Hand and Wrist MRI

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Nashville, TN

Disclosure

- No financial conflicts to disclose
- I am married to a Nurse Practitioner
- The views expressed are my own and do not reflect the official policies of the Department of the Army or the Department of Defense
- Primary reference
  - Nancy M. Major MD, Mark W. Anderson MD, Clyde A. Helms MD, Phoebe A. Kaplan MD and Robert Dussault MD. Chapter 12: Wrist and Hand. In: *Musculoskeletal MRI 3rd ed.* Elsevier: 2020: 263-294

Overview

- MRI Technique
- Anatomy
- Bone abnormalities
- Ligament abnormalities
- Tendon and muscle abnormalities
- Nerve abnormalities
- Masses

Technique

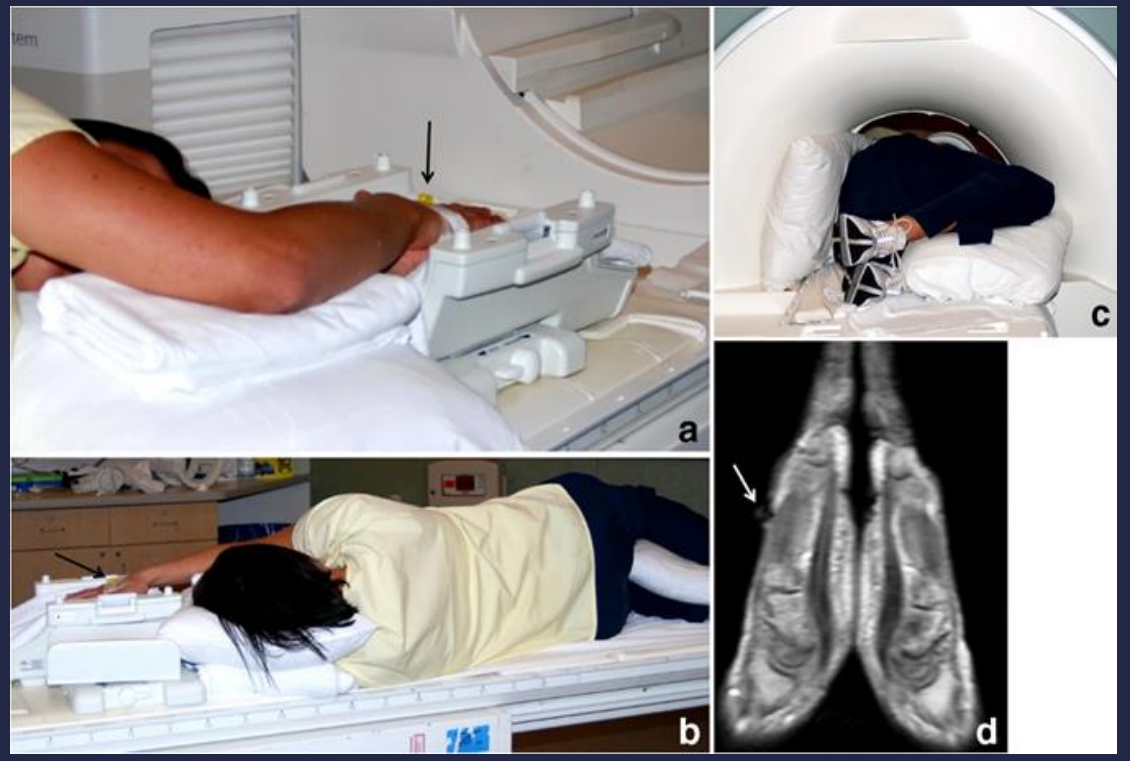
- 3T magnet
- Surface coil, preferably dedicated wrist coil
- Three orthogonal anatomic planes
- Combination of T1 and fat saturated fluid sensitive sequences
  - 3D and GRE sequences good for ligament and cartilage
- Wrist FOV to include distal radius/ulna through metacarpal bases
- Hand/finger FOV focused on region of interest

Technique

- Supine if possible, prone if necessary
- Goal is to have wrist near the isocenter of the magnet

Technique

- IV contrast for mass/infection
- Inflammatory arthritis
  - “prayer hands” (just imaging the more symptomatic side may be better)
  - +/- IV contrast
- Limited “trauma” protocol to r/o scaphoid fracture



MRI Arthrogram

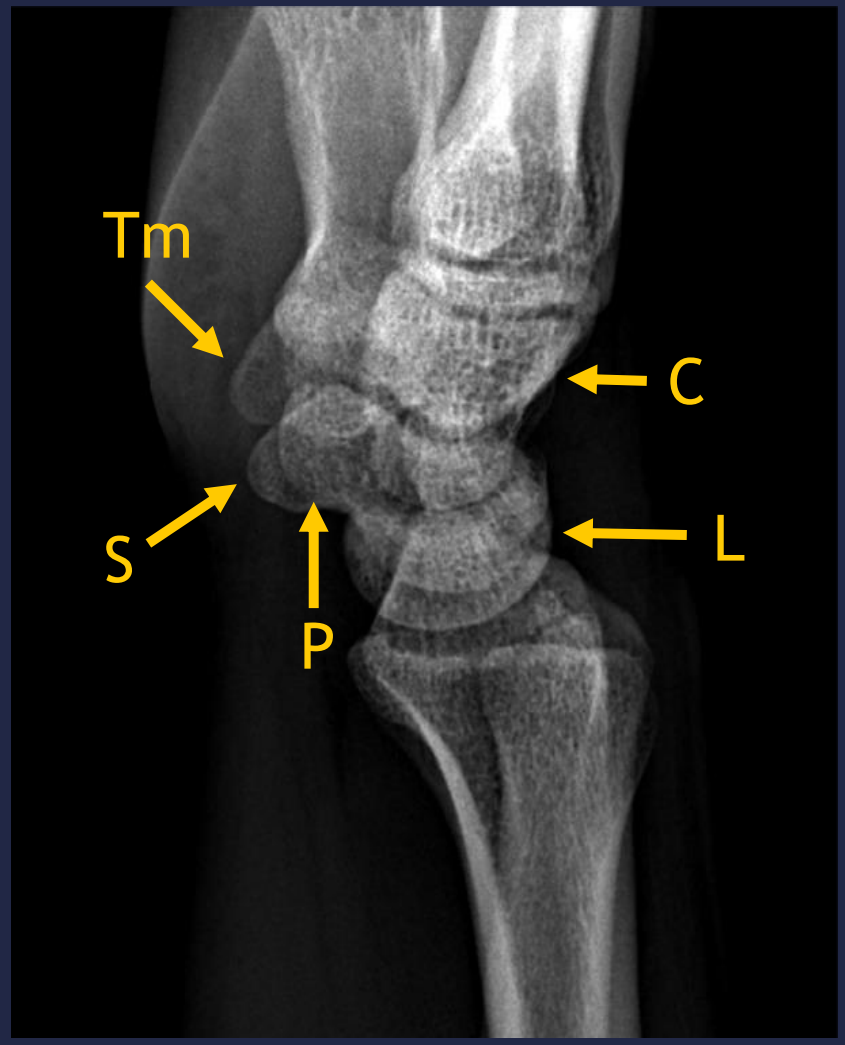
- Advantages
  - Can assess TFC, SL, and LT ligament tears
  - Shows better distention of the joint capsule to detect extrinsic ligament pathology

- Limitations
  - Invasive compared with routine MRI
  - Requires extra time and labor minutes per procedure
  - Must coordinate availability of fluoroscopic unit with that of MR scanner
  - Uses ionizing radiation
  - Potential for infection and allergy to anesthetic or contrast agent
  - Risk of artifact: bubbles, extra-articular contrast

Morcos Morcos, Dylan C. Kwait, Natalia Marks and Sana Ali. Chapter 13: Normal Wrist. In: *Musculoskeletal Imaging* 2nd ed. Saunders/Elsevier; 2015:169-182.e2

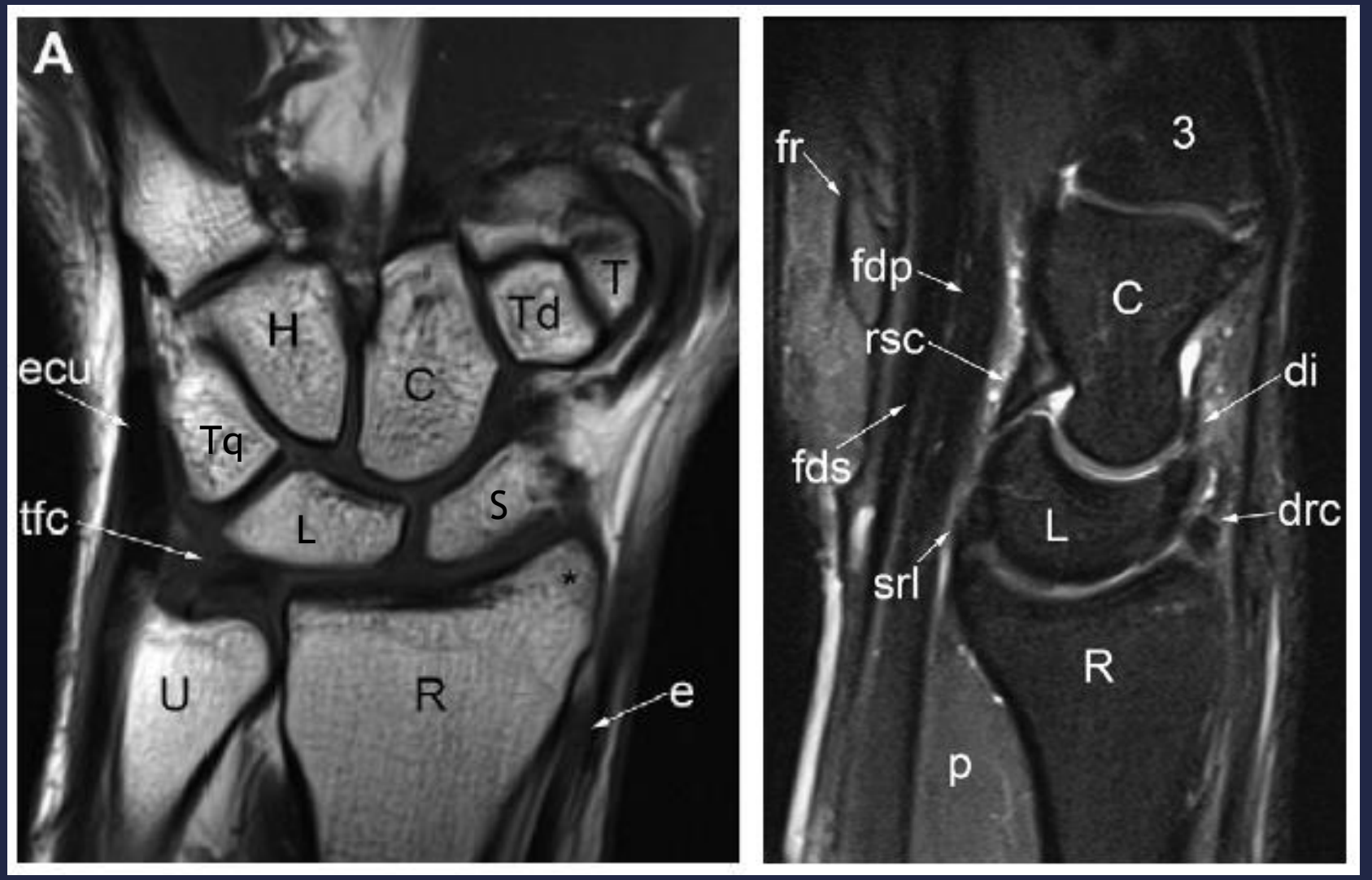
Anatomy

- Scaphoid (S)
- Lunate (L)
- Triquetrum (Tq)
- Pisiform (P)
- Hamate (H)
- Capitate (C)
- Trapezoid (Td)
- Trapezium (Tm)
- Radius (R)
- Ulna (U)
- Metacarpals (*)



