



# Thumb MRI: More to see than just the ulnar collateral ligament



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# DISCLOSURE

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# Thumb MRI:

## More to see than just the ulnar collateral ligament

### Objectives:

1. Understand the anatomy of the thumb with emphasis on the joints, sesamoids, ligaments, pulleys, tendons, and thenar muscles
2. Identify a range of thumb injuries on MRI and comprehend typical mechanisms of injury
3. Recognize typical MRI features of various thumb masses and inflammatory diseases and comprehend situations when other imaging modalities enhance characterization
4. Understand clinical disposition for thumb injuries, inflammatory conditions and masses

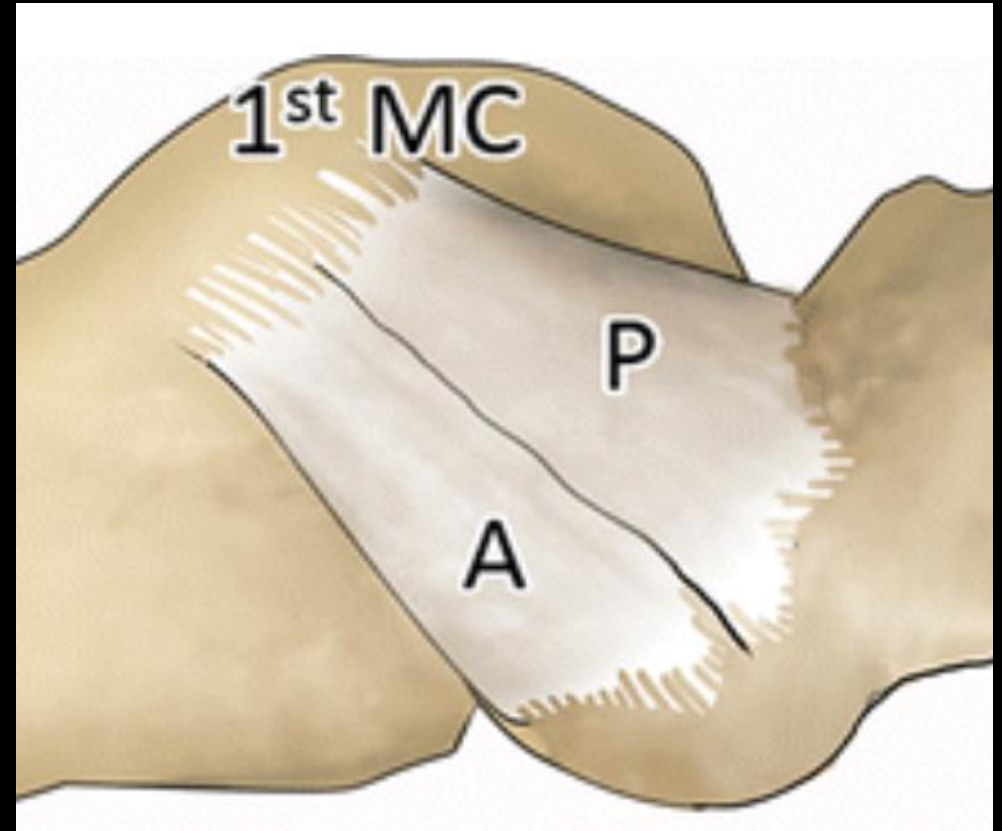
# MR Imaging Technique

SEQUENCE	TR (ms)	TE (ms)	Matrix	Slice Thickness (mm)	Voxel Size (mm)
Sagittal T1	700	11	256	3	0.3 x 0.3 x 3
Sagittal PD FS	3000	44	256	3	0.4 x 0.4 x 3
Coronal STIR	3100	10	320	2	0.3 x 0.3 x 2
Coronal PD	2700	49	320	2	0.3 x 0.3 x 2
Axial T2 FS	3900	71	256	3	0.3 x 0.3 x 3
Axial PD	2700	49	256	3	0.3 x 0.3 x 3

- Evaluation of the ligaments, muscles, and tendons is best accomplished with MRI
- “Superman position” with dedicated extremity coil is ideal with hand in the *isocenter of the magnetic field*
- For patients unable to tolerate prone positioning/shoulder adduction: image supine with hand at side
- Thumb coronal axis does not match the fingers and the wrist
  - From axial localizer: acquire coronal images parallel to the widest dimension of the proximal phalanx base
  - Sagittals are perpendicular to the coronals

# MCP Collateral Ligaments

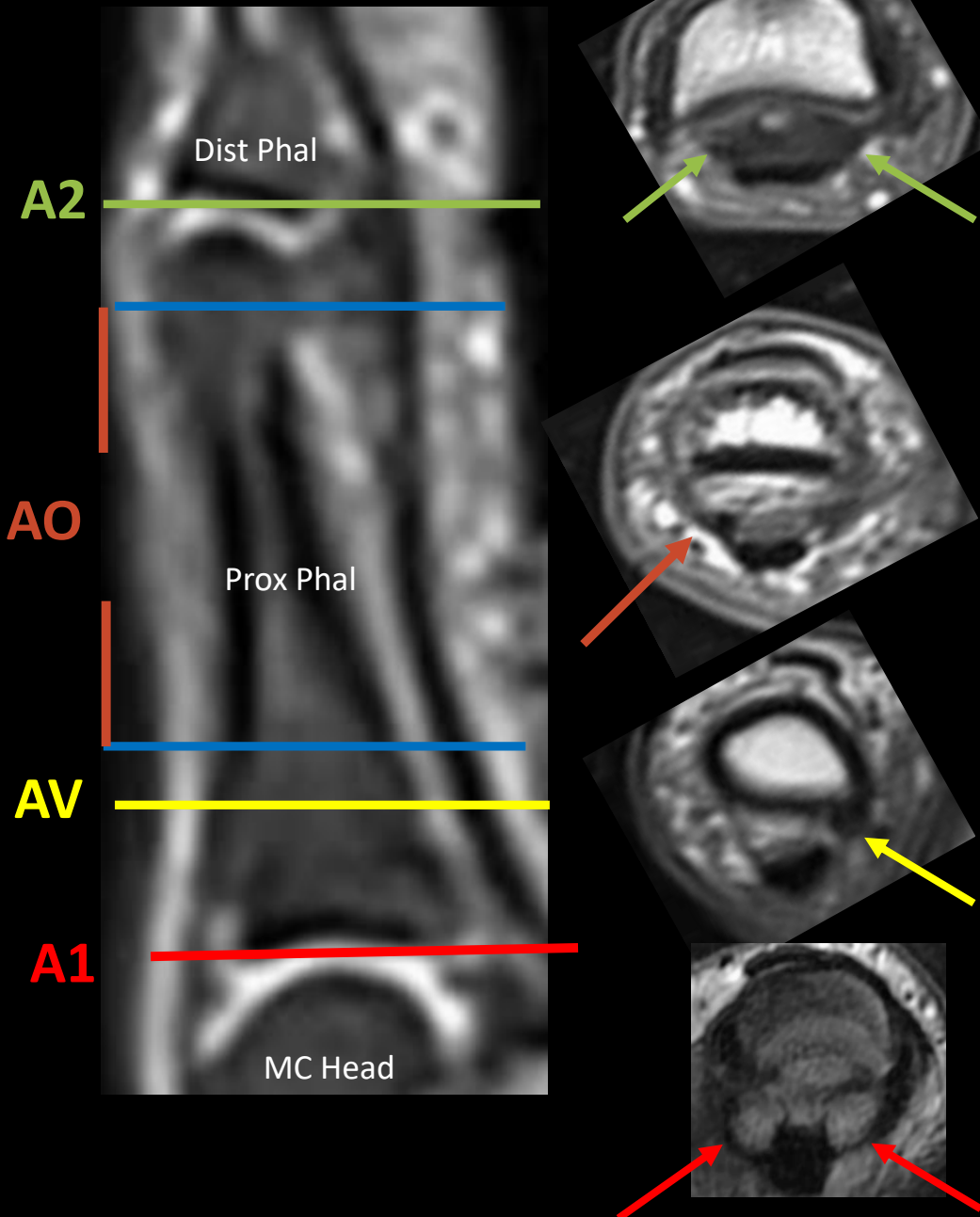
- Two components – accessory and proper
  - Proper
    - From dorsal MC to proximal 1/3 of phalanx
    - Provides stability in flexion
  - Accessory
    - Arise more volar, insert on volar plate and sesamoids
    - Provides stability in extension
- **RCL: Stener lesion rare** as there is a broader abductor aponeurosis



Rawat U, Pierce JL, Evans S, Chhabra AB, Nacey NC. High-Resolution MR Imaging and US Anatomy of the Thumb. Radiographics. 2016 Oct;36(6):1701-1716. doi: 10.1148/rg.2016160015. PMID: 27726751.

