

MR anatomy and injuries of the fingers

Priya Bhikha Patel

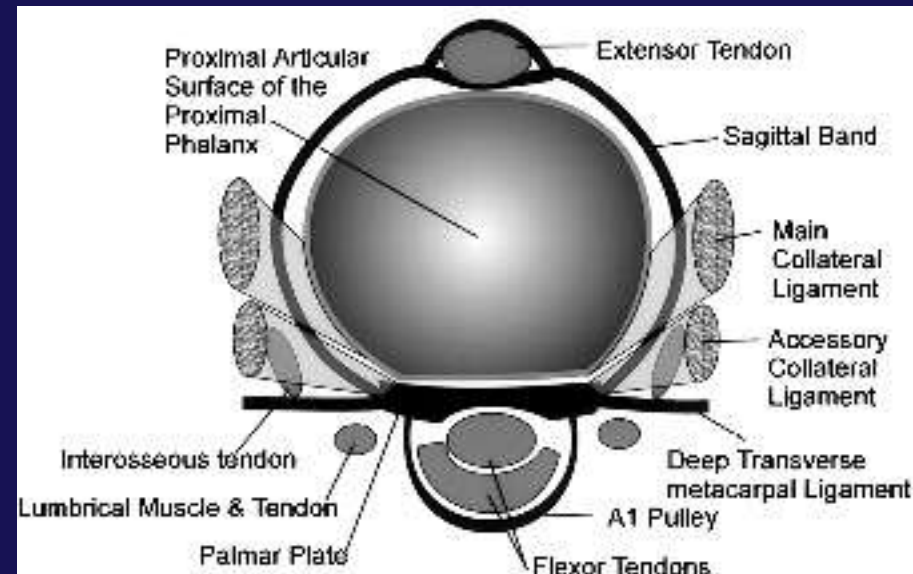
2008/9

Review of

- Anatomy and injury of
 - Extensor apparatus (extensor hood and tendons)
 - Collateral ligaments
 - Palmar plate and deep transverse metacarpal ligament
 - Annular and cruciate pulley systems
 - Flexor tendons
 - MCPJ
 - Gamekeeper's thumb
- Anatomy + injuries of PIPJ's
 - Coronal plane instability
 - Sagittal plane instability
- Anatomy DIPJ

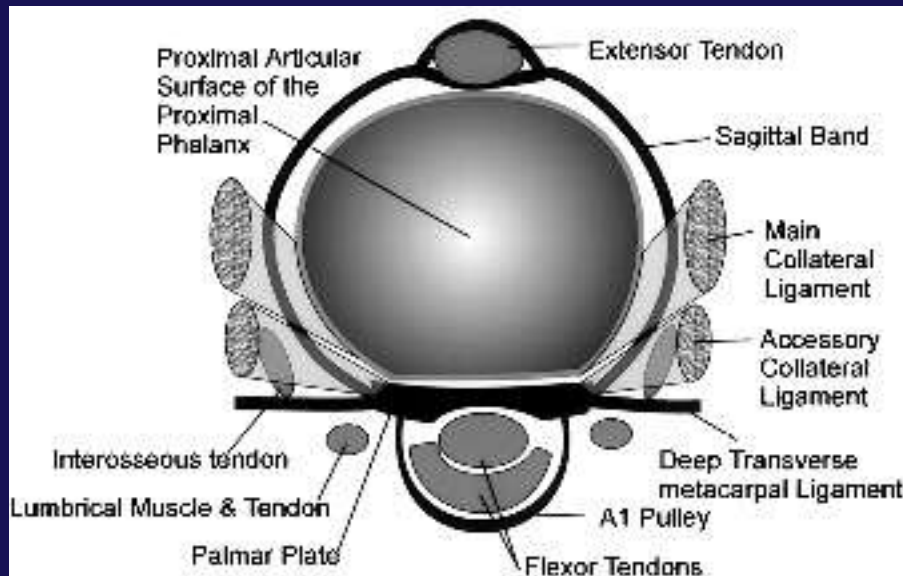
MCP Joint

- Tendons
 - Extensor and extensor hood
 - Flexors
 - longus (central slip) and brevis (splits)
- Ligaments
 - Medially--> main coll lig + accessory coll lig
 - Laterally--> main coll lig + accessory coll lig
 - Palmar--> deep transverse metacarpal ligament
- Muscles
 - Lumbricles (muscle + tendon)
 - Interosseus (muscle + tendon)
- Pulleys
- Palmar plate

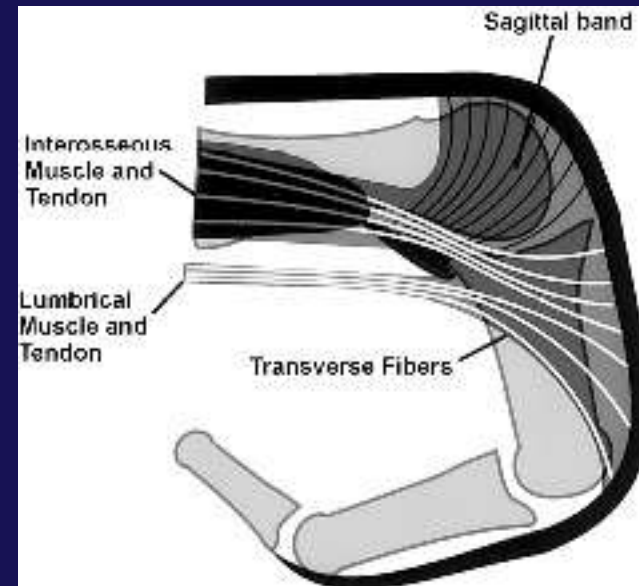


Main MCP joint structures after removal of MC head

Extensor hood: sagittal bands+transverse fibers

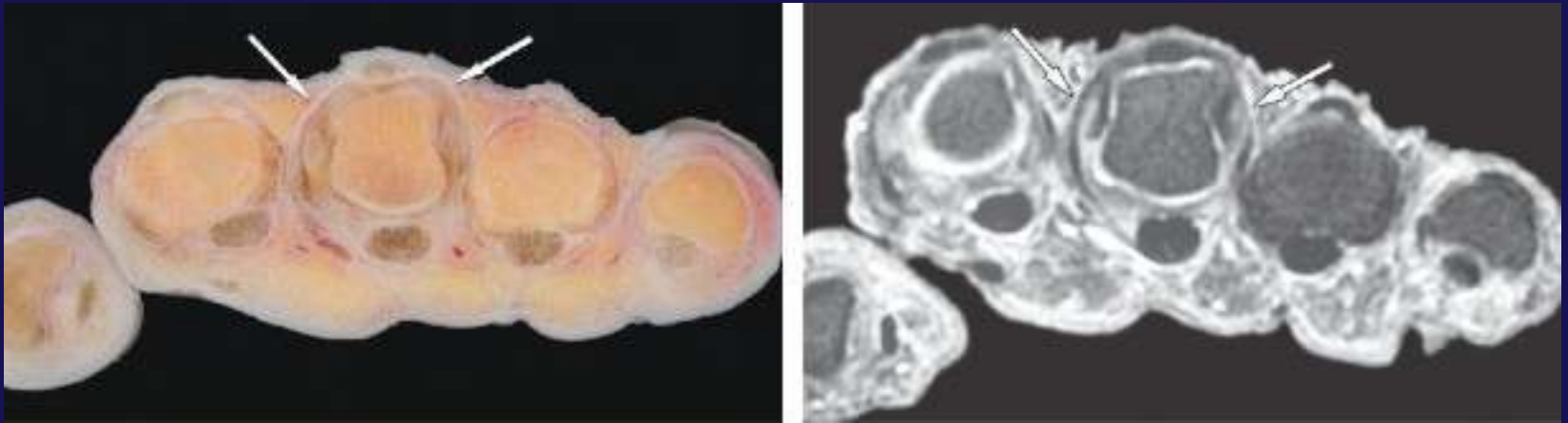


Main MCP joint structures after removal of MC head



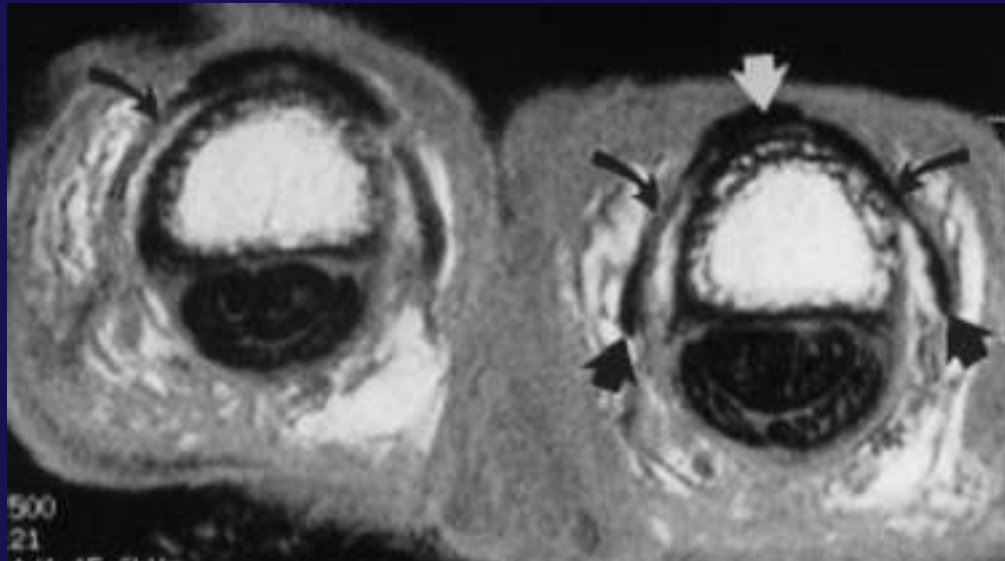
- Extensor hood has sagittal bands and transverse fibers
- Sagittal bands are located above the MCP joint line and extend from common extensor tendon to junction of palmar plate and deep transverse metacarpal lig and coursing between main collateral lig and interosseus tendon .
- Transverse fibers of interosseus and lumbrical tendons more distal to sagittal bands, over prox phalanx

Extensor apparatus at MCP joint level



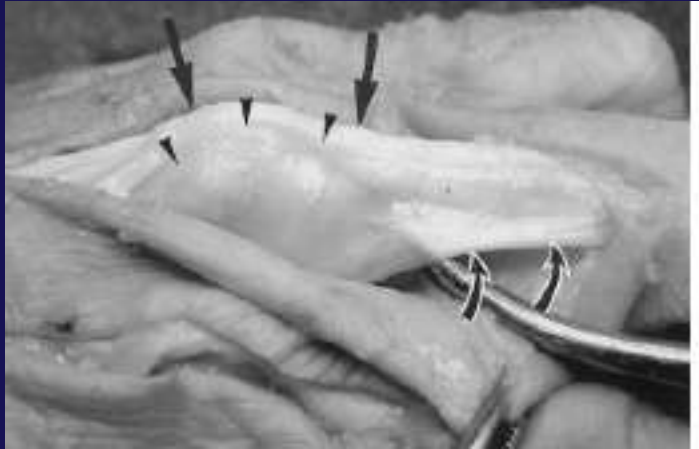
Axial anatomic slice (a) and corresponding fat-suppressed proton-density-weighted MR image (b) obtained at the MCP joint show the circumferential distribution of the dorsal apparatus over the dorsum of the fingers. Arrows = sagittal band