Anatomy

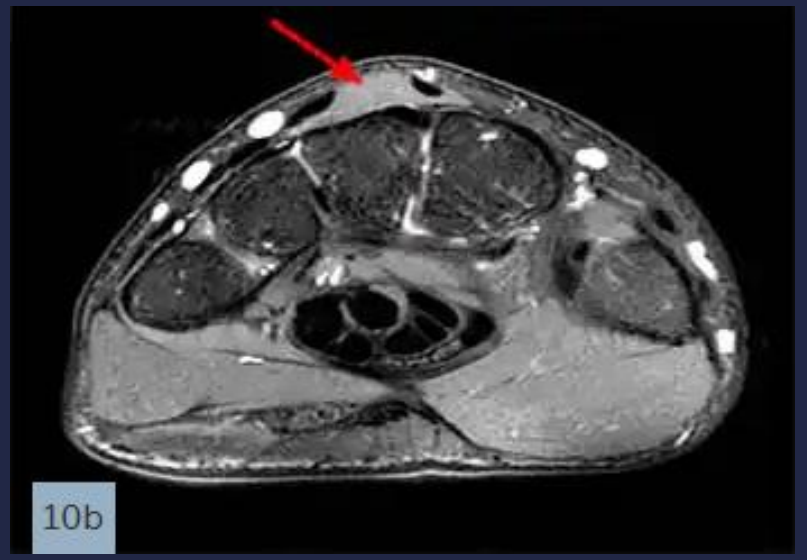
- Extensor pollicis brevis (e)
- Dorsal intercarpal lig. (di)
- Dorsal radiocarpal lig. (drc)
- Radioscaphocapitate lig. (rsc)
- Short radiolunate lig. (srl)
- Flexor retinaculum (fr)
- Flexor digitorum superficialis (fds)
- Flexor digitorum profundus (fdp)
- Pronator quadratus muscle (p)



Stein JM et al. Normal and Variant Anatomy of the Wrist and Hand on MR Imaging. Magn Reson Imaging Clin N Am 19 (2011) 595-608

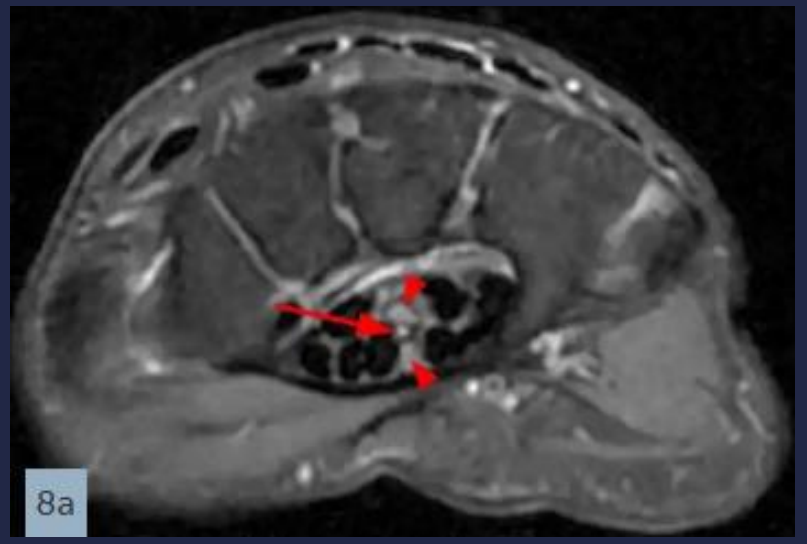
Anatomy

- Normal variants - many
  - Extenson digitorum manus brevis
    - Can simulate a mass or cyst on physical exam
    - Muscle bellies of the extensor tendons should not extend to the carpal bones



https://radsource.us/accessory-muscles-of-the-hand-and-wrist/

  - Bifid or high division of the median nerve (arrowheads), usually associated with a persistent median artery (arrow) between the two nerve trunks
    - Normal variant seen in 15% of the asymptomatic population

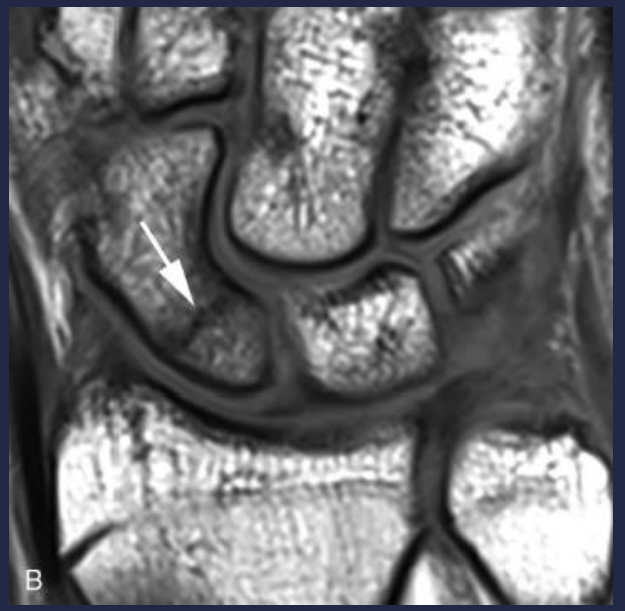


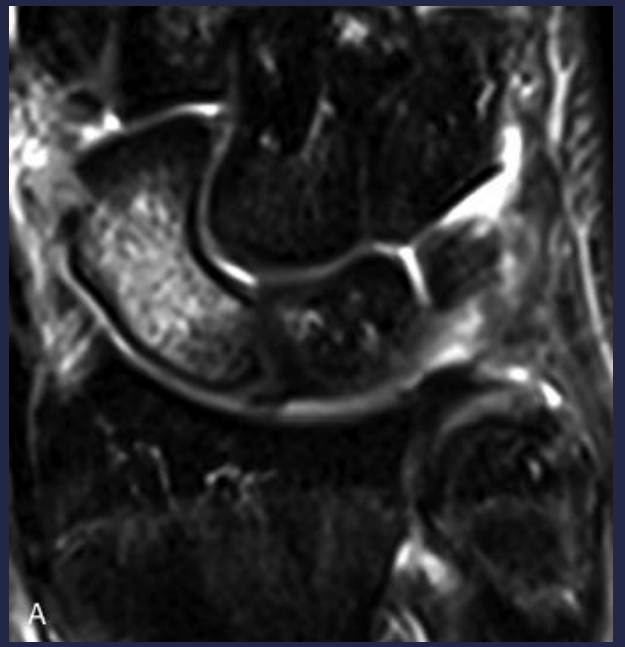
https://radsource.us/persistent-median-artery/

Bone abnormalities

- Fracture
  - Bone marrow edema
    - Bright signal on fluid sensitive sequence (T2FS, STIR, etc…)
  - Fracture line
    - Linear dark signal on T1 weighted sequence
  - Scaphoid
    - 70% of all carpal fx's
    - 16% of scaphoid fx's occult on initial radiographs

	Sensitivity	Specificity
MRI	94.2	97.7
CT	81.5	96.0
US	81.5	77.4

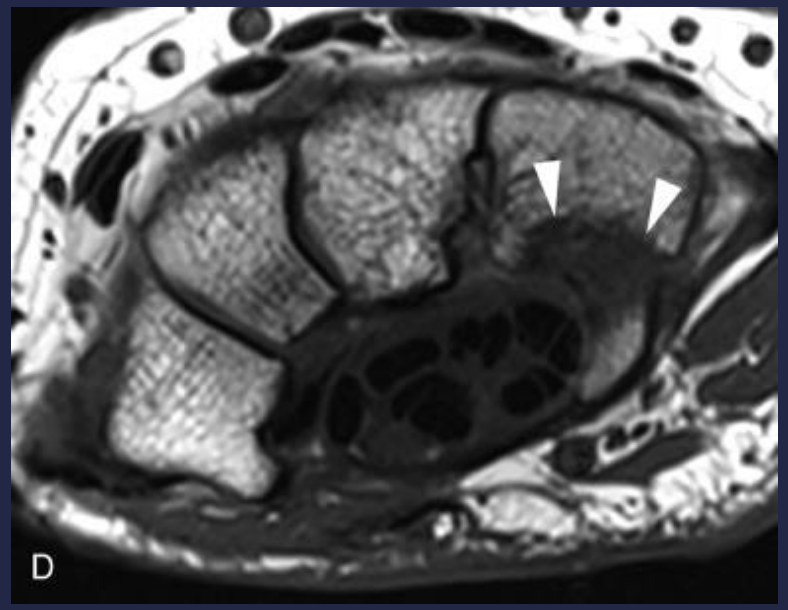


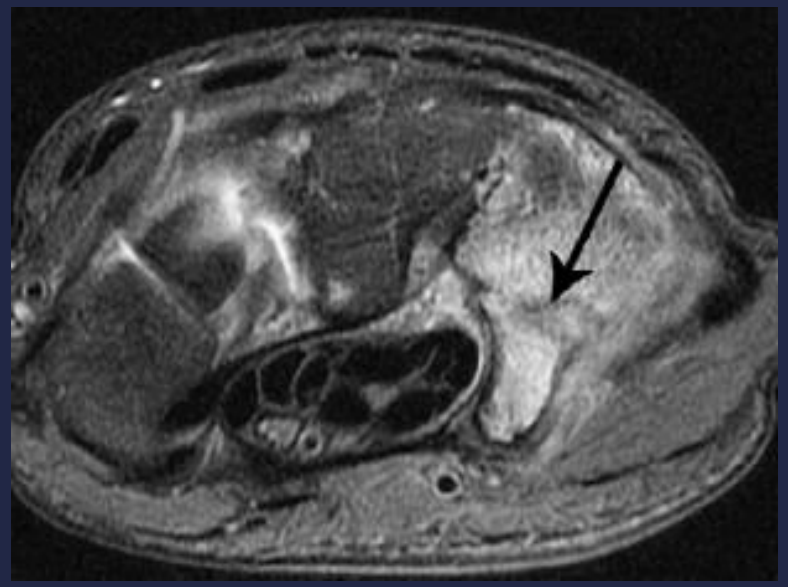


Bäcker HC, Wu CH, Strauch RJ. Systematic Review of Diagnosis of Clinically Suspected Scaphoid Fractures. J Wrist Surg. 2020 Feb;9(1):81-89. doi: 10.1055/s-0039-1693147. Epub 2019 Jul 21.

Bone abnormalities

- Fracture
  - Hook of hamate
    - 2-4% of carpal fractures
    - More common in athletes – sports with bats, clubs, racquets, etc.