# Flexor Mechanism

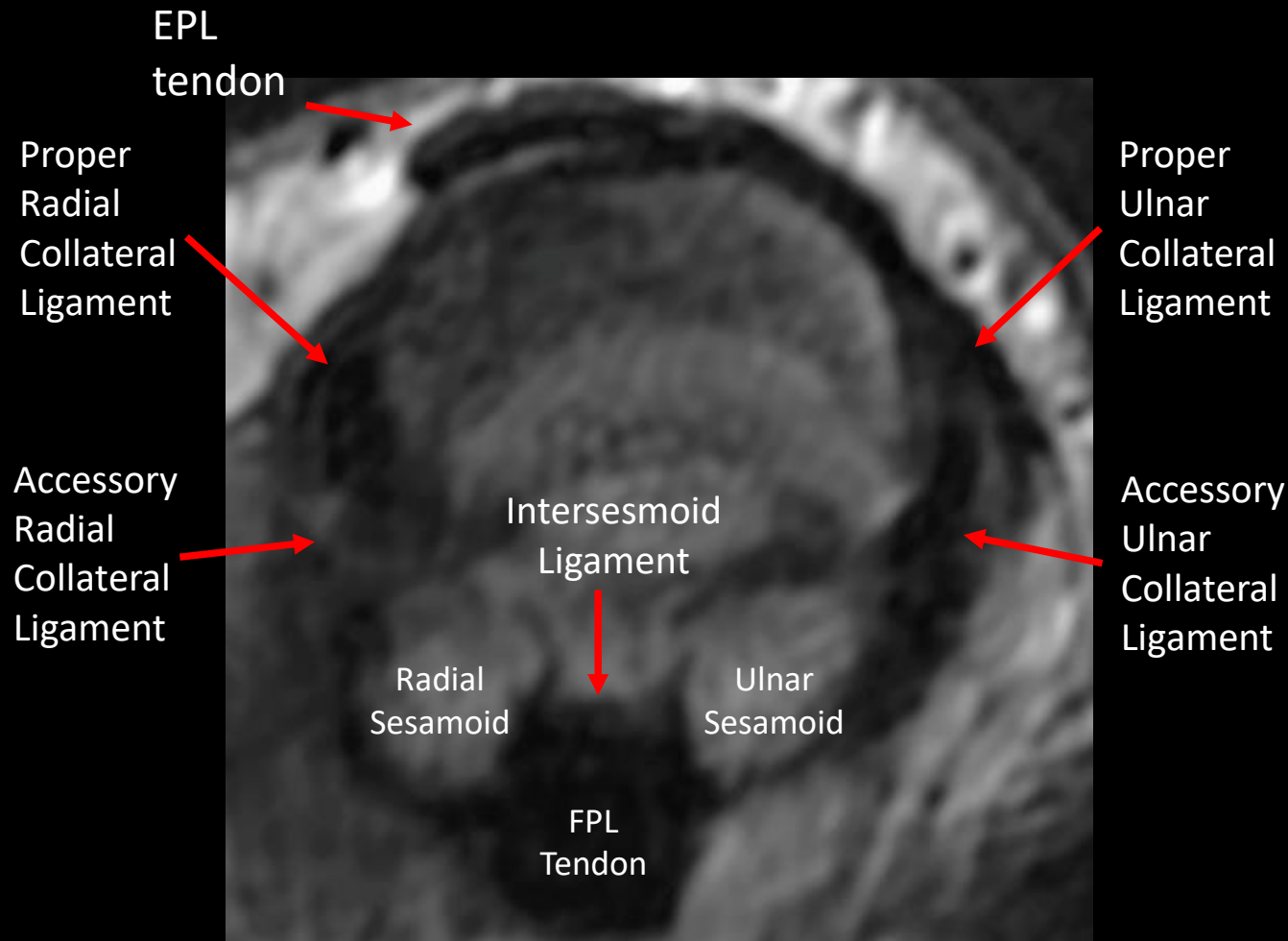
- **A1** and **A2** pulleys at the MCP and IP respectively
- **Oblique (AO) pulley** and variable **(AV) pulleys** between A1 & A2
  - **AO pulley** extends distally and radially from the adductor aponeurosis
  - **AV pulley** originates between the A1 and AO pulleys and has a variable course when present
  - Pulley importance varies by source
- **Flexor Pollicis Brevis (FPB)** primary flexor at the MCP has 2 heads:
  - Deep head arises from trapezium, trapezoid and capitate
  - Superficial head arises from the flexor retinaculum. Inserts at the radial sesamoid and proximal phalangeal base
- **Flexor Pollicis Longus (FPL)** has origins in the volar radius and interosseous membrane. Inserts at the base of the distal phalanx