Extensor hood: transverse fibers from interosseus tendon



1cm distal to MCPJ: Curved arrow = transverse fibers originating from interosseus tendon (straight black arrow) extending to ext tendon (white arrow)

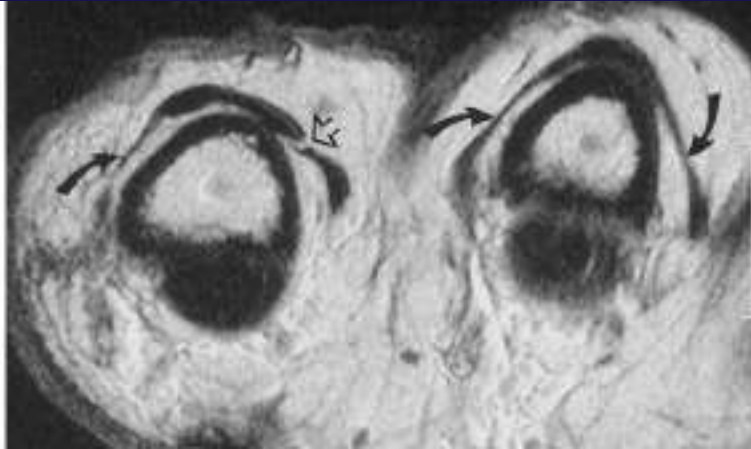
Extensor hood injuries: ulnar sagittal band disruption



Surgical exposure of extensor hood @ dorsal and ulnar aspect of 3rd MCPJ

Sagittal bands (arrowheads) stabilise extensor tendon (straight arrow)

Transverse fibers of extensor hood extending distally (lifted, curved arrows)

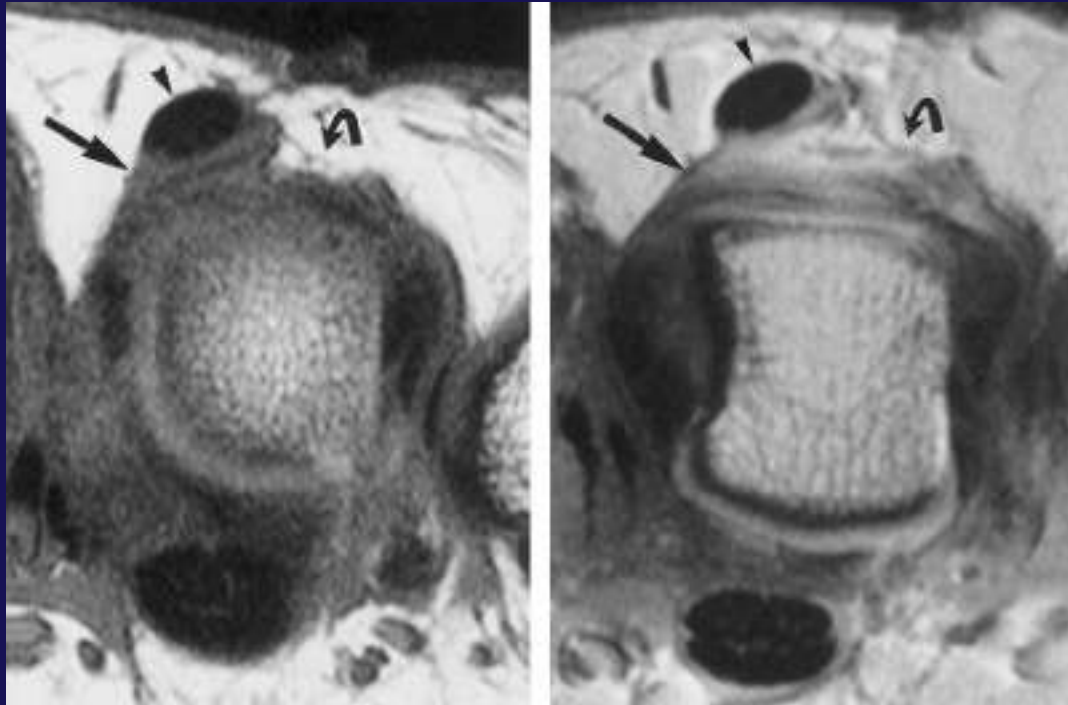


3rd MCPJ simulated extensor hood injury:

Ulnar sagittal band (open arrow) disrupted with intact radial sagittal band (curved arrow)

*radial subluxation of common extensor tendon

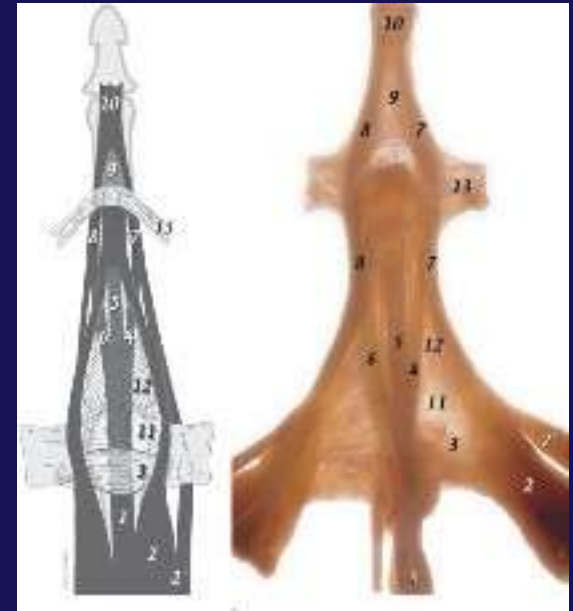
Extensor hood injury: Transverse fibers



4+ 5th MCPJ's: Radial transverse fibers (curved arrow) of extensor hood disrupted. Ulnar transverse fibers of extensor hood intact (straight arrow)

Anatomy: extensor tendons

- Finger extension involves simultaneous actions of intrinsic and extrinsic muscles
- Series of stabilising retinacular structures are present and located at the dorsal carpus (extensor retinaculum), hand (intertendinous connections) and fingers (extensor hoods)
- Near midportion of metacarpals, extensor tendons are connected by *juncturae tendinum* which prevent independent extension of the digits.
- Intrinsic muscles include: interosseus and lumbrical muscles which extend PIP+DIPJ's and flex MCPJ's
- Extrinsic muscles include: extensor digitorum communis, extensor indicis proprius and extensor digiti quinti minimi - which primarily extend MCPJ's but also the PIP + DIPJ's
- At MCP joint, extensor tendons are stabilised by extensor hood
- Distal to MCPJ, intrinsic and extrinsic tendons blend into extensor apparatus
- Extrinsic extensor tendon continues in the central(5) and lateral slips(6)
- Central slip (5) inserts on base of MP
- Intrinsic tendon contributes to form lateral slips (6) and send fibers medially to form part of central slip (5)
- Once lateral slips receive contribution from intrinsic muscles, they are called conjoined tendons
- Medial and lateral conjoined tendons (7+8) converge to form terminal tendon(10), inserting onto base of DP
- Triangular ligament (9) between conjoined tendons, keeps them in a dorsal location relative to PIPJ rotational axis



- 1 □ extensor digitorum tendon
- 2 □ interosseous muscle, 2' □ □ lumbrical muscle
- 3 □ sagittal band
- 4 □ medial slip
- 5 □ central slip
- 6 lateral slip
- 7 □ medial conjoined tendon
- 8 lateral conjoined tendon
- 9 □ triangular ligament
- 10 □ terminal tendon
- 11 □ transverse fibers
- 12 □ oblique fibers
- 13 retinacular ligament

Extensor tendon injury

- Owing to specific findings related to level of tendon injury, anatomic zones have been developed to classify location of injury
- 8 zones system commonly used with zone I at DIPJ and zone VIII at distal forearm. Odd zones correspond to articular areas
- Injuries classified as open (laceration) or closed (avulsion)
- Extensive vascularisation of the extensor apparatus predisposes to adhesion formation
- MR:
 - Partial thickness tear based on presence of areas of increased T1W(sometimes T2W) in a portion of the tendon
 - Full thickness tears appears as area of discontinuity with fraying and irregularity at ends of ruptured tendon
 - Adhesions: blurring of margins at tendinous surface, abnormal signal in surrounding fat and distortion of normal tendon anatomy



Extensor tendon injury

Classic deformity patterns:

Mallet finger (zone I):

- Lesion of bony or ligamentous attachment of extensor mechanism at DP with loss of extension at DIPJ
- Mechanism: tip of finger struck by or against object resulting in acute DIPJ flexion
- Treatment: splinting with DIPJ in extension
- Untreated mallet finger progresses to Swan-neck deformity

Boutonniere deformity (zone 3):

- Injury to central slip, at/near its insertion on base of MP (or fx of central slip attachment which is less frequent)
- Mechanism: blow to dorsum MP, acute violent flexion PIPJ or volar dislocation PIPJ
- Clin: may be missed in acute phase since lateral slips can still extend PIPJ, but over time lateral bands move volar to axis of rotation of PIPJ causing flexion PIPJ and DIPJ extension
- Treatment: Acute boutonniere: extension splinting
Surgery if soft tissue interposition prevents relocation of dislocated PIPJ or large displaced bone fragment present
- Surgical reconstruction for chronic symptomatic cases

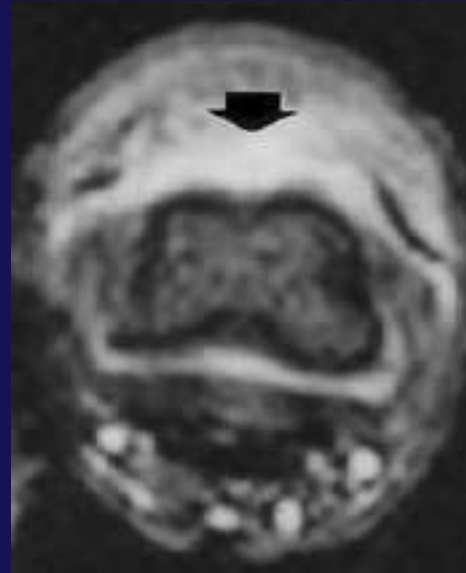
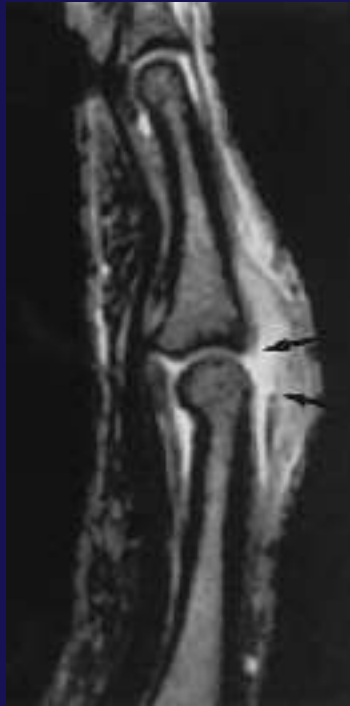
Extensor tendon injury



