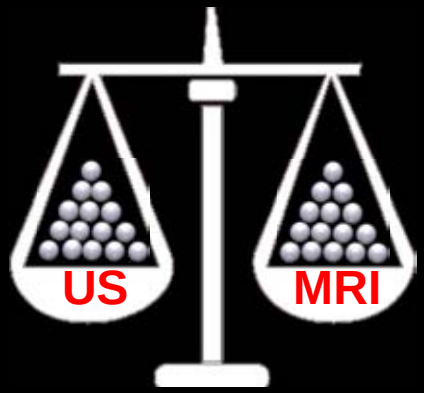
Three main US categories

- Large US-detectable nerves
  - direct nerve evaluation
  - conventional equipment needed
  - quantitative measurements
- Small US-detectable nerves
  - direct nerve evaluation
  - high-end equipment required
  - satellite vessels as landmarks
- Non US-detectable nerves

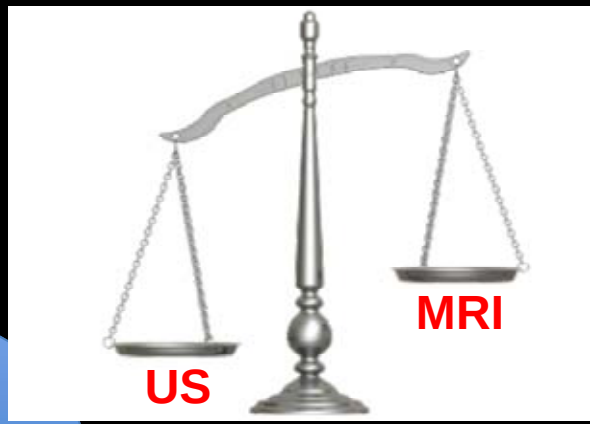
  (too small-size, too deep course, intervening bone)

Brachial Plexus Nerves
Median Nerve
Ulnar Nerve
Radial Nerve

Sciatic Nerve
Femoral Nerve
Tibial Nerve
Peroneal Nerve



Nerve Ultrasound



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Musculocutaneous
Posterior Interosseous
Distal Divisional Branches

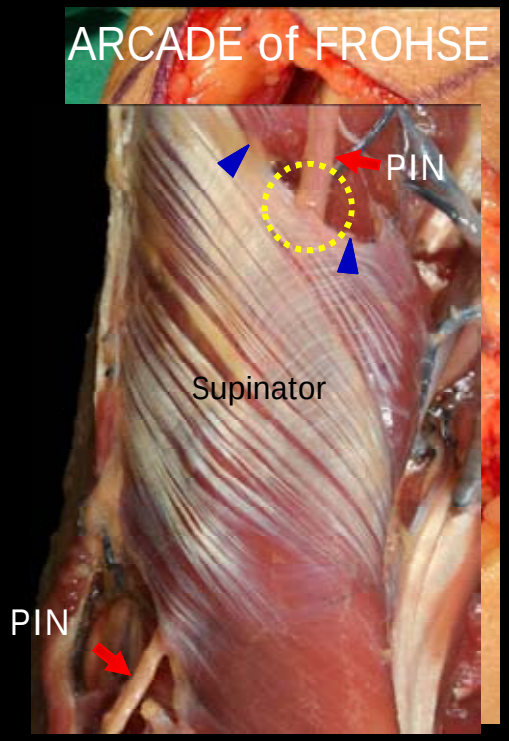
Sural
Interdigital
Superficial Peroneal
Lateral Femoral Cutaneous
Deep Peroneal
Saphenous
Plantar

