Flexor Tendon Injury

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Normal Presentation of Flexor tendon cascade

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Common Presentation of flexor tendon injury

- Straight finger

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Common Presentation of flexor tendon injury

- Straight Thumb
- Absent Tenodesis effect

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Tendon of Ring Finger looks normal or injured - ????

- Only FDS ?
- Only FDP ?
- Both FDS & FDP ?

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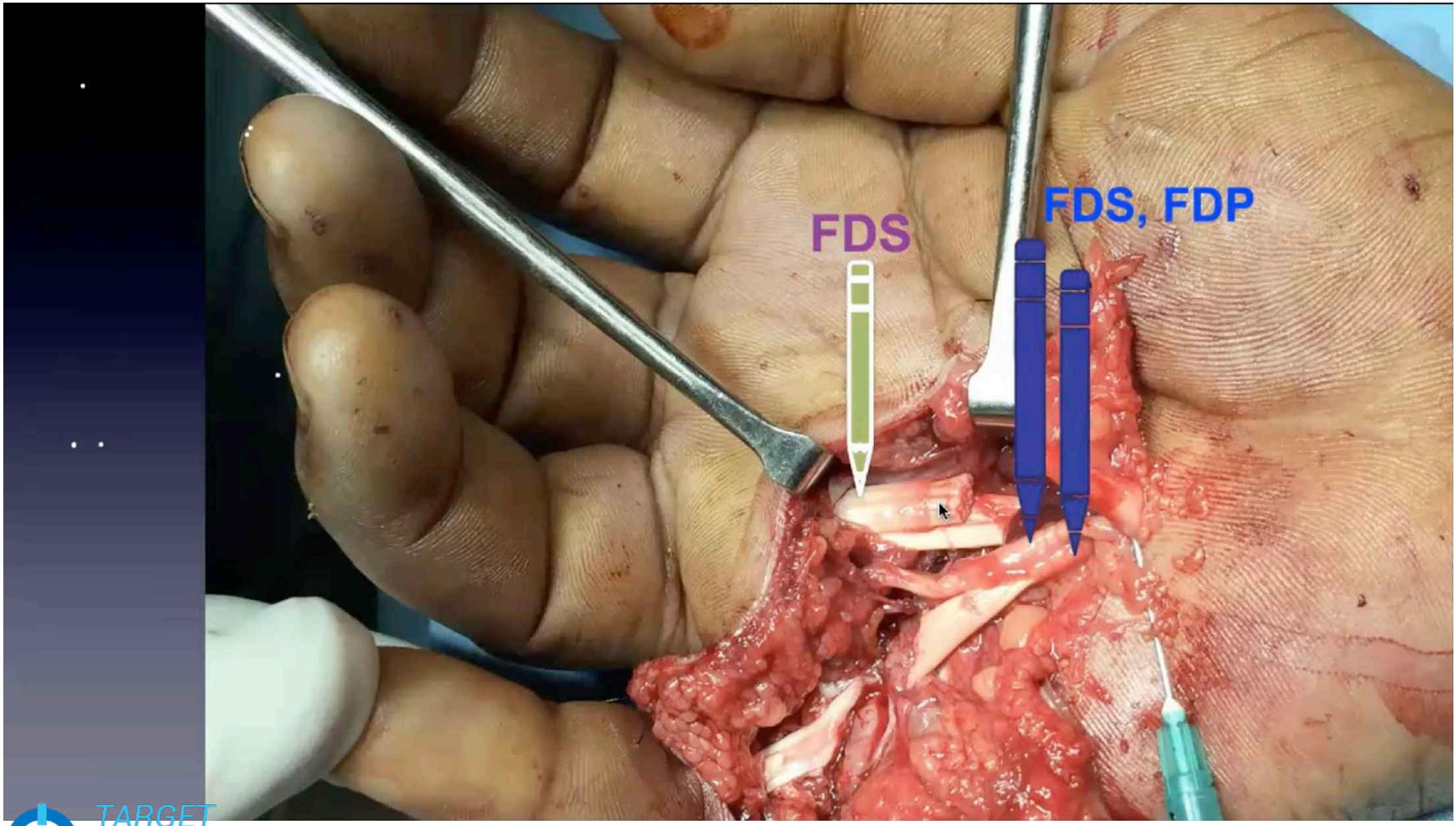