Open mallet: complete laceration of
conjoined tendon at insertion to DP base

Flexion deformity DP

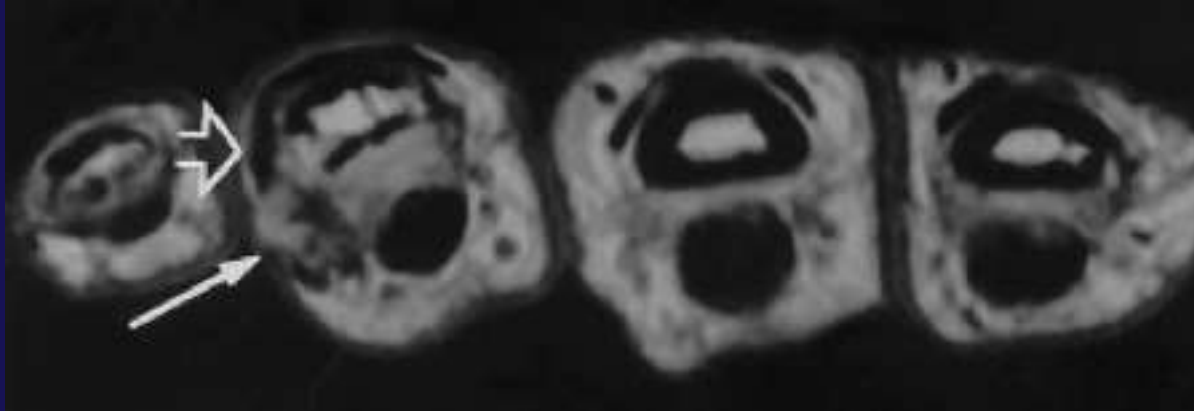
Extensor tendon injury



Zone 3 acute laceration of central slip at insertion on base of MP with arrows indicating hyperintense gap

Note absent boutonniere deformity owing to lateral slips probably still in place

Extensor tendon injury



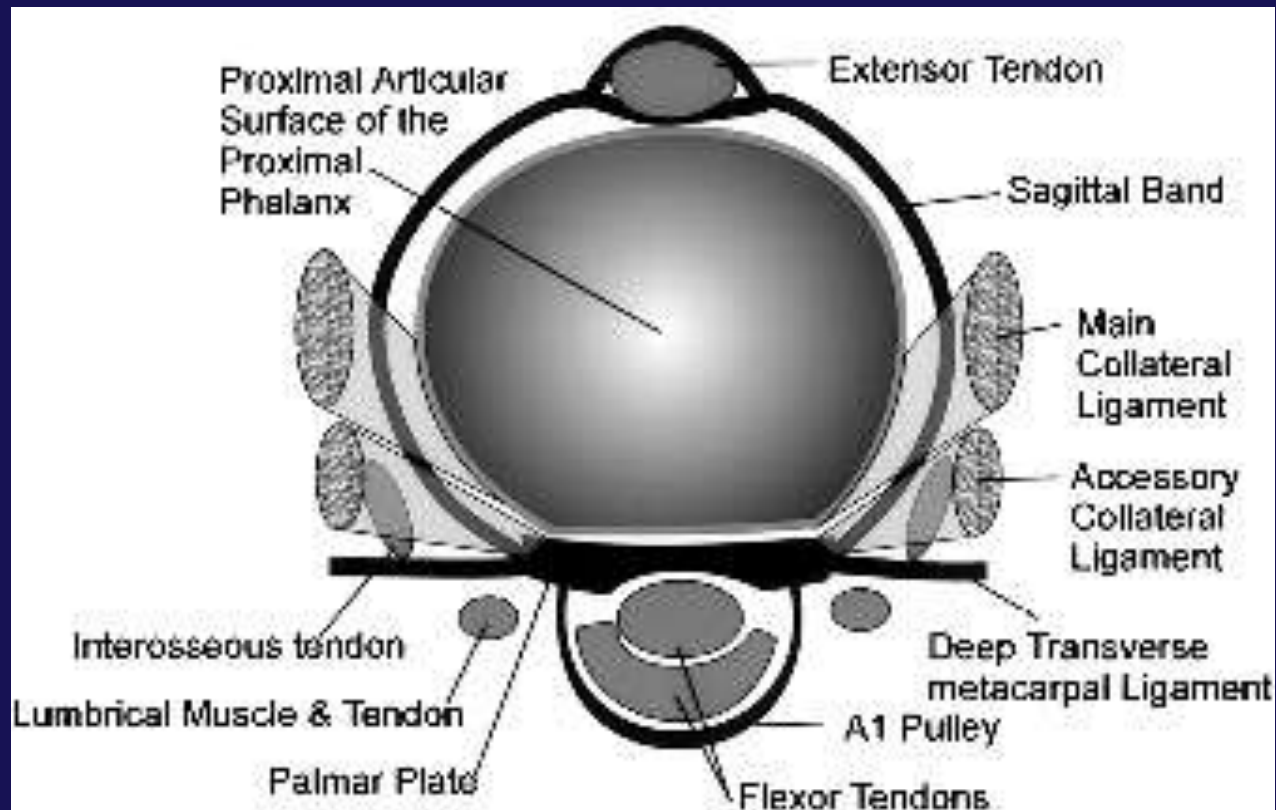
Adhesions of extensor system prox to PIPJ: Solid arrow shows hypo-intense scar and adhesions adjacent to swollen and volarly displaced lateral slip (open arrow)

Extensor tendon injury

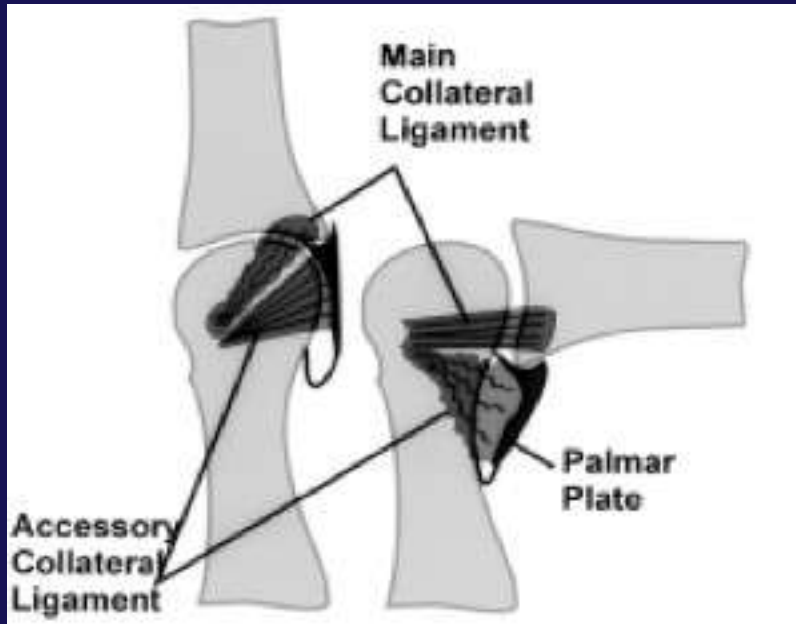


Boutonniere deformity: discontinuity of central slip at its insertion onto base of MP (long arrow) with flexion at PIPJ and extension at DIPJ

Collateral ligaments



Collateral lig complex: main + accessory ligaments



Situated on radial and ulnar sides of MCPJ

2 distinct bands: Main + accessory

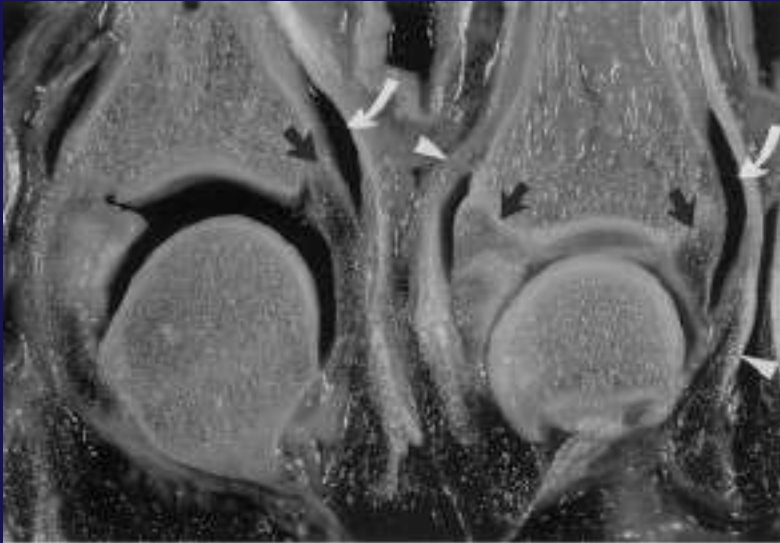
Main coll lig: extends from depressions of MC head to base of prox phalanx

Accessory coll lig: extends from MC head (in more palmar location than main) to attach distally to the palmar plate

Main collateral ligament is relaxed
In extension and taut in flexion

Accessory collateral ligament is
taut in extension and relaxed in flexion

Anatomy: main collateral ligament

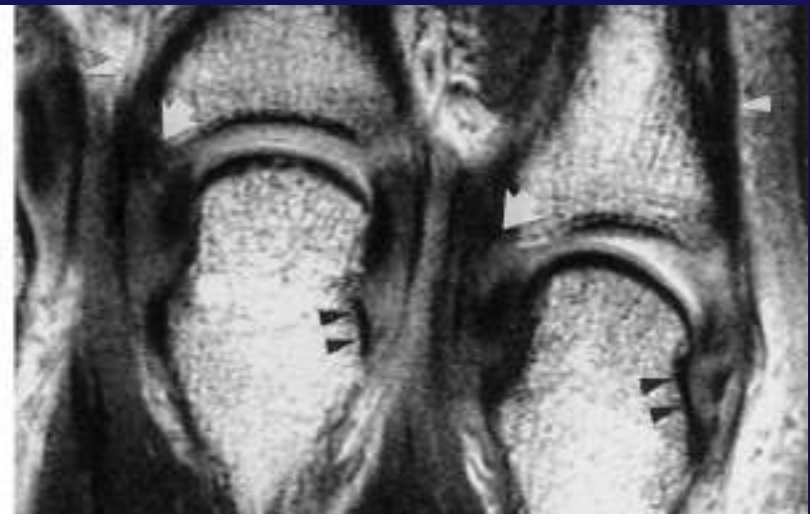
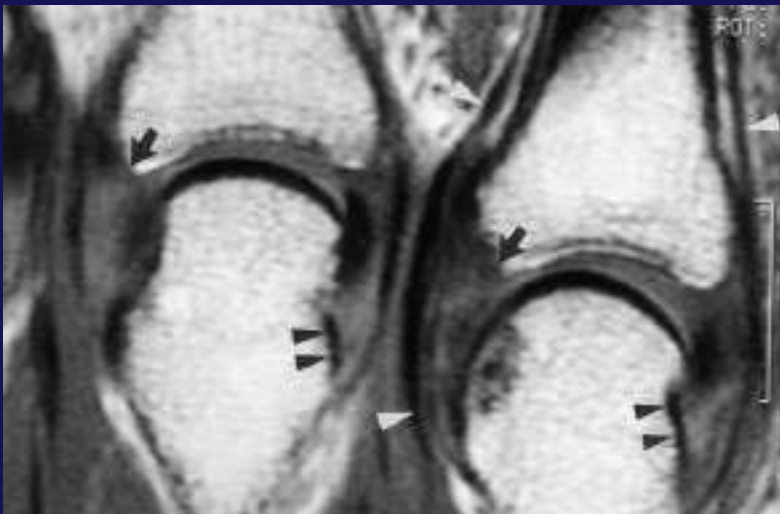


2/3 MCPJ's extended:

Main Coll Lig prox attachment (black arrowheads)
and distal attachment (straight arrows)

Interosseus tendons (white arrowhead)