PI Neuropathy – zone #1

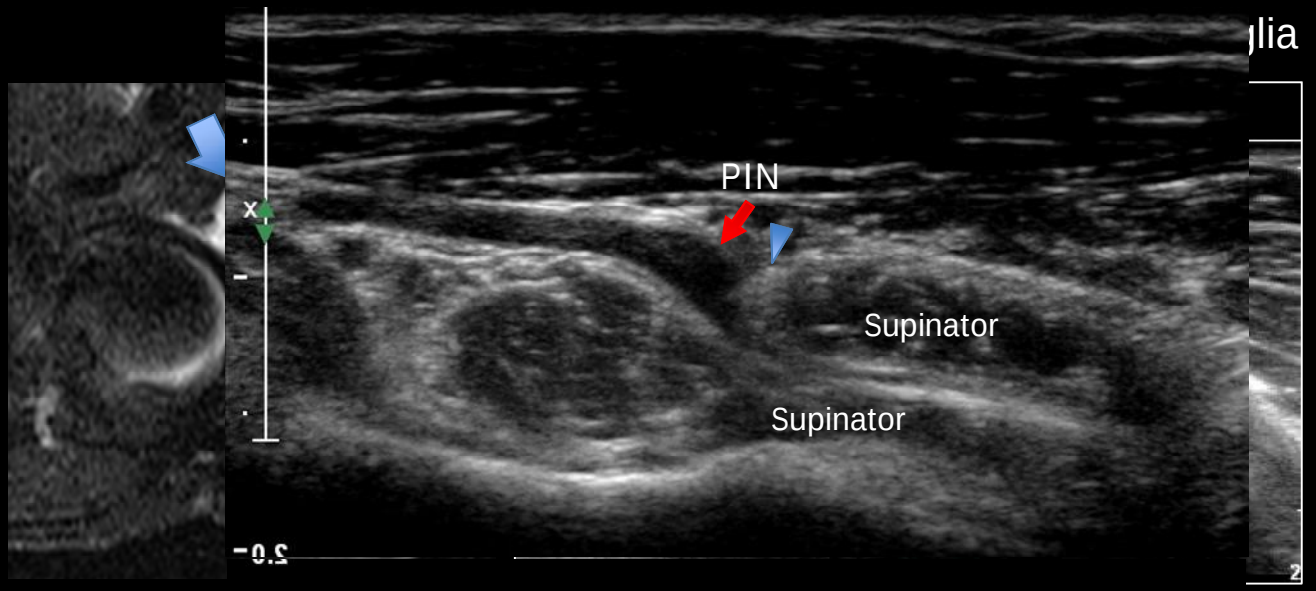
LEASH of HENRY

- arterial branches arising from the recurrent radial artery
- they cross over the PIN just proximal to the arcade of Frohse
- prominent vessels (hypertrophied leash ?}6 vessels) may cause PIN compression

Husarik et al. Radiology 2009

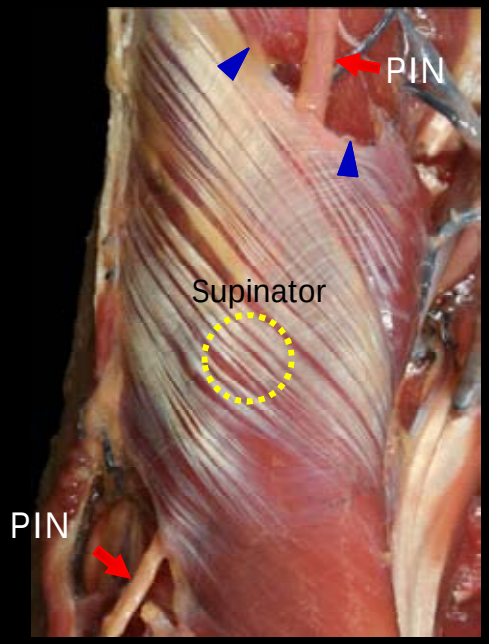


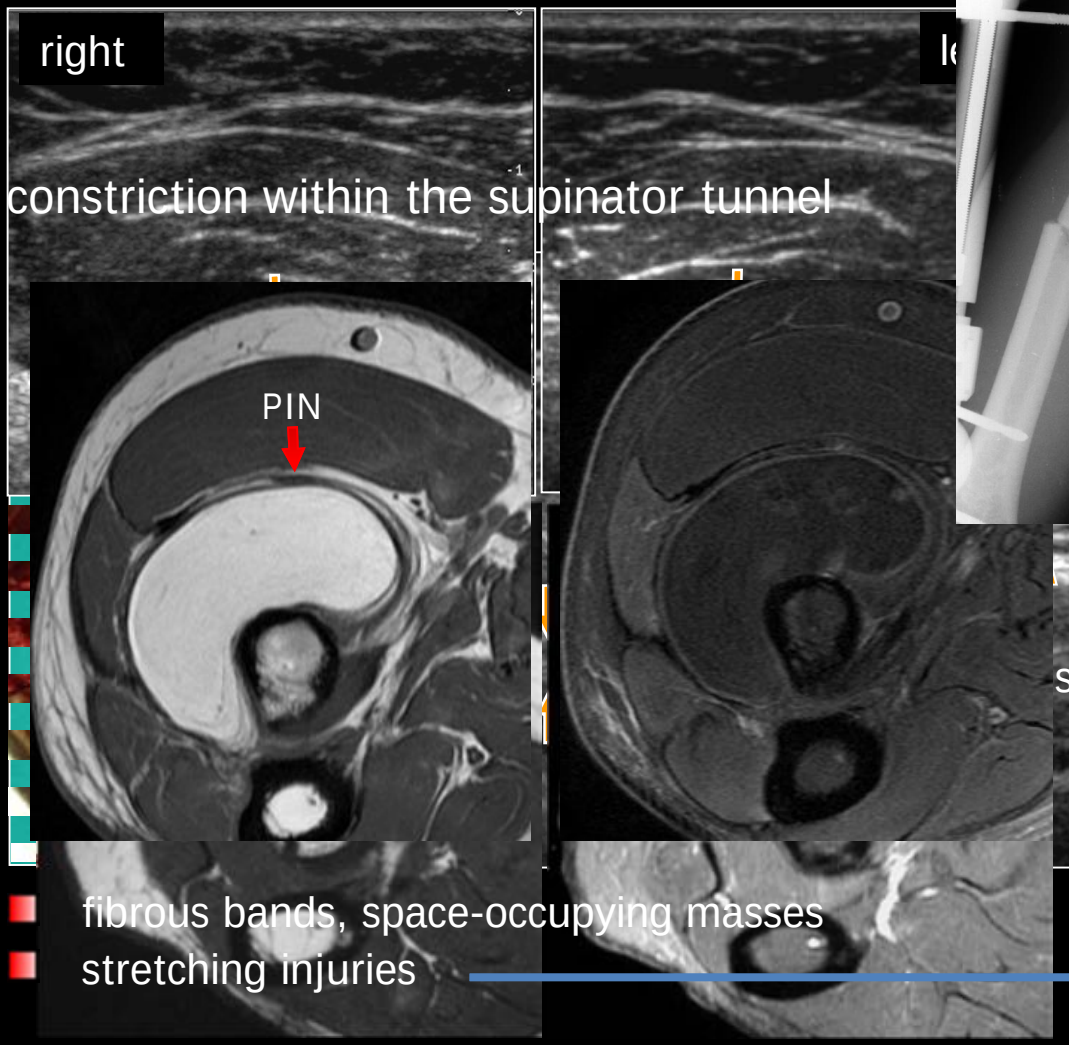
- PIN constriction at the arcade of Frohse