Lisle DA, et al. MR Imaging of Traumatic and Overuse Injuries of the Wrist and Hand in Athletes. Magn Reson Imaging Clin N Am 17 (2009) 639-654

Bone abnormalities

- Osteonecrosis
  - Proximal pole scaphoid after fracture
    - Distal to proximal blood supply
  - Lunate (Kienböck's Disease)
    - Associated with ulnar negative variance
    - Many patient's involved in manual labor
  - Low signal on T1 and T2
  - Articular surface collapse

Arnaiz J, Piedra T, Cerezal L, Ward J, Thompson A, Vidal J, and Canga A. Imaging of Kienbock's Disease. American Journal of Roentgenology 2014 203:1, 131-139

Bone abnormalities

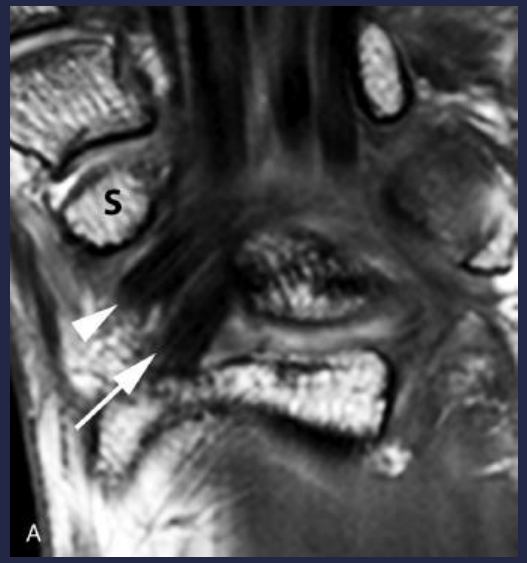
- Robert Kienböck 1871-1953
  - Austrian Radiologist
  - Early father of Radiology
  - Only publication in English is 1910 article “Concerning Traumatic Malacia of the Lunate and its Consequences”
  - Also in 1910…
    - Fell off a horse, got kicked by horse - open basilar skull fracture with hearing loss and personality changes
    - “outspoken cheerful man who loved sports and the outdoors into a quiet, secluded scholar.”

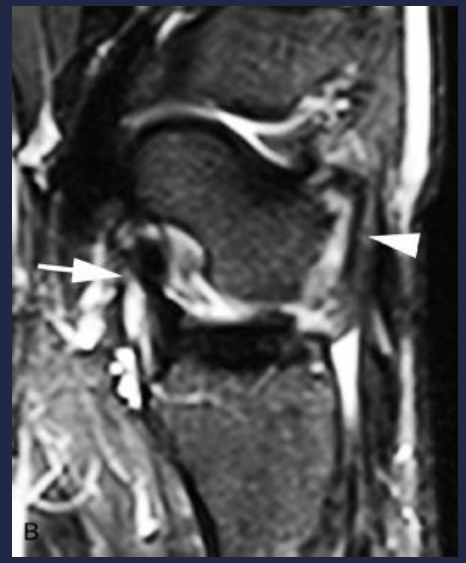
A Historical Report on Robert Kienböck (1871–1953) and Kienböck’s Disease

Jared P. Wagner, BS, Kevin C. Chung, MD, *Ann Arbor, MI*

Ligament abnormalities

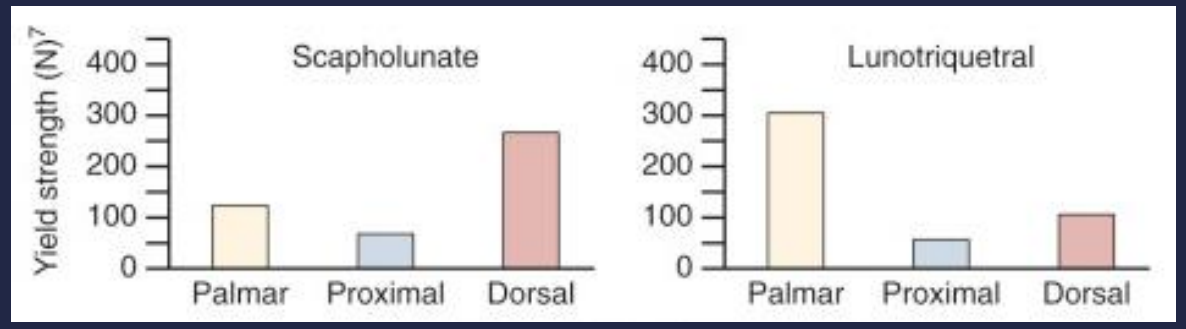
- Intrinsic carpal ligaments
  - Connect carpal bones to one another
  - Scapholunate
  - Lunotriquetral
- Extrinsic carpal ligaments
  - Connect the carpal bones to the wrist
  - Thickened portions of joint capsule
  - Volar (major stabilizers, thicker)
    - Radioscaphocapitate
    - Radiolunotriquetral (aka long radiolunate)
  - Dorsal
    - Dorsal radiocarpal ligament
    - Dorsal intercarpal ligament

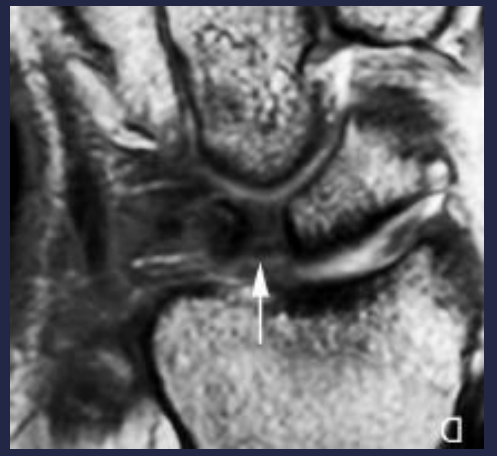


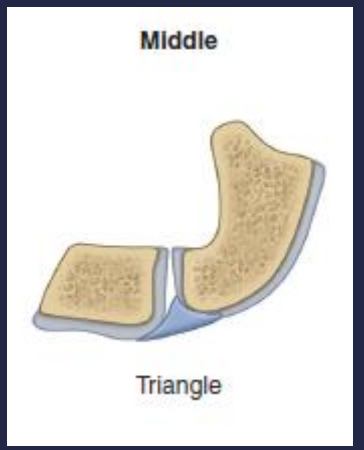


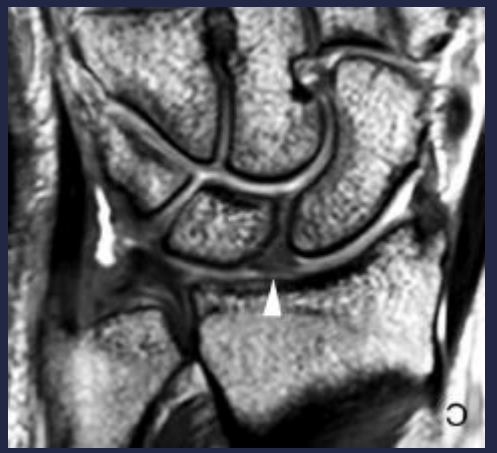
Ligament abnormalities

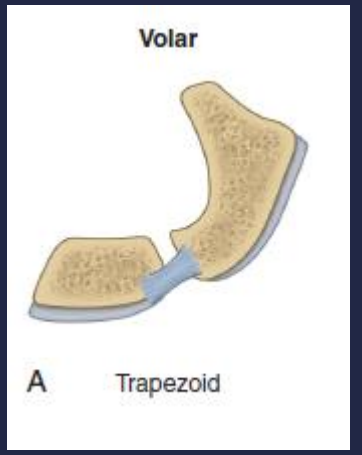
- Scapholunate ligament
  - Three distinct portions
    - Dorsal
    - Middle
    - Volar
  - Volar and middle portions may have higher signal due to less compact collagen
  - Dorsal is thickest and most important for wrist stability

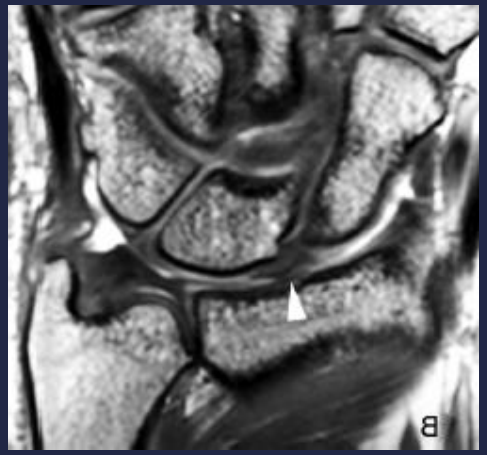










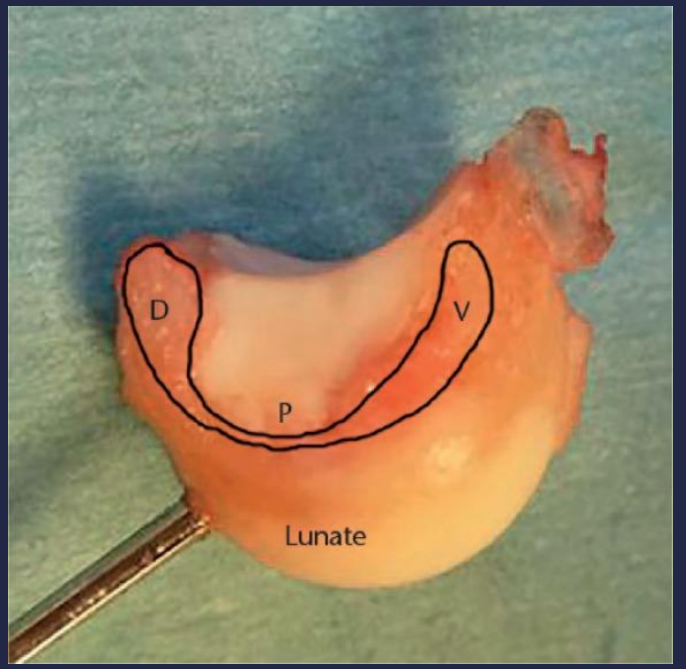


Marc Garcia-Elias and Alberto L. Lluch. Chapter 13: Wrist Instabilities, Misalignments, and Dislocations. In: *Green's Operative Hand Surgery*, 7th ed. Elsevier; 2017:418-478

Ligament abnormalities

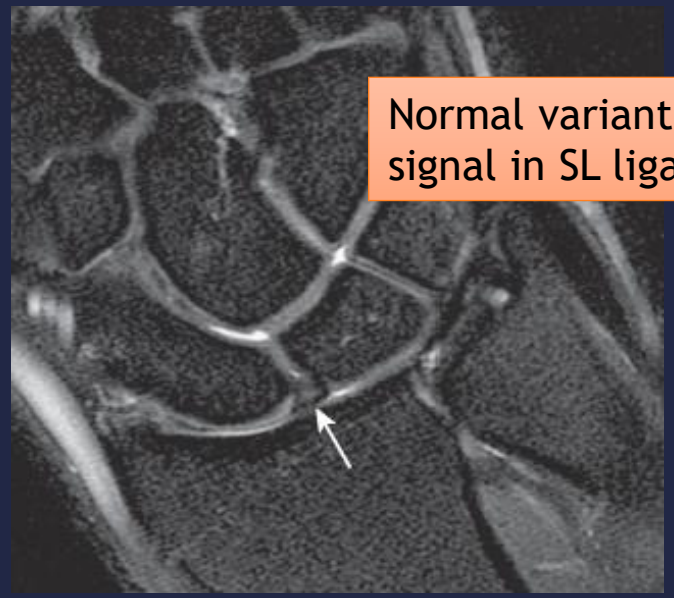
- Scapholunate ligament
  - Small perforations in middle portion are common
  - Disruption can lead to instability, SLAC wrist, arthritis

