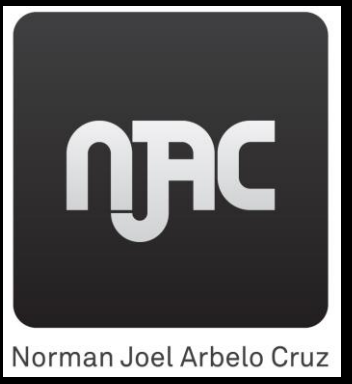


The thumb and fingers… everything that you probably forgot

Norman J Arbelo Cruz

- Special thanks to our awesome staff
  - Mama Pathria
  - Papa Resnick
  - Auntie Fliszar
  - Uncle Tudor
  - Brady “The Matrix” Kirk
  - Eddie “The hitman” …… “one love”
  - The Sampaths
  - Christine “AI” Chung…. Power3d by Watson

Disclosures

- None

- * some of the slides are busy with lots of wording. This is intended to avoid a gazillion slides and enable to make self review easier.

Objectives

- Lesser digits flexor system
  - anatomy injuries
  - pulley system and injuries
  - volar plates
  - collateral ligaments
- Thumb
  - Anatomy
  - injuries
- Lesser digits extensor system
  - anatomy
  - sagittal band
  - extensor hood and retinacular system
  - injuries

Digit flexor tendons

Digit Flexor tendons anatomy

Flexor digitorum superficialis (FDS)

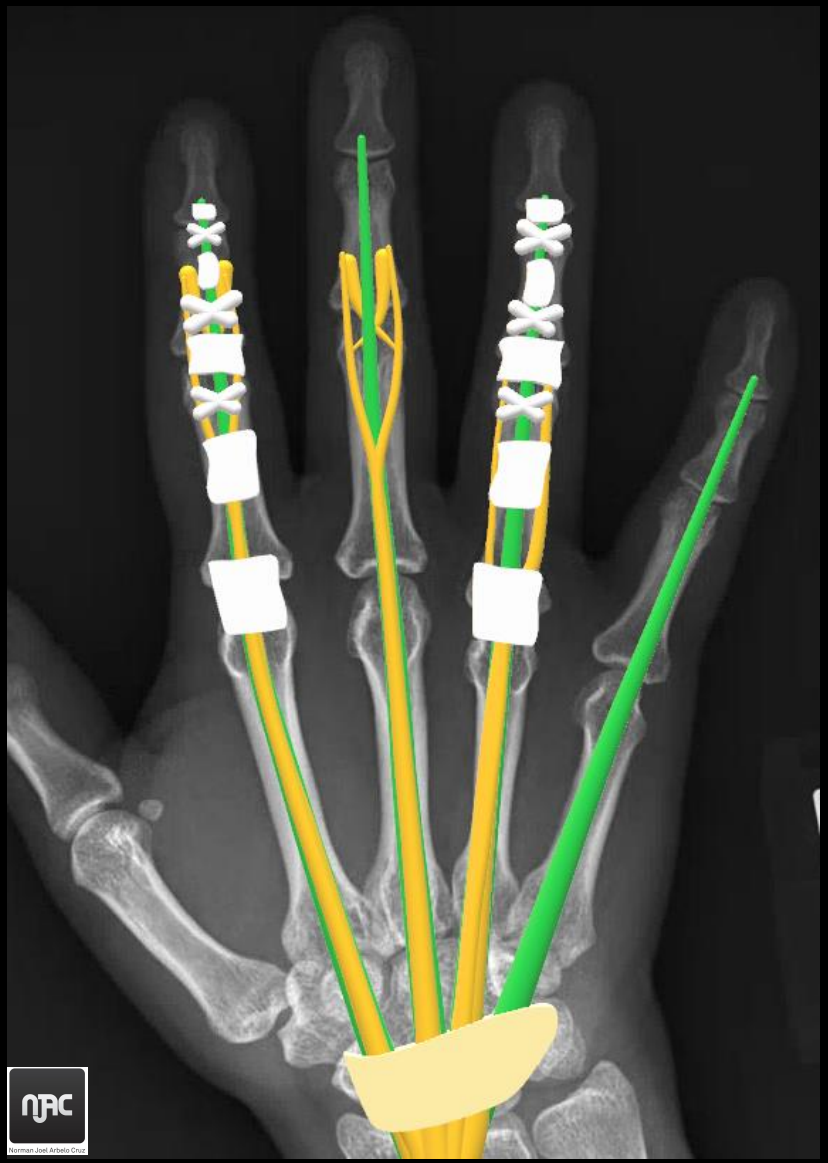
- superficial to FDP, bifurcating at the level of mid proximal phalanx
- At level PIP the slips divide again into 2 smaller slips crossing at midline and reuniting into the opposite slip forming Camper's chiasm
- Finally inserting on the middle phalanx

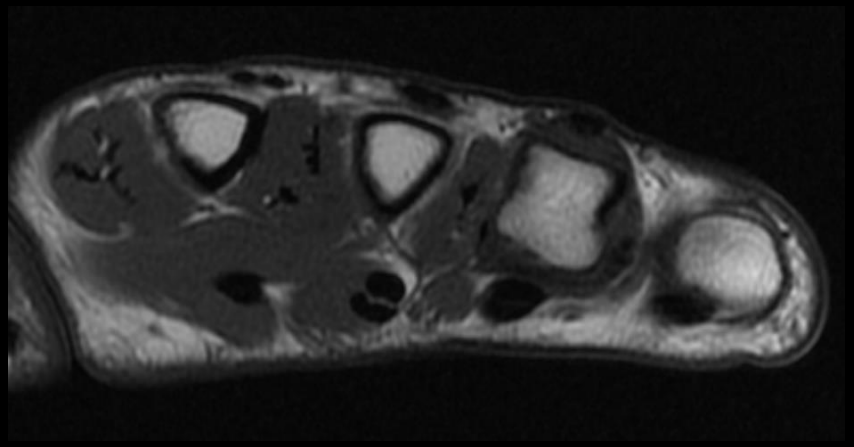
Flexor digitorum profundus (FDP)

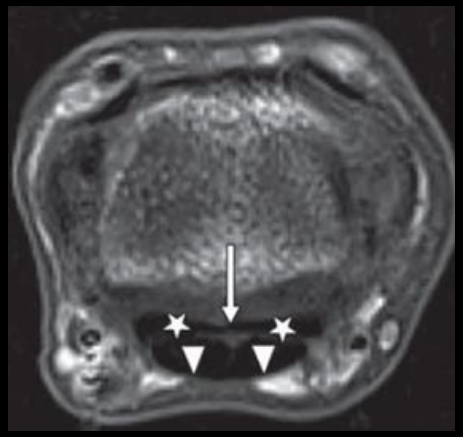
- Courses deep to the FDS, until the FDS splits at the level of mid proximal phalanx, at which point is located superficial
- Continues its course until inserting on the volar aspect of the distal phalanx
  - Distally it contains a median longitudinal groove or furrow volarly that can resemble a split tendon[1]

[1]Gupta, P. AJR 2014

FDS and FDP





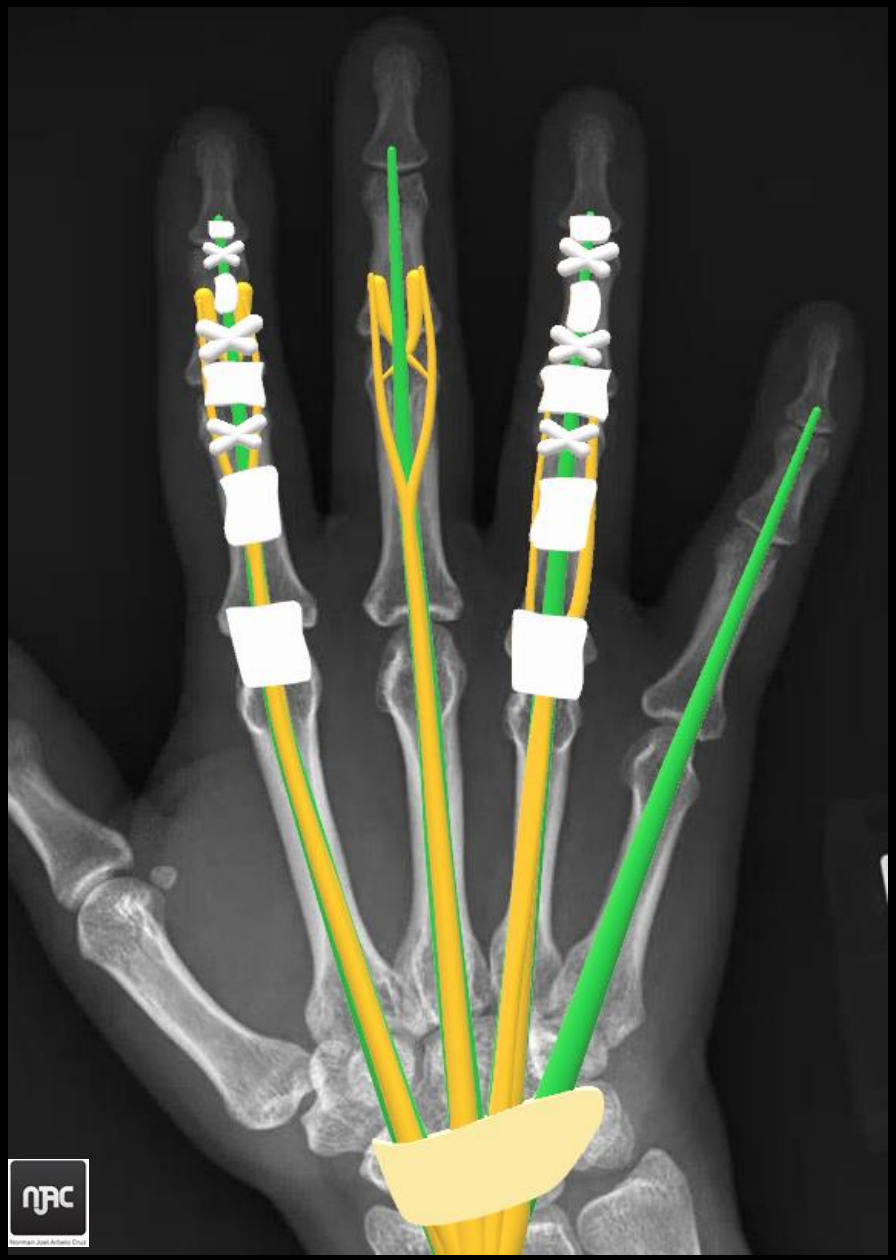


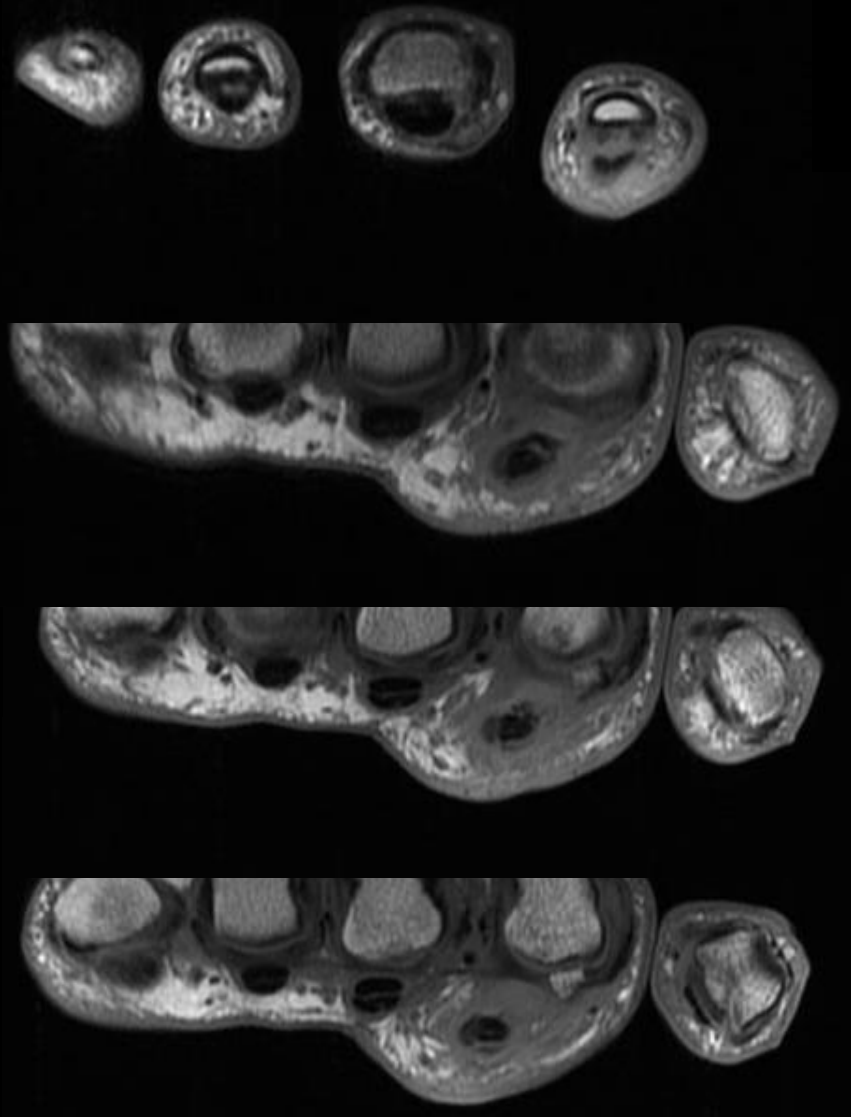
- Camper's chiasm (arrow)
- FDS with longitudinal grove (arrow heads)

Gupta,P. AJR 2014

FDS and FDP

Courtesy Dr. Smitaman and Dr. Ortiz

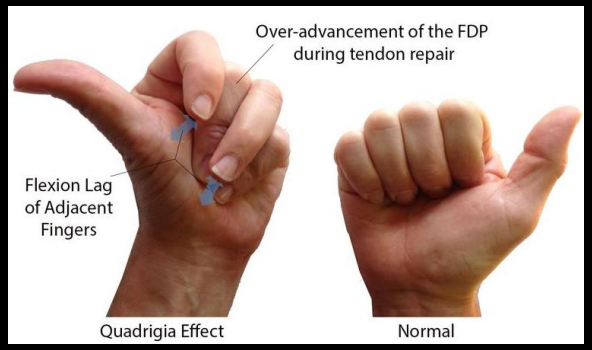




Finger flexion clinical examination

FDS

- To test hold MCPJ, PIPJ, and DIPJ of other fingers extended
- Ask patient to flex PIPJ
  - Repeat with other fingers
  - Congenital absence of the FDS is present unilaterally in 6.8%