PI Neuropathy – zone #2

- PIN constriction within the supinator tunnel



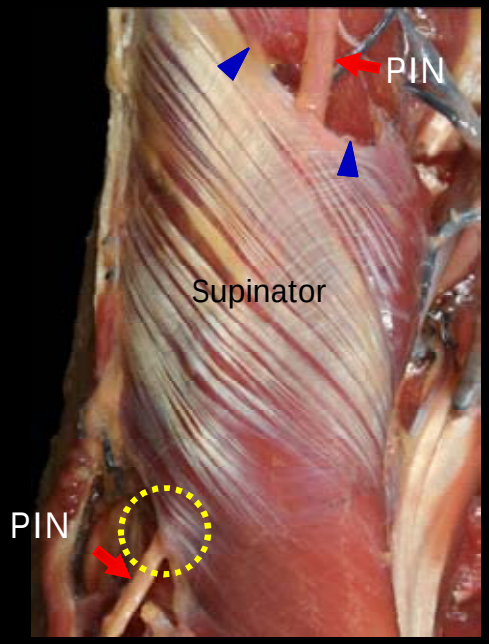


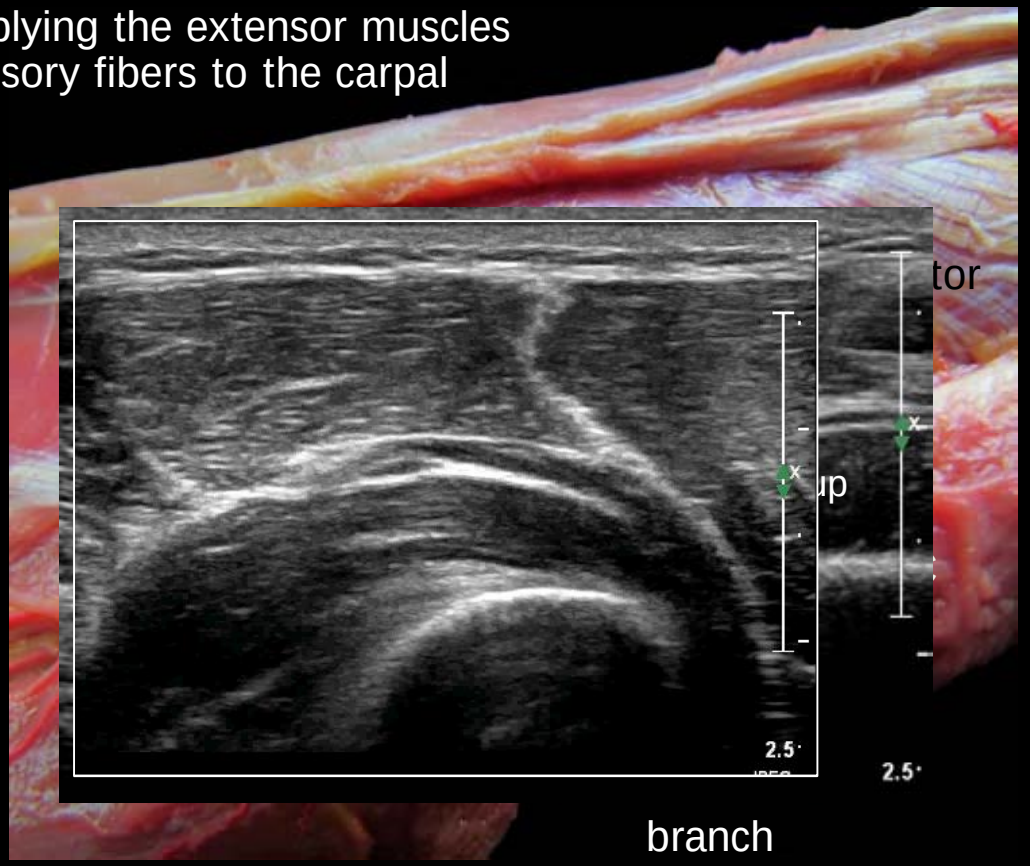
- fibrous bands, space-occupying masses
- stretching injuries