  - Tears of the intrinsic ligaments alone are usually not sufficient to produce instability
  - Carpal instability is usually related to combined tears of intrinsic and extrinsic ligaments

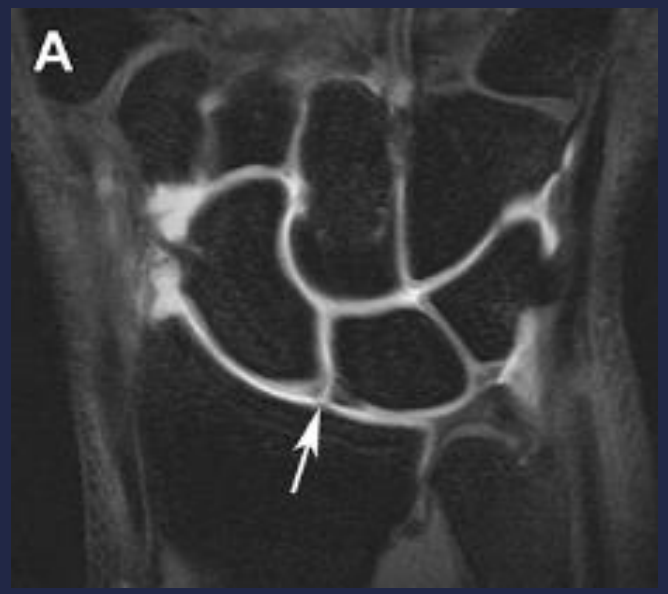


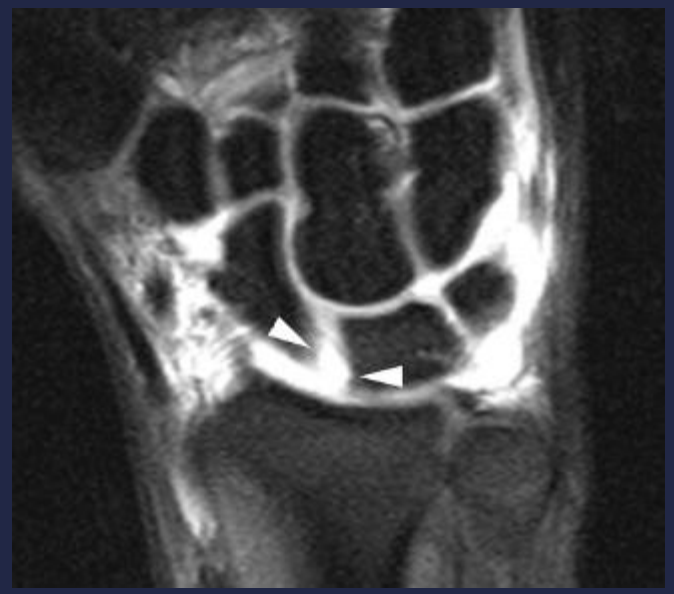
Ligament abnormalities

- Scapholunate ligament
  - Conventional MRI
    - Sensitivity 52 – 65%
    - Specificity 34 – 100%
  - MR Arthrography
    - Sensitivity 85 – 90%
    - Specificity 87 – 96%
    - Up to 100% Sn/Sp with 3T



Normal variant increased signal in SL ligament – no tear

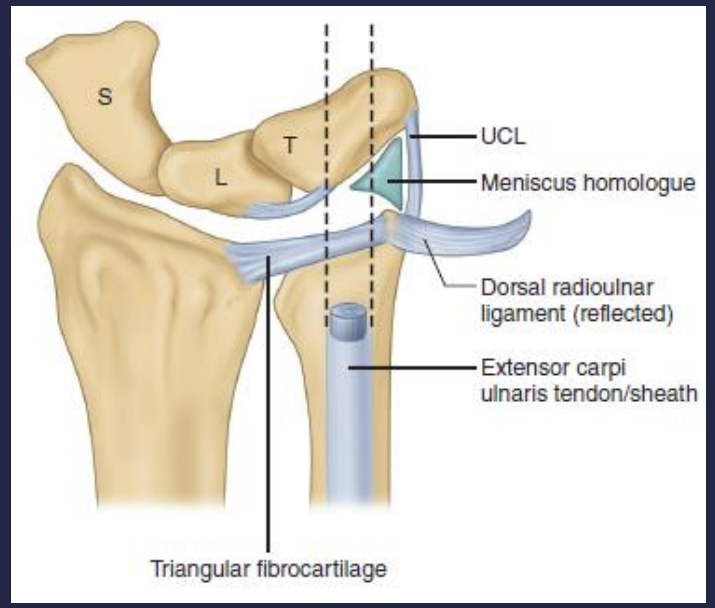




LiMarzi G, et al. Magnetic Resonance Arthrography of the Wrist and Elbow. Magn Reson Imaging Clin N Am 23 (2015) 441-455

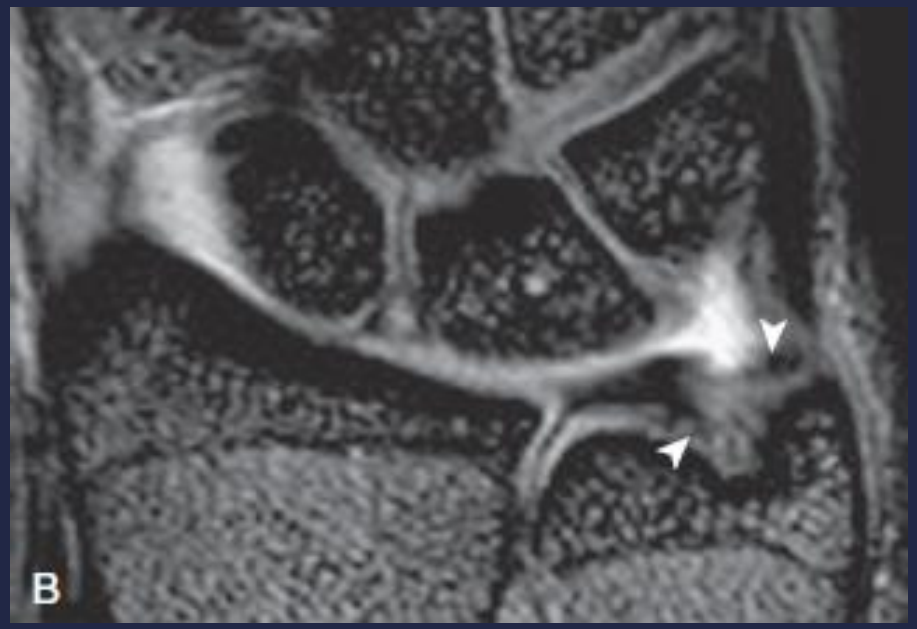
Ligament abnormalities

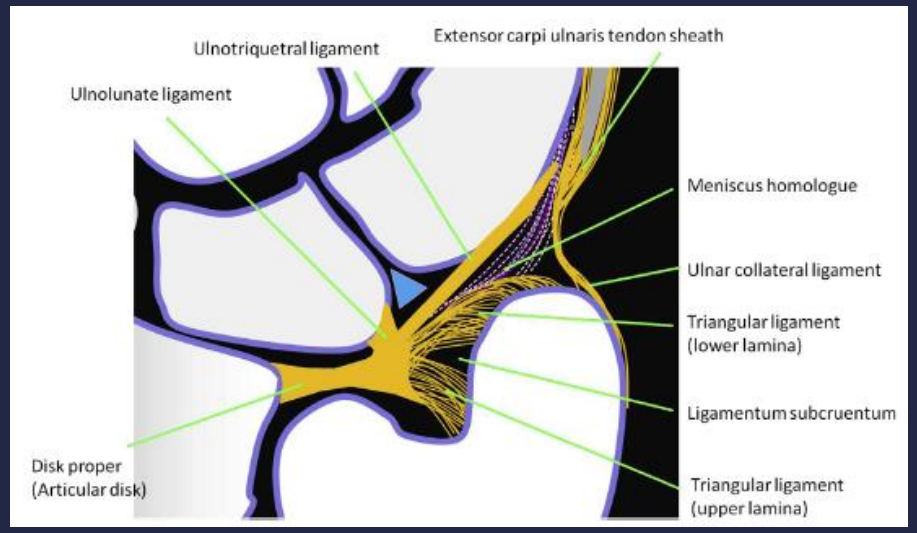
- Triangular fibrocartilage complex (TFCC)
  - Components
    - Triangular fibrocartilage
    - Radioulnar ligaments (dorsal and volar)
    - Extensor carpi ulnaris tendon sheath
    - Ulnar collateral ligament
    - Meniscus homologue
  - Function
    - Absorbs axial loading forces (20% pass through ulnar side of wrist)
    - Stabilizes ulnar side of wrist and distal radioulnar joint



Ligament abnormalities

- Triangular fibrocartilage
  - Fibrocartilaginous biconcave disk
  - Attachments
    - Radial side
      - Articular cartilage of distal radius
    - Ulnar side
      - Styloid
      - Fovea
      - Ligamentum subcruentum





Cody ME, et al. MR Imaging of the Triangular Fibrocartilage Complex. Magn Reson Imaging Clin N Am 23 (2015) 393-403

Ligament abnormalities

- Triangular fibrocartilage tears
  - Radial sided tear
    - Less likely to heal, may require surgery
    - High MRI accuracy
  - Ulnar sided (peripheral) tear
    - More likely to heal
    - Harder to diagnose
    - MRA may help
  - Degenerative tear
    - Older patients

Ligament abnormalities

- Ulnar collateral ligament of the thumb injury (Gamekeeper/Skiier's Thumb)
  - Forced abduction of 1st MCP joint
  - Avulsion fx at ulnar base of proximal phalanx (1/3 of cases)
  - Ligmentous injury only (2/3 of cases)

Ligament abnormalities

- Non-displaced tear
  - Ligament discontinuity, typically near distal attachment

Normal UCL

Non-displaced tear

Vassa R, Garg A, Omar IM. Magnetic resonance imaging of the wrist and hand. Pol J Radiol 2020; 85: e461-e488

Ligament abnormalities

- Displaced tear - UCL fragment can become retracted or folded on to itself
  - Stener lesion
  - “Ball on a string” or “yo-yo”
  - Dynamic US may aid in diagnosis