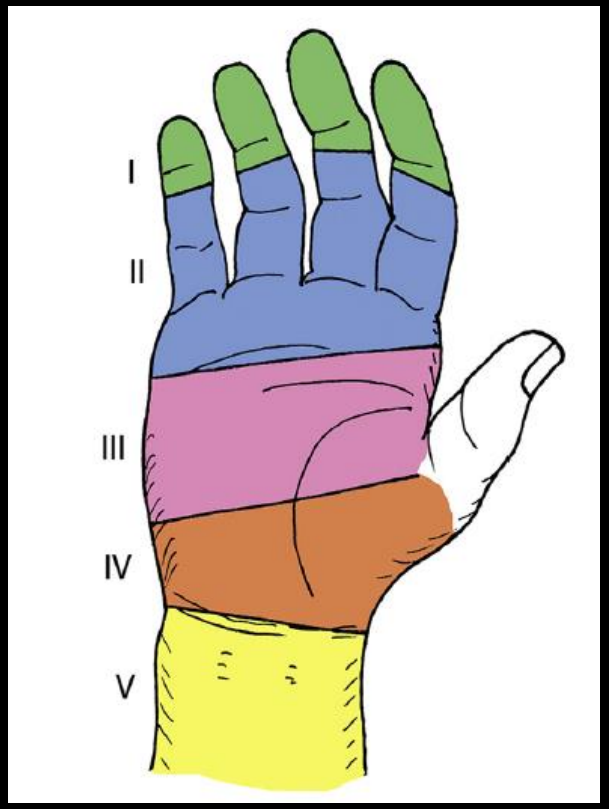


FDP

- To test place hand supine, press middle phalanx into table and ask patient to flex DIPJ
- Quadriga effect
  - Tendon shortened due to surgery or injury
  - Since FDP tendons share a common muscle belly, this leads to a flexor lag
  - Examined by asking patient to make a fist
    - Fingers adjacent to injured digit will not fully flex

Flexor tendon injuries

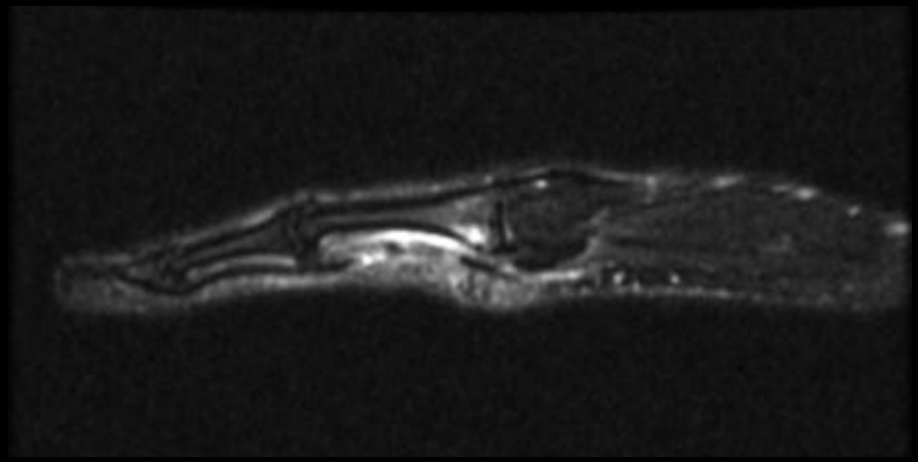
- Injuries are not as common as the extensor tendons
  - Divided into 5 zones
    - Zone 1 – FDP insertion to distal insertion of FDS
    - Zone 2 (no man's land) – FDS insertion to distal palmar fold
      - Problematic repair owing complexity of this region. Carry worst prognosis
      - Historically, zone 2 injuries were considered surgically irreparable.
    - Zone 2-5
      - Injuries may involve both FDS and FDP resulting in loss of active flexion
- Most common injuries are lacerations and avulsion injuries
  - FDP is more commonly avulsed than the FDS
  - FDP avulsion can be osseous or soft tissue
    - Jersey finger



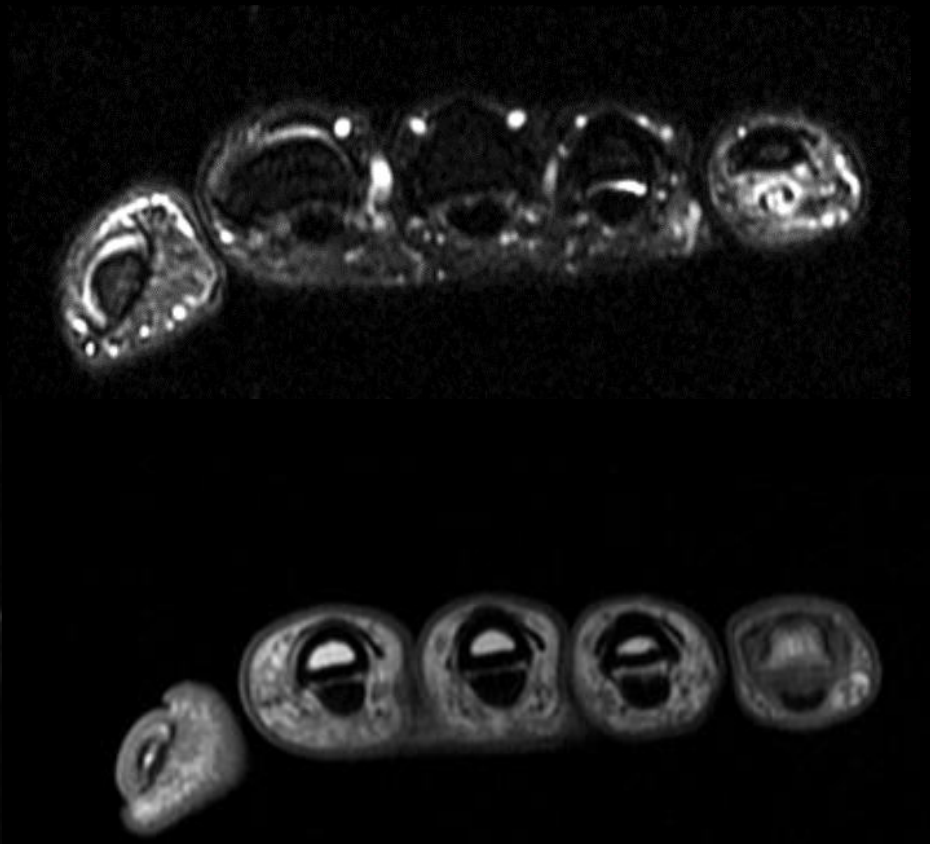
Newton AW. Orthopaedics and Trauma 2018

Flexor tendon injuries

- 33yo male with small finger pain.

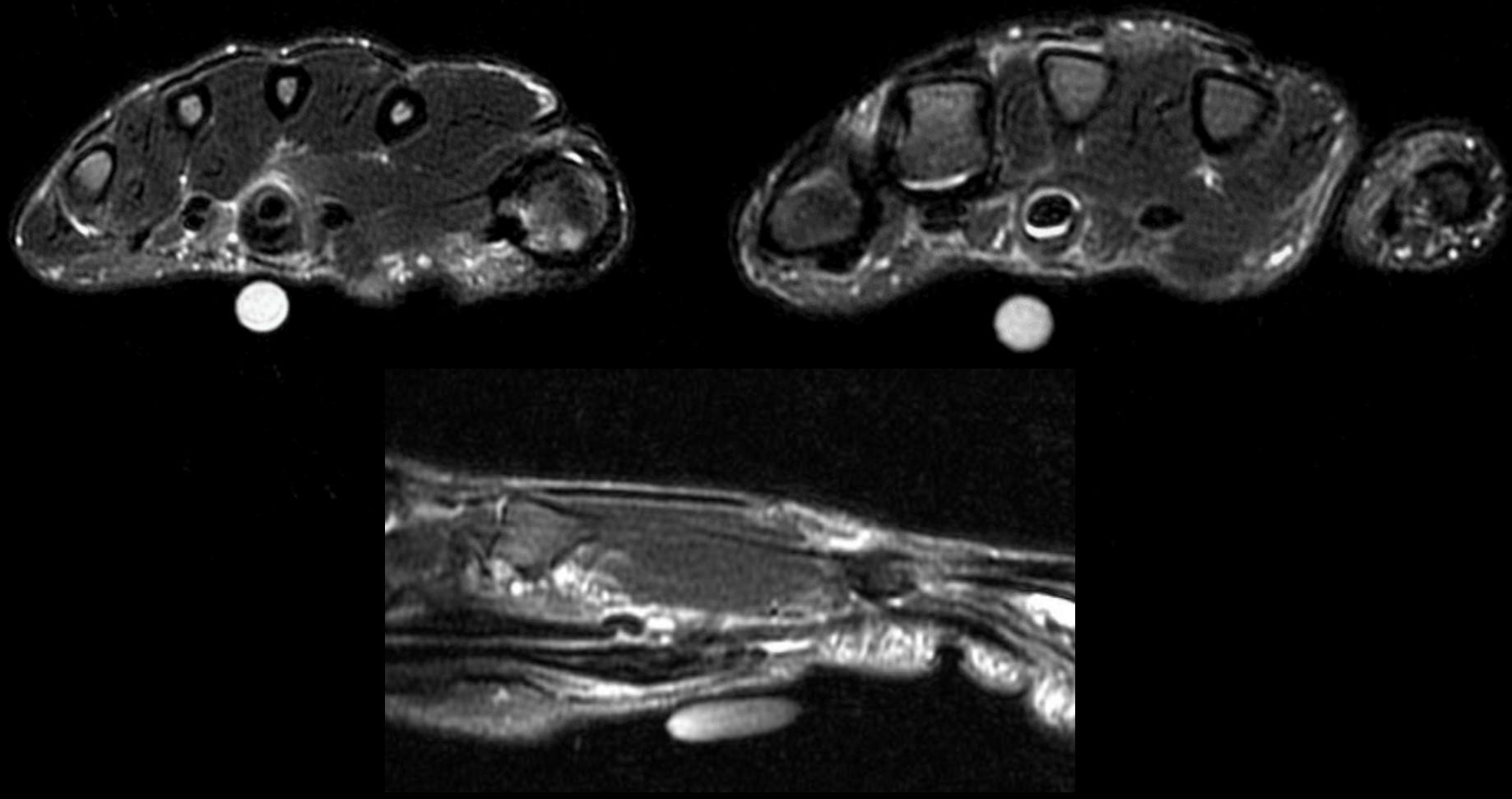


Jersey finger if tear of FDP at insertion



Rupture of FDS and injury to A2 pulley.
Courtesy Dr. Brady Huang

Flexor tendon injuries



Complete tear and retraction of the FDS.
Courtesy Dr. Brady Huang

Pulley system

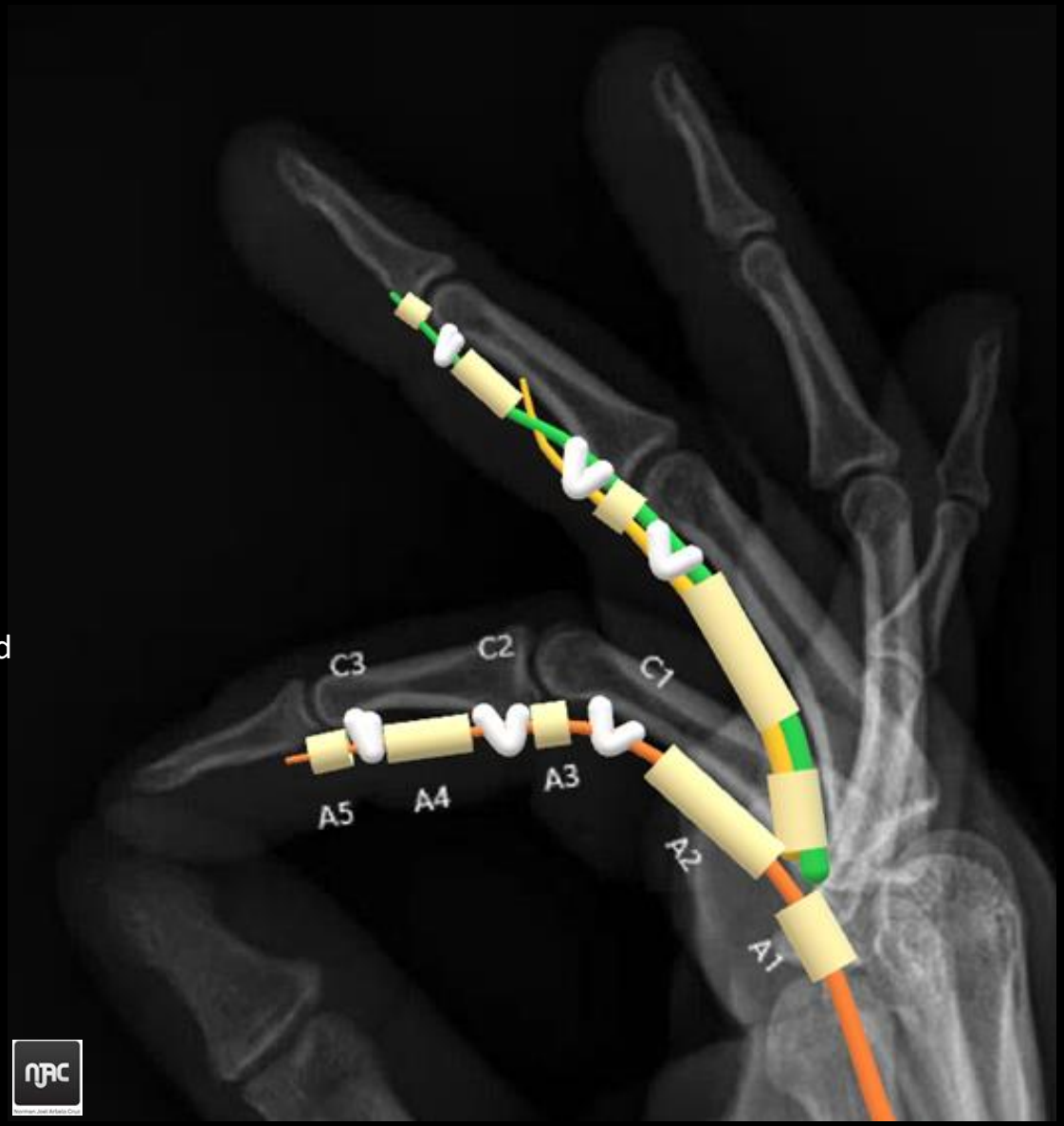
- Retinacular structures that maintain the flexor tendon relationship to the joint axes
  - Ensure optimal muscle effort and tendon excursion while flexing finger
  - Prevent buckling or bowstringing
  - Allow efficient conversion of translational force of the muscle to a rotational movement of the fingers
    - Without a pulley, a larger excursion and effort of the tendon would be required to generate same degree of motion.
- Composed of the transverse carpal ligament, palmar aponeurosis and digital flexor pulley[1]
  - Digital flexor pulley composed of
    - Synovial component – tendon sheath
    - Pulley (retinacular) – fibrous reflections