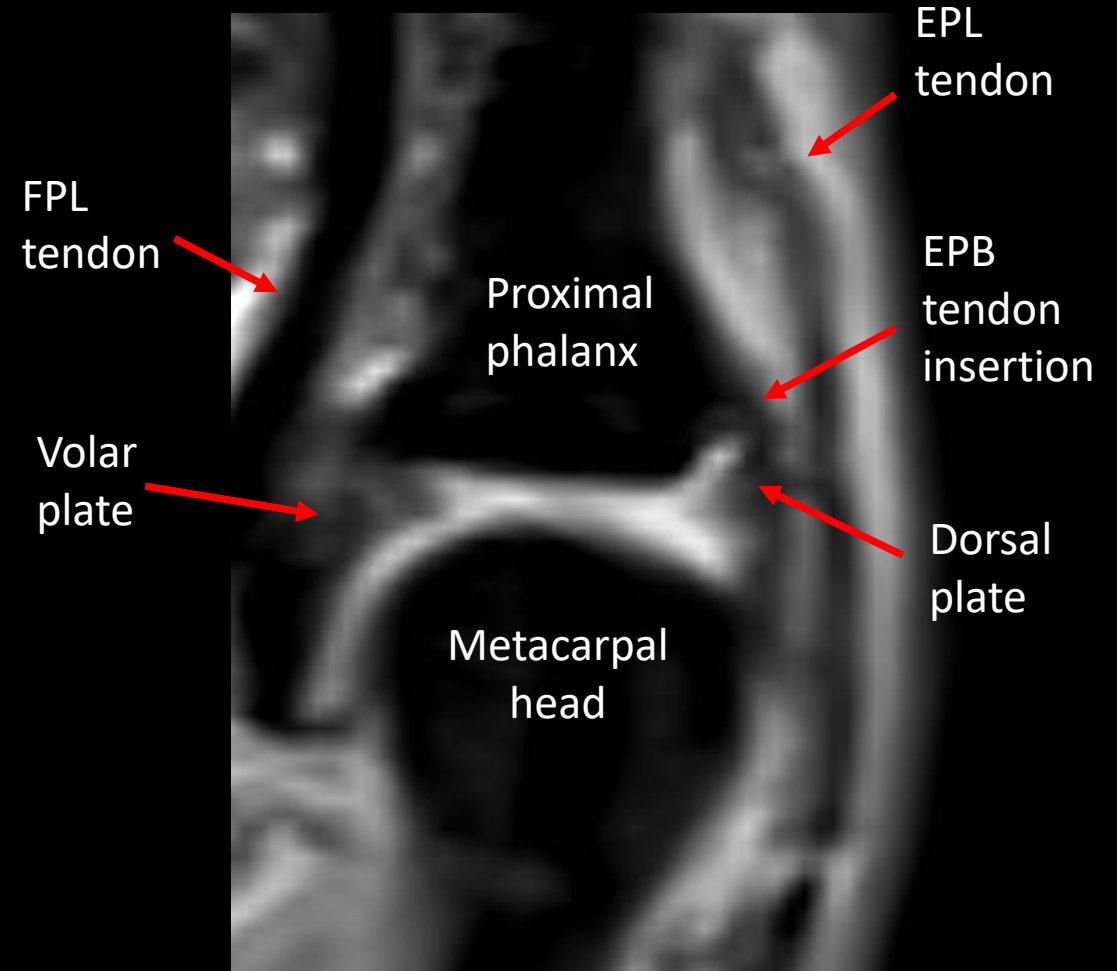
# Extensor, Sesamoids, and Plates

- **Extensor pollicis brevis (EPB)** is in the 1<sup>st</sup> **extensor compartment**
  - EPB inserts at the dorsum of proximal phalanx and is the primary MCP extensor
- **Extensor pollicis Longus (EPL)** crosses from the 3<sup>rd</sup> **extensor compartment** and is ulnar to the EPB
  - Extensor pollicis longus inserts on the distal phalanx
- **Extensor Hood** merges with the extensor tendon fibers and is composed of 2 parts
  - **Sagittal bands** at the level of the MCP – visible on MRI
  - Triangular expansion beyond the sagittal band, which envelops the extensor pollicis longus tendon as it extends to its insertion onto the distal phalanx
- **Sesamoids**
  - Reduce friction and increase tendon leverage
  - Radial and ulnar sesamoids embedded in the volar plate
  - Hyaline cartilage on the deep surface
  - Single sesamoid at the interphalangeal joint with variable presence
- **MCP Volar Plate**
  - Thick fibrocartilage - resists joint hyperextension
  - Origin at volar neck of the metacarpal
  - Inserts dorsal base of proximal phalanx
- **MCP Dorsal Plate**
  - Fibrocartilage at the MCP not as large as the volar plate
  - Aids in stabilization

# Thumb MCP Joint Anatomy



**Axial** PD MR image of the thumb **metacarpophalangeal** joint



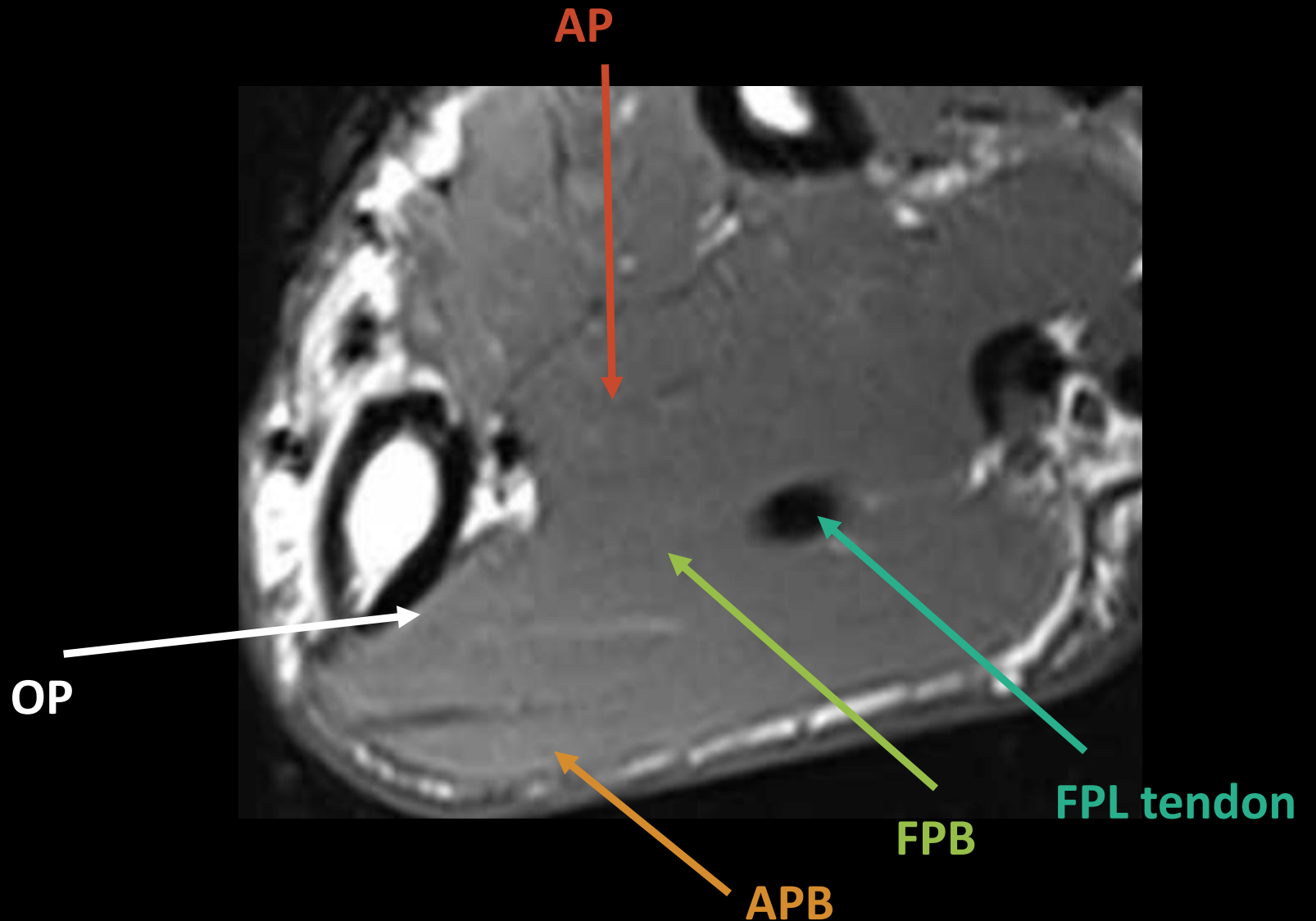
**Sagittal** PD FS MR image of the thumb **metacarpophalangeal** joint



# Muscles

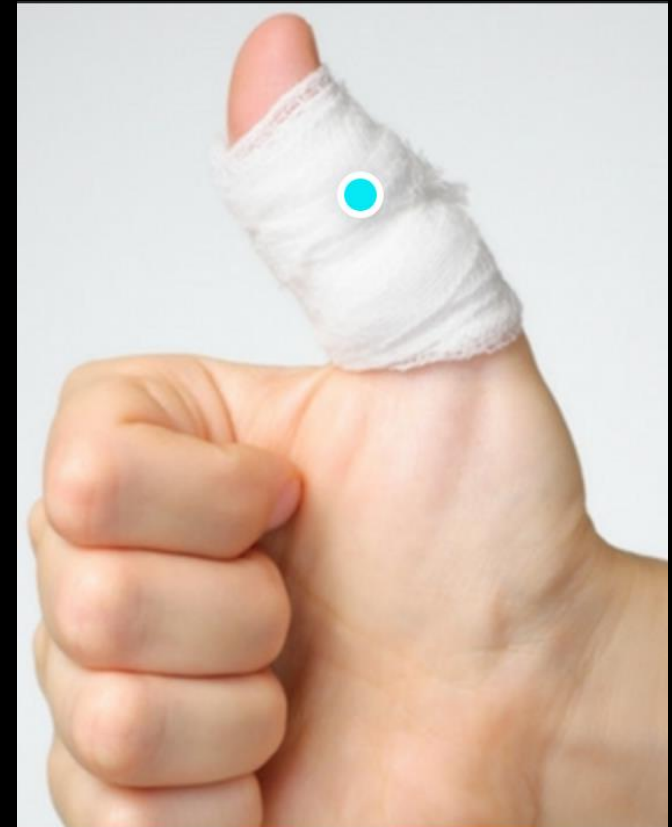
All the Thenar muscles arise from the flexor retinaculum