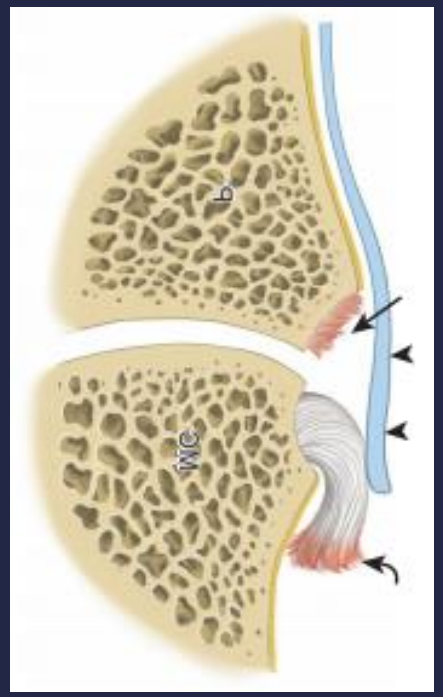


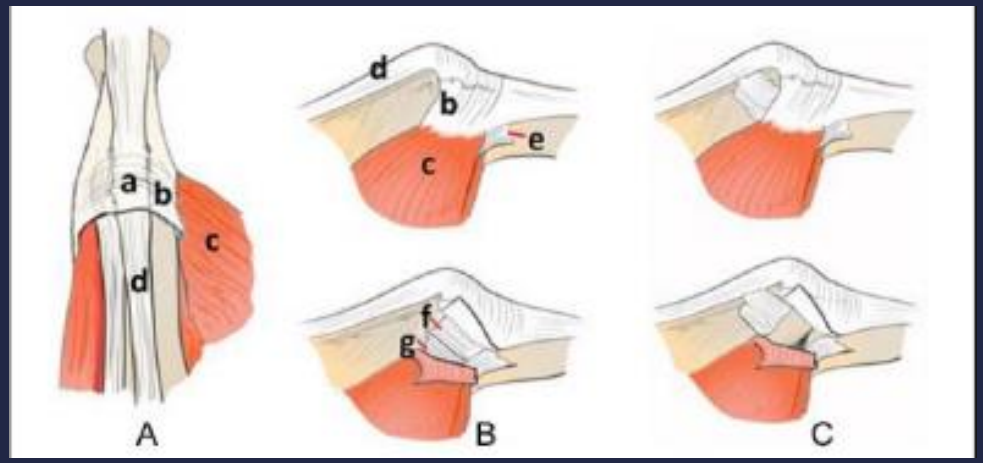
Table 1
Classification of UCL injury based on ligament appearance on MR imaging

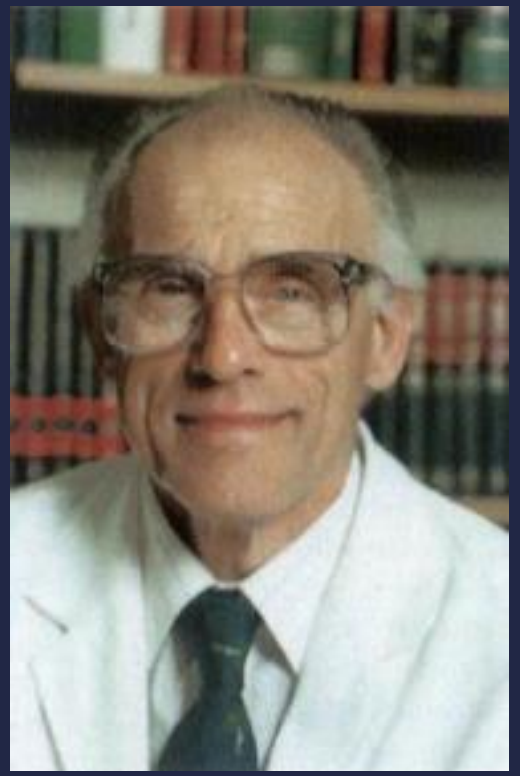
Group	UCL Appearance	Treatment
1	Partial/undisplaced tear	Immobilization
2	Complete tear ≤3-mm displacement	Immobilization
3	Complete tear ≥3-mm displacement (buckled/quasi-Stener lesion)	Surgical repair
4	Stener lesion	Surgical repair

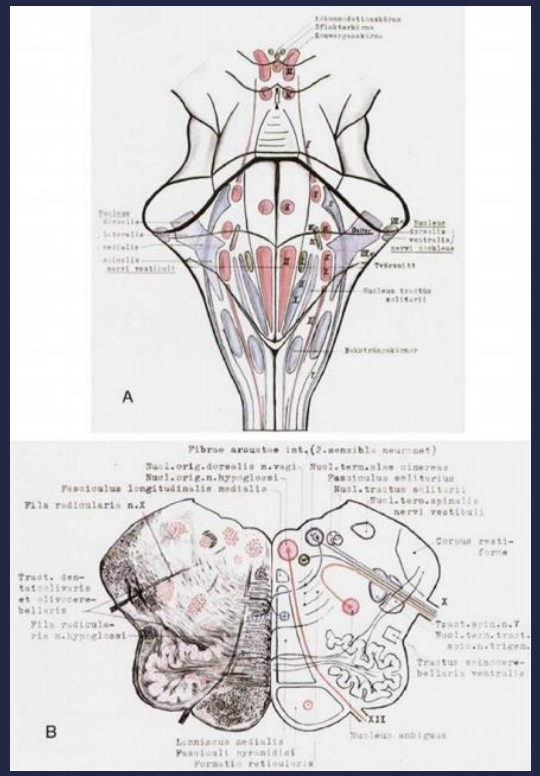
Milner CS, Manon-Matos Y, Thirkannad SM. Gamekeeper’s thumb—a treatment-oriented magnetic resonance imaging classification. J Hand Surg Am 2015;40(1):90–5;

Ligament abnormalities

- Bertil Stener (1920-1999)
  - Swedish surgeon
  - First to describe the anatomy and treatment of the displaced UCL of the 1st MCP joint
  - Extensive work in Orthopedic Oncology
  - Skilled medical illustrator
  - Avid tennis player



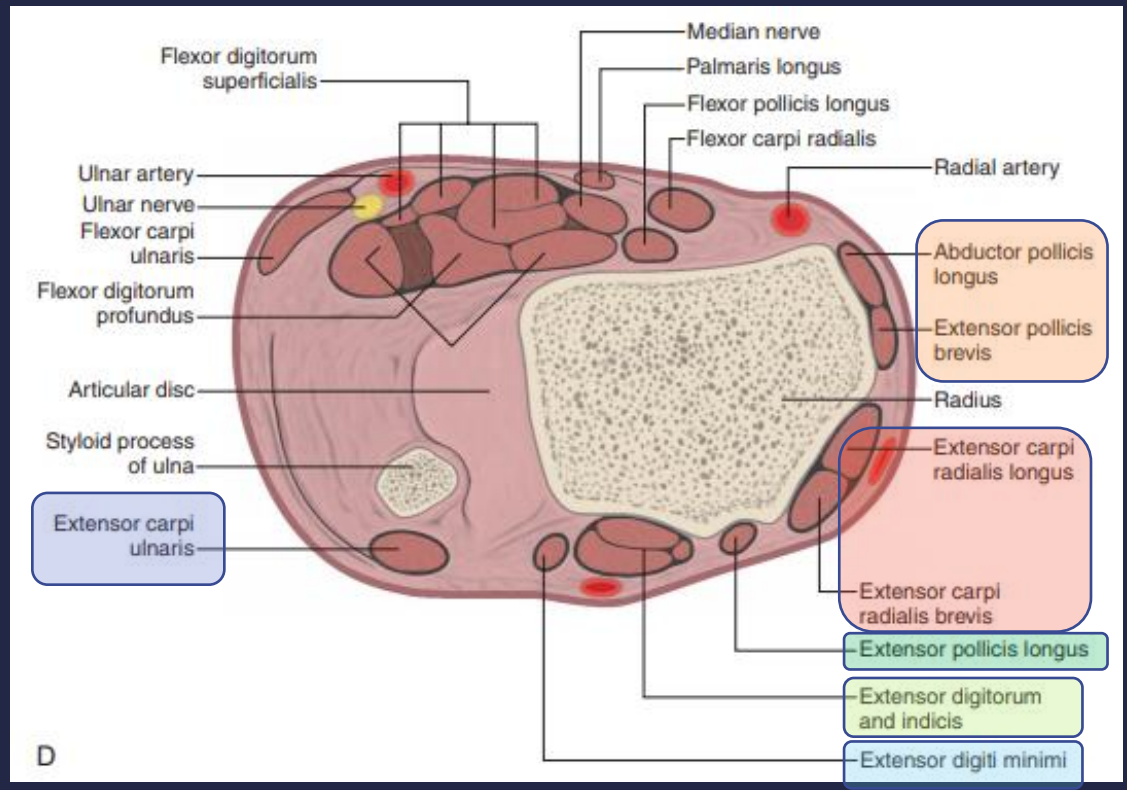




Lark ME, Maroukis BL, Chung KC. The Stener Lesion: Historical Perspective and Evolution of Diagnostic Criteria. Hand (N Y). 2017 May;12(3):283-289

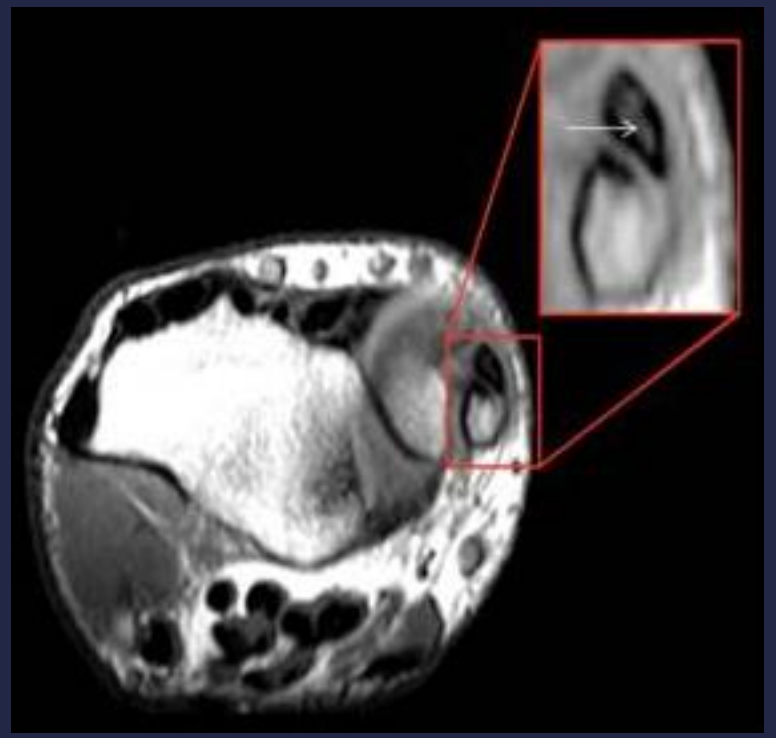
Tendon abnormalities

- Anatomy
  - Dorsal wrist
    - 6 extensor compartments
    - Lister's tubercle separates 2 & 3
    - ECU in characteristic groove
  - Volar wrist
    - Carpal tunnel
      - Median nerve
      - Flexor digitorum profundus
      - Flexor digitorum superficialis
      - Flexor policis longus
    - Guyon canal
      - Ulnar nerve, artery, veins



Tendon abnormalities

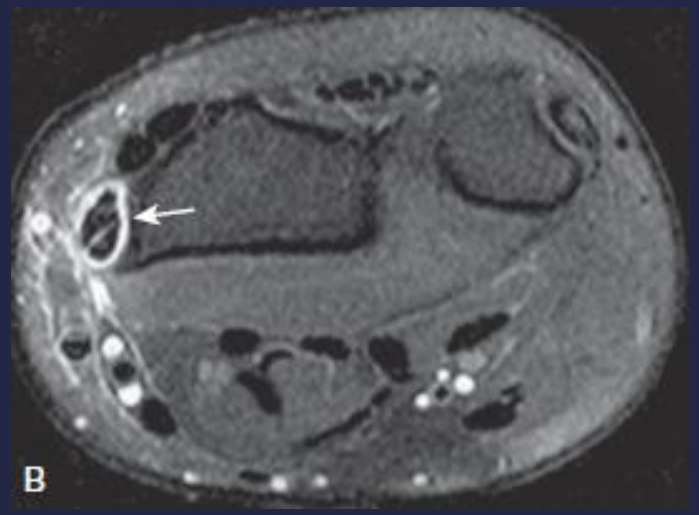
- Tear
  - Partial vs full-thickness
- Tendinosis
  - Thickening and increased intrasubstance signal
  - Increased signal in ECU can be normal variant
    - "…the signal is a result of the normal inter-tendinous ground substance located centrally between the two distal heads of the ECU at the level of the ulna styloid process."