[1]Doyle JR. Clinical orthopaedics and related research 2001

Pulley system

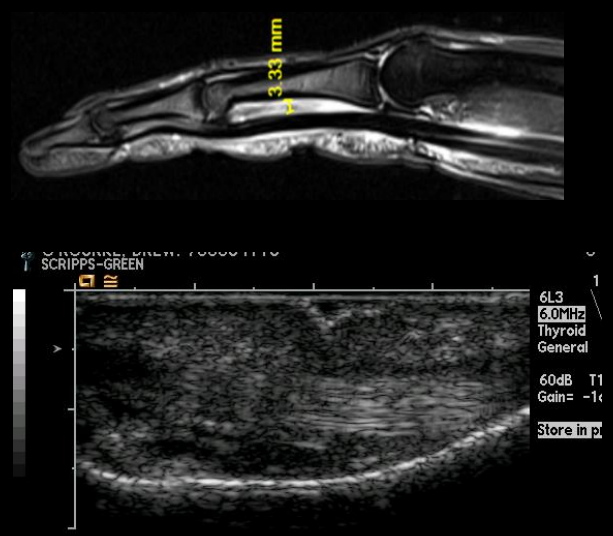
- Consist of localized thickening of the digital tendon sheath
  - 5 annular
  - 3 cruciate
  - A1, A3, A5
    - Located at level of the joint and attach to volar plate
      - MCP, PIP, and DIP respectively
  - A2 and A4
    - Located mid portion of proximal and middle phalanx
  - C1, C2, and C3
    - Located distal to A2, A3 and A4
    - Allow some degree of bowstringing

Thumb pulleys will be discussed in thumb section

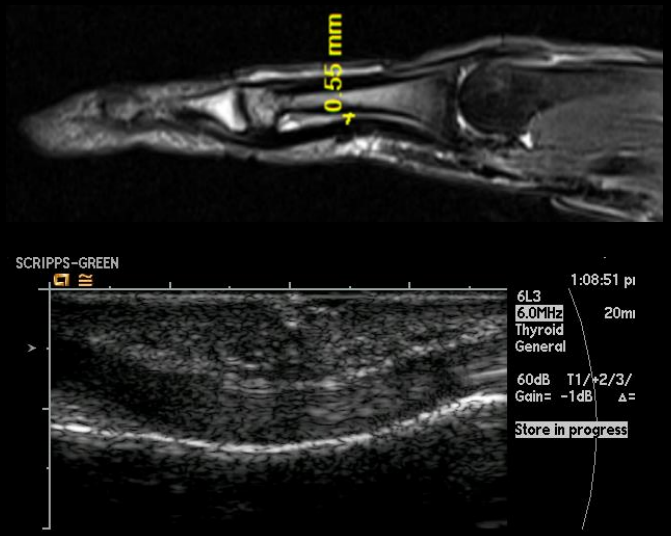


Pulley system

- Bowstringing is characterized by a gap between the flexor tendon and the volar surface of the bone



LT 3RD DIGIT LNG FLEXED



RT 3RD DIGIT LNG FLEXED

- Optimal visualization of these injuries is performed while flexing finger. Dynamic imaging, such as ultrasound provide advantage.

Courtesy Dr. Brady Huang


I JUST WISH I COULD UNDERSTAND...
WHY I SHOULD CARE!

Pulleys

TABLE 4. Moment Arm and Motion at the Metacarpophalangeal, Proximal Interphalangeal, and Distal Interphalangeal Joints

Joints	Moment Arm (millimeters)	Lost Joint Motion (degrees)
Metacarpophalangeal	2 mm increase (10 to 12)	85 to 68
Proximal interphalangeal	1.5 mm increase (7.5 to 9)	110 to 88
Distal interphalangeal	1 mm increase (5 to 6)	65 to 52
		260 to 208* (total)

*Finger tip fails palm: 2.5 +/− cm (1 inch).
A comparatively slight increase in the moment arm results in a significant loss of finger flexion.

TABLE 5. Joint Range of Motion, Moment Arm, and Tendon Excursion

Joint (ROM)	Moment Arm (millimeters)	Excursion (millimeters)+
Metacarpophalangeal (85)	10*	14.8*
	12	17.8
Proximal Interphalangeal (110)	7.5*	14.4*
	9	17.3
Distal Interphalangeal (65)	5*	5.7*
*Normal Values		
	34.9* versus 41.9	
+*Joint ROM* X MA = Excursion 57.29°		

The relationship between required range of motion, normal and increased moment arm, and the resultant excursion. Joint range of motion divided by one radian multiplied by the moment arm yields excursion (see text.) MA = moment arm.

Doyle JR. Clinical orthopaedics and related research 2001

Pulleys

TABLE 6. Flexor Tendon Biomechanics After Pulley excision with the Skin Intact

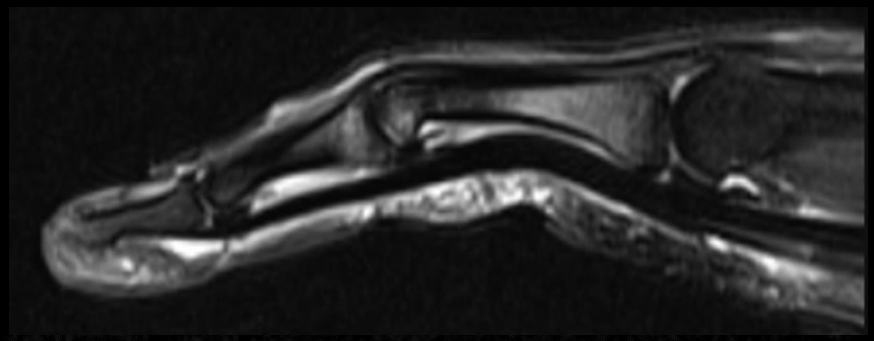
Pulley(s) Excised	Intact	Percent difference	
		Tendon Excursion	Work of Flexion
A1	A2, A4	−0.64 ± 2.04	10.00 ± 8.16
A2	A1, A4	8.50 ± 1.62	44.10 ± 7.15
A4	A1, A2	9.93 ± 3.40	19.95 ± 10.21
A1, A2	A4	20.56 ± 3.67	62.36 ± 13.91
A2, A4	A1	33.66 ± 4.60	107.04 ± 22.77
A1, A4	A2	9.69 ± 1.91	39.83 ± 8.70
A1, A2, A4	none	65.09 ± 6.21	172.35 ± 15.30

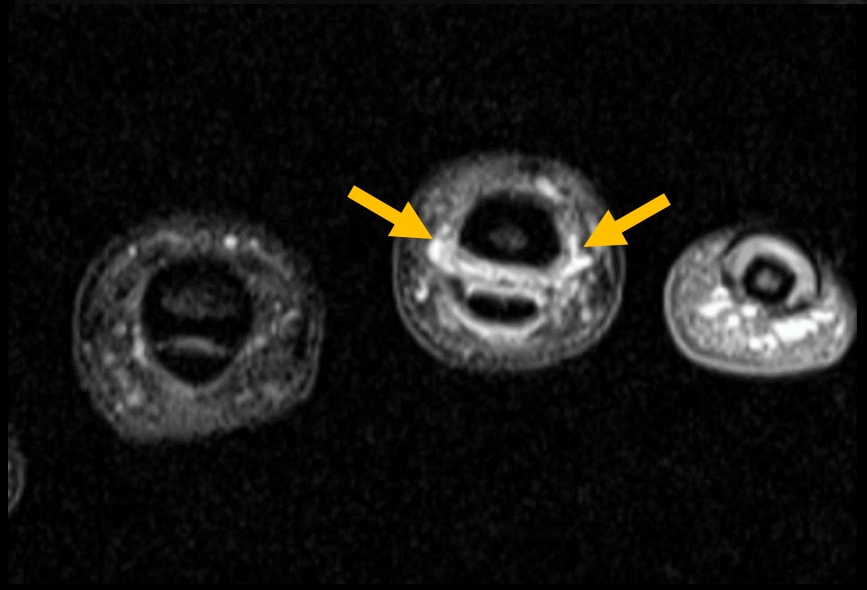
A = annular pulleys.

(Table adapted from data from Peterson WW, Manske PR, Bollinger BA, et al: Effect of pulley excision on flexor tendon biomechanics. J Orthop Res 4:96–101, 1986.)

Doyle JR. Clinical orthopaedics and related research 2001

Pulley injury



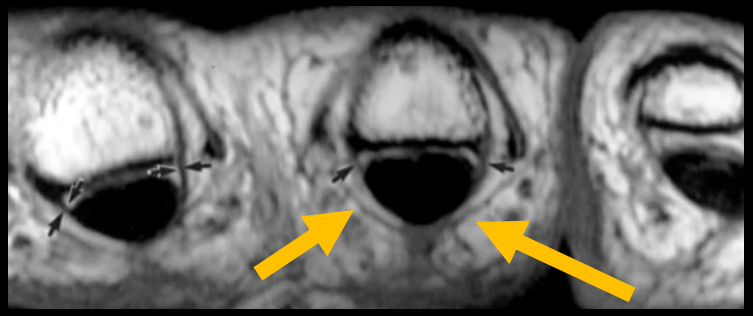


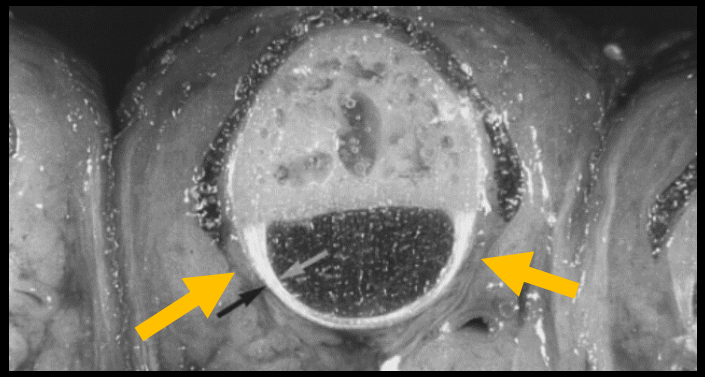
- Injuries: A2 > A3 > A4 > A1
- Gap between flexor tendon and phalanx should be <1-2 mm
- Partial tear → conservative tx
- Complete tear → surgery

Clavero JA. *RadioGraphics* 2002

Pulleys

- If surgery needs to be performed
  - Preservation or reconstruction of all components of the pulley system is a worthy goal, but not always possible
  - Most important pulleys to preserve or reconstruct are the A2 and A4 pulleys[1]





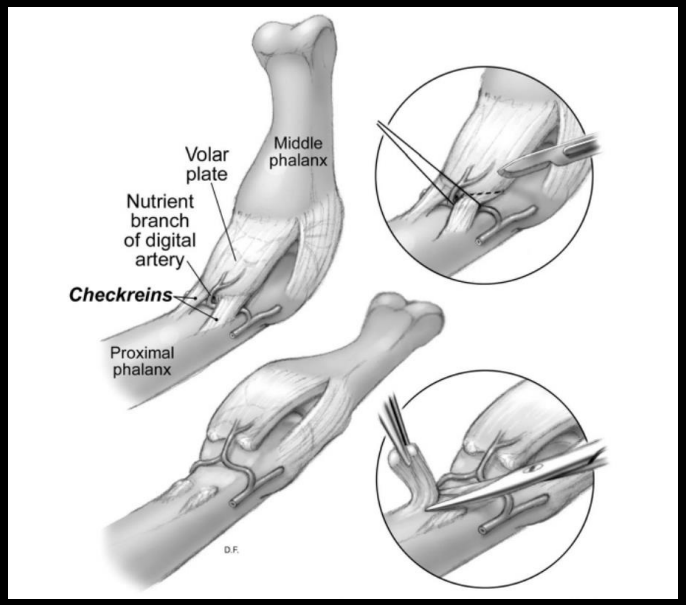
Hauger O. *Radiology* 2000

[1]Gupta, P. AJR 2014

Volar plates

- Dense fibrocartilaginous structure located volar to the joint capsule and helps prevent hyperextension of the joints.
  - 3 volar plates in digits
  - 2 volar plates in thumb
- Collateral ligaments also contribute to stability
- PIPJ volar plate has different arrangement proximally
  - Plate extends into two appendages known as check-rein ligaments
  - the space between the check-rein ligaments allow passage for digital vessels under the flexor sheath and vincular arteries.

Thumb has both dorsal and volar plates



Craft, RO. Plastic and reconstructive Surgery 2011

Volar plates

- Multiple classifications for volar plate injuries
  - Most used are[1]
    - Eaton's
    - Keifhaber-Stern
  - Stable injury usually involves <40% of the articular arch
  - Unstable injuries involve >40%, with volar plate and collateral ligaments attached to the fracture fragment

Table 1

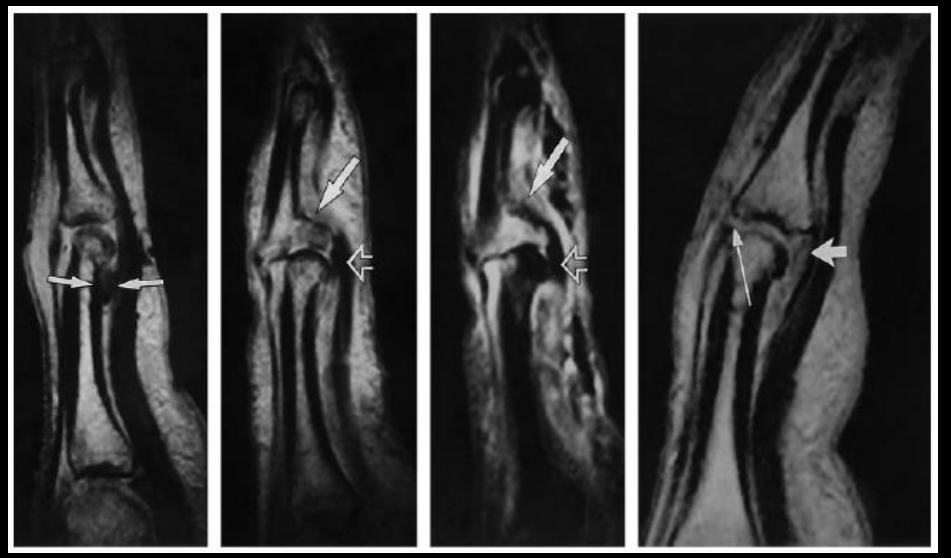
Classification systems of volar plate injuries

	Eaton classification of volar plate injuries[3]
Type 1	Avulsion of the volar plate without a fracture or dislocation
Type 2	Complete dorsal dislocation without fracture and avulsion of the volar plate
Type 3a	Fracture-dislocation with <40% PIPJ surface with dorsal portion of the collateral ligaments remaining attached to the middle phalanx (stable)
Type 3b	Fracture-dislocation with >40% PIPJ surface with little or no ligament remaining attached to the middle phalanx (unstable)
	Keifhaber-Stern classification of volar plate injuries[4] (modification of Hastings classification)
Stable	Avulsion fracture involving <30% articular base of the middle phalanx
Tenuous	Avulsion fracture involving 30%-50% articular base of the middle phalanx; reduces with <30° of flexion
Unstable	Avulsion fracture involving <50% articular base of the middle phalanx but requires >30° flexion to maintain reduction

PIPJ indicates proximal interphalangeal joint.