- **Abductor Pollicis Brevis (APB)**
  - Inserts on radial base of PP
- **Opponens Pollicis (OP)**
  - Inserts on radial aspect of 1<sup>st</sup> Metacarpal
- **Flexor Pollicis Brevis (FPB)**
  - Inserts radial sesamoid & base of PP
- **Adductor Pollicis (AP)**
  - Not a thenar muscle
  - Oblique and transverse heads



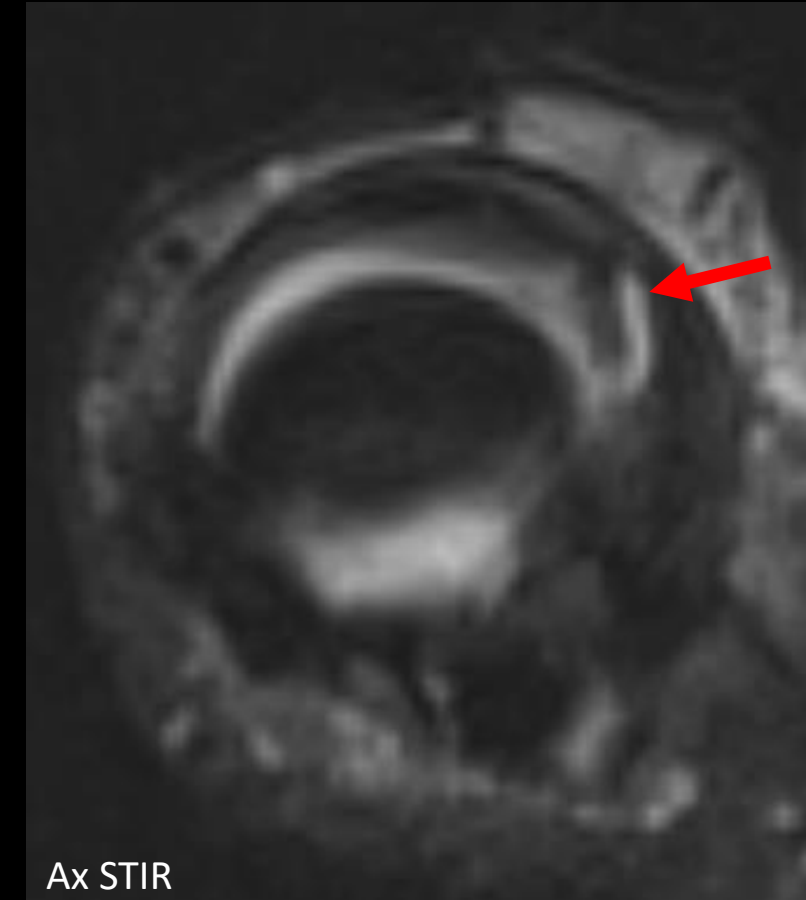
# Thumb pathology which presents on MRI

- Injuries
  - Acute
  - Chronic (Osteoarthritis)
- Soft tissue lesions
- Osseous lesions
- Deposition Disease
- Arthritides



# MCP UCL tear

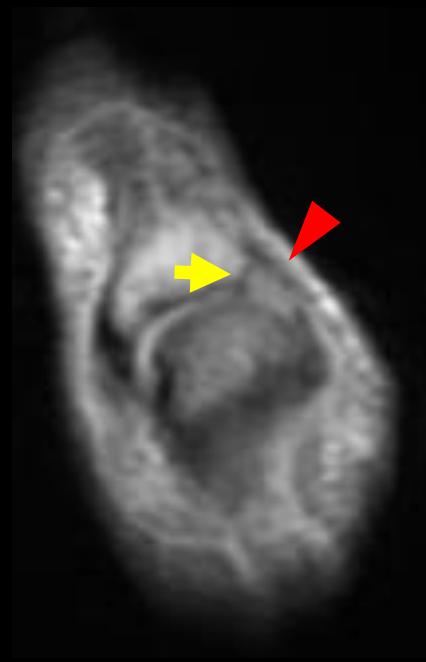
- **Valgus stress**
  - Strains and tears the proper UCL
  - Continued valgus force radially displaces the volar plate and sesamoids and accessory UCL
- UCL injuries best seen on *coronal images*



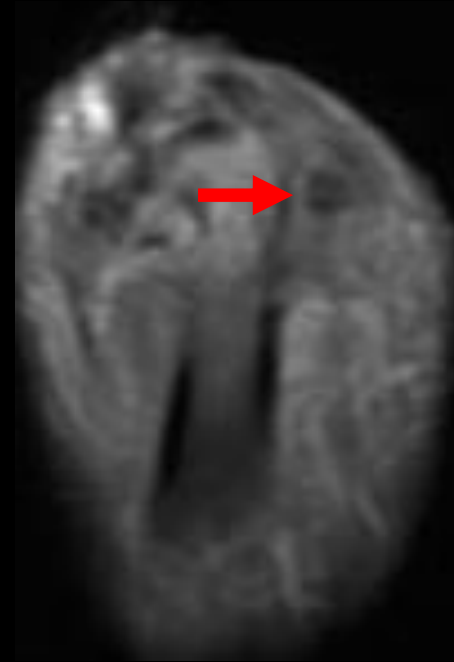
56 year old woman with persistent pain after fall. Coronal STIR shows UCL tear near it's proximal attachment (**arrow**). Torn UCL remains near its attachment site, deep to adductor aponeurosis (**arrowhead**). Axial STIR show the elevated UCL at base of proximal phalanx.

# MCP UCL Stener Lesion

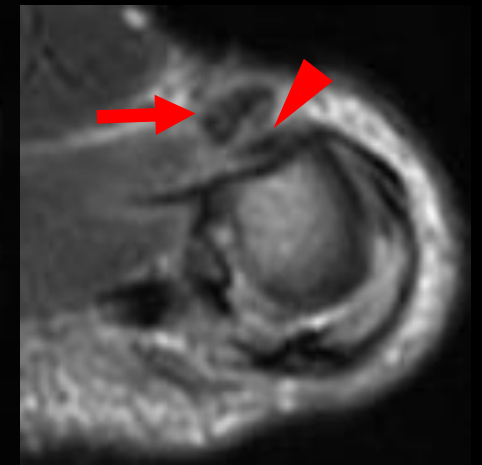
- Stener lesion: radial subluxation after UCL tear moves the torn UCL away from the phalangeal base, with *proximal retraction superficial to the adductor aponeurosis*
  - First described by orthopedic surgeon Dr. Bertil Stener in 1962
  - **Yo-yo** on a string appearance
  - Requires **surgical repair** to bring torn ligament back to proximal phalangeal base