Intermetacarpophalangeal spaces (curved arrow)
betw MCL and interosseus tendon



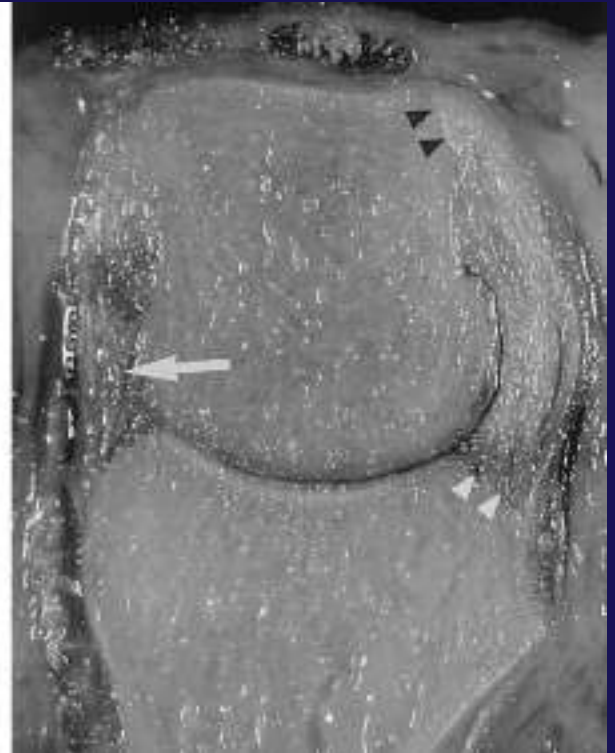
Main collateral ligament: flexion



T1

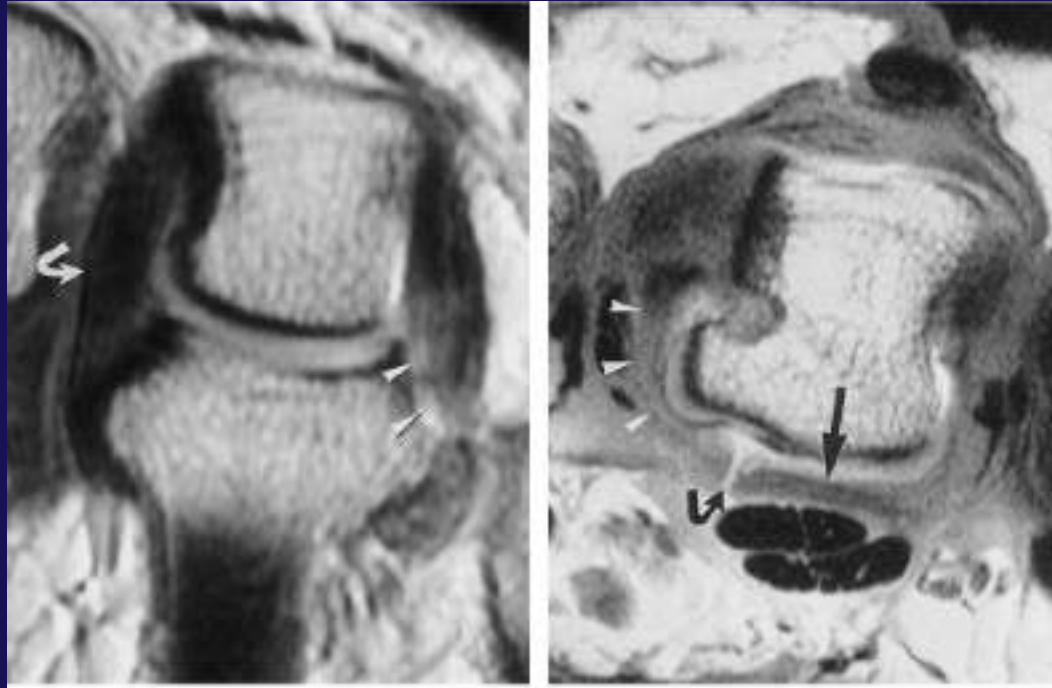


MR arthro



3rd MCPJ flexed: (white arrow) Taut main collateral lig with prox attachment (black arrowheads) and distal attachment (white arrowheads)

Main and accessory collateral ligament injuries



Collateral lig complex injuries: MR arthro 3rd MCPJ flexed

Main ulnar collateral ligament (arrowheads) detached at its distal insertion site. Main radial collateral ligament (arrow) intact.

Accessory ulnar collateral ligament is detached at its distal insertion site (curved arrow) at the palmar plate (straight arrow)

Palmar plate + Deep transverse metacarpal ligaments (DTML)

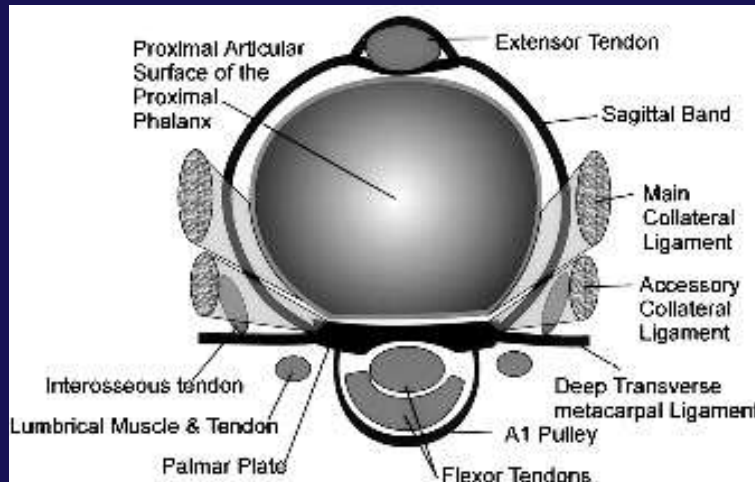


Palmar plate:
Volar aspect of MCPJ

Thin membranous capsule proximally with thick distal attachment at base of proximal phalanx

Attached to accessory collateral ligaments on either side

Prevents hyperextension and dorsal subluxation of MCPJ



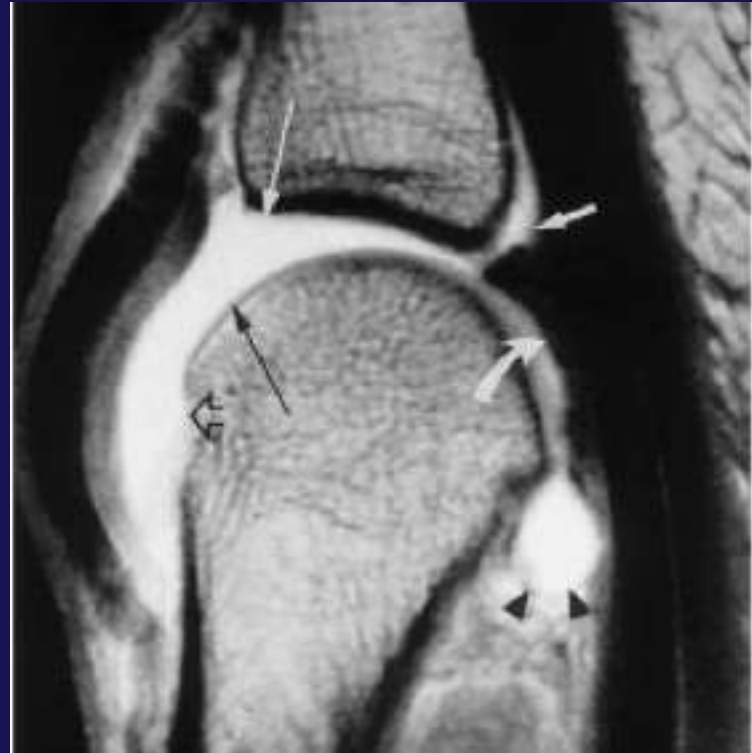
Deep transverse metacarpal ligament:

Consist of 3 flattened bands connecting prox phalanges of 2nd -5th MCPJ's

Interosseus muscles/tendons lie dorsal to DTML

Lumbrical muscles, digital vessels + nerves lie on palmar aspect of DTML

Palmar plate with MCPJ extension



Sag MR arthro: extended 3rd mcpj:

Palmar plate (curved arrow)

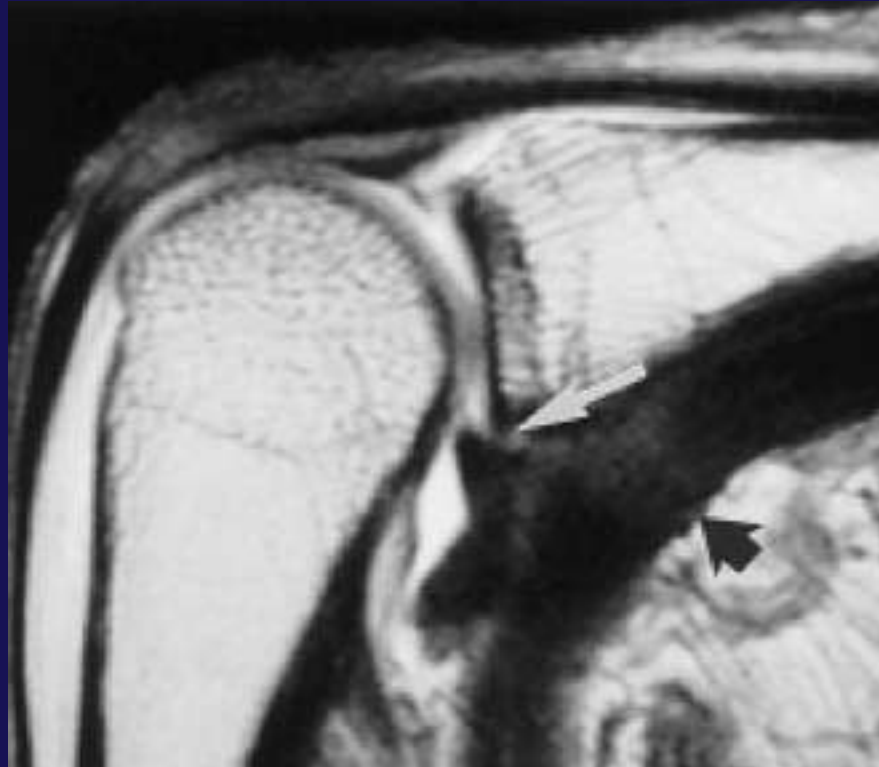
Distal recess of palmar plate (short solid arrow specimen and white arrow MR))

Proximal recess (arrowheads)

Bare area (open arrow)- betwn cartilage (long straight arrow) and dorsal insertion of capsule