[1]Pattni, A. Eplasty 2016

Volar plates

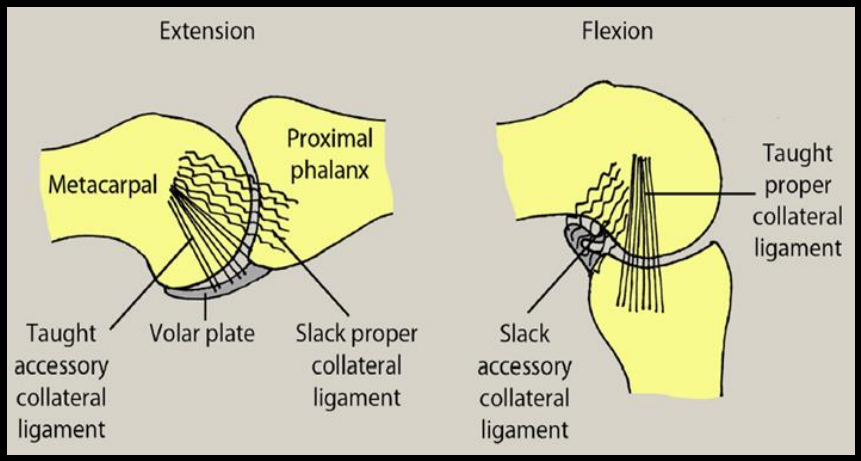


Clavero, JA. Radiographics 2002

- Need to place special attention to location of avulsed volar plate.
  - Displacement of the plate between fracture fragments or located in joint space may affect healing and reduction attempts.

Collateral ligaments

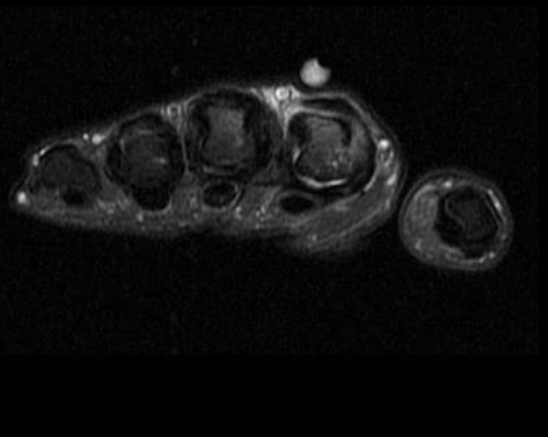
- Main stabilizers of the MCP and IP joints
  - Injury can lead to instability
  - Thumb UCL most commonly affected
- Accessory collateral ligament are contiguous with the volar plate



Newton et al. Orthopeadics and trauma 33:1

Collateral ligaments

- Right hand pain for several weeks, caught in a sliding door sometime in August. Radiographs from 9/22/2017 were negative. Pain not improving. No history of rheumatologic disease noted in epic.



Dupuytren Contracture (palmar fibromatosis)

- Most common superficial fibromatosis
  - Affects 1-2% of population
  - Seen almost exclusive in Caucasian
    - Usually >65yo
    - Men most affected
  - Etiology not well understood
    - Trauma, microvascular injury, immune mediated, genetic factors
  - Presents painless subcutaneous nodule
    - May progress into fibrous cords that attach and cause traction to the flexor tendons

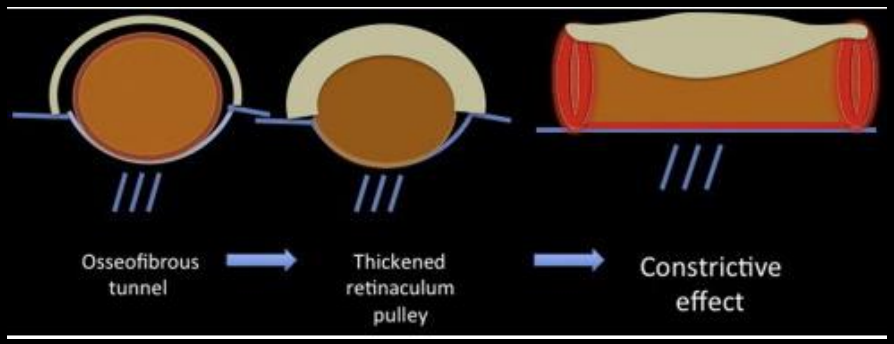
Left hand mass versus possible torn tendon.
Courtesy Dr. Brady Huang

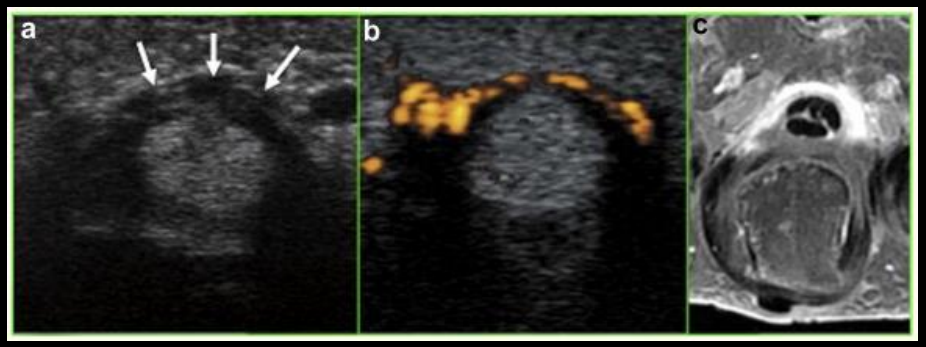
Murphy, MD Radiographics 2009

Stenosing tenosynovitis (tenovaginitis)

- Inflammation, thickening, and mechanical mass effect upon a tendon
  - De Quervain tenosynovitis
  - Trigger finger
  - Trigger thumb

- It's common for diagnosis not be apparent prior to imaging
  - Thus important for radiologist to be aware of this entity

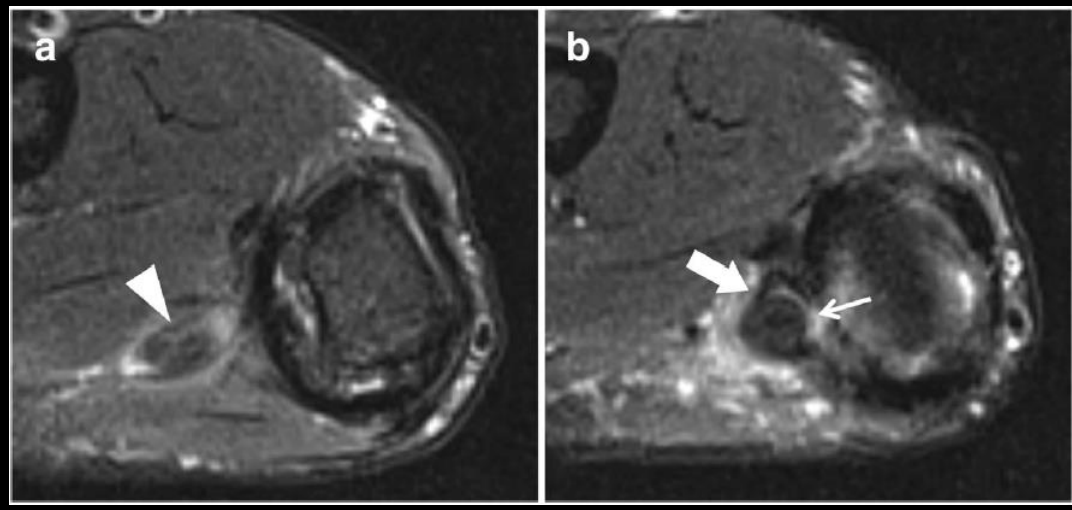




Vuillemin, V. J Ultrasound 2012

Stenosing tenosynovitis (tenovaginitis)

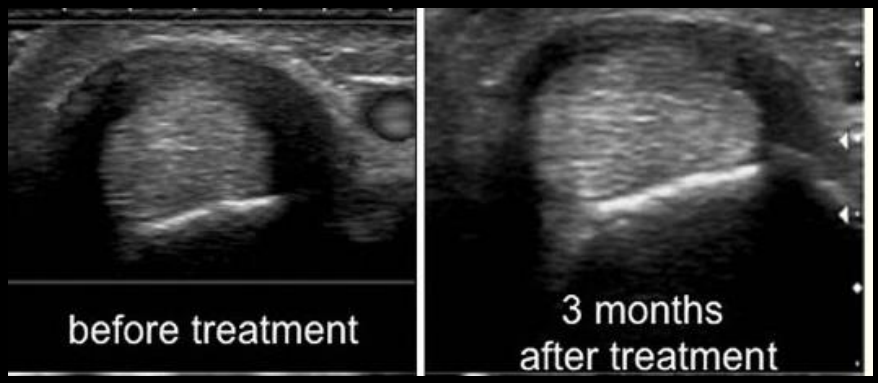
- Represents one of the most common conditions seen in practice of hand surgeons
  - Thumb and ring finger most commonly affected
  - Common risk factors
    - DM
    - obesity
    - female
    - certain occupations with high activity levels



Chang, EY. Skeletal Radiol 2015

Stenosing tenosynovitis

- Can be a result of a multitude of factors
  - Mechanical
  - Inflammatory process
  - Tumors
  - Hormonal
- Non-operative management provides satisfactory results
  - Failures treated with A1 pulley release



Vuillemin, V. J. ultrasound 2012

Don’t worry

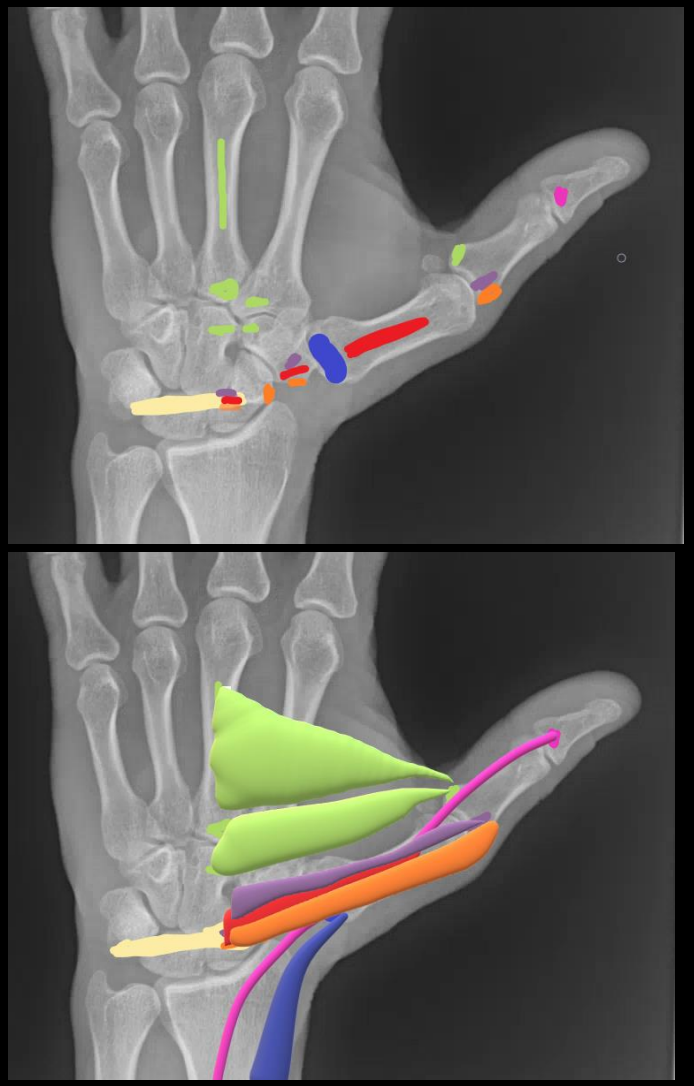
- We covered already half of the stuff and most of the technical factor

Anatomy of the thumb

The volar thumb

- Carpo and Metacarpal
  - Adductor pollicis
    - Transverse head
    - Oblique head
- Thenar muscles
    - Abductor pollicis brevis
    - Flexor pollicis brevis
    - Opponens pollicis
- Forearm
  - Abductor pollicis longus
  - Flexor pollicis longus

Volar hand

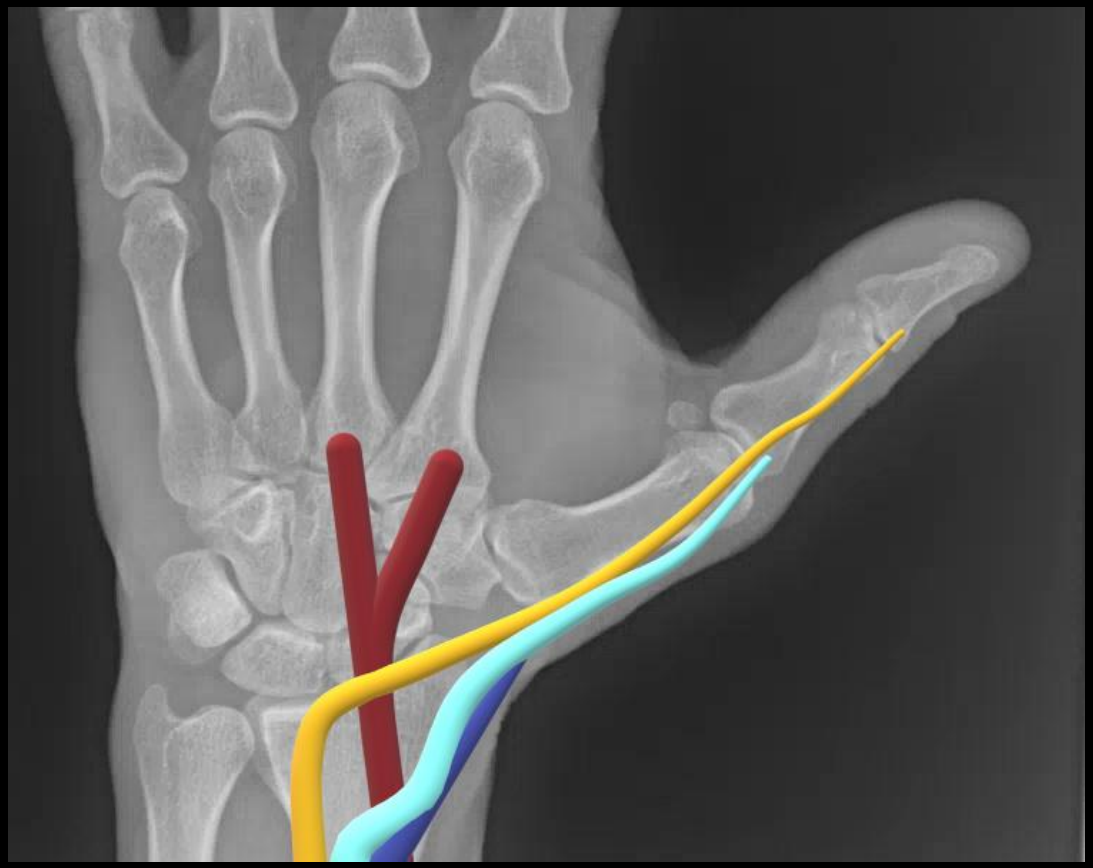


The volar thumb

- Quick facts
  - Adductor pollicis
    - Inserts at
      - ulnar base 1st proximal phalanx
      - 1st MTP joint volar plate
      - Contributes fibers to extensor hood (forms adductor aponeurosis)
  - Abductor pollicis brevis
    - Shares insertion with the flexor pollicis brevis tendon at lateral base 1st proximal phalanx
      - Also contributes fibers to the extensor hood
  - Flexor pollicis brevis (FPB)
      - Consists of superficial and deep components
      - Common tendon insertion with the abductor pollicis brevis tendon.
      - Also innervation by branches of the deep-ulnar nerve
  - Opponens pollicis
    - Abducts, flexes, and rotates 1st metacarpal
    - Draws thumb across palm