Cor PD FS



Cor PD FS  
Dorsal

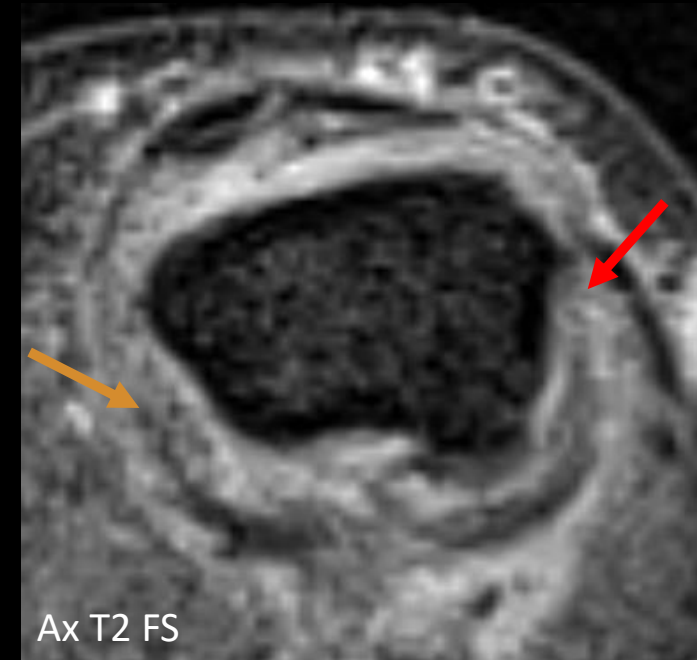


Ax PD FS

41 year old women with thumb hyperextension injury. Coronal and axial PD FS images at the MCP show a Stener lesion. The UCL is absent at the proximal attachment (**arrow**). The adductor aponeurosis is in normal position (arrowhead). The torn UCL is “balled up” and retracted proximally, positioned superficial to the aponeurosis (**arrow**).

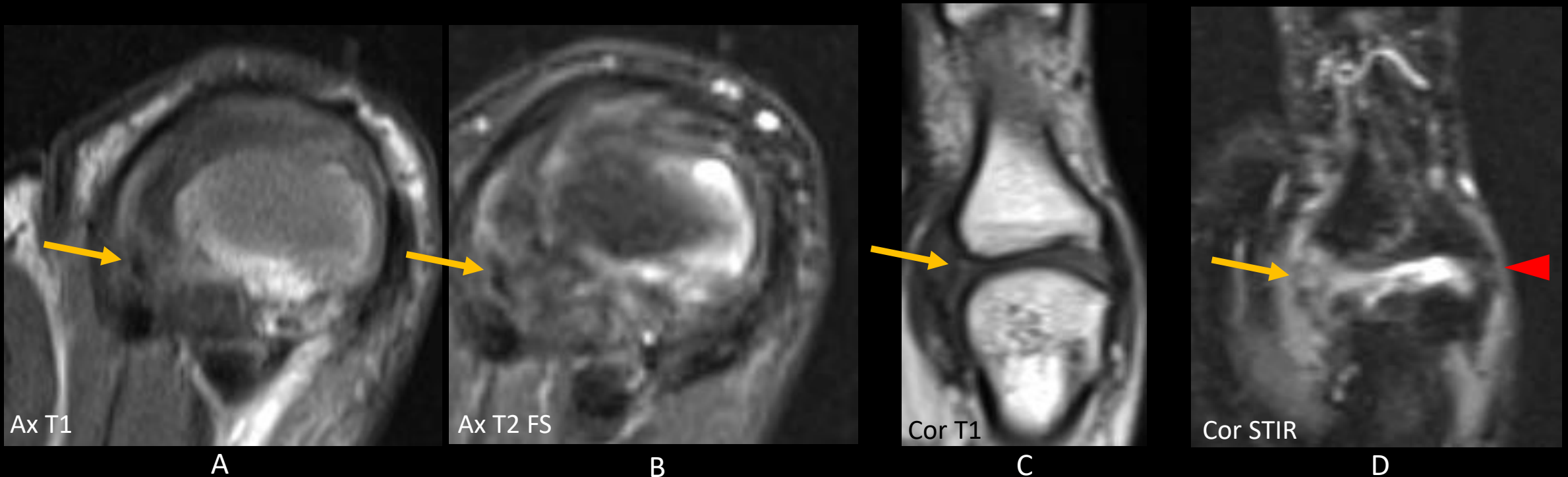
# MCP Radial Collateral Ligament Injuries

- **Varus stress and forced adduction**
  - Volar-ulnar subluxation of the proximal phalanx is common because of the strong force from the adductor pollicis
- MRI findings of disruption of the ligament. Surrounding edema if acute
- Operative Management
  - Grade III (complete rupture) especially with ulnar deviation from the unopposed adductor pollicis and extensor pollicis longus . Volar subluxation of 3mm or more is indicative of complete tear
  - Chronic injuries with instability



48 year old woman with persistent pain after falling and dislocating her thumb. Coronal STIR and Ax T2 FS shows **UCL** and **RCL** tears from the metacarpal head

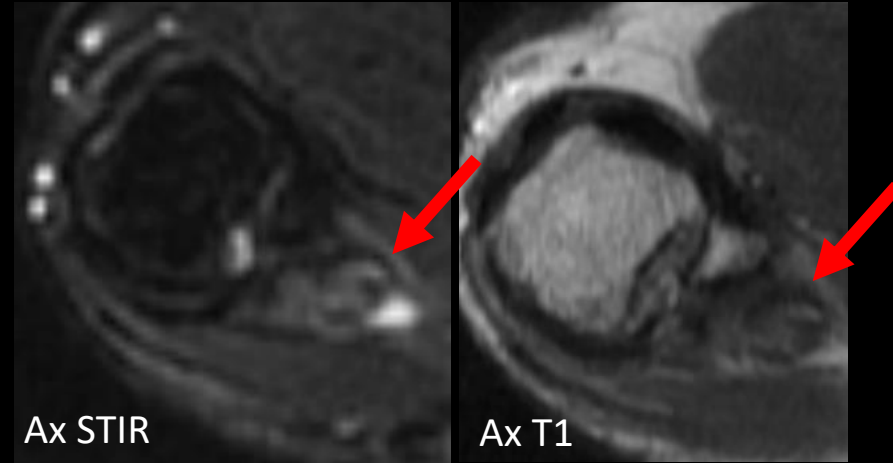
# MCP Accessory Collateral Ligament Injuries



Accessory ulnar collateral ligament injury in a 26 year old soldier. Axial T1 (A) and T2 FS (B) and coronal T1 (C) and T2 FS (D) show disruption of the accessory band of the UCL (arrows). The obliquity of the accessory band increases the need for multiple planes to improve detection. There is also sprain of the proper RCL seen in image D (arrowhead).

# MCP Flexor Mechanism Pathology

- **Flexor pulley injuries** are rare. Rock climbing is the prototypical sport. Sources vary on rating the overall importance of each pulley, but all agree that *bowstringing* is the result of sequential pulley/tendon sheath ruptures



Axial STIR and T1 a 68 year old woman rancher show high grade partial tear of the FPL (arrow)

- **Flexor Tendon ruptures**

- *Trauma*
- *Rheumatoid arthritis* due to tendon erosion in the carpal tunnel
- *Post-operative* (rare): improper position of the radial volar fixation plate distal to the transverse radial ridge



Axial STIR of 63 year old woman with thumb pain shows longitudinal split tearing of the FPL (arrow)

# MCP Sesamoid Injuries

- Caused by forced extension or direct trauma
- Sesamoids are avascular so injury may lead to AVN
- Can be associated with volar plate or collateral ligament injuries
- Rarely sesamoids can be displaced intraarticularly resulting in joint impingement
  - Volar plate may be intact
  - Accessory collateral ligament rupture with the resulting aperture allowing for sesamoid movement