PI Neuropathy – zone #3

ANATOMICAL CONSIDERATIONS

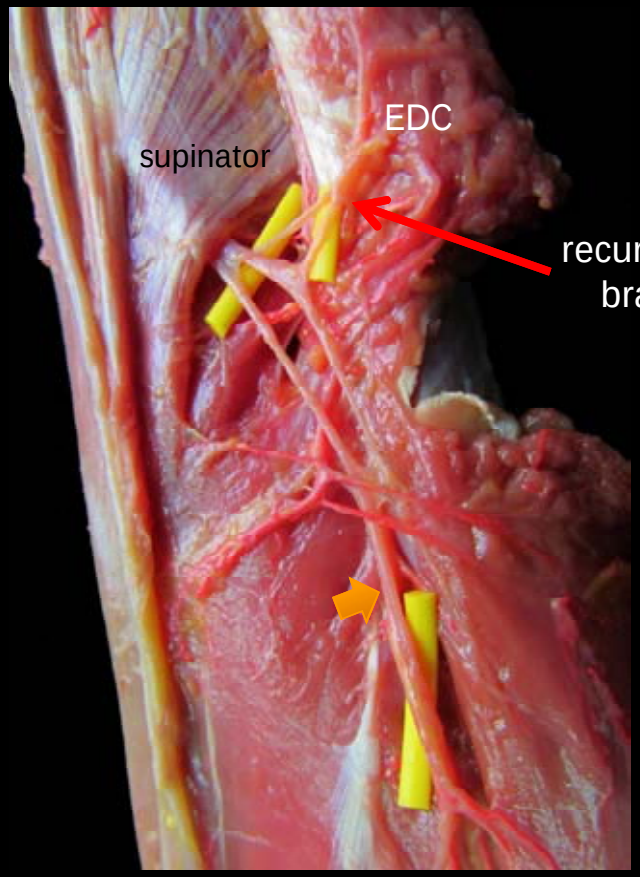
- after exiting the supinator, the PIN sends a recurrent branch for the EDC
- it then descends the forearm supplying the extensor muscles and ends at the wrist sending sensory fibers to the carpal ligaments and joints