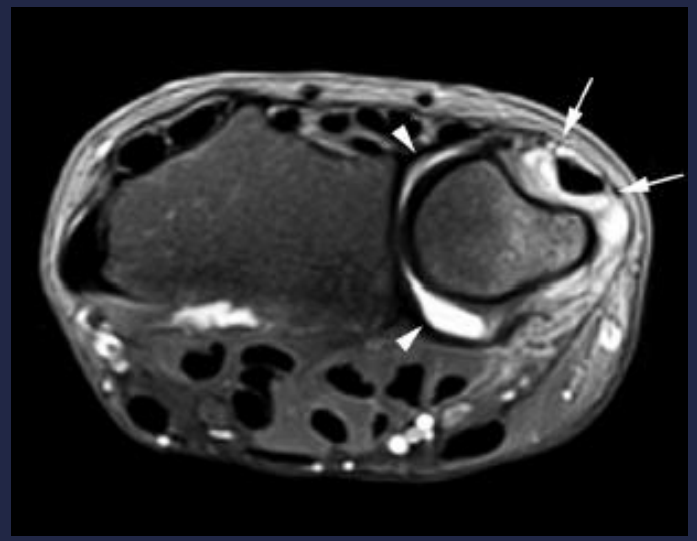


Ali, Sayed et al. "The extensor carpi ulnaris pseudolesion: evaluation with microCT, histology, and MRI." Skeletal radiology vol. 44,12 (2015): 1735-43.

Tendon abnormalities

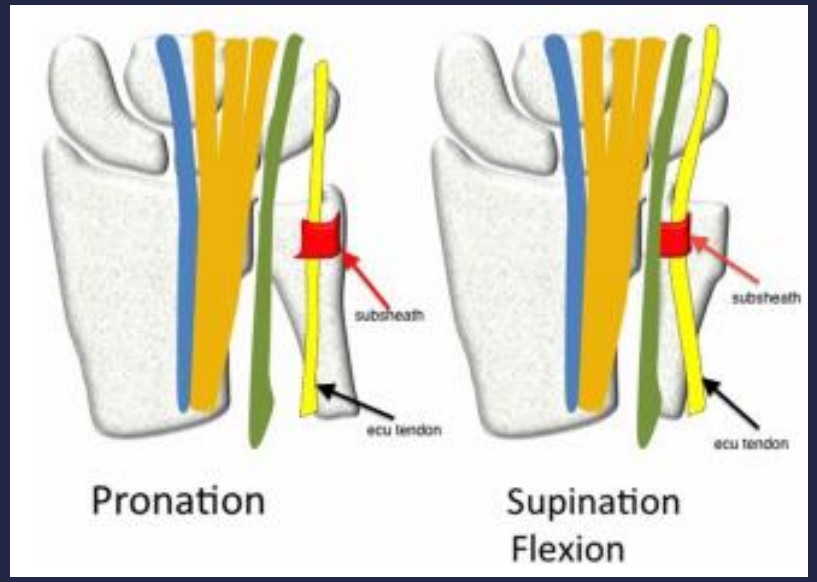
- Tenosynovitis
  - Fluid in tendon sheath, synovial thickening
  - de Quervain tenosynovitis - stenosing tenosynovitis of the 1st extensor compartment
    - Moms, rowing, racquet sports, workplace related repetitive stress injury
  - ECU – look for other ulnar sided pathology (e.g. TFCC)
    - Tennis, rowing
  - Infection/inflammation (e.g. RA)





Tendon abnormalities

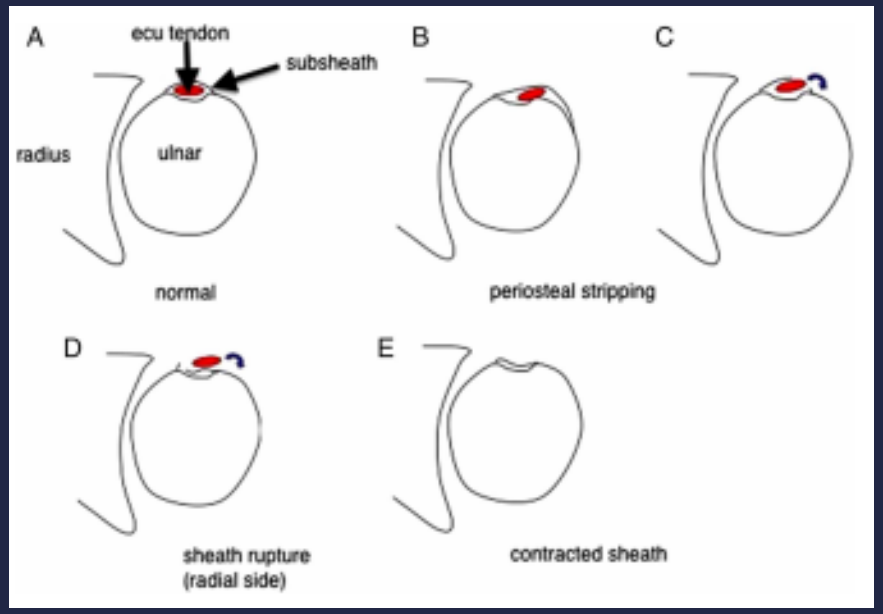
- Extensor carpi ulnaris (6th extensor compartment)
  - In full supination, the ECU tendon exits the 6th compartment at an angle – increasing tension on supporting structures and making it vulnerable to injury
  - Worse when combined with flexion and ulnar deviation (holding an object close to the chest)

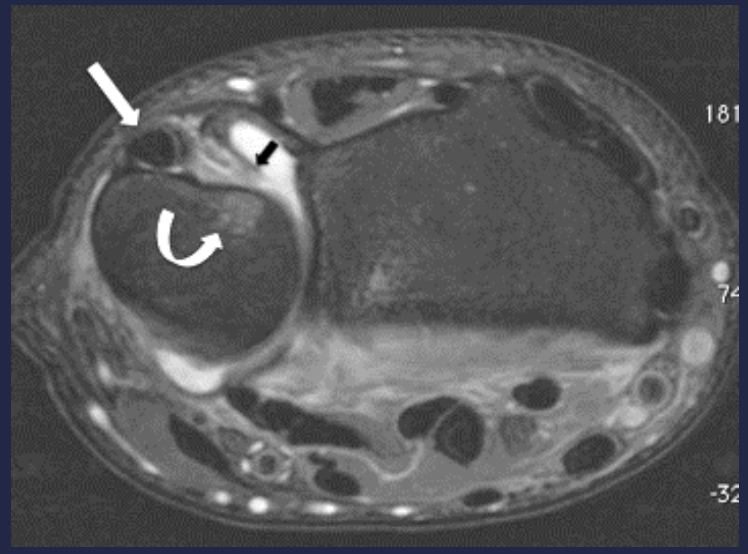


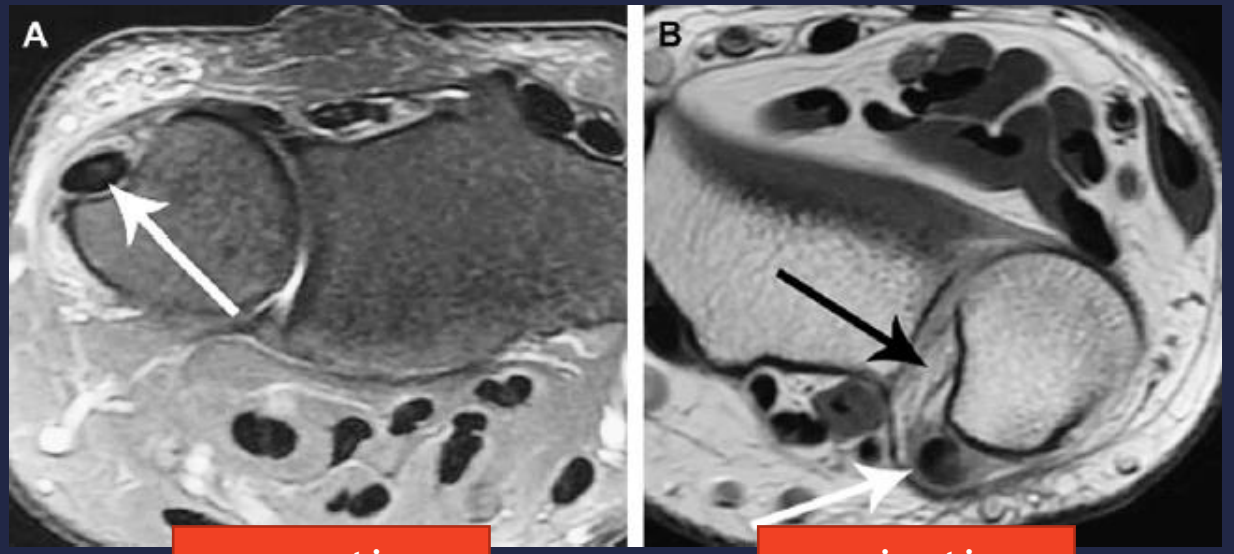
Campbell D, Campbell R, O'Connor P, et al. Br J Sports Med 2013; 47:1105–1111.