32 year old man fell on outstretched hand. Sagittal T1 and Coronal PD FS MRI image of the volar to the MCP joint shows a dark signal ulnar sesamoid fracture (arrow) with associated bone marrow and soft tissue edema



# Volar Plate Injury

- Forced sudden hyperextension
  - Falls and sports most common
- Volar plate equal importance to collateral ligaments for stability
- Deficiencies lead to sagittal plane instability
- Patients unable to maintain joint flexion during pinch and grip



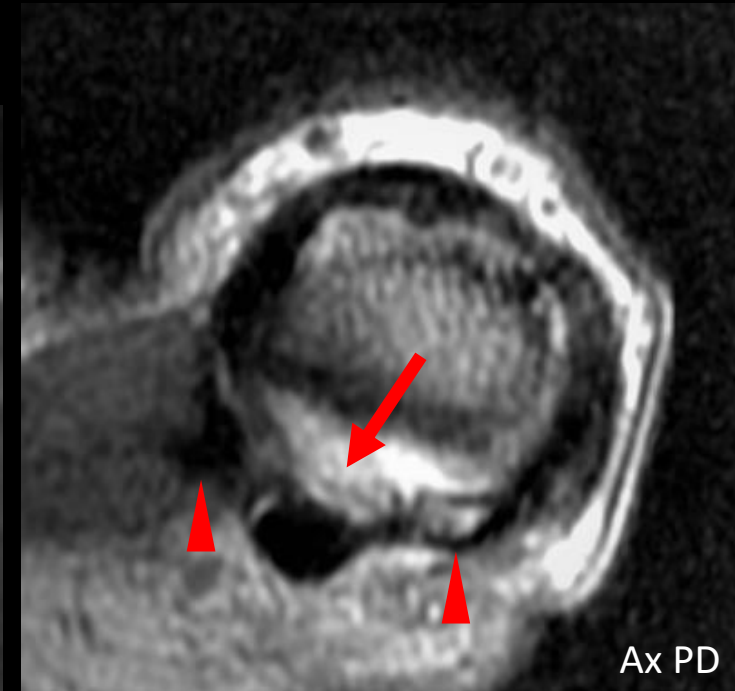
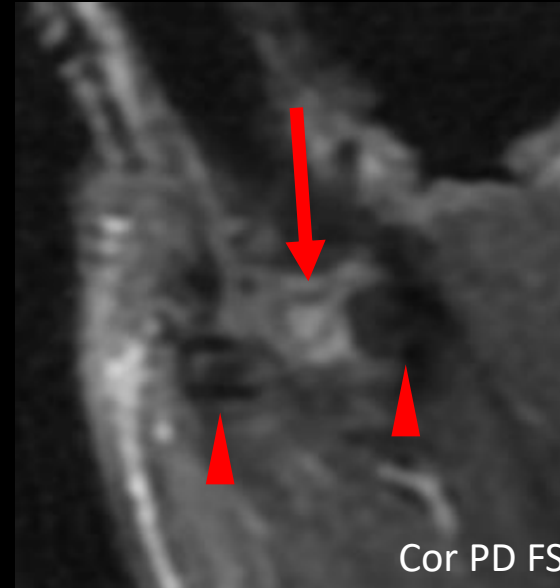
49 year old man with remote thumb injury from fall. Sagittal PD FS shows tear of the MCP distal volar plate attachment (arrow) without edema



48 year old woman fell on outstretched hand. Sagittal STIR shows tearing of the MCP proximal (arrow) and distal (arrow) volar plate with surrounding edema

# Intersesamoid Ligament Tear

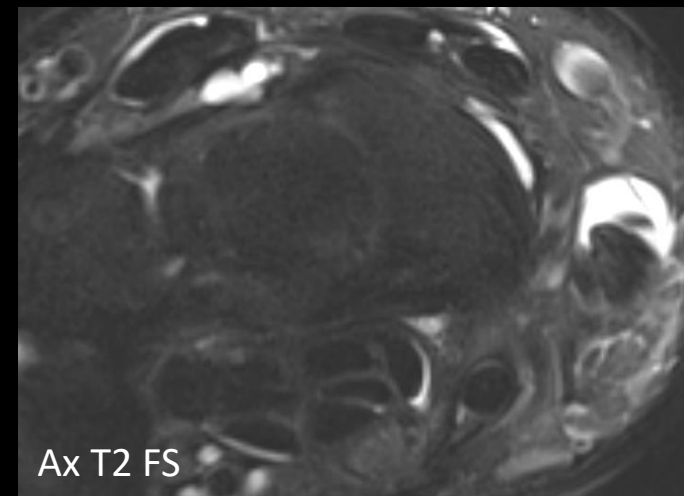
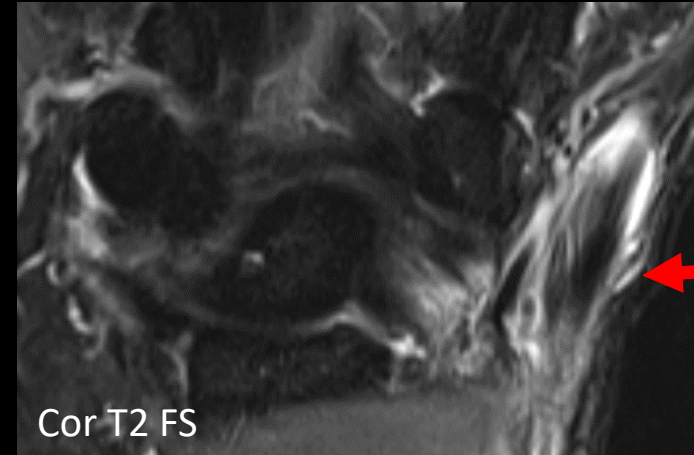
- Forced sudden hyperextension
  - Falls and sports most common
- Similar mechanism to and often *associated with volar plate injuries*
- Deficiencies lead to sagittal and rotational instability
- *Diastasis of the sesamoids is a clue*
- Sesamoids may be displaced distally or proximally



48 year old man fell on outstretched hand. Coronal PD FS and Axial PD shows complete tear of the intersesamoid ligament (arrow) and diastasis of the sesamoids (arrowhead)

# De Quervain Tenosynovitis

- Caused by repetitive microtrauma at extensor retinaculum
- 1<sup>st</sup> extensor compartment
  - Extensor pollicis brevis (EPB)
  - Abductor pollicis longus (APL)
- Tendon thickening and edema restricts normal tendon glide through the compartment
- Women > Men
  - “Baby wrist” – flexion and ulnar deviation
  - Golf and racquet sports
- Treated by rest and splinting
  - Corticosteroid injection
  - Surgical release



Coronal and axial T2 fat suppressed MR imaging shows tenosynovitis and tendinosis in the 1<sup>st</sup> extensor compartment

# Surgical considerations for MCP injuries

- *Many injuries do not undergo MR evaluation*
  - Orthopedic surgeon physical examination and radiograph findings are often adequate for diagnosis and management
  - Primary care providers may be more likely to obtain MR imaging
- Stener lesions are treated **surgically**
  - Non-treatment results in chronic MCP instability and post-traumatic osteoarthritis
- Collateral ligament and volar plate injuries
  - Often treated conservatively with splinting
  - May be managed surgically if there is persistent joint instability

# Masses

- Soft tissue

- Benign - - many

- Ganglion – the most common
    - Pseudotumors
    - Tenosynovial Giant Cell Tumor
    - Vascular malformations
    - Glomus tumor
    - Nerve Sheath Tumor
    - Fibromatosis/Solitary Fibrous tumor
    - Myositis ossificans (Non-Neoplastic)
    - Nodular Fasciitis (Non-neoplastic)

- Malignant (rare)

- Undifferentiated Pleomorphic Sarcoma (UPS) - Most common
    - Synovial Sarcoma
    - Epithelioid Sarcoma
    - Melanoma– probably more frequent than UPS but often not imaged
    - Squamous Cell Carcinoma