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Proper evaluation of tendon injury
is very important
And
not just Just straight finger is enough

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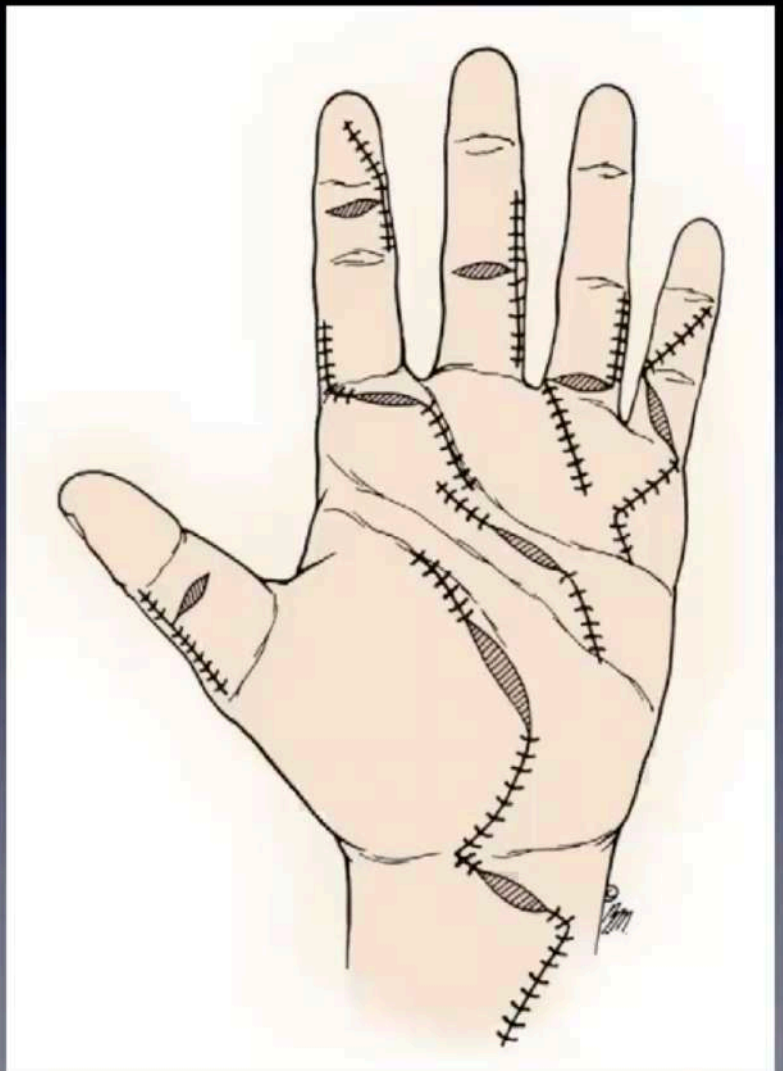
Examination and approach - skin

- Number of skin laceration
- Severity of skin laceration



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Examination and approach - skin condition