The dorsal thumb

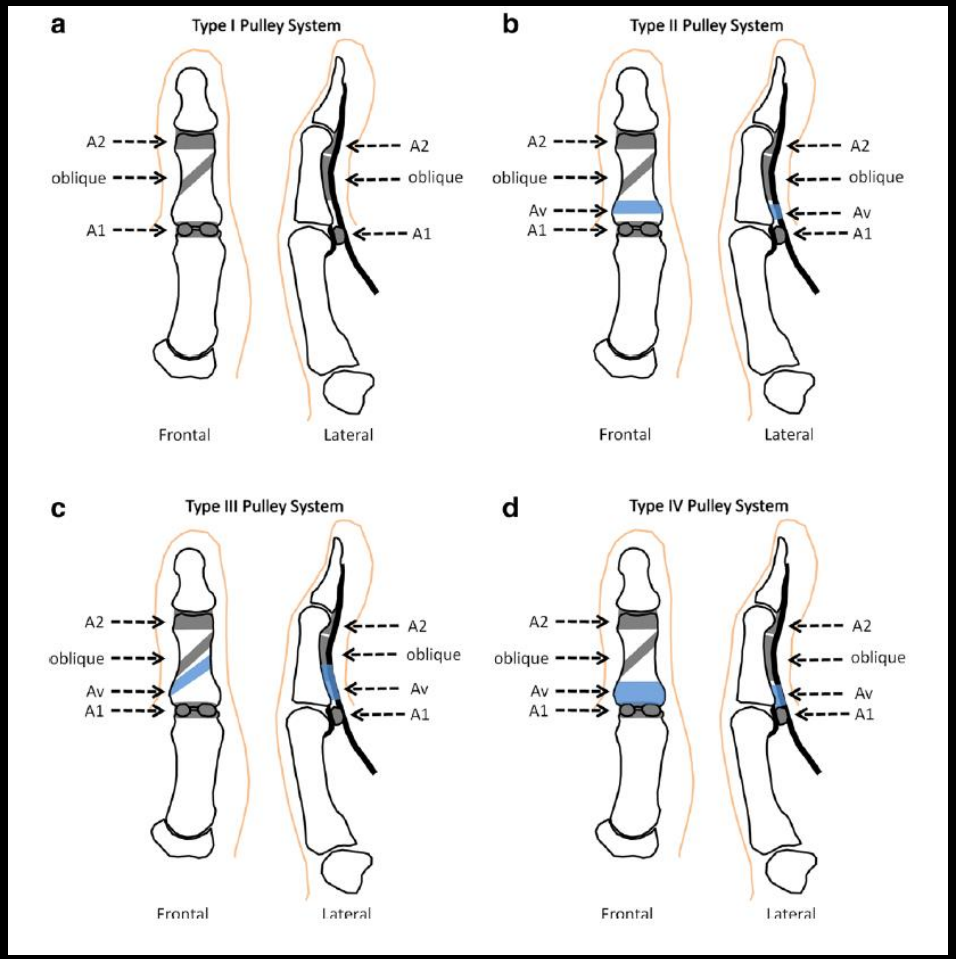
- Note location of the 2 intersection sites



- Extensor pollicis brevis (EPB)
- Extensor pollicis longus (EPL)
- Extensor carpi radialis brevis and longus

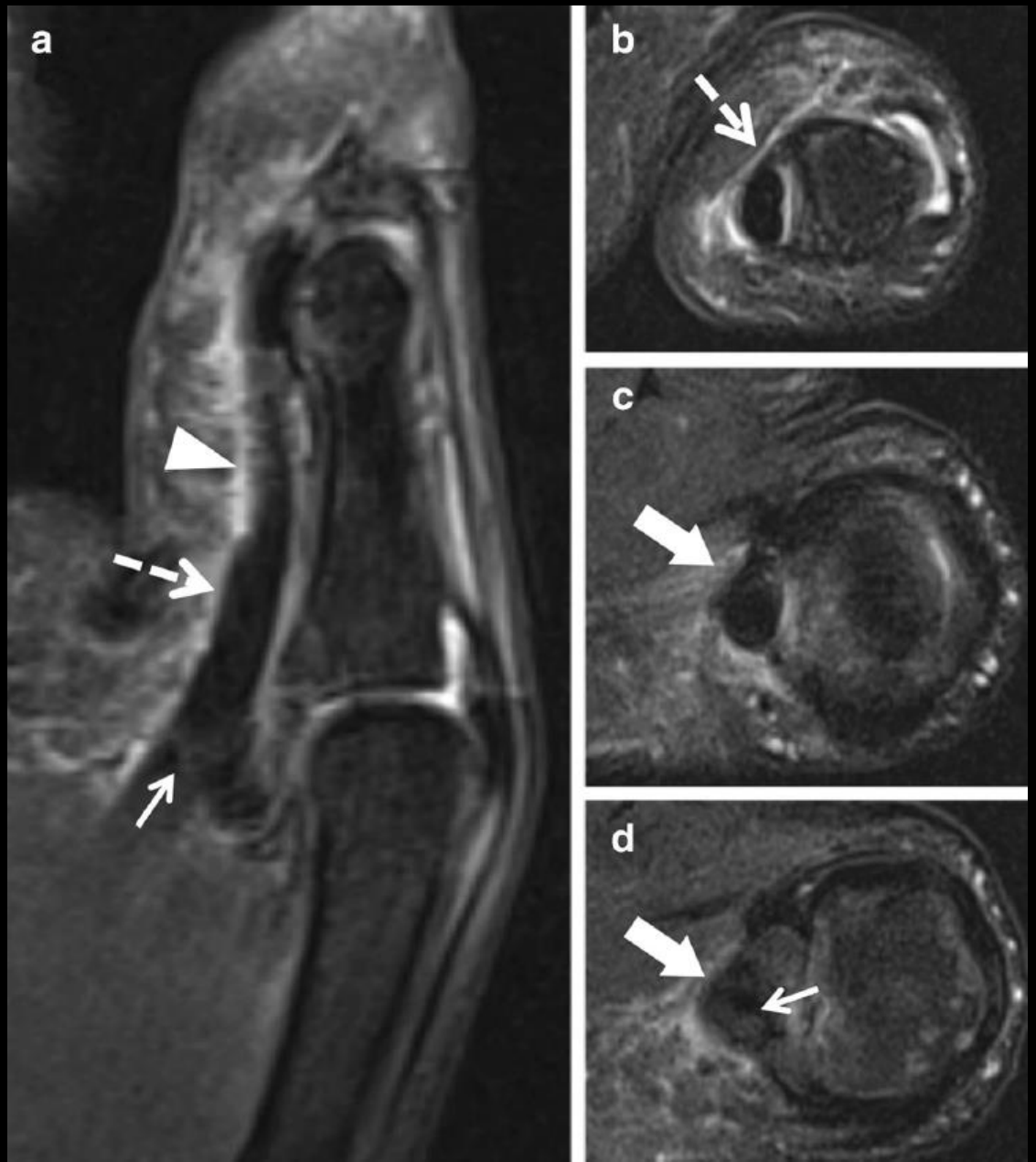
Pulleys of the thumb

- 4 pulleys described
  - A1 and A2
  - Oblique
  - Av (3 types)
    - Present in up to 93% specimens
      - Type I – transverse with a small gap between A1
      - Type II – no gap
      - Type III – triangular converging to radial side



Chang, EY. Skeletal Radiol 2015

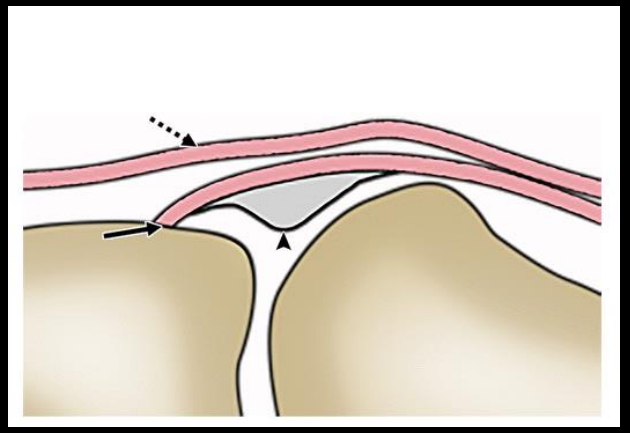
Trigger Thumb

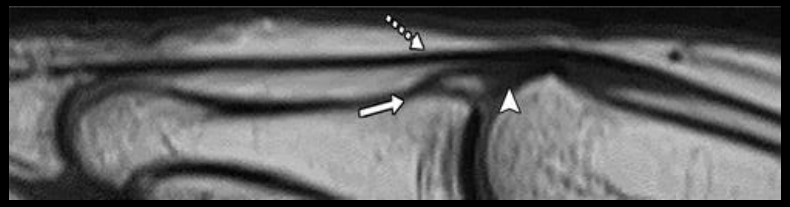


Chang, EY. Skeletal Radiol 2015

Thumb MCPJ

- Similar to MCPJ of the lesser digits with some major exceptions
  - Complex range of motion
  - Accesory collateral ligaments attach to sesamoids
  - Flexor tendon don't exhibit splitting, instead the FPB attaches to radial sesamoid and proximal phalanx radial base
  - Presence of a dorsal plate that's blends with the EPB with no definite osseous attachment

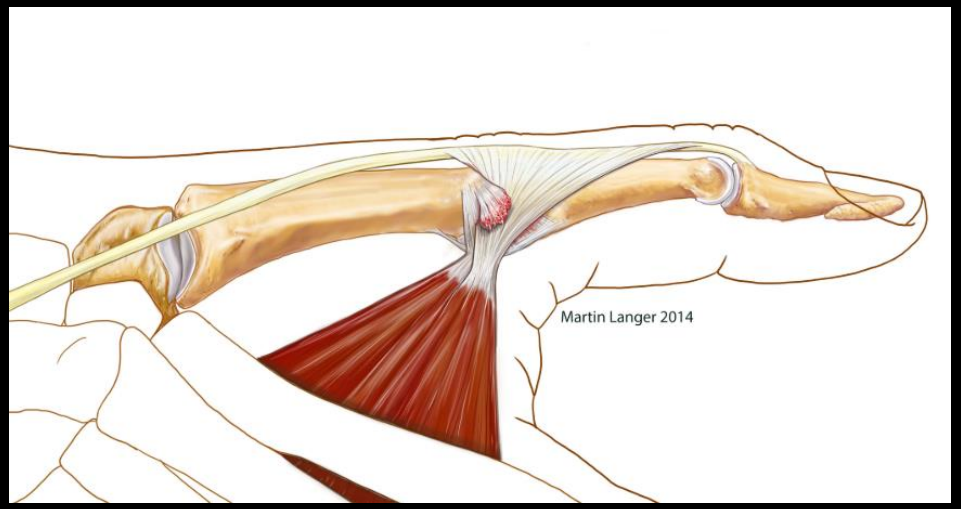




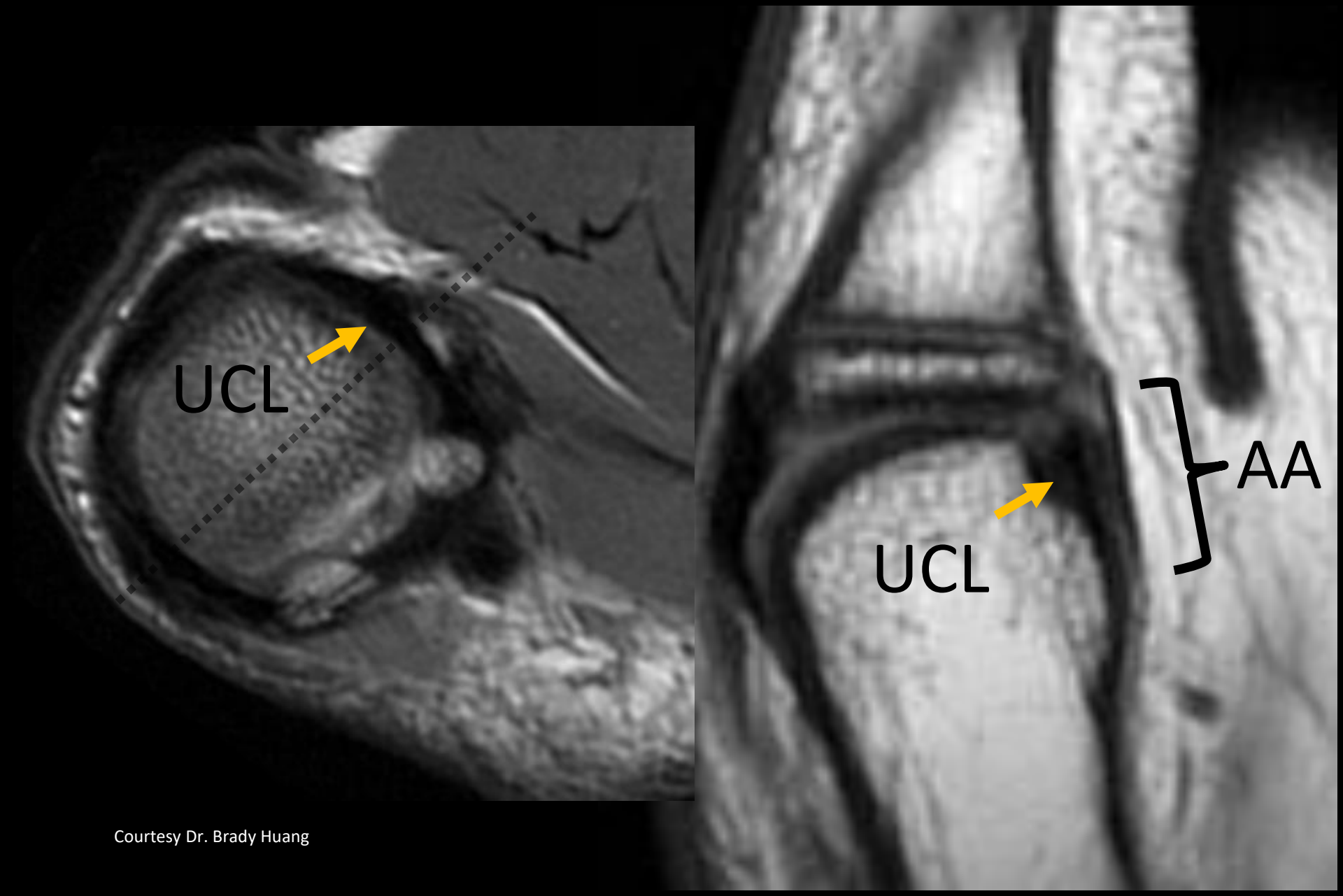
Rawat, U. Radiographics 2016

Thumb UCL tear

- Violent hyperabduction of the thumb
  - Tear of the ulnar collateral ligament
    - Type I - tear at osseous attachment
    - Type II – tear midsubstance ligament
    - Type III - osseous avulsion
  - Stener lesion – torn ligament displaces superficial to adductor aponeurosis