- Osseous

- Benign

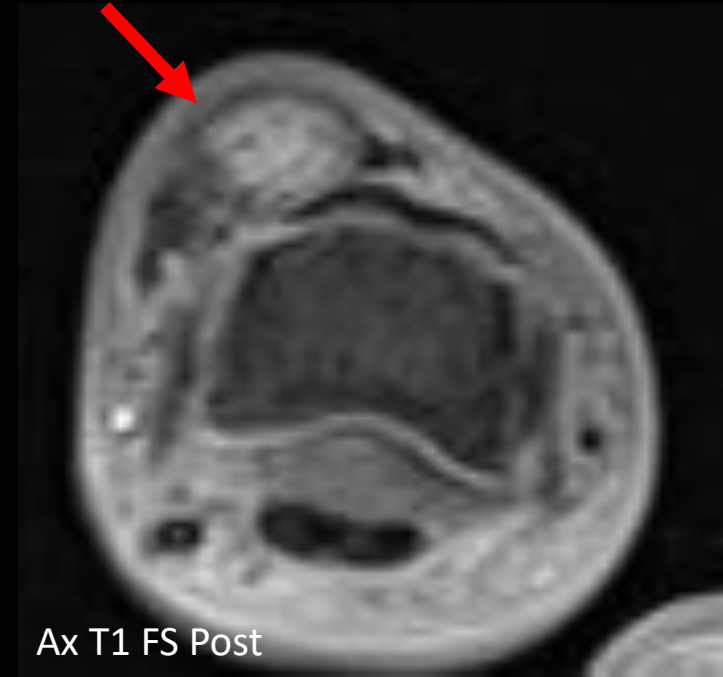
- Enchondroma
    - Giant cell tumor
    - Bizarre parosteal osteochondromatous proliferation
    - Aneurysmal Bone Cysts (ABC)

- Malignant

- Osteosarcoma
    - Chondrosarcoma
    - Ewing's Sarcoma
    - Metastatic Disease – rare ~0.1%. Lung, breast and renal most common primary

# Tenosynovial Giant Cell Tumor

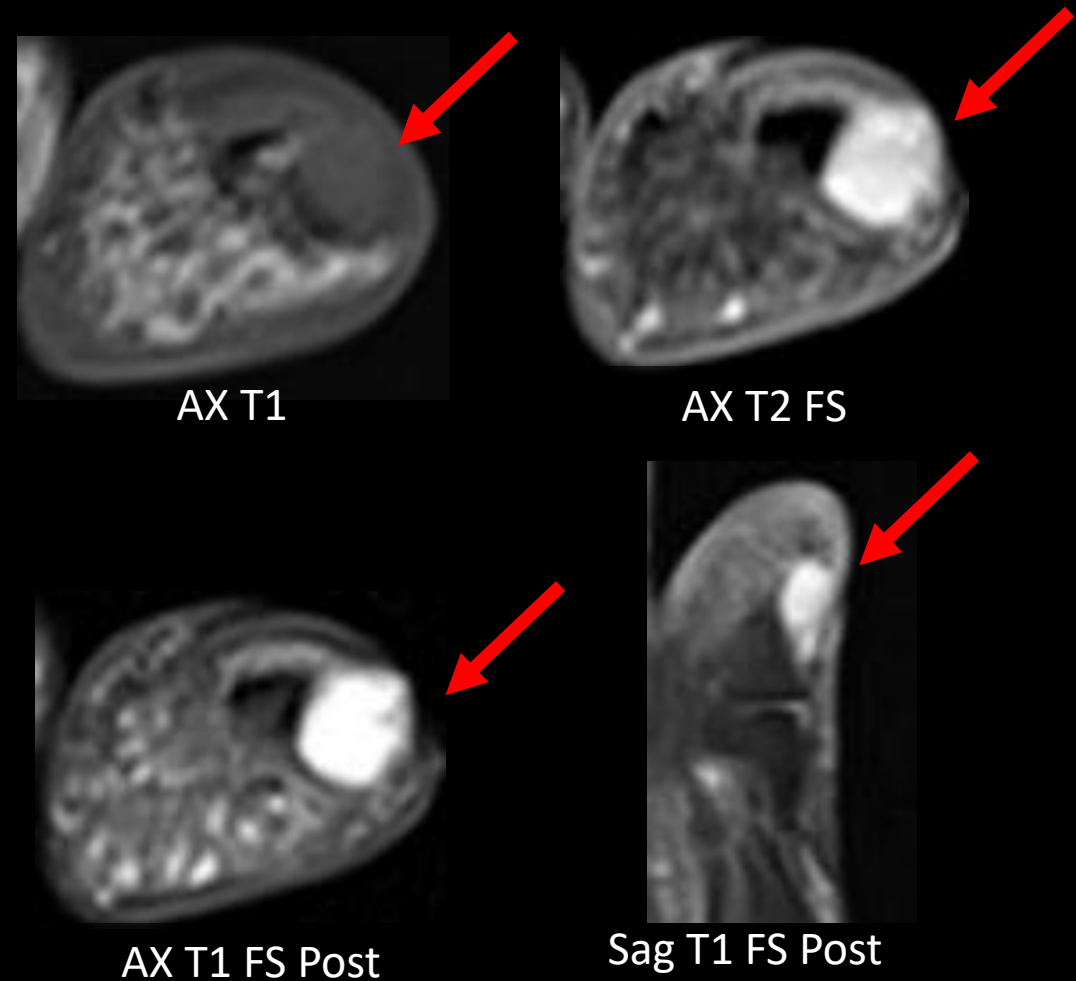
- Arises from the synovium *near the joints, tendon sheaths, bursae*
- 2<sup>nd</sup> only to ganglion for frequency of wrist/hand tumors
- *Volar more common than dorsal*
- Benign but can be locally aggressive
- Broad age incidence; most common in 3rd-5th decades
- Female : Male ~ 2:1
- MR Imaging non-specific
  - Soft tissue mass arising from or in close proximity to a tendon sheath
  - T1 low-intermediate
  - T2 variable (often dark components)
    - **Hemosiderin laden macrophages**
  - Moderate contrast enhancement in a majority



30 year old woman with palpable thumb mass. Axial T1 FS post gadolinium contrast MR image shows a mass (**arrow**) arising from the extensor tendon sheath with tissue diagnosis of tenosynovial giant cell tumor

# Glomus Tumor

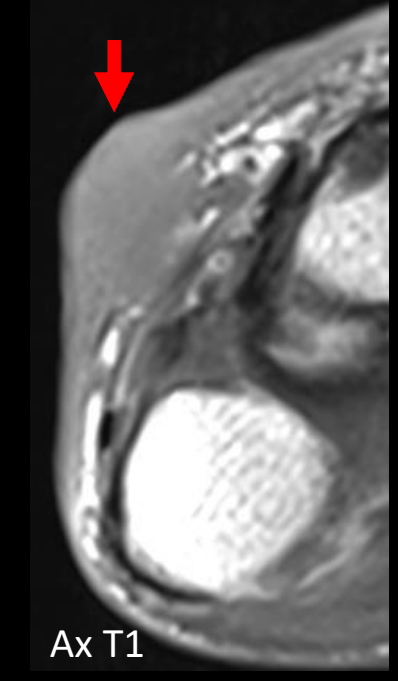
- Mesenchymal neoplasm of the neuromyoarterial glomus bodies
- Propensity for subungual region and distal phalanx
- Severe pain is typical
- MR Findings:
  - Intermediate T1 signal
  - Hyperintense T2 signal, often homogeneous
  - **Intense enhancement** with gadolinium is typical



50 year old female with left thumb painful subungual mass (arrow). T1 isointense, T2 hyperintense mass with gadolinium enhancement.