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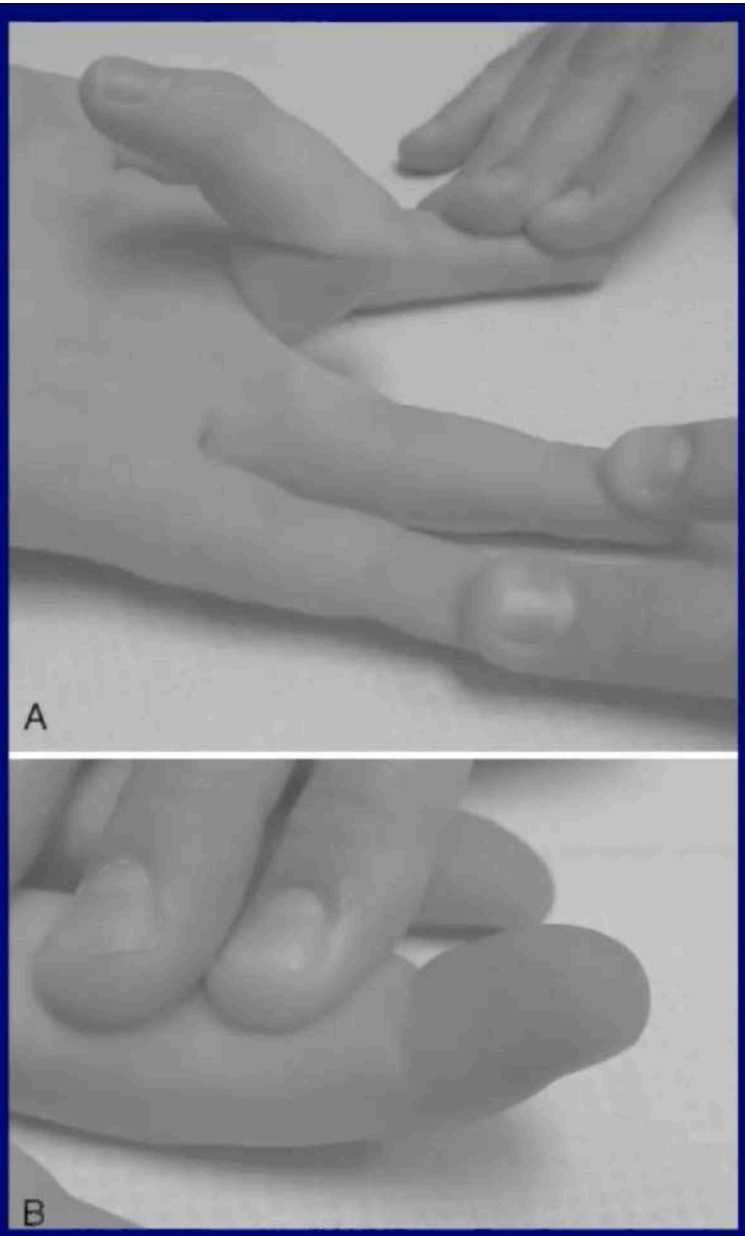
Examination & approach

- Active and passive ROM and not just deformity



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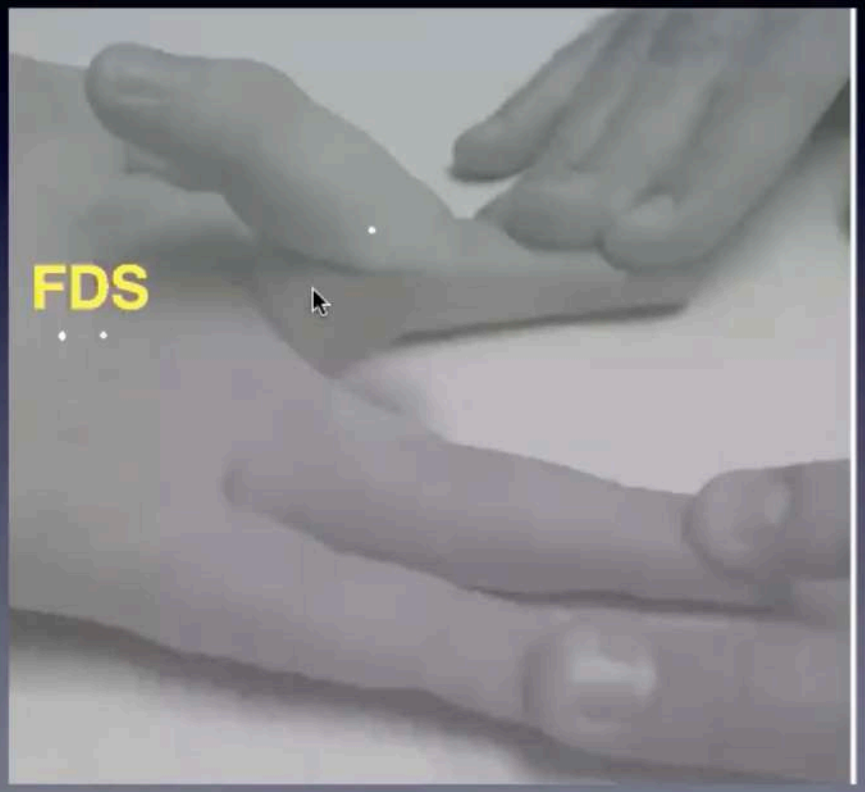
Pre-op evaluation FDS, FDP Tendon