Tendon abnormalities

- ECU subsheath injury
  - Subluxation or dislocation
  - ECU tendon displacement of up to 50% of the tendon width from the ulnar groove may be observed in asymptomatic patients
  - Dynamic US or MRI in supination

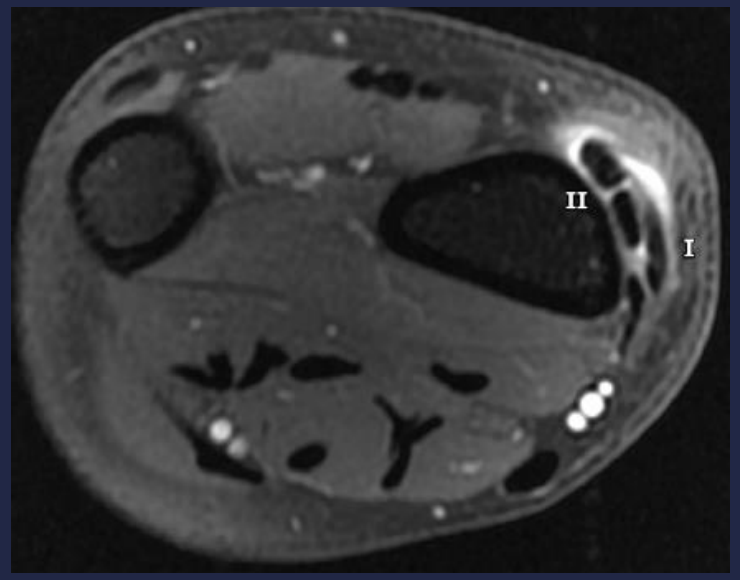


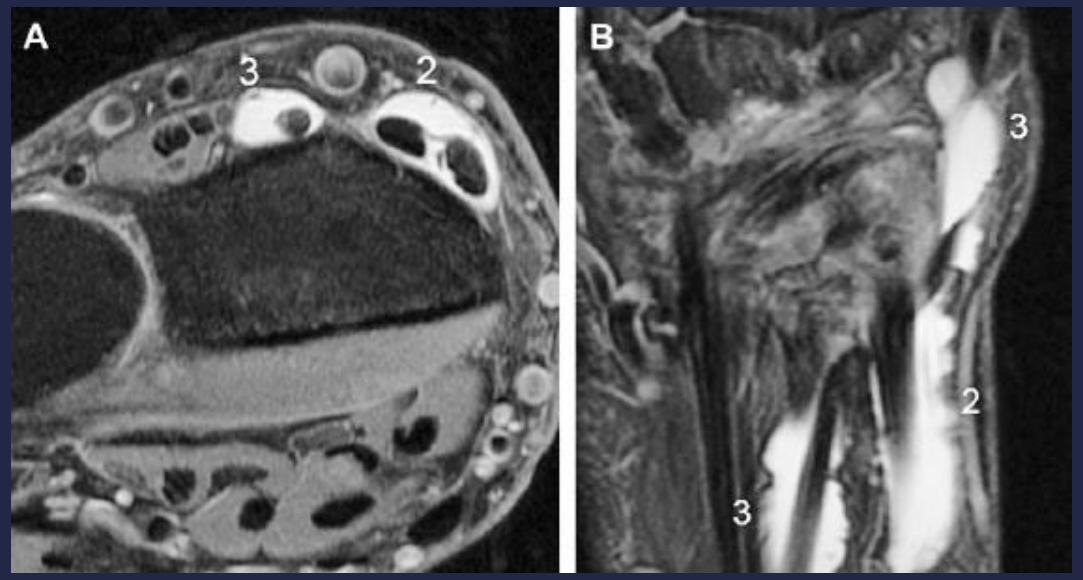




Tendon and muscle abnormalities

- Intersection syndrome –
  - Peritendinosis where the 1st extensor compartment tendons cross over the 2nd extensor compartment tendons approximately 4 to 8 cm proximal to Lister's tubercle
    - Common in skiing, rowing, shoveling, raking
    - May need to increase MRI FOV
  - A less common distal intersection syndrome may occur where the 3rd compartment tenson crosses over the 2nd compartment tendons distal to the Lister tubercle



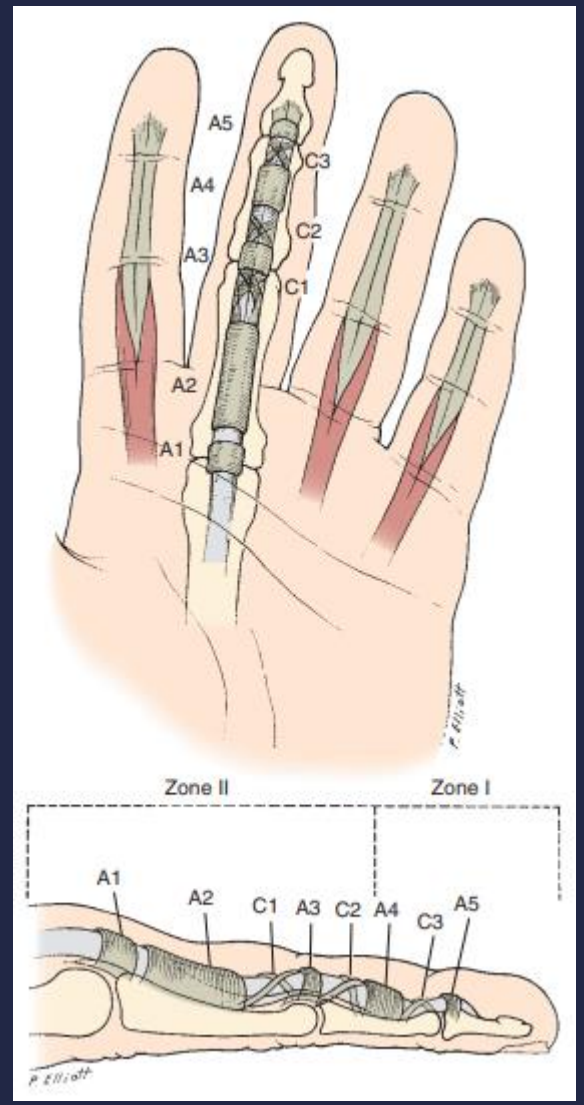


Lisle DA, et al. MR Imaging of Traumatic and Overuse Injuries of the Wrist and Hand in Athletes. Magn Reson Imaging Clin N Am 17 (2009) 639-654

Tendon abnormalities

- Pulley injury
  - Injury to A2 is common (climbers)
  - Isolated A4 injury typical in baseball pitchers
  - Thickening, irregularity, increased signal
  - Volar displacement of flexor tendon (bowstringing)
    - ≤1mm normal
    - >3mm complete A2 rupture
    - >5mm suggests combined A2/A3 rupture

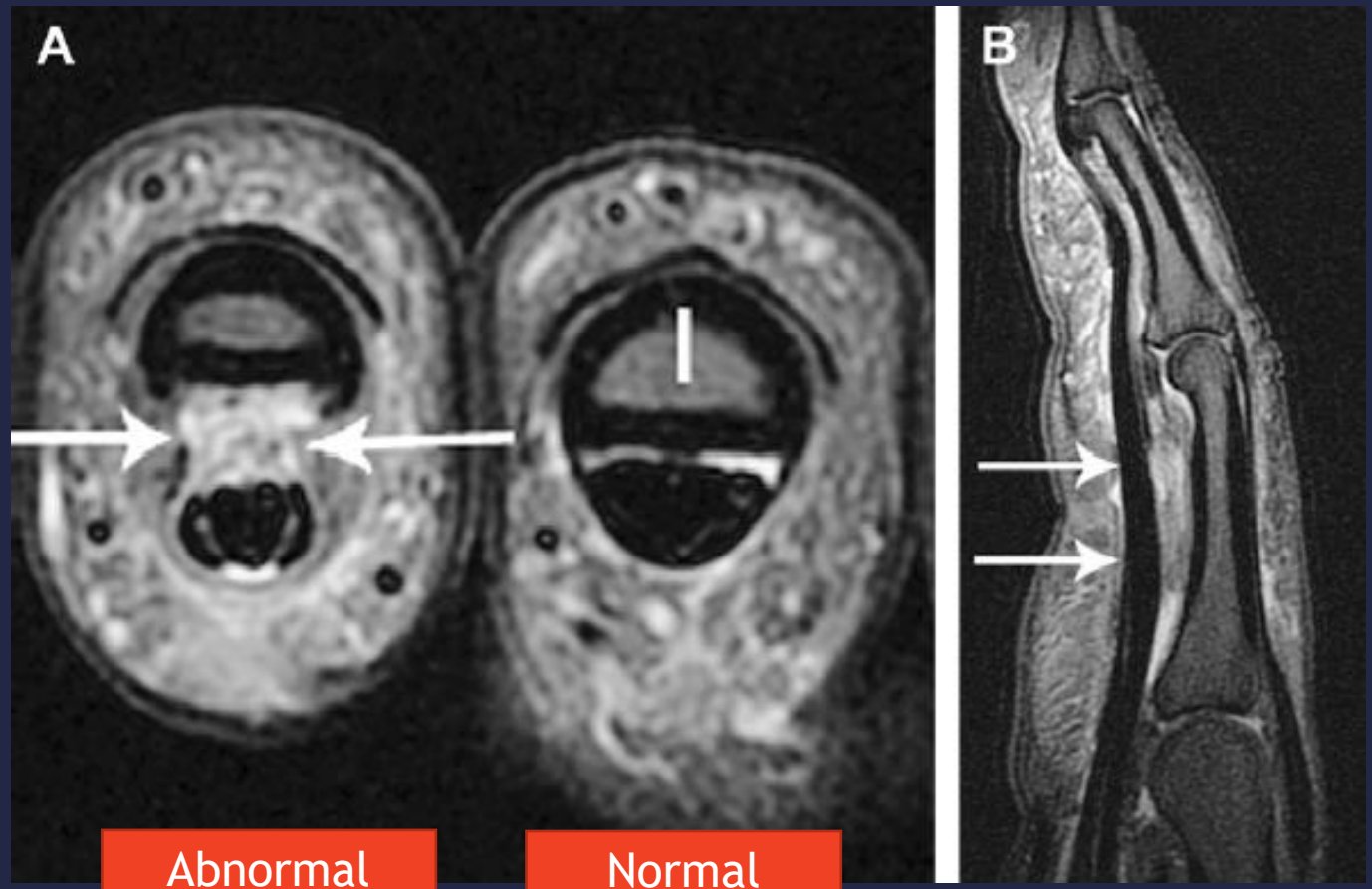
    - Bowstringing that extends from PIP joint to base of proximal phalanx also c/w complete A2 rupture



Jon A. Jacobson. Chapter 5: Wrist and Hand Ultrasound. In: *Fundamentals of Musculoskeletal Ultrasound* 3rd ed. Elsevier; 2018:168-222.e4

Tendon abnormalities

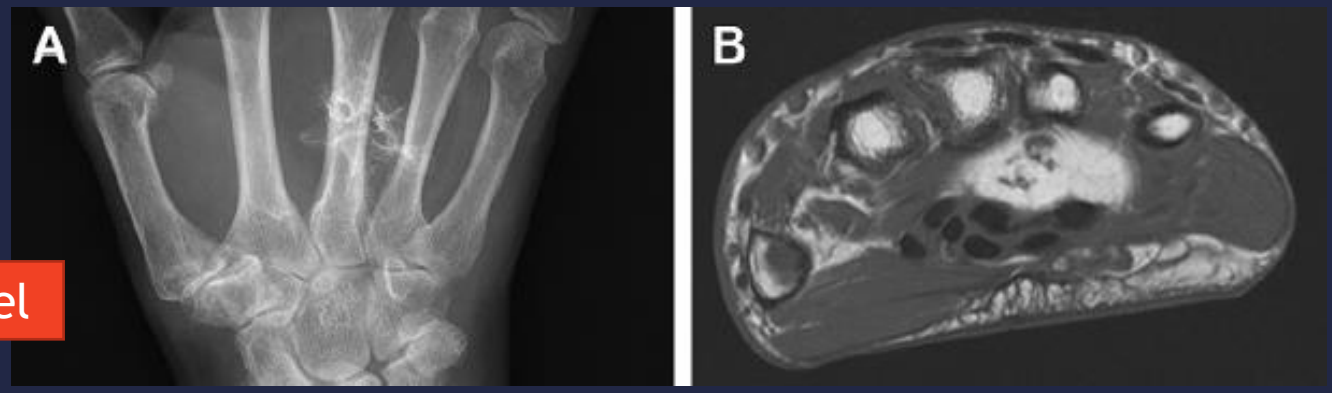
- Pulley injury
  - A2 pulley tear in 28 y/o rock climber