# Squamous Cell Carcinoma

- In the hand, most common in:
  - Subungual region
  - Thumb and index finger
- Typically a superficial tumor which can aggressively invade soft tissue structures and bone
- Often ill-defined mass with non-specific T1 hypointense and T2 hyperintense signal with contrast enhancement. Often associated soft tissue and bone marrow edema



61M s/p renal transplant with history of SCCa and new nodule on the base of thumb. Sagittal STIR, Sagittal T1, and axial T1 MR images show a ill-defined T1 hypointense, STIR intermediate mass (arrows) involving the skin and subcutaneous fat adjacent to the MCP joint. Adjacent soft tissue edema is present Tissue diagnosis was consistent with SCCa.



# Vascular Malformations

- Capillary:

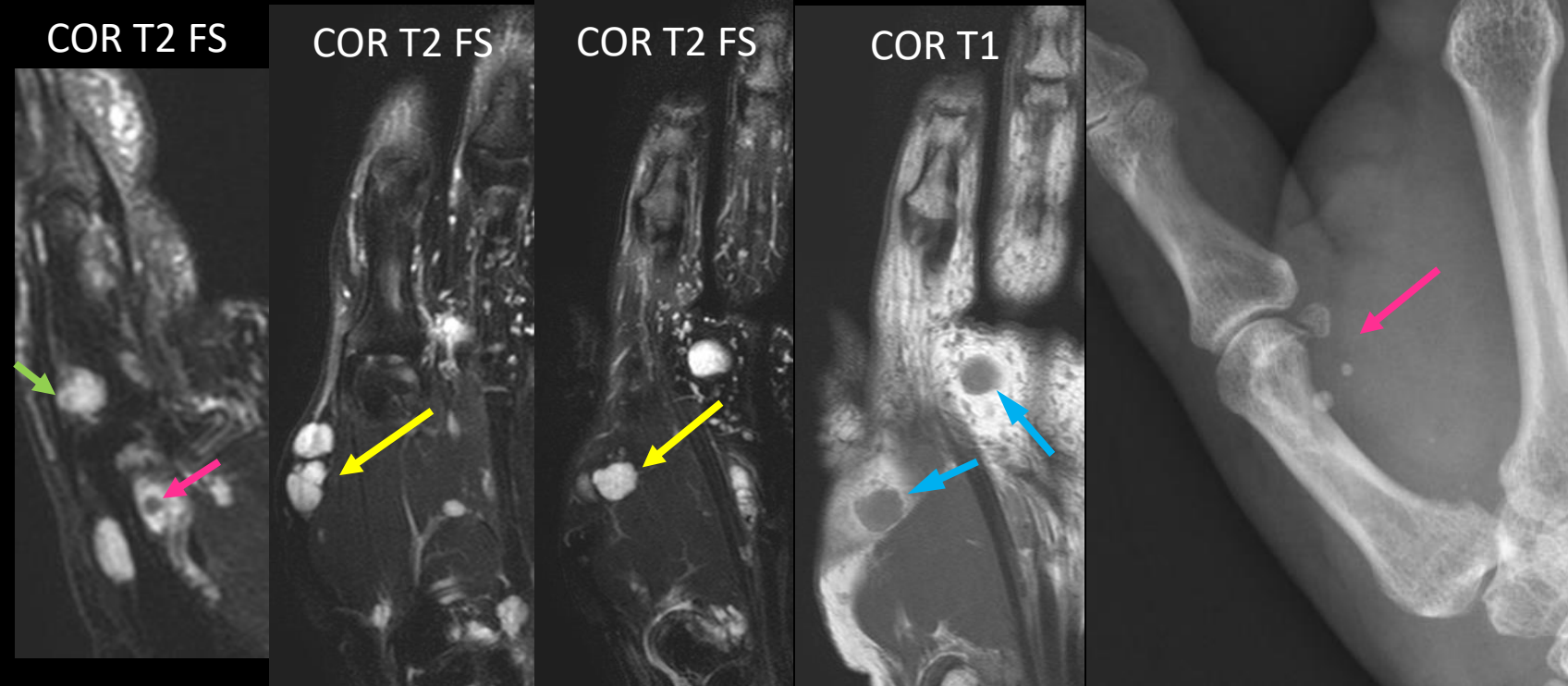
- Occurs at birth. Skin discoloration (port wine stain). No perilesional edema

- Low Flow Venous:

- Septated, lobulated mass **without flow voids**. May have low signal foci corresponding to phleboliths. Delayed postcontrast T1 imaging will show diffuse enhancement of the slow flowing channels

- High Flow Vascular Lesions:

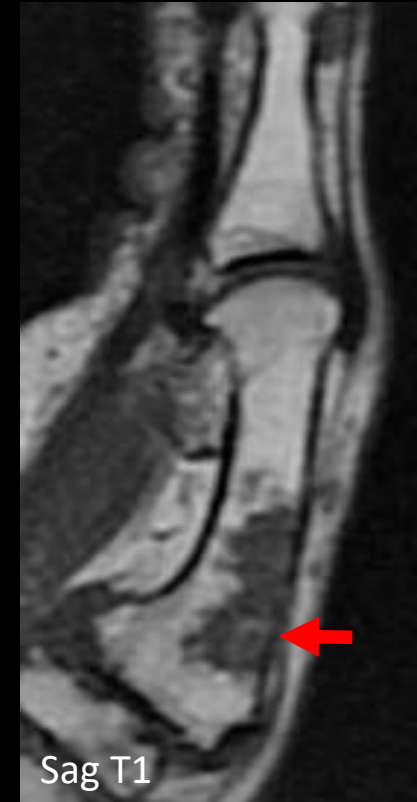
- Enlarged, serpentine arteries and draining veins. May have **flow voids**. High signal on T1 may represent hemorrhage or thrombosis



36 y/o male with venous malformations. Radiographs - **phleboliths** in a soft tissue collection are virtually pathognomonic. MRI - **T1 isointense**, **T2 hyperintense**. The lesion crosses tissue planes extending into **bone**, muscle and subcutaneous tissue.

# Enchondroma

- Benign bone tumor composed of mature hyaline cartilage
- 40-65% of enchondromas are found in the hand
  - Thumb least involved
  - Small finger most involved
- Generally incidental
  - May result in **pathologic fracture**
  - Repeated fracture may prompt surgical treatment
    - Curettage w/bone graft
    - Recurrence rare
- Enchondroma protuberans
  - Rare form with exophytic growth pattern



62 year old woman with incidental thumb bone lesion on radiograph for distal radius fracture. Coronal STIR shows lobulated high signal intensity. Sagittal T1 shows low-intermediate signal with small focus of internal fatty marrow (**arrow**).

# Surgical Considerations for Tumors

- Surgical open biopsy often needed
  - Core needle biopsy needles are often too large for effective imaging guided biopsy
- It is imperative to identify tumor extent and boundaries for pre-surgical planning
  - Invasion or abutment?
    - Tendon sheaths
    - Joints
    - Muscles
    - Neurovascular structures
- Identify variant anatomy
  - Accessory muscles or tendon slips

# Thumb pathology which presents on MRI

- Injuries
  - Acute
  - Chronic (Osteoarthritis)
- Soft tissue lesions
- Osseous lesions
- Deposition Disease
- Arthritides



# Conclusion

- The thumb has unique anatomy among the digits resulting in injuries that are distinct from the finger
- Performing high quality MR imaging of the thumb has unique challenges
- Besides MCP UCL tears, there are many more injuries in the thumb that can be diagnosed with MRI
- Recognizing common injuries, masses, and inflammatory conditions enable the radiologist to assist the clinician in the correct disposition of the patient which may include conservative, further diagnostic, or surgical measures

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