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Note terminology -

Pain / Painless / Intact / Partial tendon injury

- Active flexion of PIP joint indicate - **Intact / Partial FDS**
- Pain during Active flexion of pip joint indicate - **Partial FDS injury**
- Active flexion of PIP joint **does not rule out** partial FDS injury

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Examination & approach
Sensation and viability of fingers

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Pre - op evaluation - Nerve

- Light touch and static 2 point discrimination is preferred

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Pre - op evaluation - vascular

- Delayed Capillary refill of Volar digital pulp and nail bed - Arterial injury

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Examination and approach

- X-ray is essential for foreign body , fracture

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Tendon injury - Easy to diagnose

- Same time its difficult to Repair atraumatically and its Rehabilitation
- Understanding of Surgical Anatomy of flexor tendon is important

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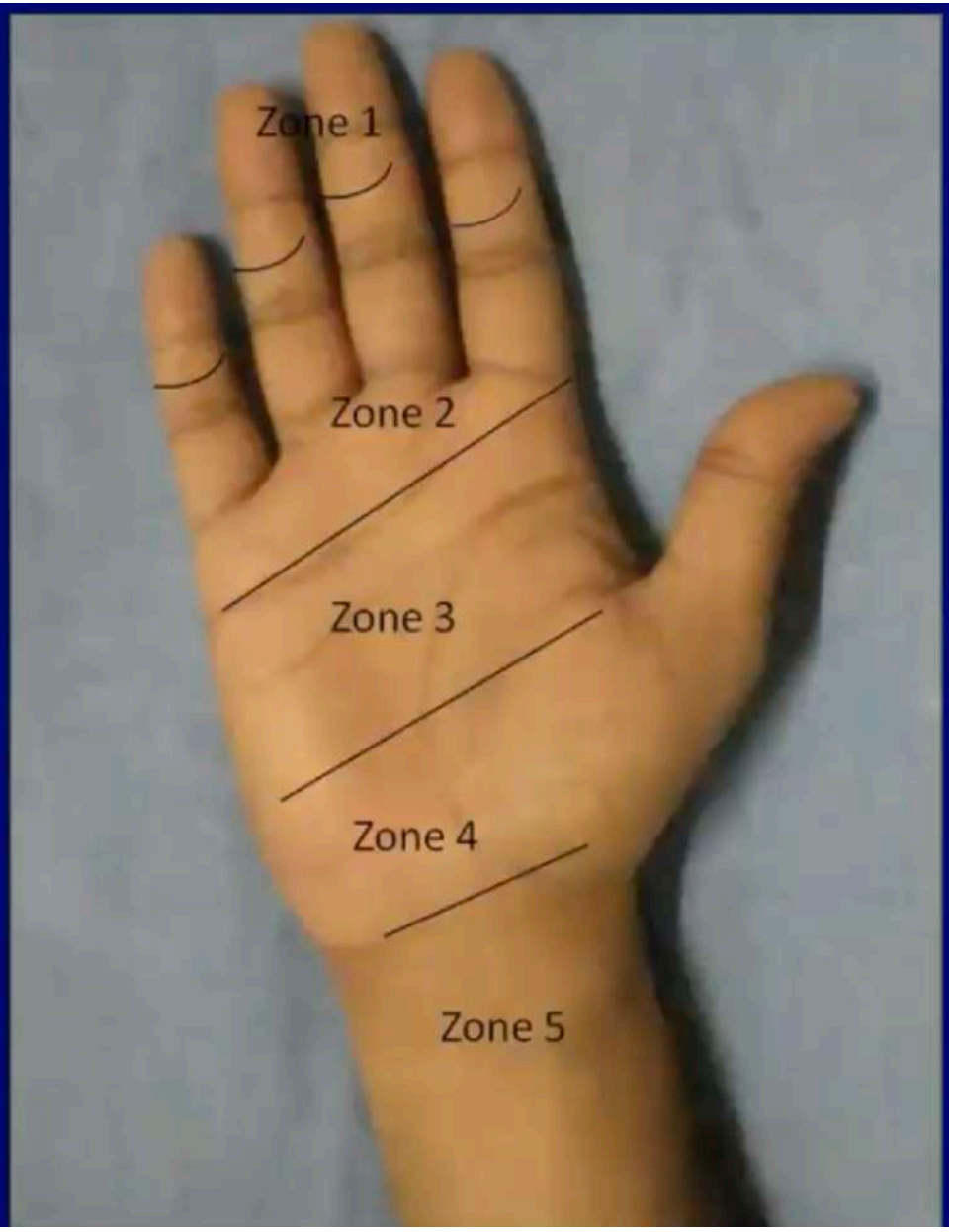
Verdan Zones of flexor tendon