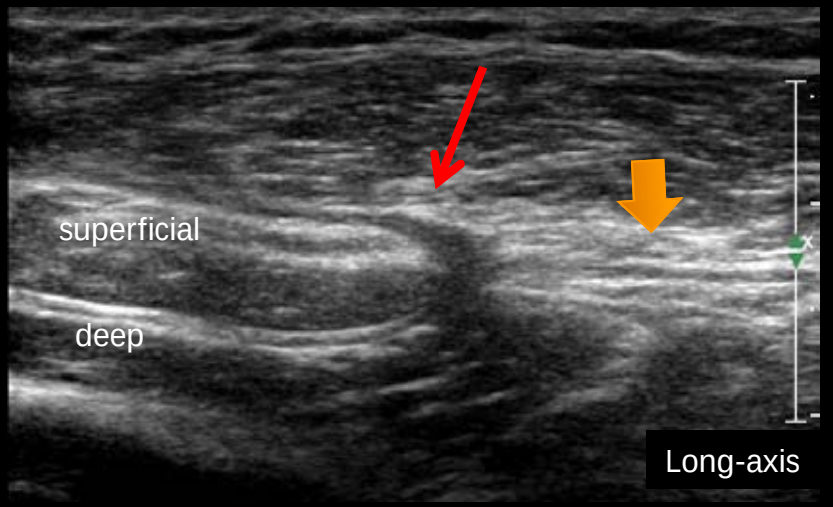


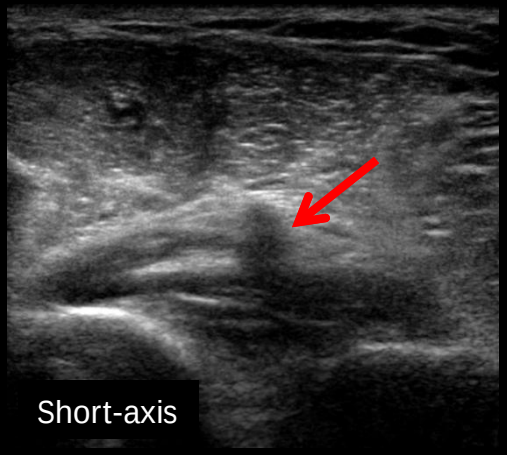


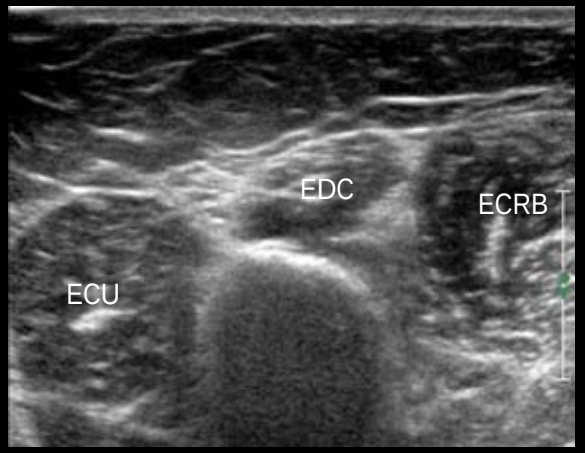
PI Neuropathy – zone #3

- Isolated compression of the recurrent branch

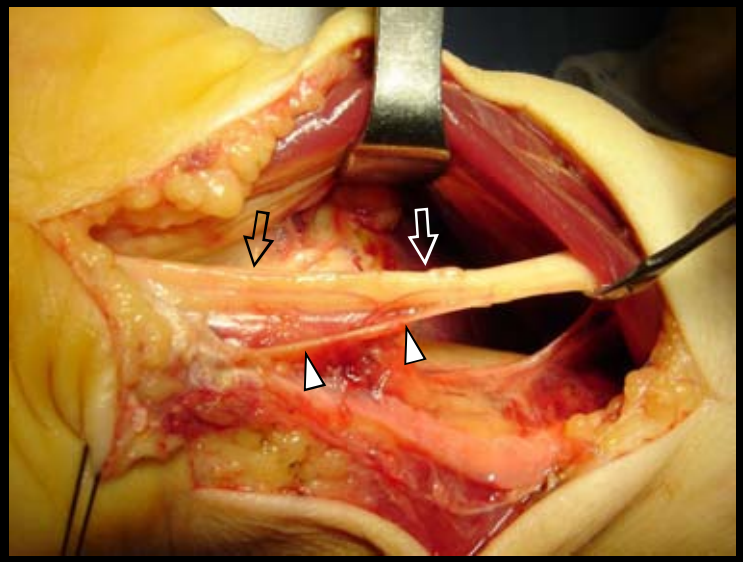




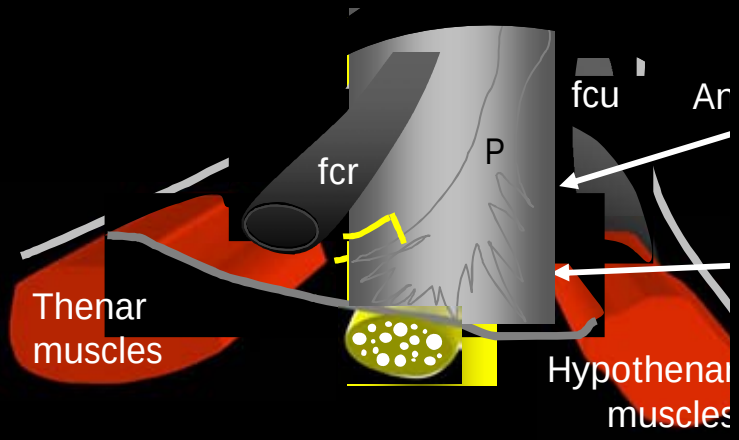


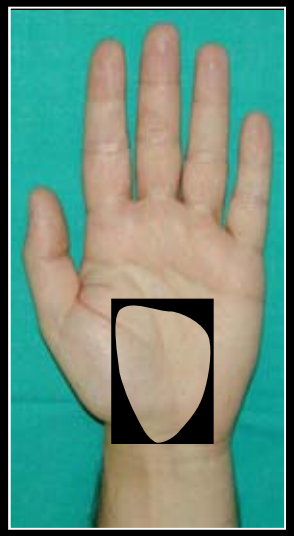


Palmar Cutaneous Branch



- originates from the radial side of the MN about 2-3 inches above the wrist crease
- courses parallel to the MN and then pierces the antebrachial fascia or the retinaculum
- crosses the base of the thenar eminence directly over the tubercle of the scaphoid





Clinical Findings

- numbness and dysesthesia over the thenar aspect of the proximal palm (burning pain Æ neuroma)
- common cause of persistent pain after carpal tunnel release