Flexor tendons

Palmar plate with MCPJ flexion



3rd MCPJ in flexion -MR arthro:
Angled palmar plate

Distal recess (white arrow) is compressed

Flexor tendons (black arrow) applied to bone surface

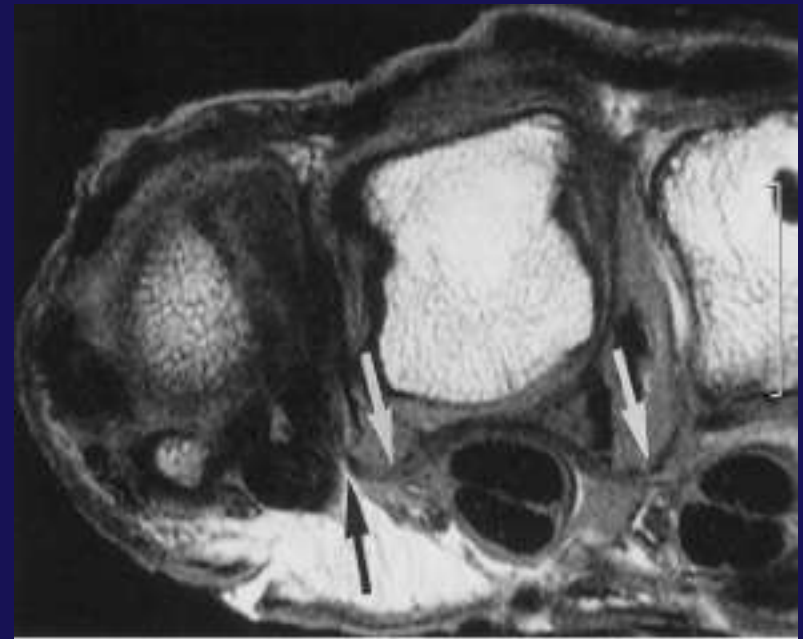
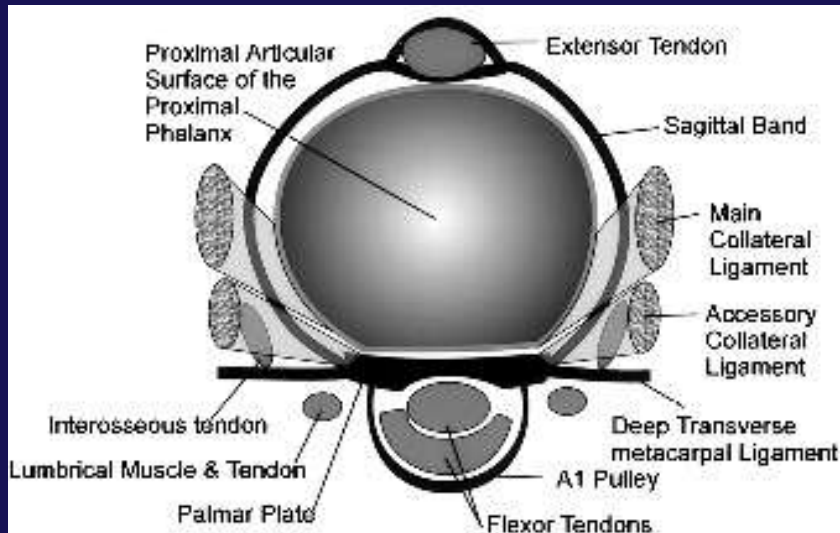
Palmar plate detachment



MR arthro 3rd MCPJ:

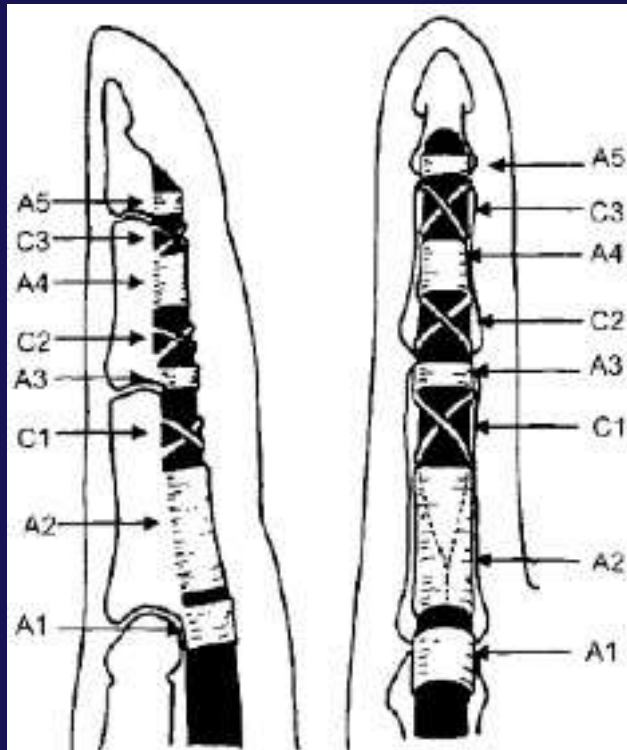
Detachment (curved arrow) of palmar plate (arrowheads)
Near its distal insertion at the base of the proximal phalanx in
close relation to the distal recess (straight arrow) of the palmar
plate

Deep transverse metacarpal ligament disruption



4th MCPJ: Deep transverse metacarpal ligament (white arrows) is disrupted betw 4th+5th MCPJ's at its ulnar attachment (black arrow) at the palmar plate

The annular and cruciate pulley systems

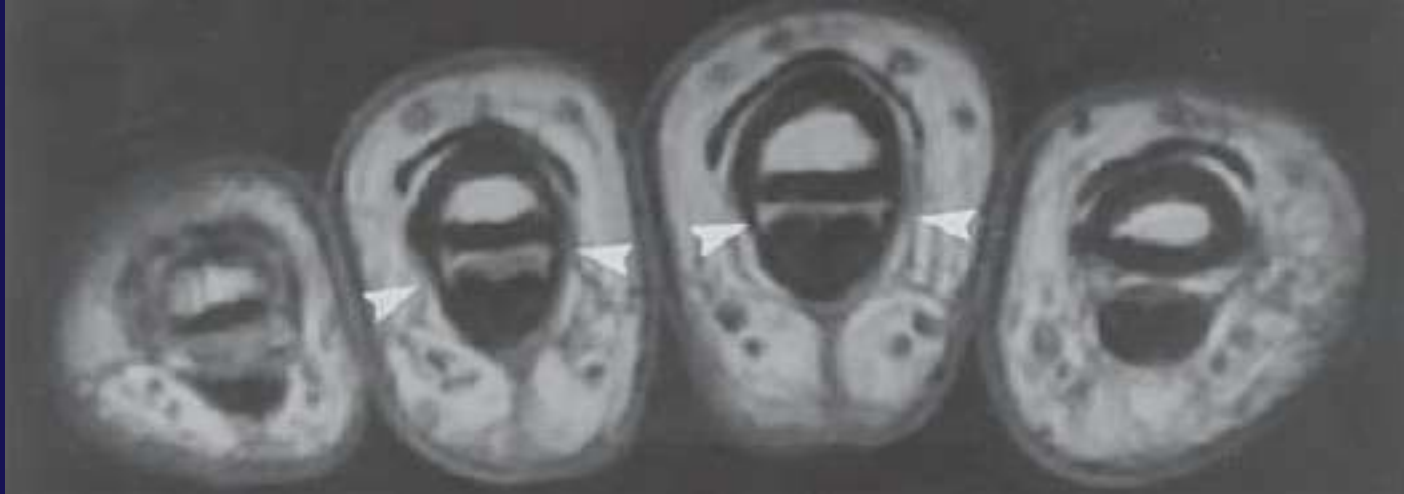


Annular pulleys: transverse, well defined areas of thickening of the flexor tendon sheath

Cruciform pulleys: formed by crisscrossing fibers of components of the annular pulley system; are variable in prevalence and shape

Main function: fix the tendon sheaths to the bony skeleton thereby stabilising the tendon during finger flexion and avoiding “bowstringing”.

Normal annular pulley



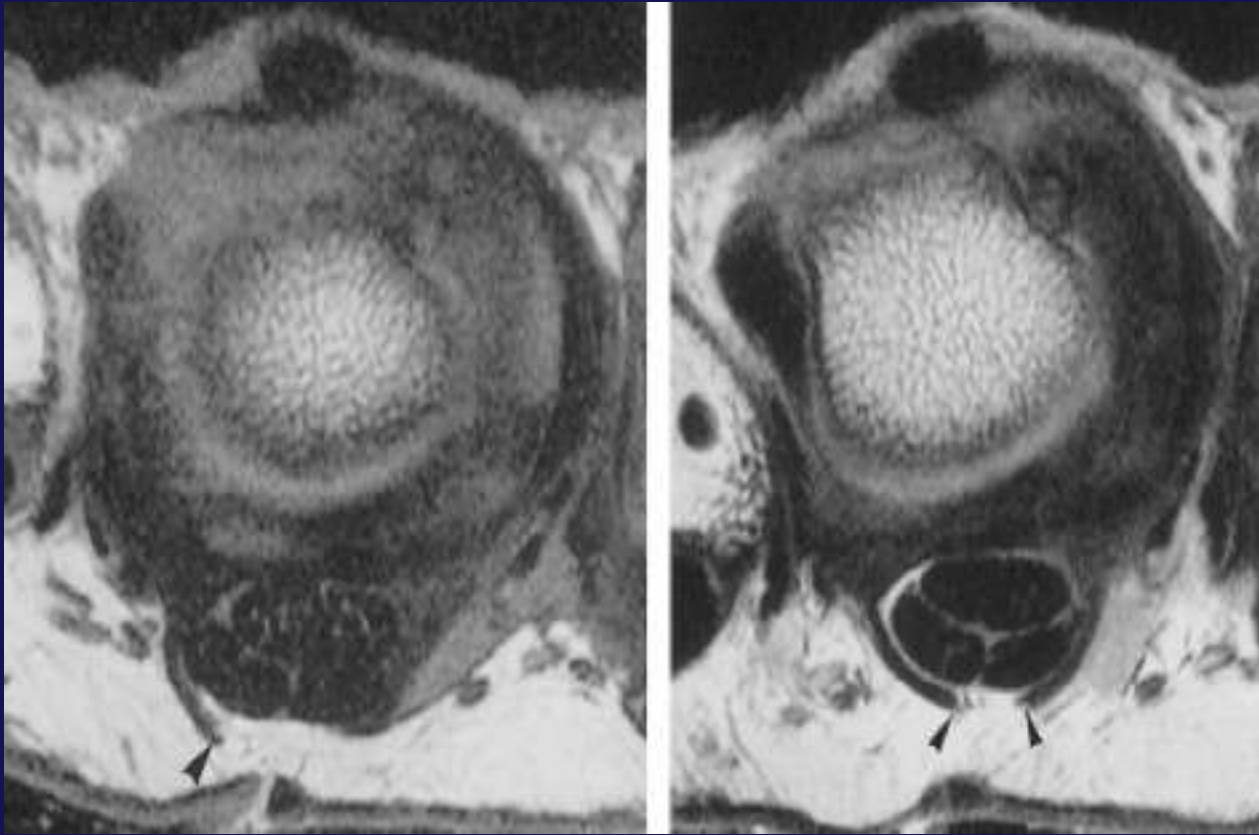
A2 pulleys at level of middle phalanx

Complete disruption of A2 pulley



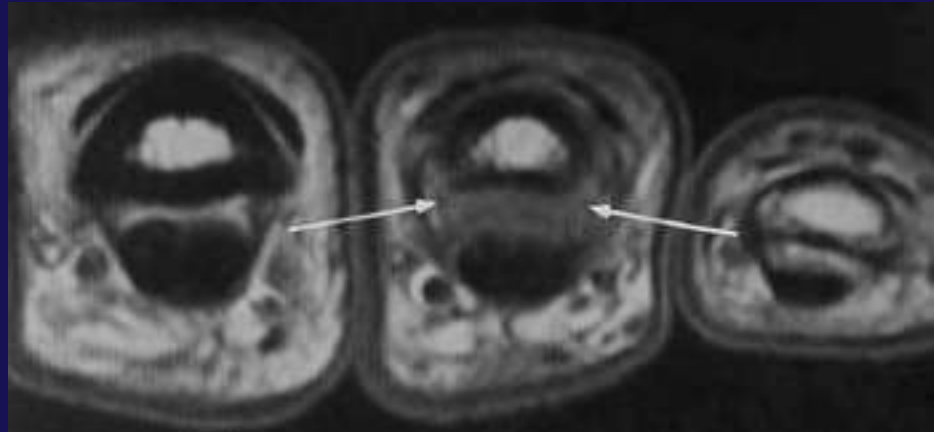
Increased gap between flexor tendon and prox phalanx during flexion