- Laceration injury in hand should be checked for **structure** injured according to zones involved in that hand



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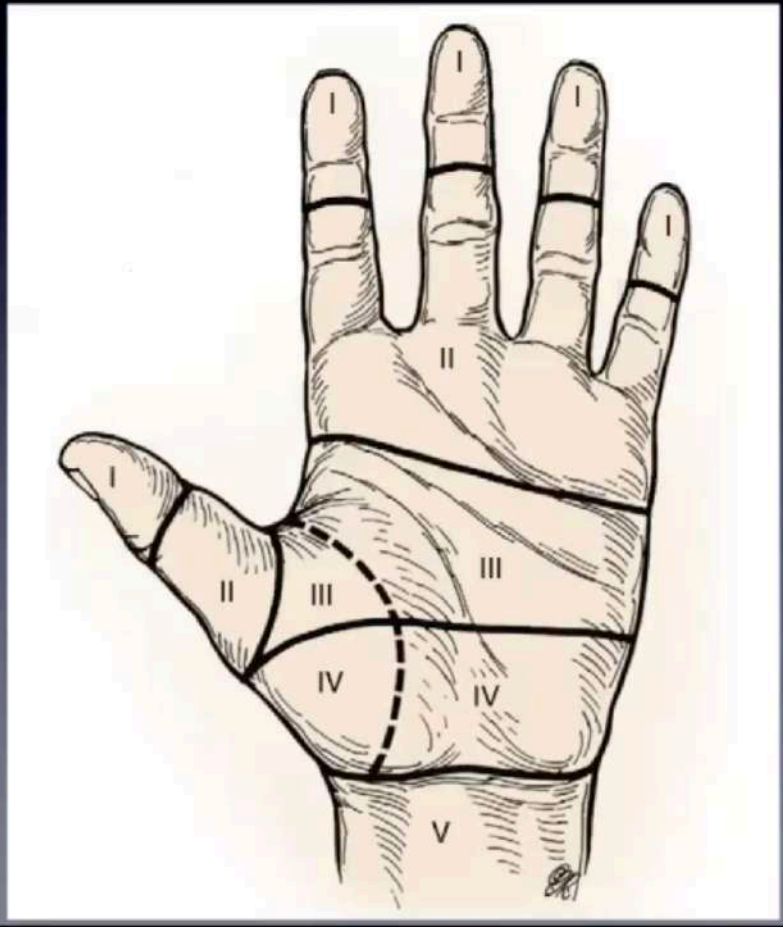
Zone 5