Lisle DA, et al. MR Imaging of Traumatic and Overuse Injuries of the Wrist and Hand in Athletes. Magn Reson Imaging Clin N Am 17 (2009) 639-654

Nerve abnormalities

- Carpal tunnel syndrome
  - Most common upper extremity entrapment neuropathy
  - Median nerve compression due to mass effect in the fibro-osseous carpal tunnel (trauma, mass, tenosynovitis)
  - MRI for atypical cases, suspected mass, or symptoms after surgery
    - Increased size/signal of median nerve proximal to carpal tunnel
    - Denervation edema/atrophy of the thenar muscles
    - Bowing of flexor retinaculum



Lipoma in carpal tunnel

Nerve abnormalities

- Carpal tunnel syndrome
  - Median nerve enlargement
    - Cross sectional area (CSA) proximal to carpal tunnel
    - CSA > 15 mm2
      - sensitivity 85.5%
      - specificity 100%

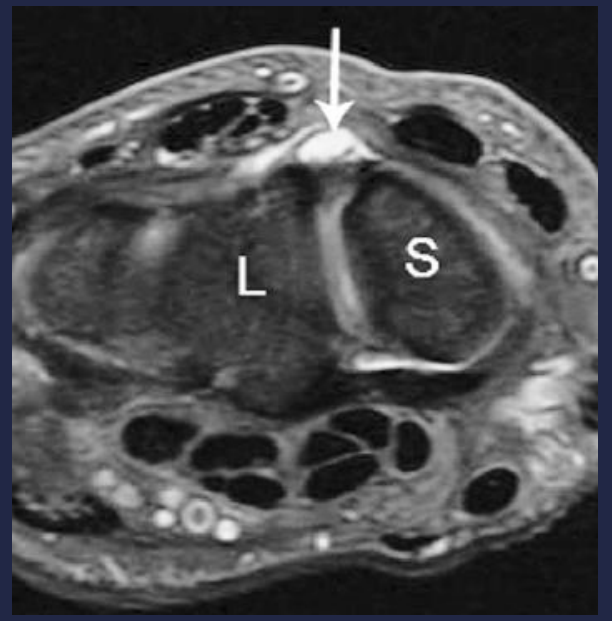
CSA 14.6mm2

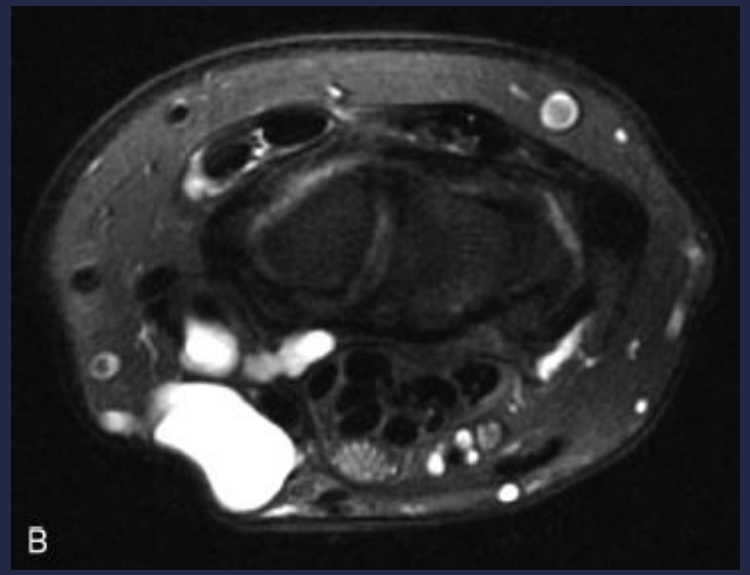
CSA 44.0mm2

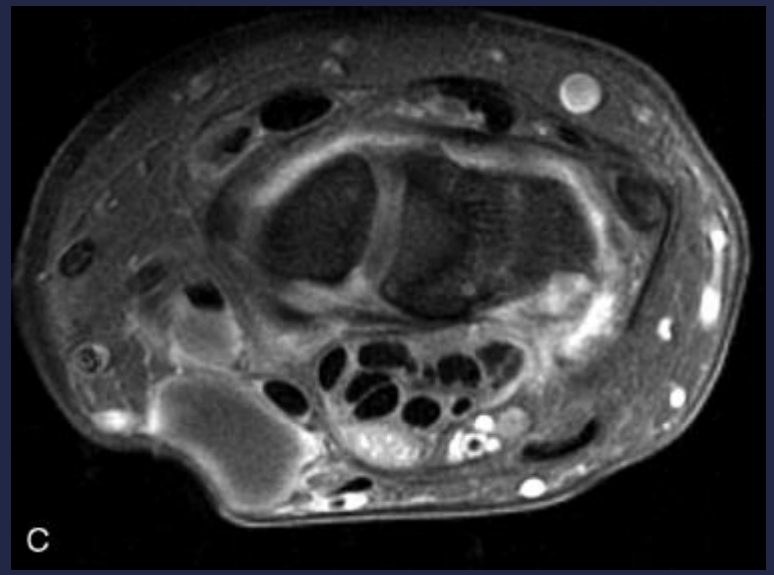
Ng, A.W.H., Griffith, J.F., Tong, C.S.L. et al. MRI criteria for diagnosis and predicting severity of carpal tunnel syndrome. Skeletal Radiol 49, 397–405 (2020).

Masses

- Masses
  - Ganglion cyst
    - Usually contain thick mucoid fluid
    - 50% of asymptomatic patients
    - 30% due to ligament tears
    - Clinical correlation

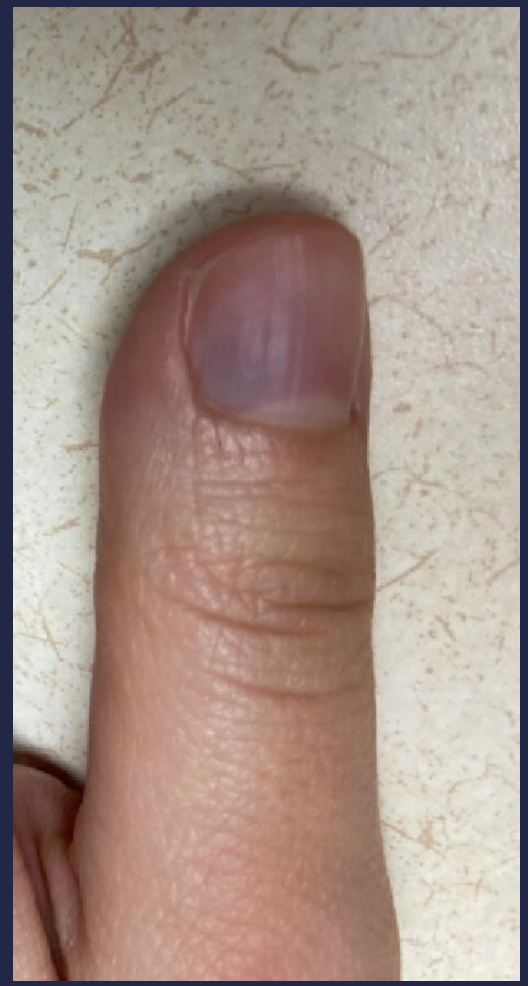






Masses

- 32 y/o Female
- Left thumb pain
- Worse in the cold



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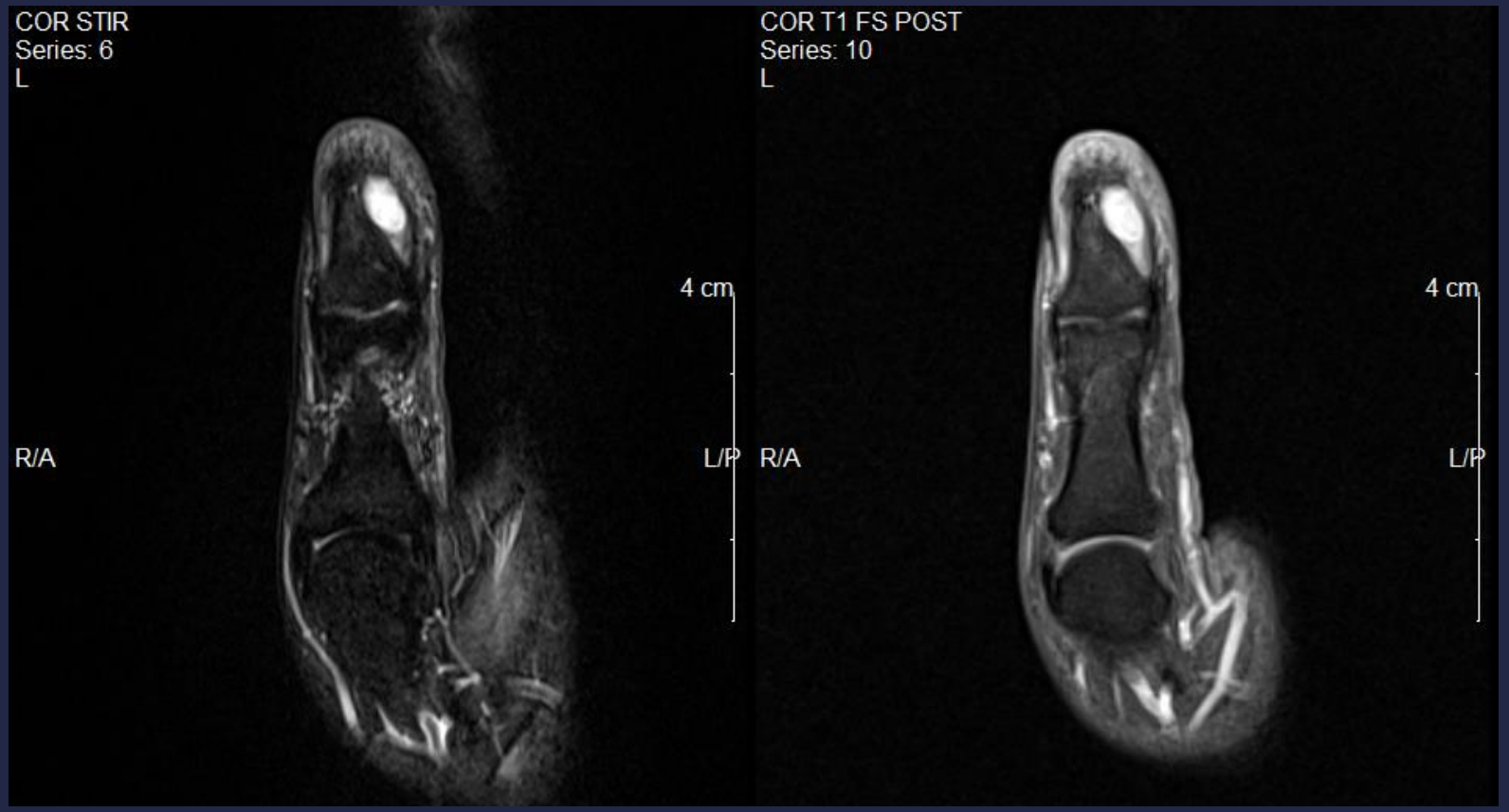

Masses

- Glomus tumor
  - Benign tumor of neuromyoarterial glomus
  - Found throughout the body, but concentrated in fingertips
  - Responsible for thermoregulation
  - Clinically
    - Severe pain
    - Cold sensitivity
  - MRI
    - Well defined
    - T2 hyperintense
    - Avid enhancement

Questions?