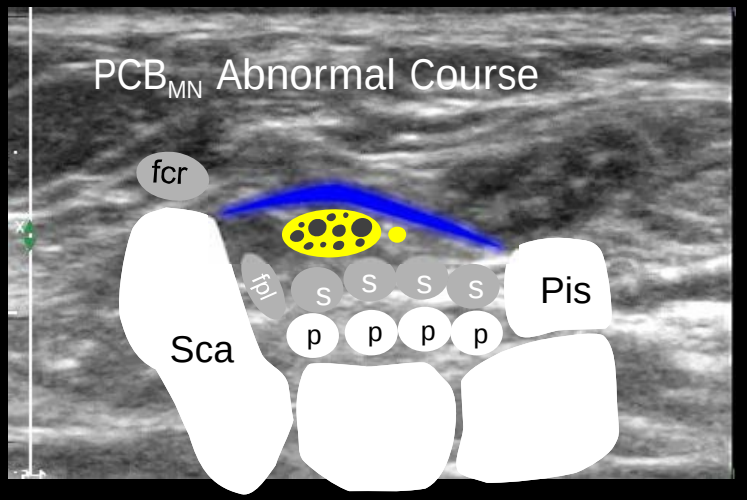
Palmar Cutaneous Branch

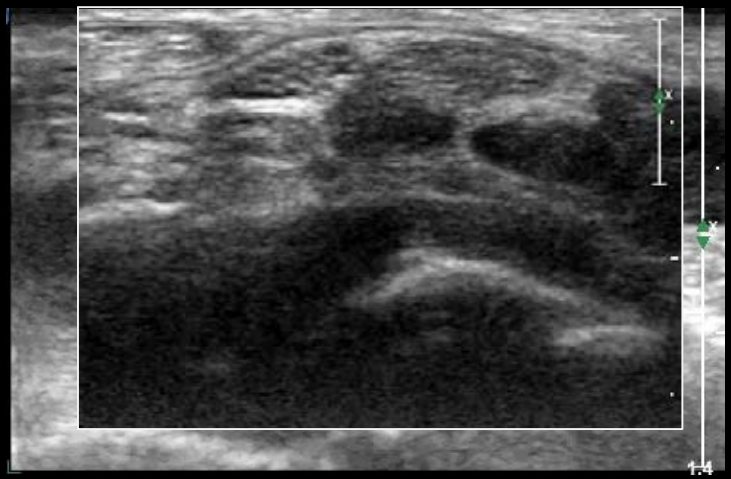
PCB_{MN} Compression Neuropathy

- focal hypoechoic swelling of the nerve as it pierces the antebrachial fascia-flexor retinaculum (PCB tunnel)
- thickened fascia