- **Musculotendinous junction to proximal aspect carpal tunnel**



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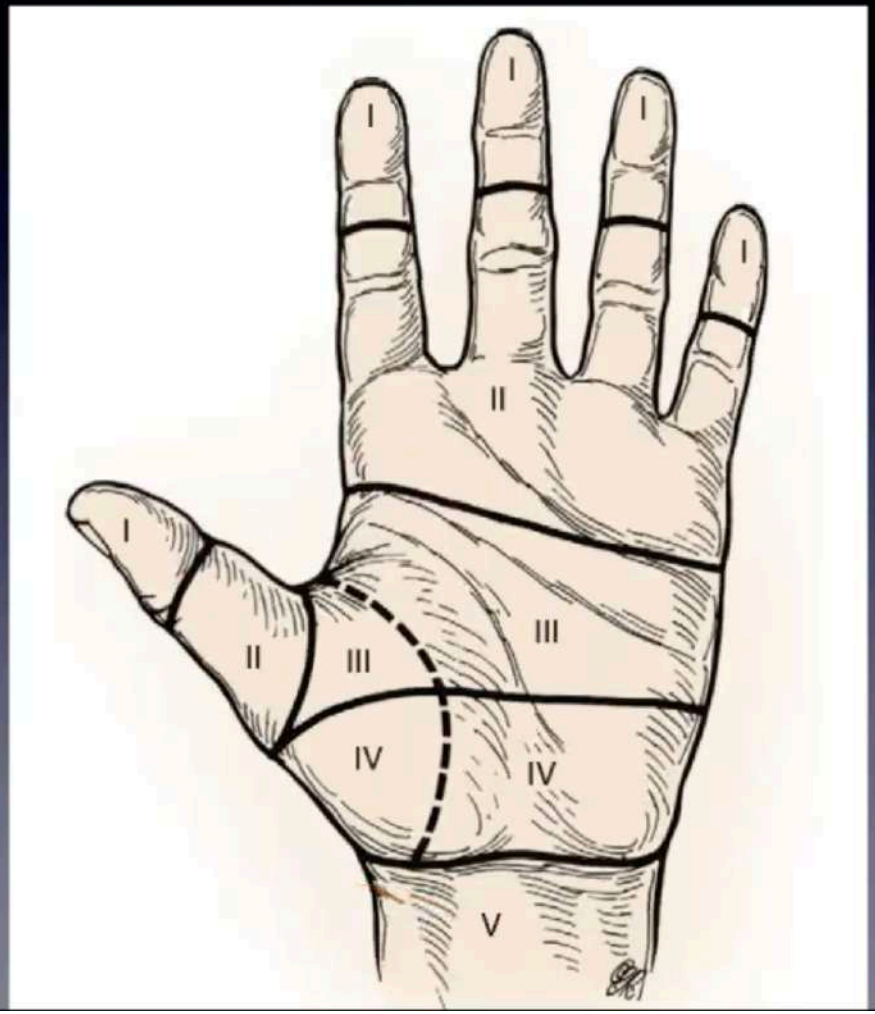
Zone 4 - Carpal Tunnel region



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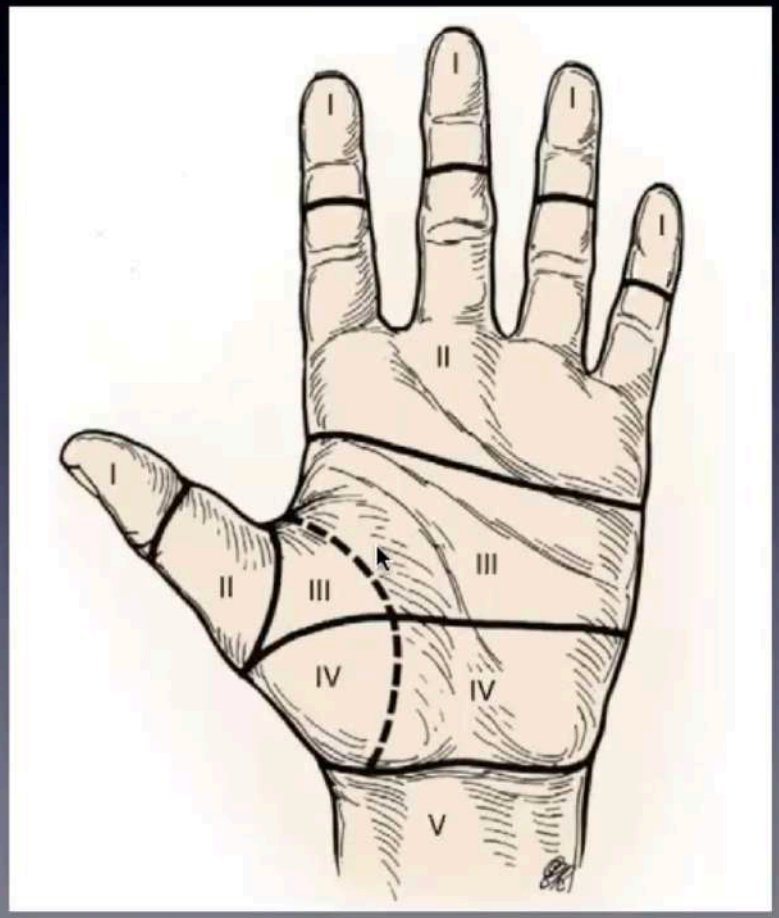
Zone 3