Thumb UCL Tears



Courtesy Dr. Brady Huang

Thumb UCL Tears

UCL Tear, no retraction

Courtesy Dr. Brady Huang

UCL Tear, Stener lesion

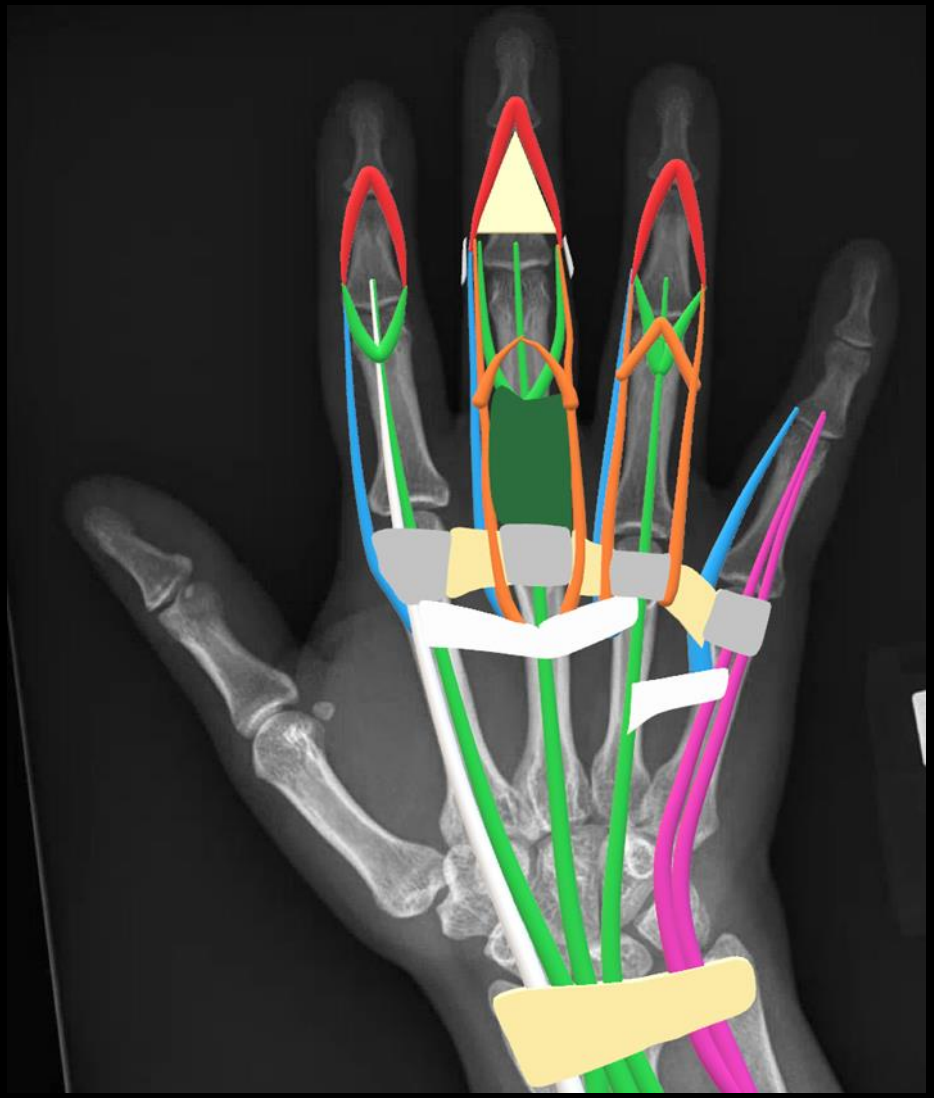
Digit Extensor tendons

Digit Extensor tendons

Digit extensor tendon anatomy

- Extensor tendons
  - Extrinsic
    - Extensor digitorum comunis (Ec)
    - Extensor indexes propius(Ei)
    - Extensor digiti minimi quinti (Ed5)
  - Intrinsic
    - Interosseous
      - Palmar (3)
        - » Flexion MCP and adductor
      - Dorsal (4)
        - » Flexion MCP and abductor
    - Lumbricals
      - Located palmar to deep transverse palmar ligament
      - Flexor MCP
      - Only tendon originates in tendon and inserts in tendon

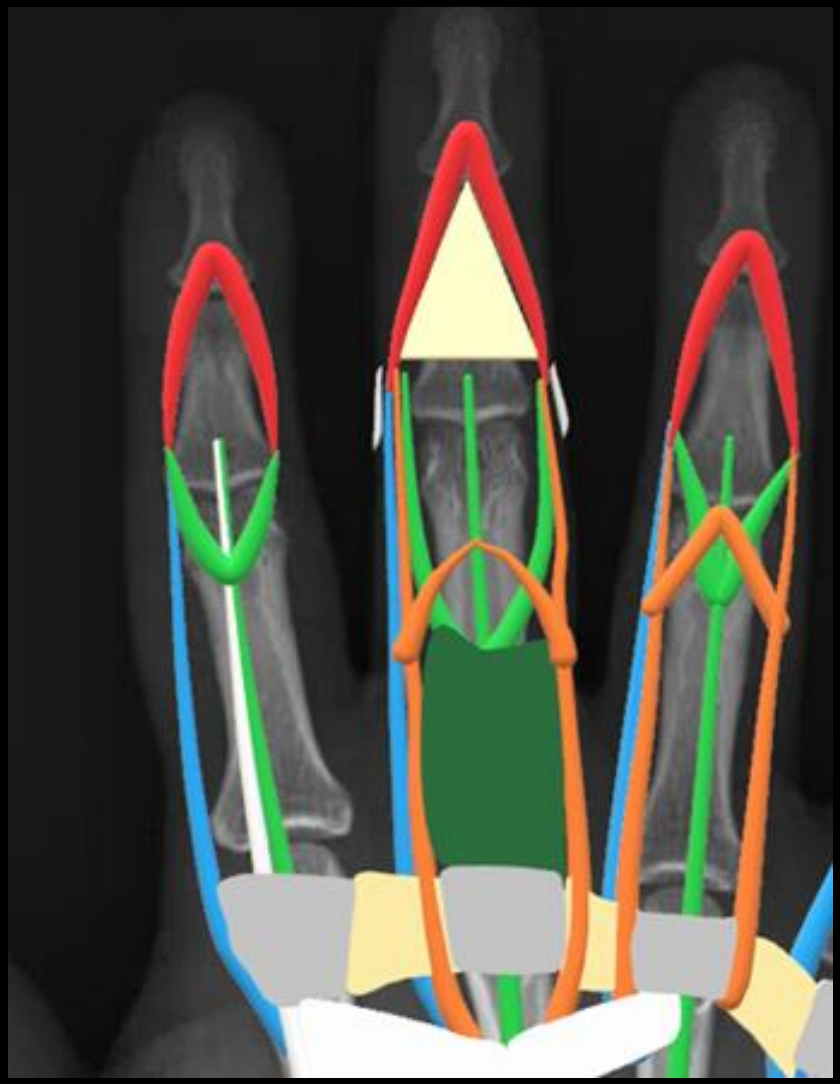
No tendinous insertion of the EDC to the base of proximal phalanx has been demonstrated



Digit extensor tendon anatomy

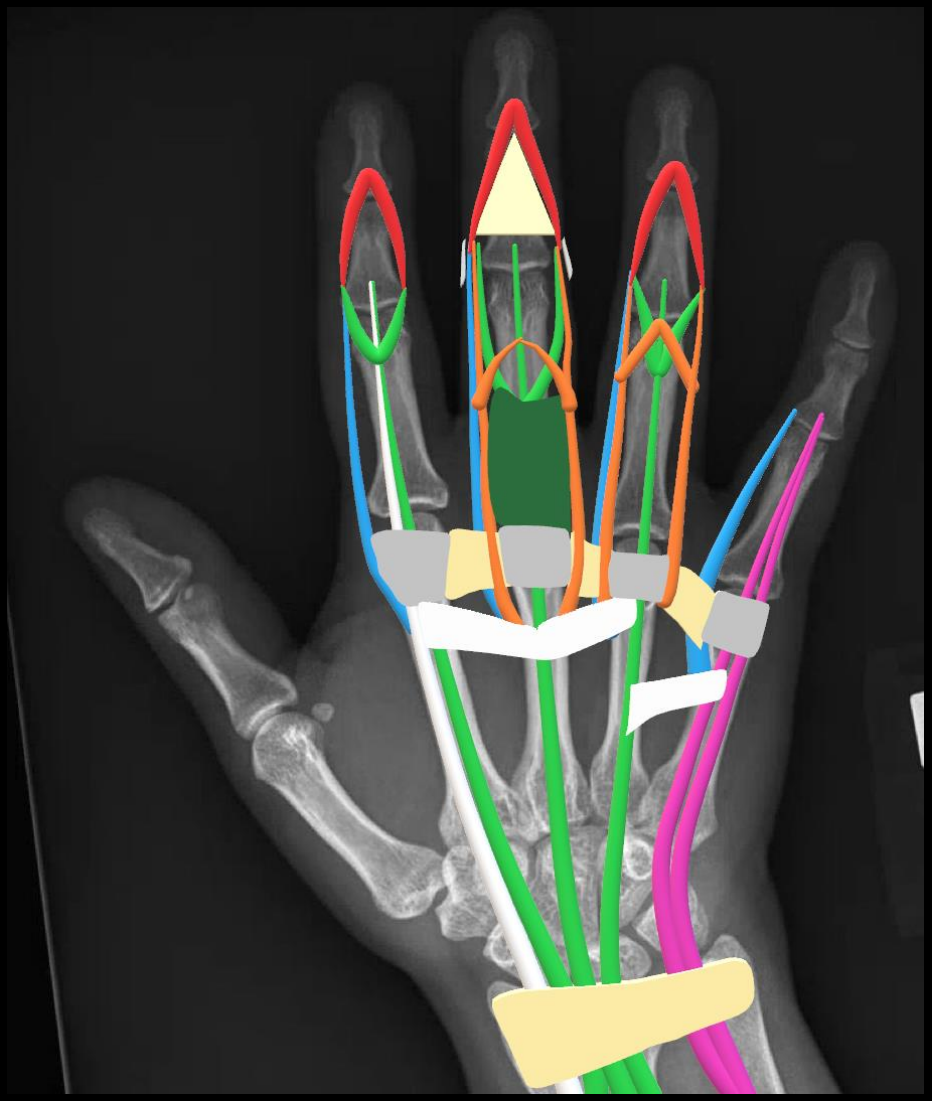
- Retinacular system
  - Extensor hood
    - Sagittal band
    - Aponeurotic expansion of the interossei lateral band at each side of digit to base of proximal phalanx between and central slip
  - Retinacular ligaments
    - Secure conjoint tendon to flexor sheath preventing dorsal subluxation[1]
  - Triangular ligament

    Attach the conjoint tendon to dorsum of middle phalanx to prevent palmar subluxation[1]