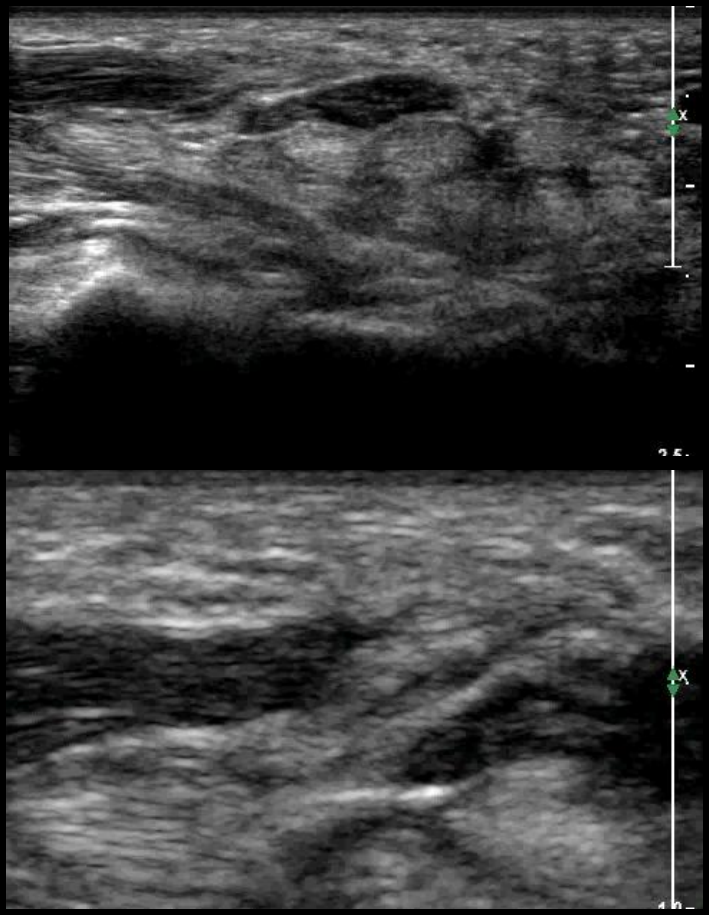
After Carpal Tunnel Release

- too radial-sided surgical access



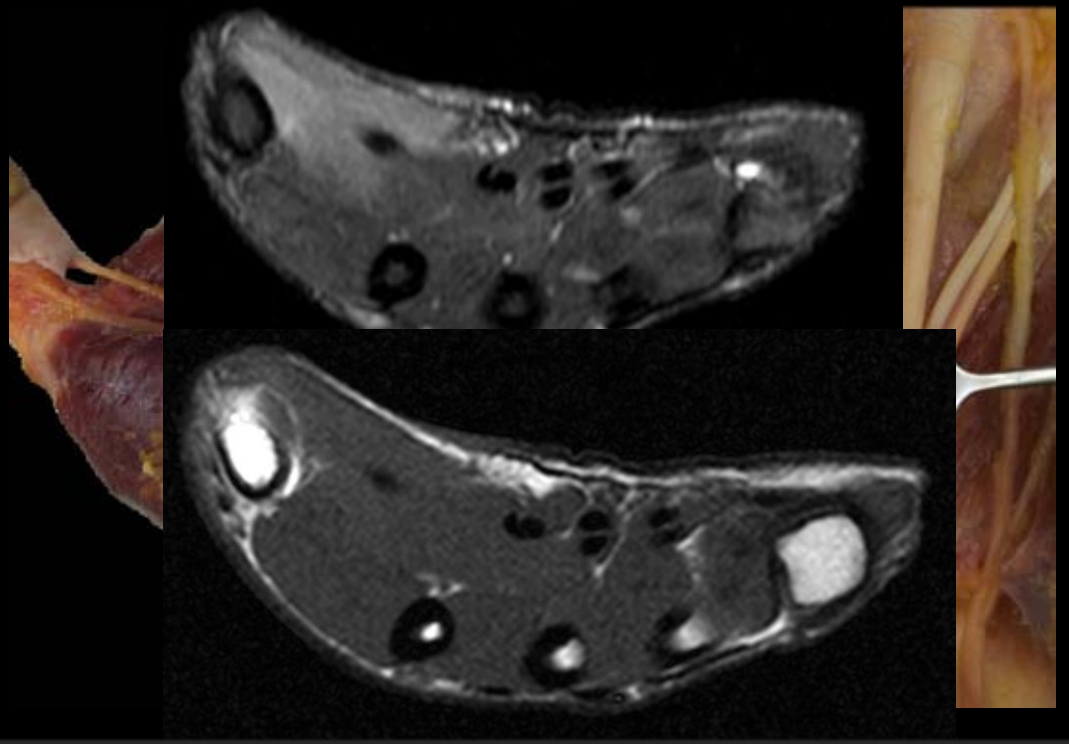


Recurrent Motor Branch Neuropathy



RECURRENT MOTOR BRANCH

- "the million dollar nerve"
- arises from the median nerve distal to the flexor retinaculum (92% of cases, intraligamentous origin in 8%)
- winds around distal border of retinaculum to reach the thena

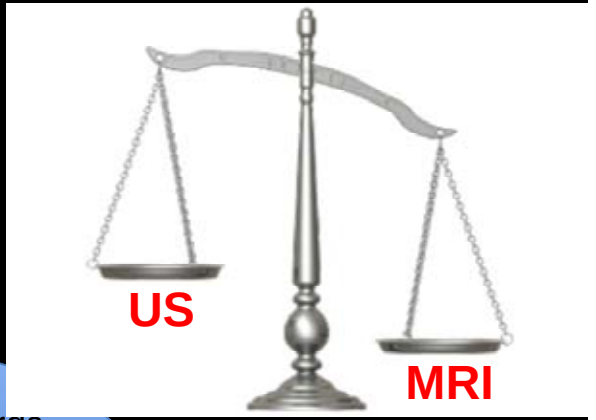


Nerve Ultrasound

Three main US categories

- Large US-detectable nerves
  - direct nerve evaluation
  - conventional equipment needed
  - quantitative measurements
- Small US-detectable nerves
  - direct nerve evaluation
  - high-end equipment required
  - satellite vessels as landmarks
- Non US-detectable nerves

(too small size, too deep course, intervening bone)



Brachial Plexus Cords
(costoclavicular space)
Lumbosacral Plexus
Sciatic & Femoral (intrapelvic)

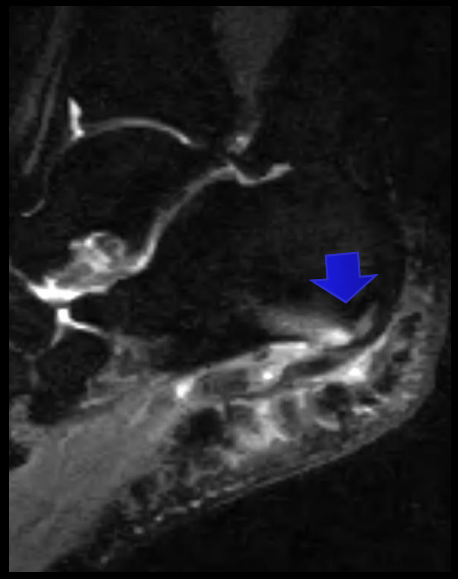
Superior & Inferior Gluteal
Iliohypogastric, Ilioinguinal
Genitofemoral
Deep Peroneal (leg)
Medial & Inferior Calcanear

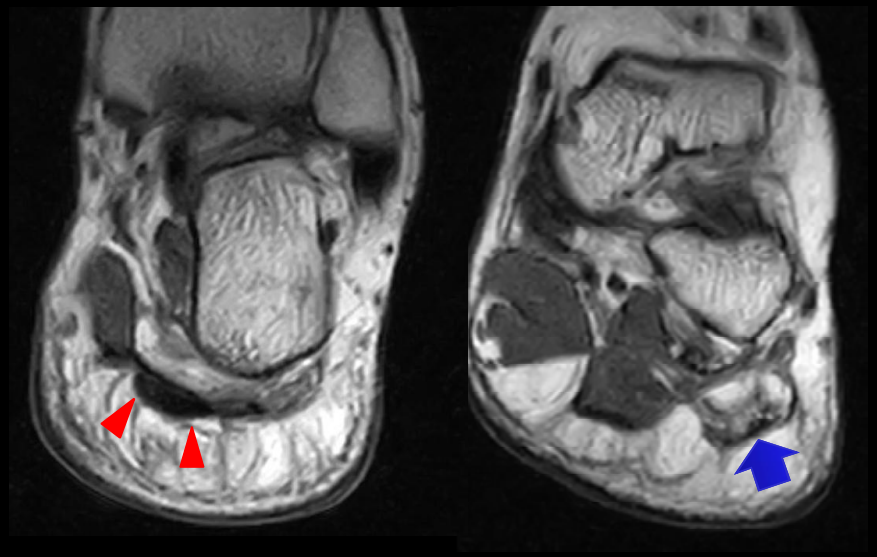
overlooked!