- origin of lumbricals muscle from FDP



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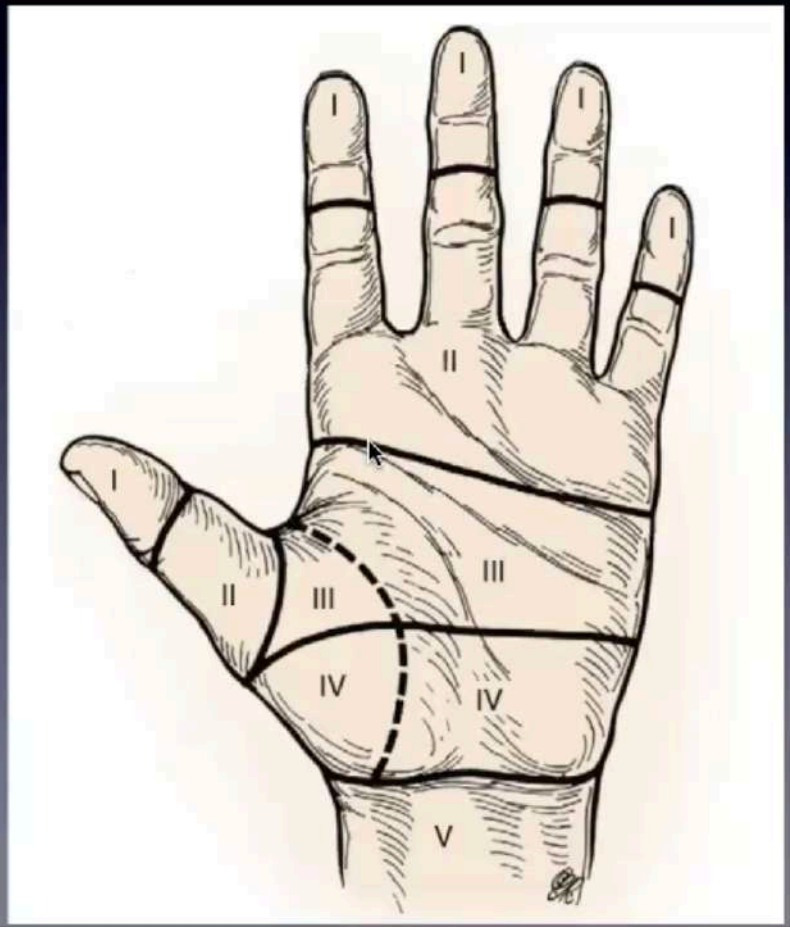
Zone 2

- proximal aspect of A1 pulley [no man's island]



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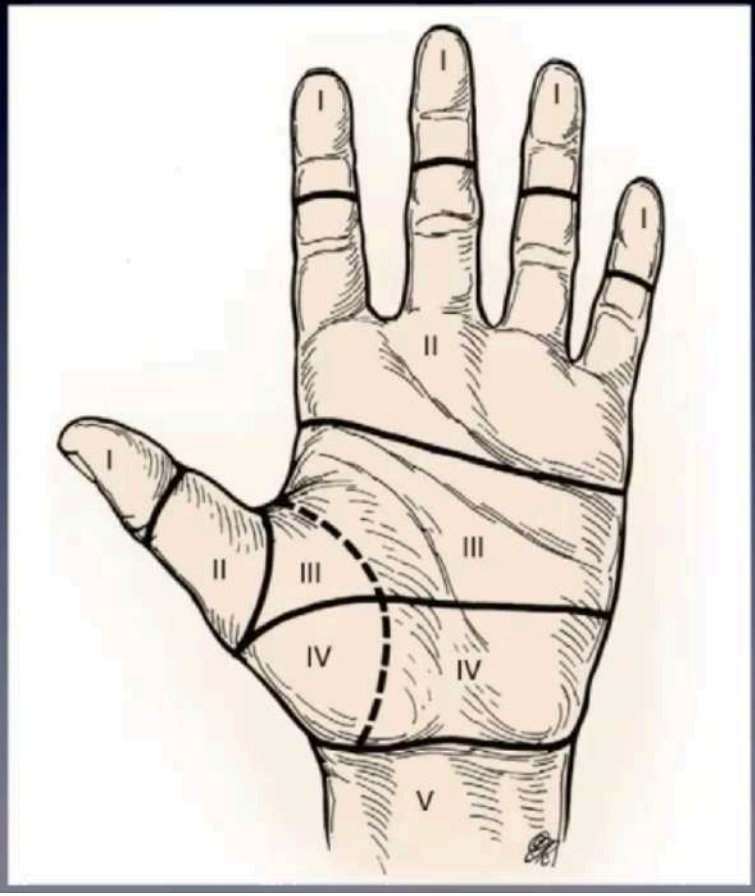
Zone 1