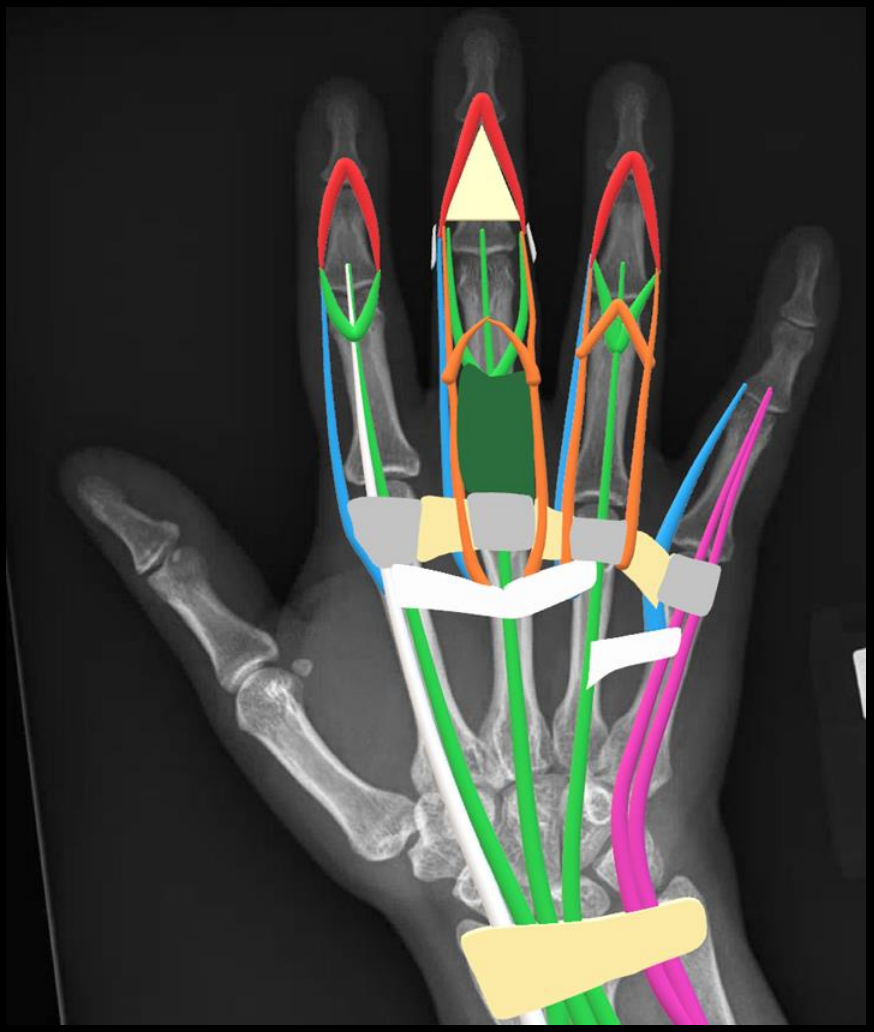


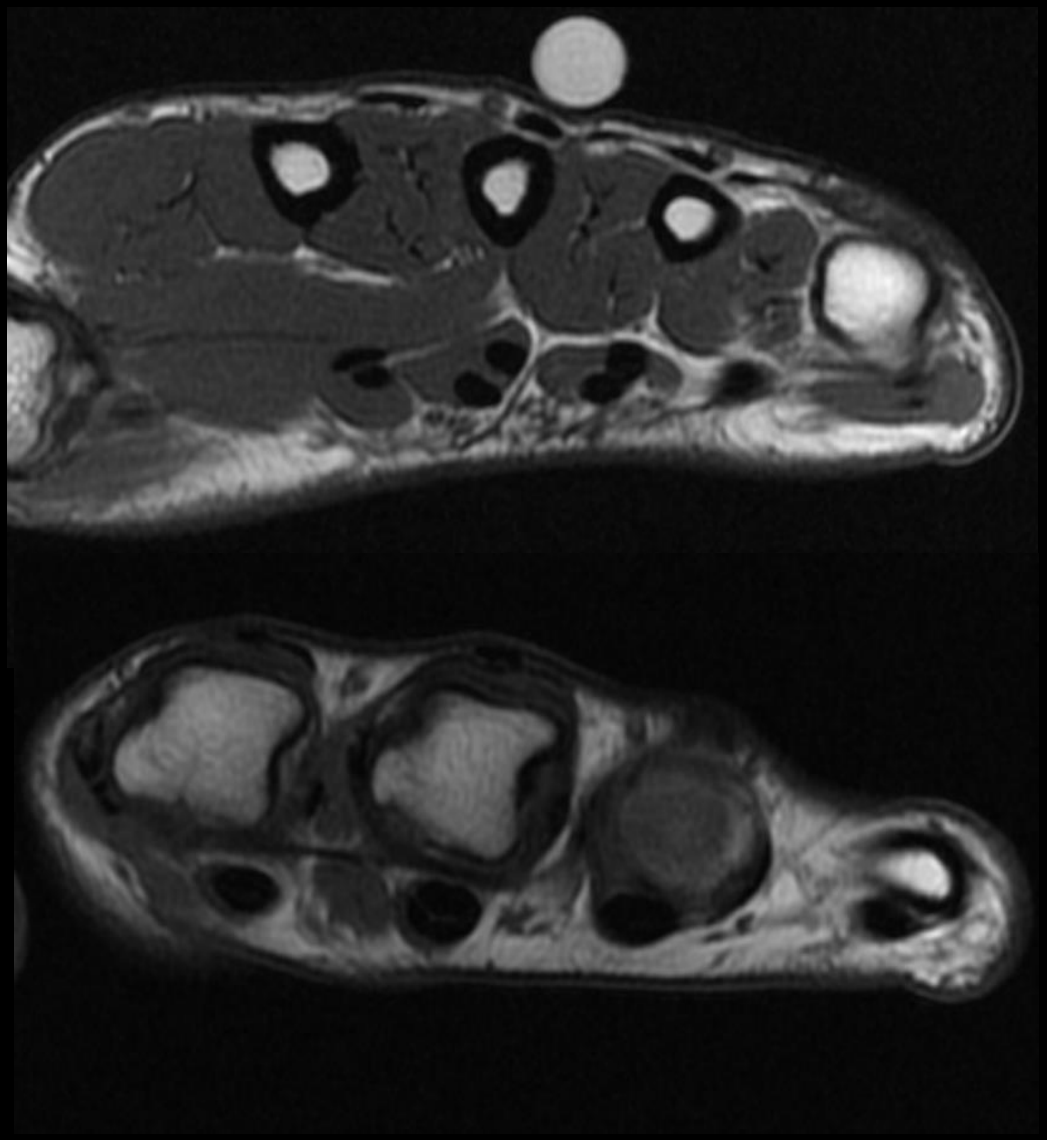
[1]Gupta, P. AJR 2014

Digit extensor tendon anatomy



Digit extensor tendon anatomy





Sagittal band (SB)

- Collagenous structure with a palmar origin from a confluence of the volar plate and flexor tendon sheath.
  - A1 pulley, transverse metacarpal ligament
  - Run superficial to the capsule and collateral ligaments
    - Splits to a thin superficial and thick deep layer to envelop the EDC
  - Proximal margins are free
  - Distal margin blends with the aponeurotic expansion of the interossei

Gupta, P. AJR 2014

Extension of MCP joint

- “Extension of the MCP joint is carried out mainly by the common extensor muscle and the appropriate extensor muscles by means of pulling the tendons over the sagittal band”

- Initially tough that extension of the MCP joint was by a lasso or sling effect from the SB

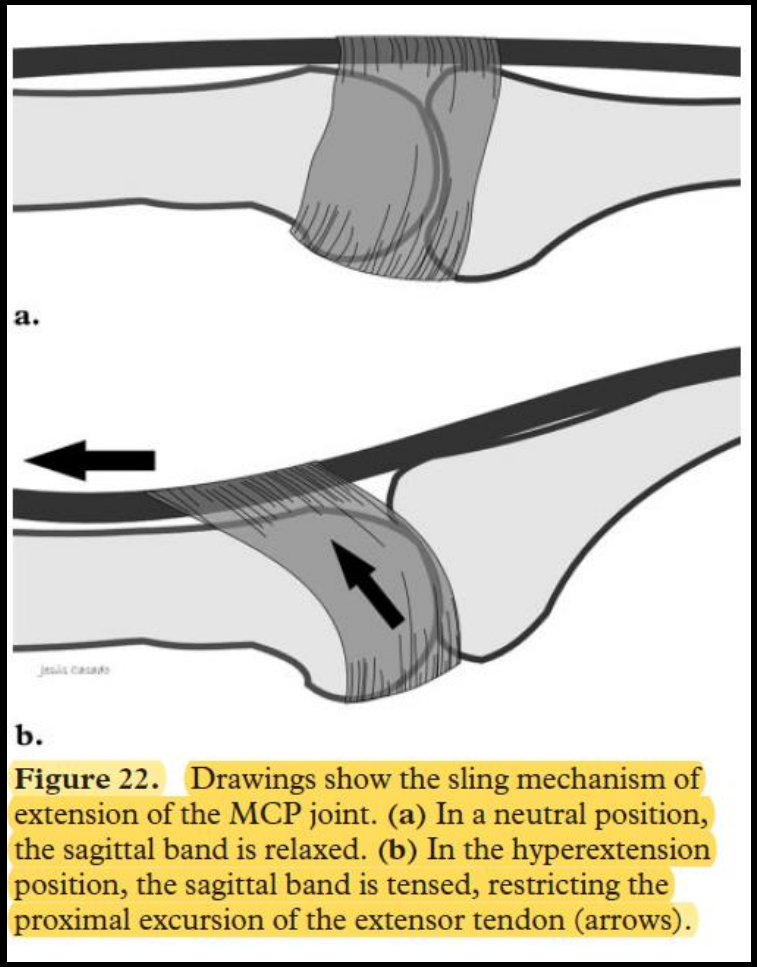


Figure 22. Drawings show the sling mechanism of extension of the MCP joint. **(a)** In a neutral position, the sagittal band is relaxed. **(b)** In the hyperextension position, the sagittal band is tensed, restricting the proximal excursion of the extensor tendon (arrows).

Clavero JA Radiographics 2003

Extension of MCP joint

SCIENTIFIC ARTICLE

Mechanics of Metacarpophalangeal Joint Extension

Timothy G. Marshall, BMedSc, MBBS,* Brahman Sivakumar, MBBS, MS,*
Belinda J. Smith, BAppSc,* Mark S. Hile, BE(Hons), MBBS*

TABLE 1. Mean (Range) Force in Newtons Before and After Division of EDC or SB, With MCP Joint in Neutral and Flexed Positions

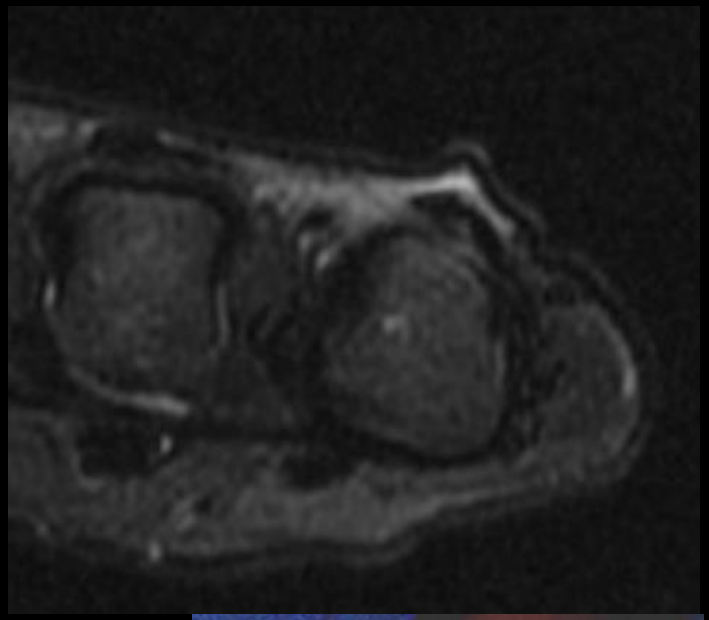
	EDC			SB		
Position	Intact	Divided	*P* Value	Intact	Divided	*P* Value
Force (N) with MCP joint in extension	1.14 (0.32–1.92)	0.19 (0.00–0.47)	< .05	1.00 (0.42–1.48)	0.89 (0.14–1.48)	.13
Force (N) with MCP joint in 45° flexion	1.88 (1.24–2.35)	1.22 (0.58–2.02)	< .05	1.88 (1.49–2.15)	1.74 (1.08–2.33)	.16

Conclusions The sagittal bands do not primarily extend the MCP as a sling or lasso. The extensor tendon continuation to the extensor hood and middle phalanx is the major extension motor. The MCP joint is extended by the torque generated by the extensor tendon passing the joint carrying a force and possessing an extension moment arm.

Marshall TG. *J Hand Surgery* 2018

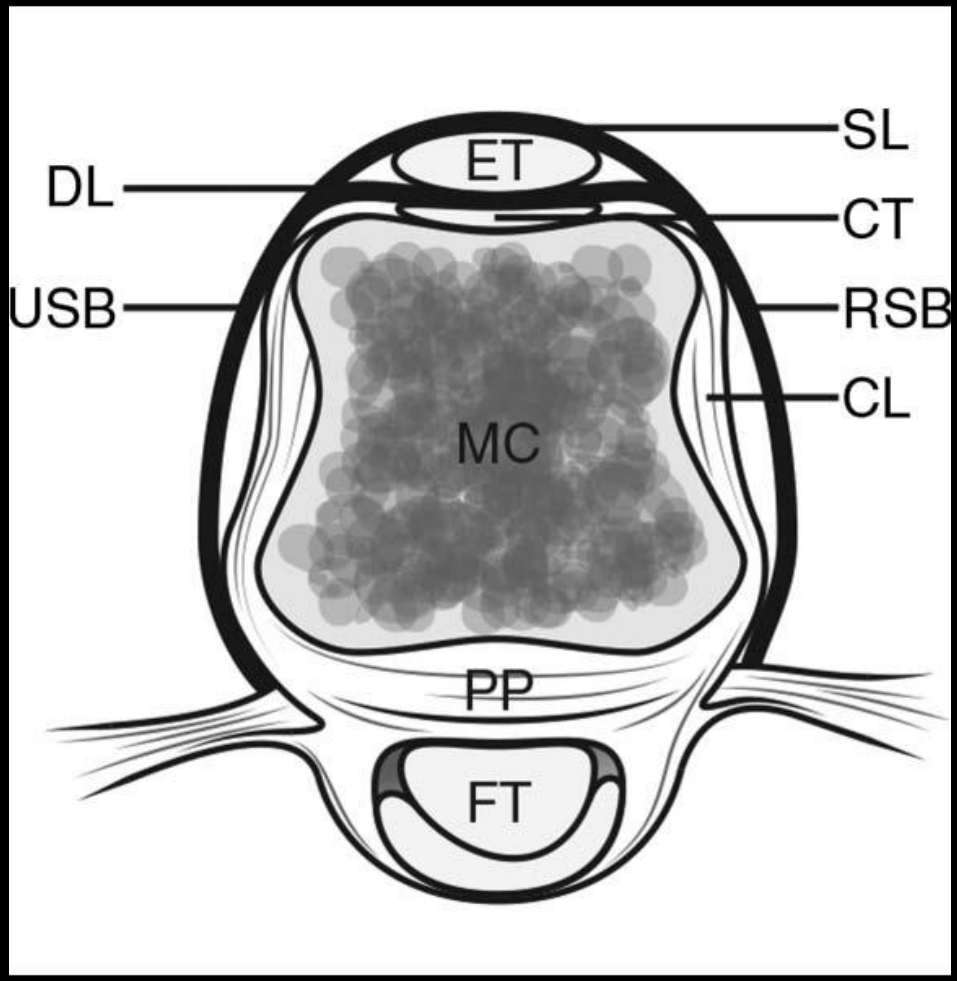
Sagittal band injury

- Usually closed injuries resulting from resisting finger extension or direct trauma
  - Punch to mouth with laceration
    - 10% become infected
- Boxer's knuckle most commonly involve radial sagittal band
  - May lead to instability
  - Ulnar subluxation
- Classified into 3 types
    - Type 1 – contusion without tear or instability
    - Type 2 – tears associated with extensor tendon snapping without complete dislocation
    - Type 3 – tendon dislocation into the intermetacarpal groove



Kleinhenz PB. *J Am Acad Orhop Surg* 2015

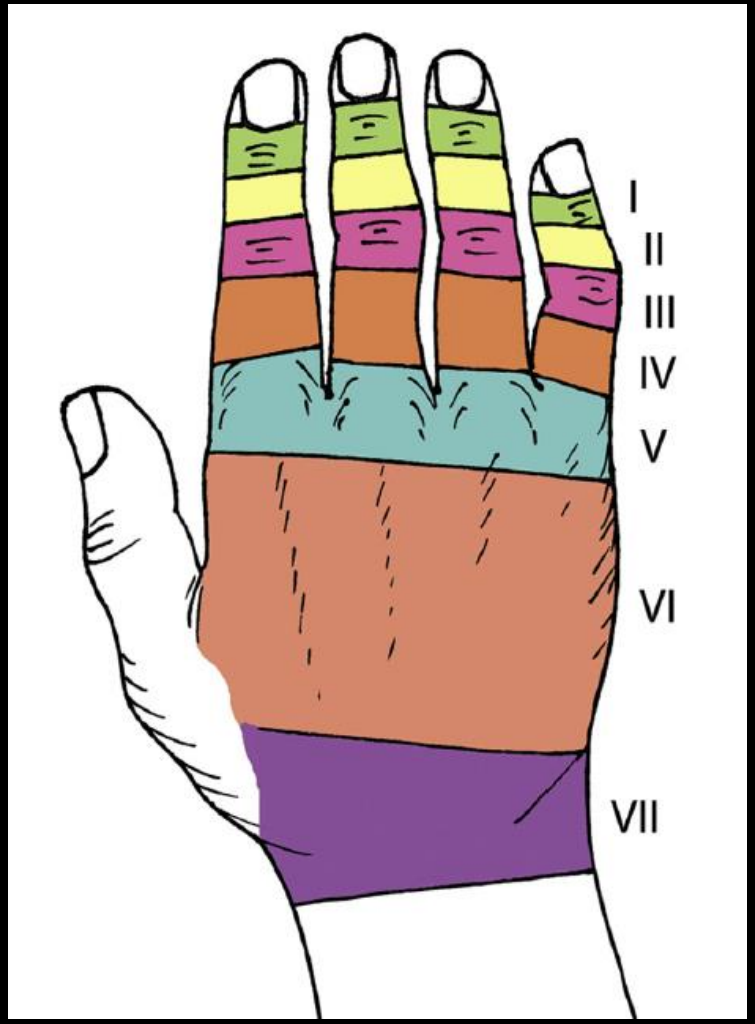
Extensor Hood Injury



Kleinhenz PB. *J Am Acad Orhop Surg* 2015

Extensor injuries

- Most important injuries
  - Mallet finger
    - Zone I
  - Boutonniere deformity
    - Zone III