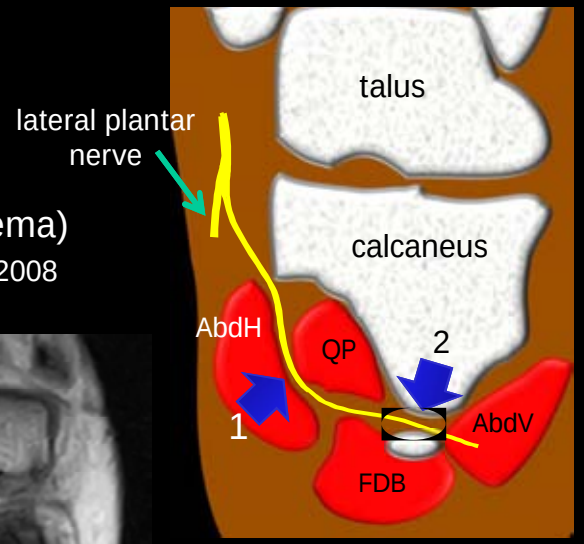
Baxter Neuropathy

- cause of chronic heel pain (up to 20% of cases)
  - more common in females (footwear?)
  - hypertrophied AbdH (runners)
  - hyperpronated foot (flatfoot), obesity
  - microtrauma against a heel spur
  - severe plantar fasciitis (FDB and adjacent soft-tissue edema)

Baxter et al. 1989; Recht et al. 2007; Chundru et al. 2008

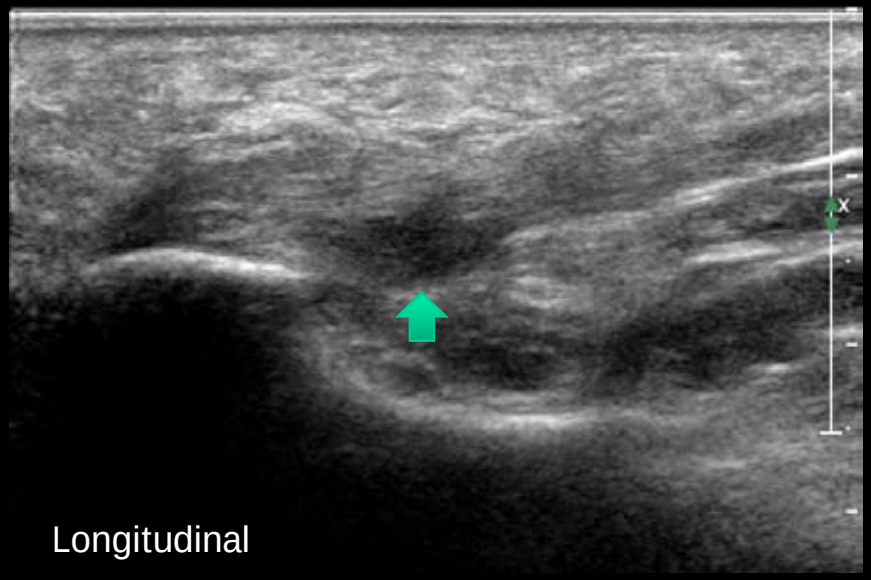




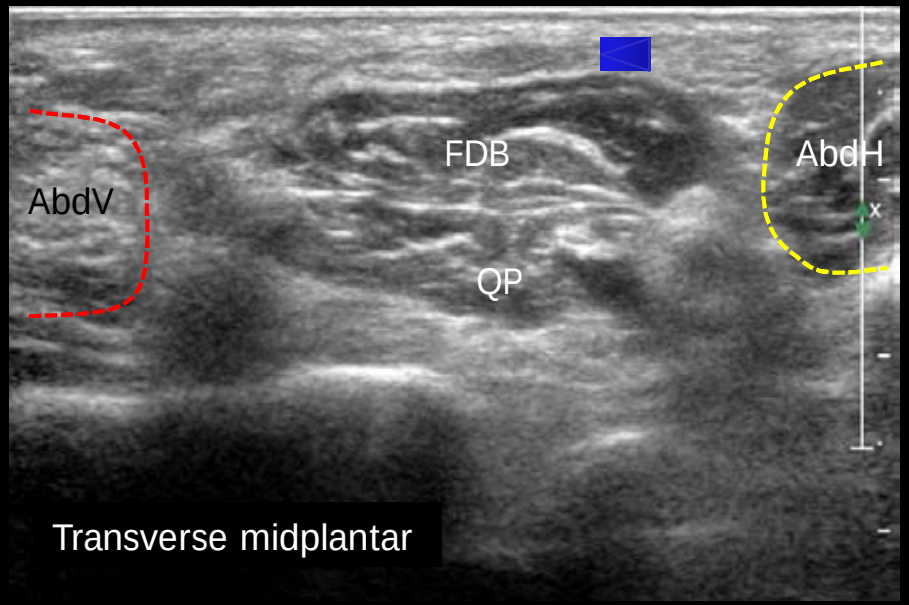


Selective involvement of the AbdV

Baxter Neuropathy



Longitudinal



Transverse midplantar

Conclusion

- The ability of US to depict nerves makes it possible to study nerve abnormalities in a variety of entrapment neuropathies

Main advantages of US over MR imaging

- higher spatial resolution Æ abnormalities of small nerves
- time effectiveness, lower cost, availability
- easy technique of examination
- long nerve segments evaluated in a single study