Disrupted A1 pulley



4th MCPJ Ax T1W and MR arthro: Disrupted A1 pulley (arrowheads)

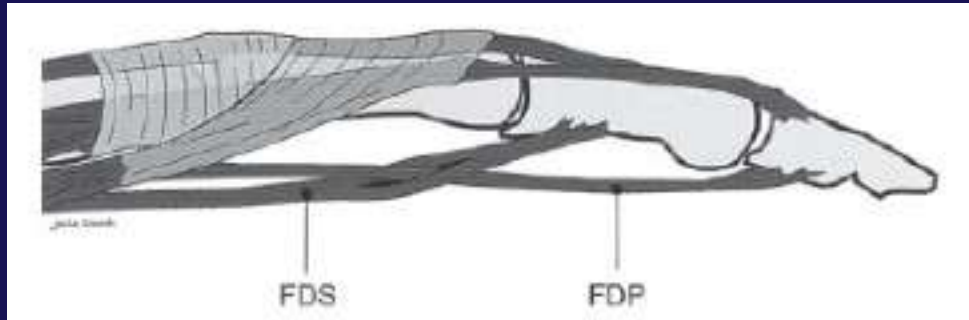
Partial annular pulley rupture



Ax T1W MR: Thickening and increased signal intensity of A2 pulley

Sag T2W MR: No significant gap betwn flexor tendon and bone

Anatomy: flexor tendons



FDS: Splits at level of distal MC, passes around FDP and re-unites deep to FDP at PIPJ. Inserts onto middle portion of middle phalanx

FDP: inserts onto base of distal phalanx



Volar view of FDS showing chiasm . Arrows indicate joining of the 2 slips (at level of PIPJ) before separate insertions on the MP.

Anatomy: flexor tendons



Ax T1W image distal to PIPJ: Arrows showing 2 slips of FDS tendon immediately before their insertion on mid portion MP.



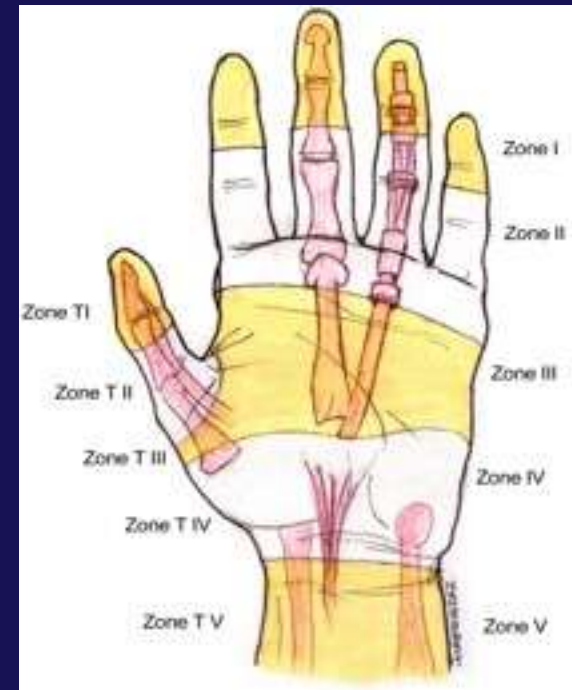
Midsagittal T1W: FDP Tendon (arrows) with distal insertion on base of DP (arrowhead)



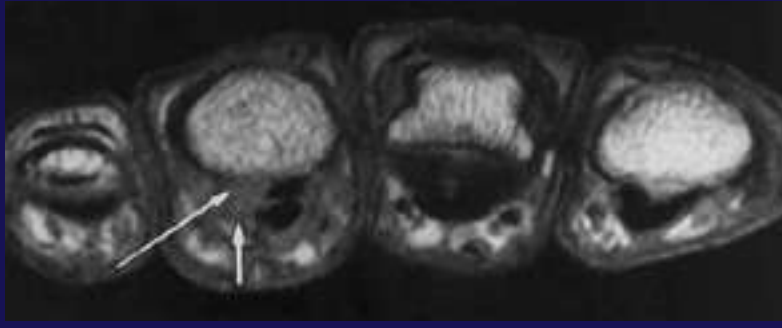
Parasagittal T1W: Insertion of FDS tendon on MP (arrow)

Injury of flexor tendons

- Classified as open or closed injuries
- Open injuries- usually lacerations
- Closed injuries-involve avulsions at insertion sites of FDS and FDP or involve the pulley system
- Anatomic level of tendon injury based on a system of Zones which guide therapeutic plan and influence prognosis:
 - Zone I: From distal insertion of FDP tendon to distal insertion of FDS tendon
 - Zone II (no man's land): distal insertion of FDS tendon to palmar plate of MCPJ.
 - Lacerations in zone II most frequent and carry worst prognosis.
 - Zone III: Proximal part of A1 pulley to distal flexor retinaculum
 - Zone IV: region of carpal tunnel
 - Zone V: distal forearm
- Injuries to zones III,IV and V complicated by injuries to major neurovascular structures and lumbricals
- Treatment:
 - FDP tendon laceration in zone I: primary repair
 - Zone II lesions: controversial. Isolated FDP laceration without FDS injury may be treated conservatively.
 - Zone III-V: usually primarily repaired



Injury of flexor tendons



Partial tear FDP tendon and disruption medial slip FDS tendon:

- AX T1W MR at MCPJ shows intermediate signal in half fibers of FDP tendon (short arrow).
- Medial slip of FDS tendon (long arrow) completely disrupted.



Complete laceration of FDP tendon with a gap between the tendon ends (arrows)
Metallic artifacts present from open wound

Flexor tendon: closed injury

- Include avulsion of FDP and FDS tendons
- FDP>>FDS avulsion
- FDP avulsion:
 - Caused by hyperextension during active flexion, more commonly sports related injury
 - Lesion called “sweater finger” or “jersey finger”
 - FDP tendon of 4th finger most commonly injured
 - Loss of active flexion at DIPJ
 - 4 main types:
 - Type I: retraction of tendon into palm
 - Type II: tendon retracts to PIPJ. Small bone fleck may be avulsed at PIPJ level
 - Type III: Avulsion of large bone fragment from DP. Fragment remains attached to FDP tendon and only retracts to level of A4 pulley.
 - Type IV: Type III lesion with simultaneous avulsion of FDP from fracture fragment.
- FDS avulsion:
 - Rare. Most associated with FDP injury
 - Forced extension against contracted flexor muscle
 - Loss of flexion at PIPJ

Flexor tendon: closed injury



Discontinuous FDP tendon (arrow)

FDS tendon intact (arrowheads)



Absent FDP in tendon sheath (arrowheads)
2 bands FDS tendon present (arrow)

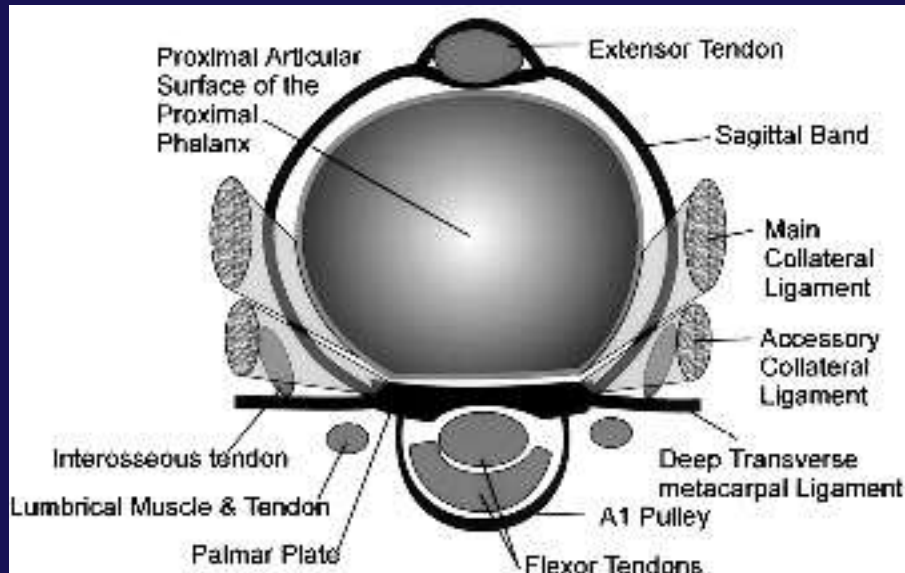


Retracted FDP tendon at prox metacarpal (long arrow)
consistent with type I injury

FDS (short arrow) partially imaged

Quick review of MCPJ

Recap MCPJ: Sagittal bands, A1 pulley, DTML, lumbrical m.



2/3rd mcpj's MR arthro:

Fibrous connection (curved arrow) betw the proprius and common extensor tendon

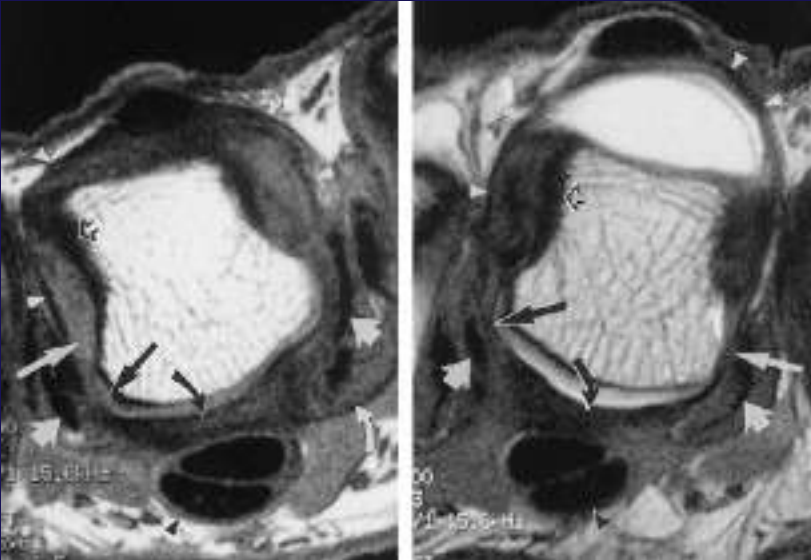
Sagittal bands (arrowheads)

A1 pulley (thin straight arrow)

DTML (open arrow)

Lumbrical muscle (thick straight arrow)

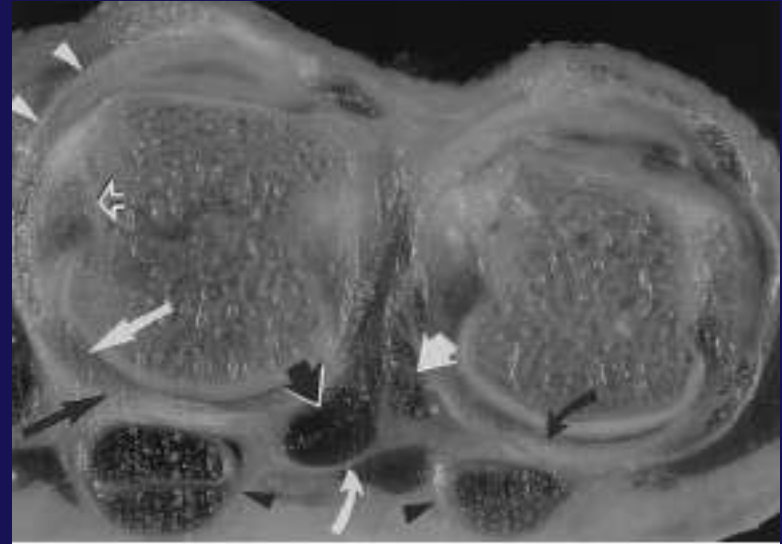
Recap MCPJ: accessory collateral ligament, sagittal bands, IO muscles, A1 pulley, DTML



2/3rd MCPJ's in extension:
Accessory collateral ligament proximal attachment (open arrow), distal attachment (long straight black arrow) and taut body (long straight white arrow)

MR arthro: Accessory collateral ligament again.