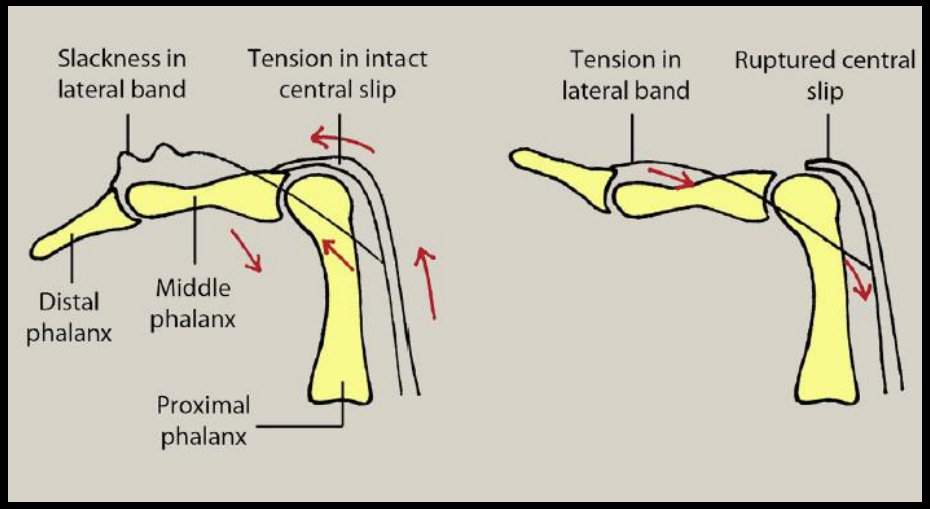
Newton AW. Orthopaedics and Trauma 2018

Extensor injuries

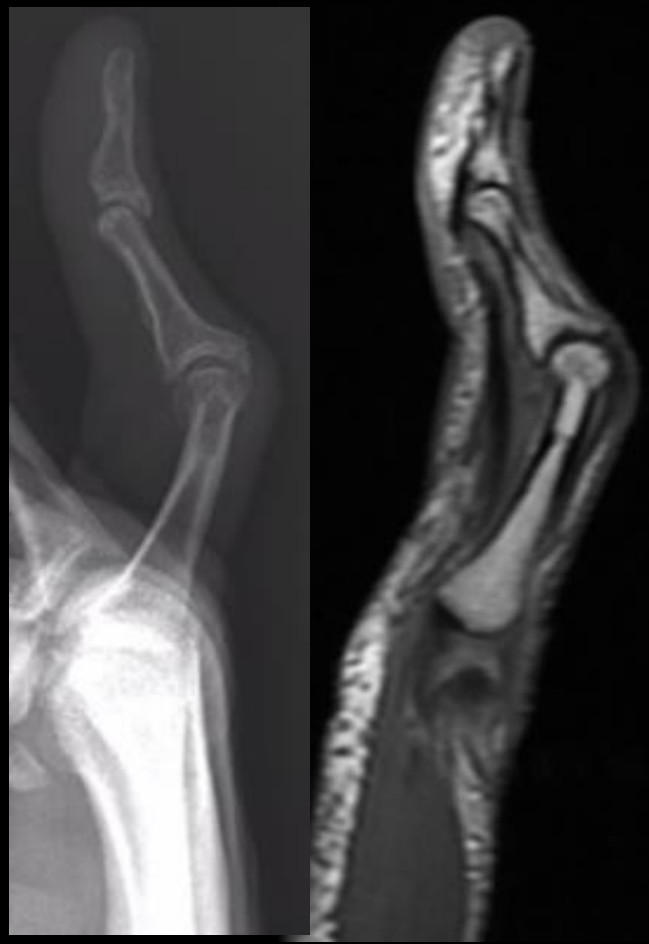
- Mallet finger (zone 1)
  - Forced flexion at DIP while PIP is extended
    - Produces an avulsion injury of terminal tendon
  - Ask patient to extend fingers
    - If DIPJ is flexed, but the other joint are extended

Extensor injuries

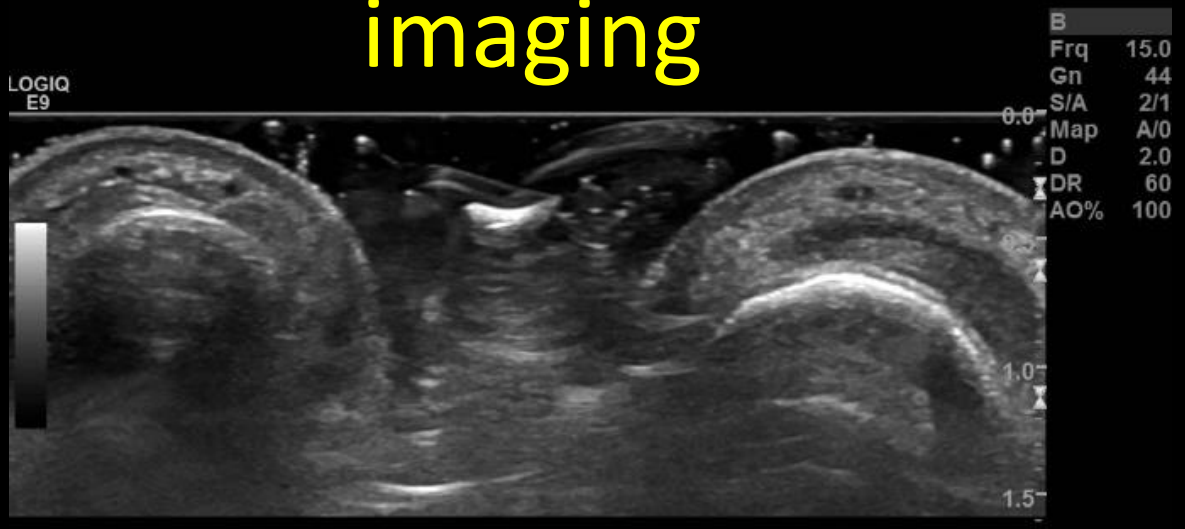
- Boutonniere deformity
  - Injury to the central slip
    - Initially PIPJ extension occurs owing to lateral bands
    - But progresses as lateral slips sublux
    - PIPJ extension with DIPJ flexion

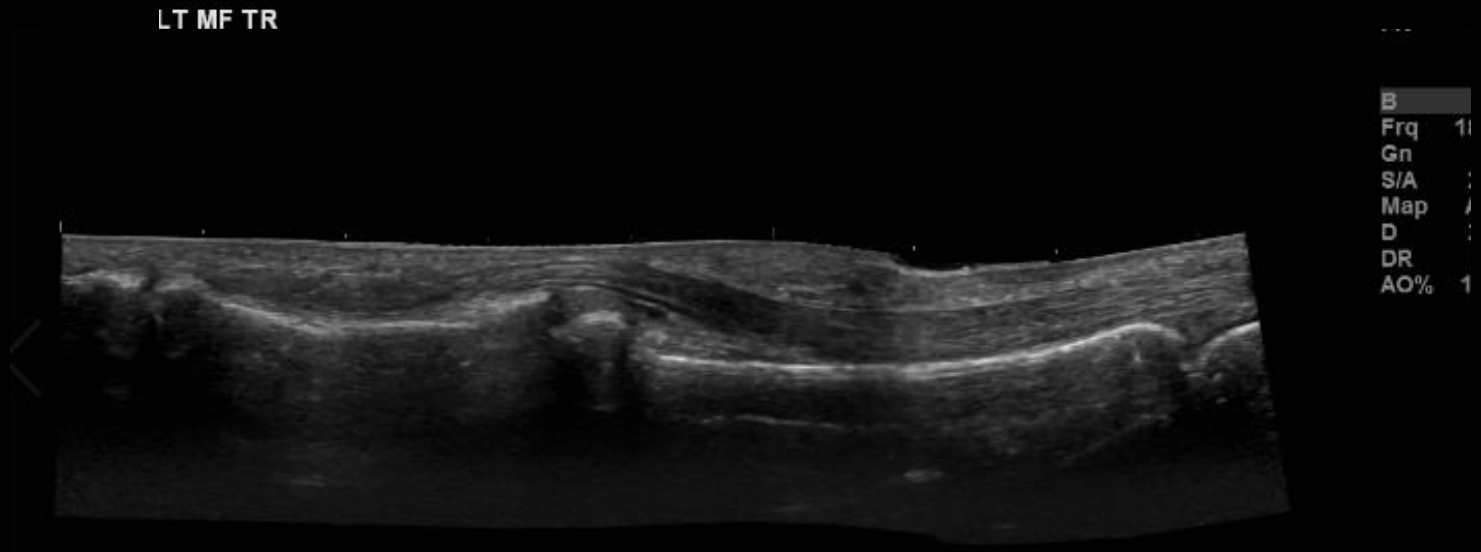


Newton AW. Orthopaedics and Trauma 2018

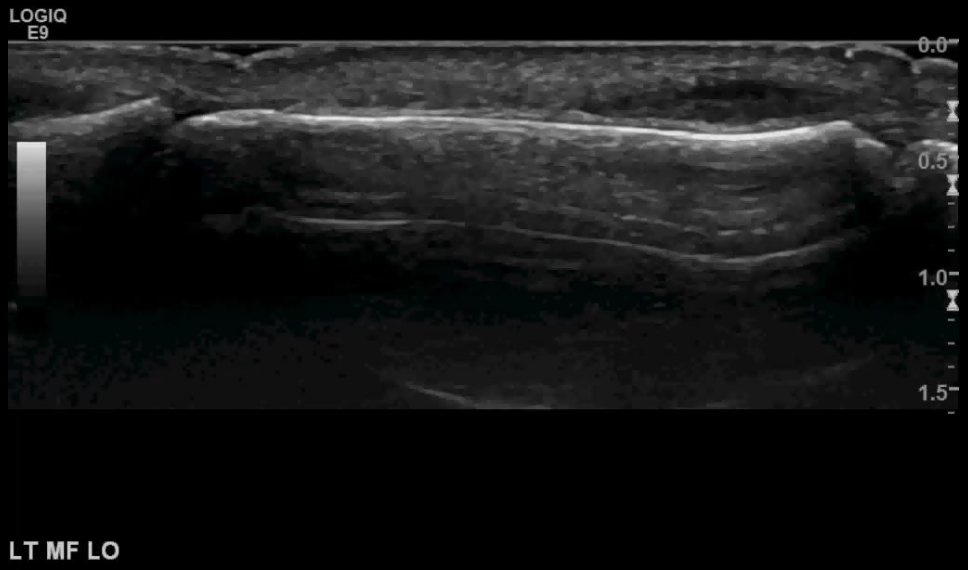


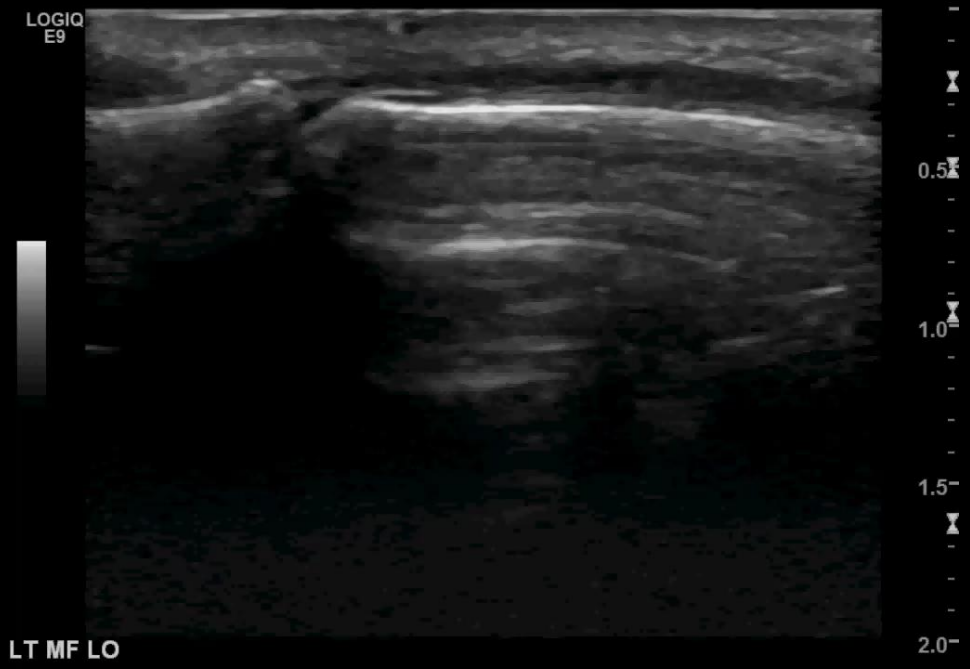
Extensor tendon injury dynamic imaging





Extensor tendon injury dynamic imaging

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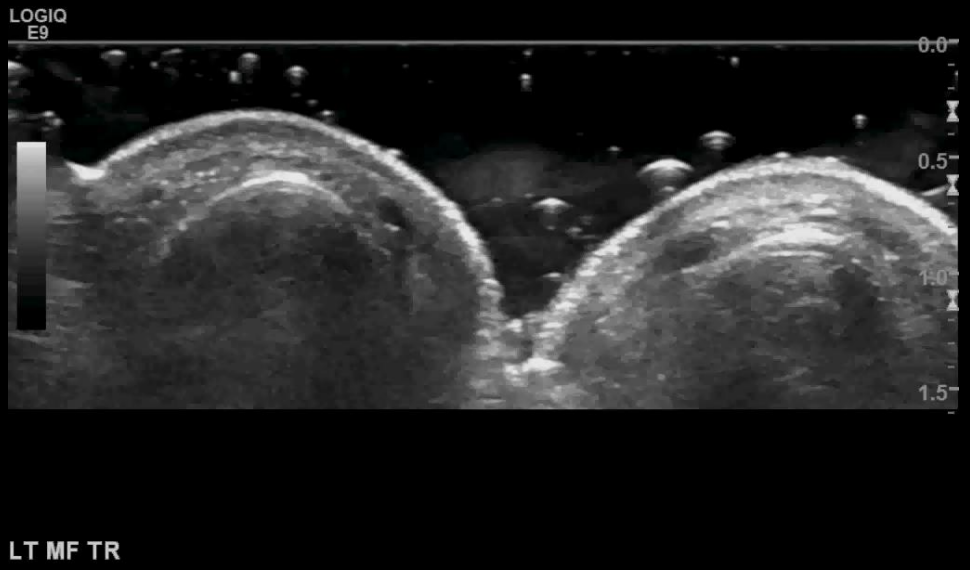
Extensor tendon injury dynamic imaging



Summary

- Understand concept that both extensor and flexor mechanism of the digits consist both of tendinous and retinacular structures that work as a single unit
  - Failure of the retinaculum (pulley) leads to increased effort and work
    - Place attention to location of flexor tendon on sagittal
  - Failure of the tendon may lead to complete failure of joint
    - Early bouttonniere deformity may be masked

Thanks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CO
KVP : 80kV
X-ray Tube Current : 800mA
Exposure Time : 21msec
mAs : 16.8mAs

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