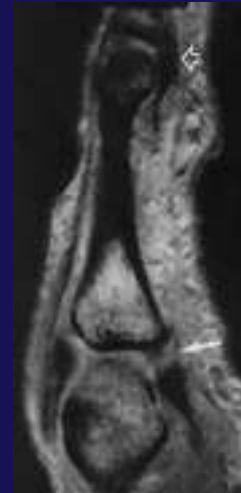
Sagittal bands (white arrowheads)
 Interosseus muscle (short black arrow)
 Interosseus tendon (short white arrow)



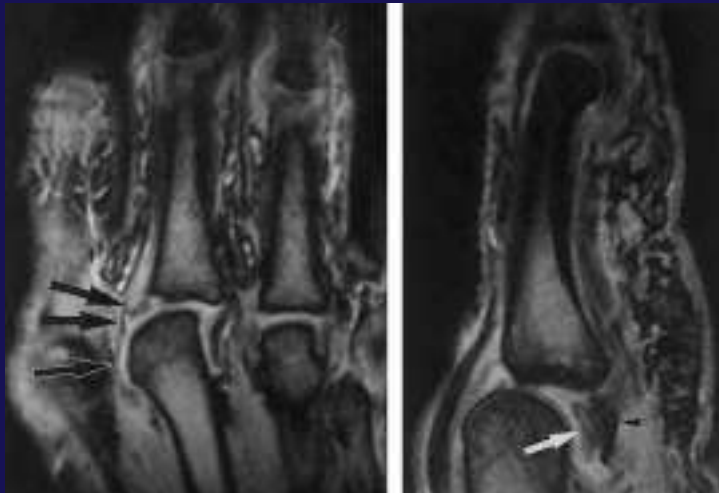
Interosseus tendon (short white arrow)
 Palmar plate (curved black arrow)
 A1 pulley (black arrowhead)
 DTML (curved white arrow)

MCPJ dislocation

- Uncommon
- Usually dorsal dislocation, following forced hyperextension
- May be simple or complex
- Simple dislocation: no volar plate interposition. Treated conservatively
- Complex: volar plate interposed and reduction not possible. Treatment is open surgical reduction

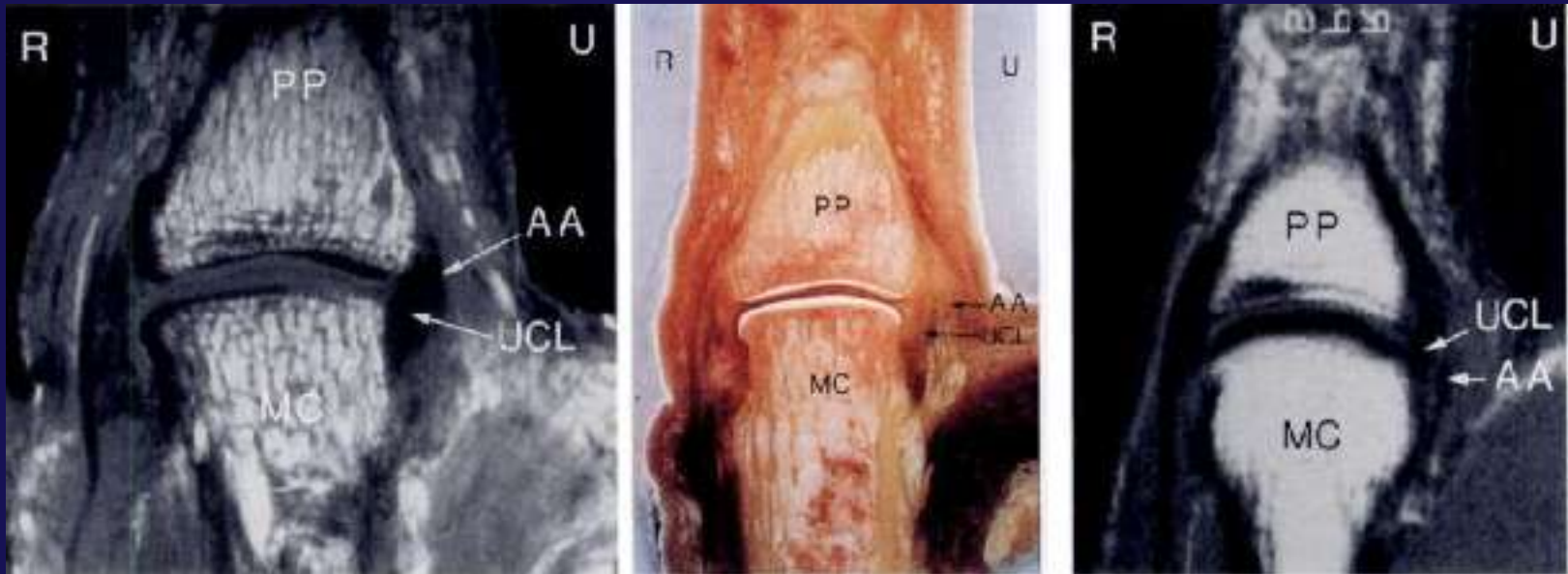


Simple MCPJ dislocation with avulsion of volar plate

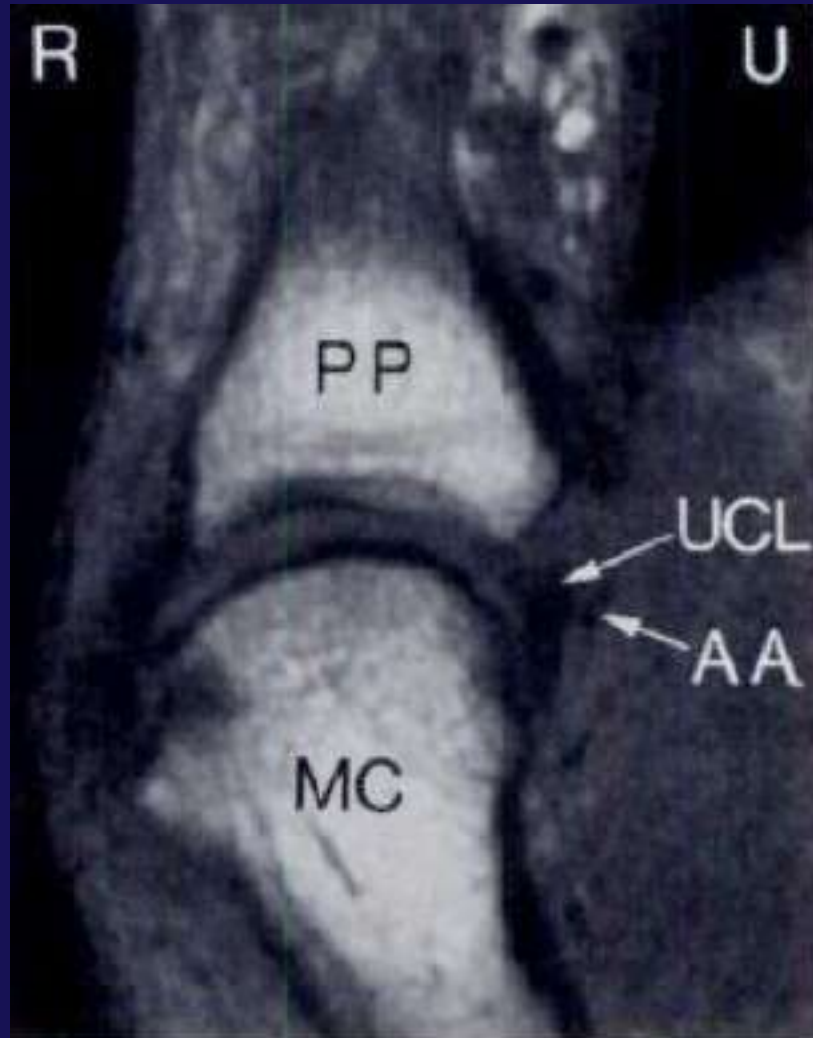


Complex dislocation: complete tear radial collateral ligament with intra-articular interposition (arrows)
Arrowhead- volar plate

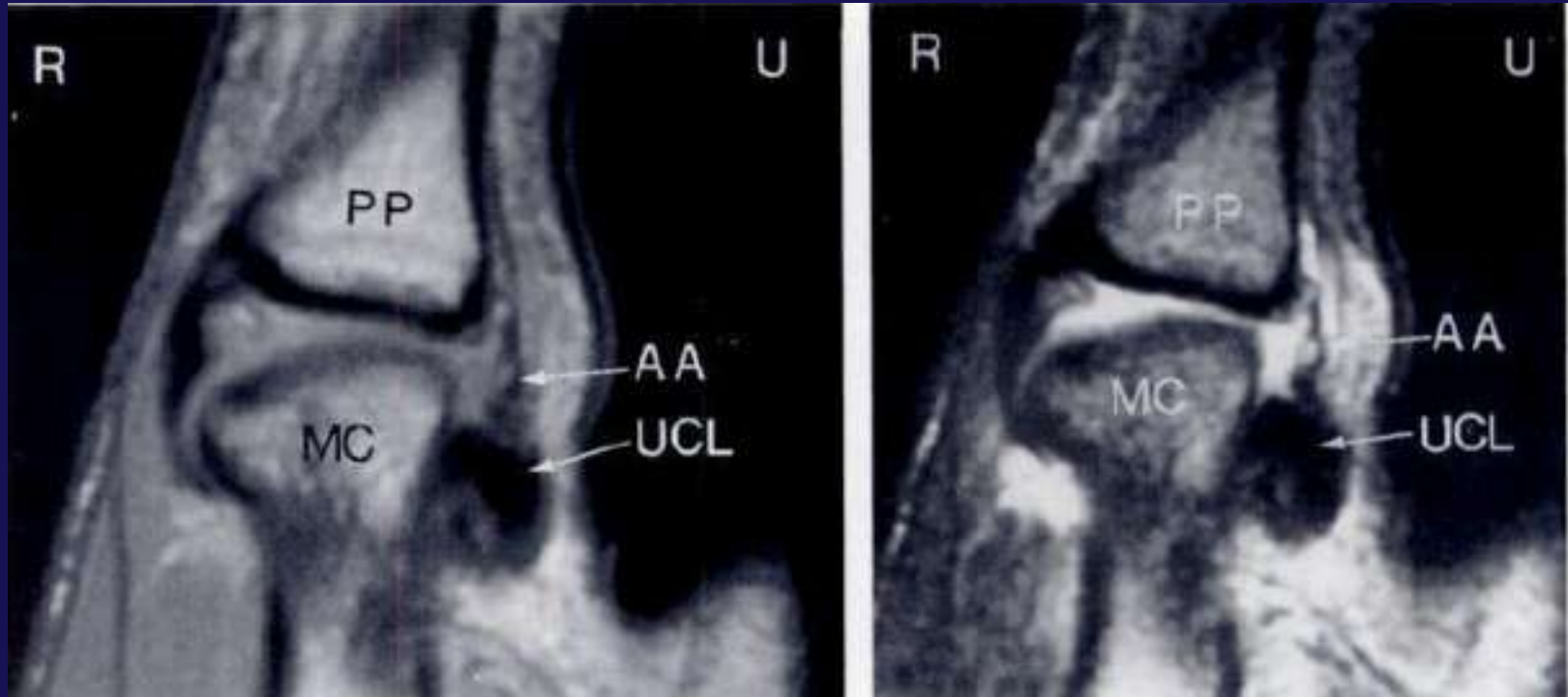
Thumb MCPJ: Normal anatomy



Gamekeeper's thumb (without Stener lesion)

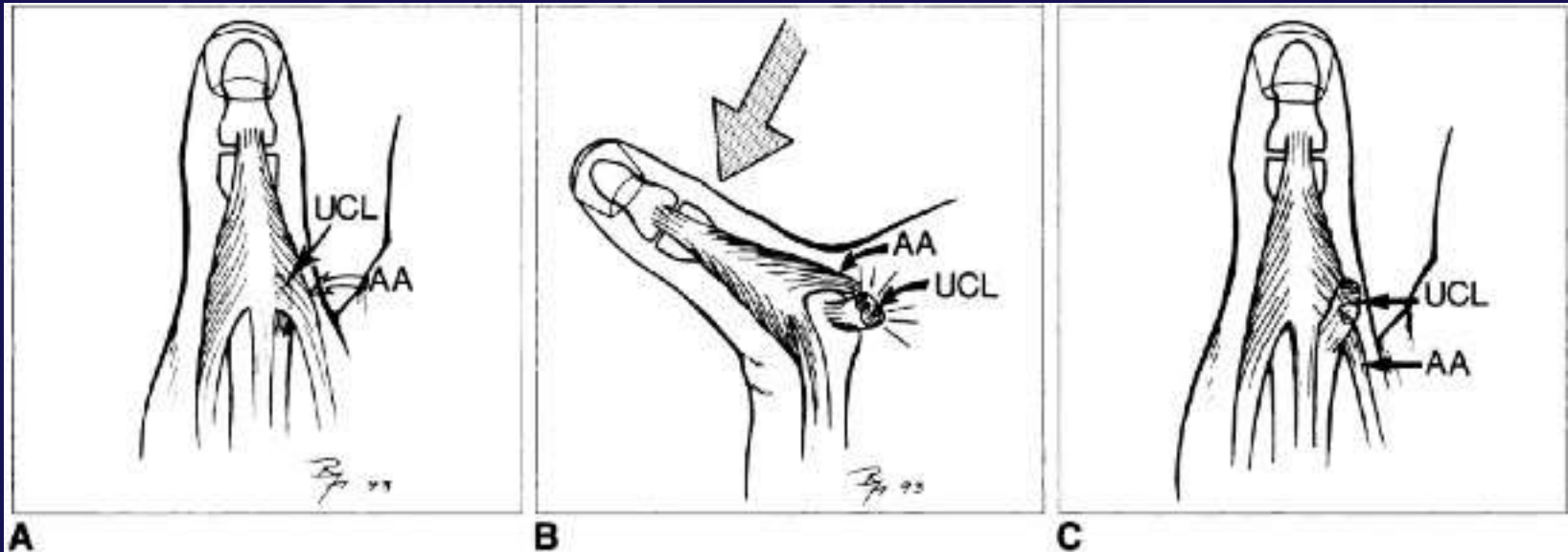


Gamekeeper's thumb with Stener lesion



Gamekeeper's thumb:

Pathogenesis of Stener's lesion



A UCL normally deep to adductor aponeurosis

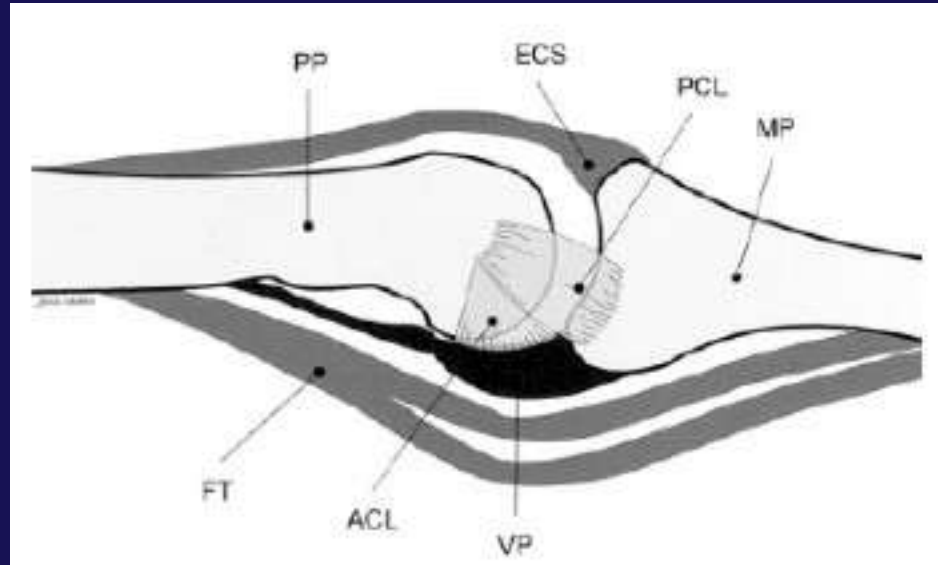
B UCL torn after acute abductive force to thumb

C When thumb returns to neutral position, UCL may relocate superficial to AA resulting in Stener lesion

PIPJ

- Main stabilisers
 - collateral lig
 - Main/proper (from dorsolateral aspect head of prox phalanx to volar and lateral aspect base of mid phalanx)
 - Accessory (from dorsolateral aspect head prox phalanx to volar plate)
 - volar plate
 - thick fibrocartilage structure constituting volar aspect of joint capsule
 - U-shaped prox attachment to prox phalanx is more elastic due to 2 lateral bands called the “checkrein” ligaments
 - Distal attachment is more firm at volar lip of base of mid phalanx
 - Prevents hyperextension of PIPJ
- Dynamic stabilisers:
 - Extensor mechanism
 - Central slip inserts on dorsal tubercle mid phalanx
 - Lateral slips connected by retinacular lig.
 - Flexor tendon
 - Retinacular ligaments

Normal PIPJ anatomy



- ACL: accessory collateral ligament
- ECS: extensor central slip
- FT: flexor tendon
- MP: middle phalanx
- PCL: proper (main) collateral lig
- PP: prox phalanx
- VP: volar plate

Collateral ligaments+ volar plate of the PIPJ

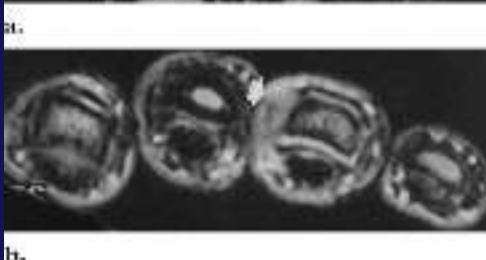


PIPJ injuries

- Coronal plane instability
 - Occurs with ab/ad-ducting force to the extended jnt
 - Results in lig sprain, partial tear or complete tear with jnt luxation



Complete proximal tear of radial collateral ligament (arrows)

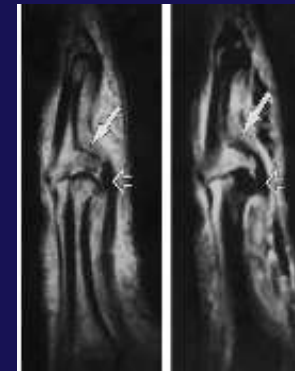


PIPJ injuries

- Sagittal plane instability
 - Caused by hyperextension or rotational longitudinal compression of PIPJ
 - Results in 3 types of injuries
 - Type 1: avulsion of volar plate from base of MP
 - Type 2: extensive involvement of peri-articular soft tissues, volar plate avulsion and split between components of collateral lig complex--> greater instability with subluxation/luxation of MP
 - Type 3: fracture-dislocation of volar base of MP
 - Stable if <40% of articular surface involved
 - Unstable if >40% articular surface involved with volar plate and collateral lig attached to fragment



Type 1 hyperextension lesion of PIPJ

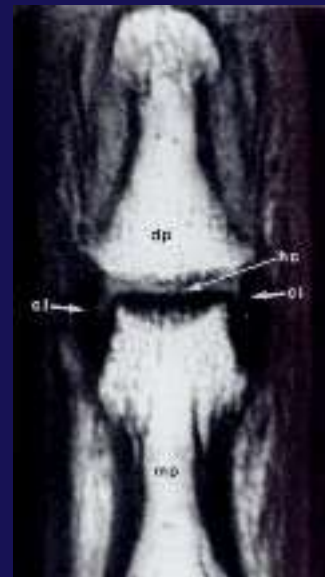
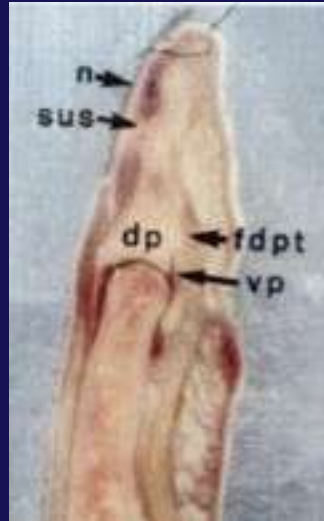


Type 3 hyperextension lesion (unstable fracture/dislocation)
With volar plate attached to fragment



Volar dislocation of PIPJ w/
tear of volar plate and partial
tear extensor central slip
(thin arrow)

DIPJ



DP: distal phalanx

VP: volar plate

SUS: subungual space

N: nail

FDPT: flexor digitorum profundus tendon

CL: collateral ligaments

HC: hyaline cartilage

Ee: extensor expansion

The End!

References

- MRI imaging of the finger: Correlation with normal anatomic sections. Erickson SJ, Kneeland BJ et al. AJR 152: 1013-1019 May 1989
- Extensor mechanism of the fingers: MR Imaging-anatomic correlation. Clavero JA, Golano P et al. Radiographics 2003;23:593-611
- MR Imaging of the Metacarpophalangeal joints of the Fingers. Part I. Conventional MR imaging and MR arthrographic findings in cadavers. Theumann NH, Pfirrmann CWA, Resnick DR et al. Radiology 2002;222:437-445
- MR Imaging of the Metacarpophalangeal joints of the fingers. Part II. Detection of simulated injuries in cadavers. Pfirrmann CWA, Theumann NH, Resnick DR et al. Radiology 2002;222:447-452
- MR Imaging of Ligament and Tendon Injuries of the Fingers. Clavero JA, Alomar X, Monill JM et al. Radiographics 2002;22:237-256
- Normal Anatomy and simulated lesions in cadavers at MR Imaging, CT and US with and without contrast material distension of the tendon sheath. Hauger O, Chung CB, Lektrakul N et al. radiology 2000; 217: 201-212
- Ulnar collateral ligament of the thumb: MR findings in cadavers, volunteers, and patients with ligamentous (Gamekeeper's Thumb). Hinke DH, Erickson SJ et al. AJR 1994;163:1431-1434
- Internal Derangements of Joints. Resnick DR, Kang HS, Pretterklieber ML. 2nd Ed. Vol 1 1335-1396