- Distal to insertion of FDS



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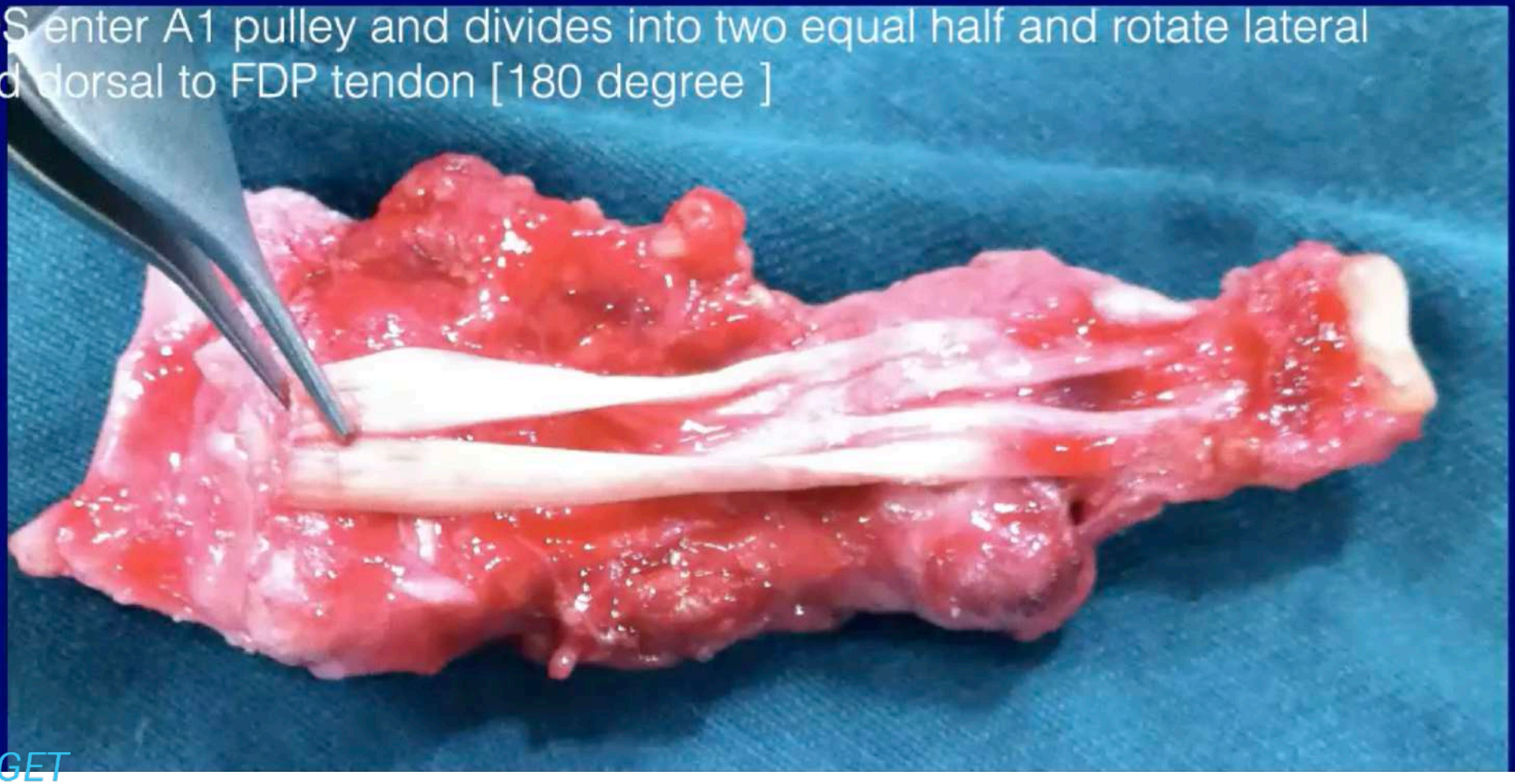
Zones 2 flexor tendon anatomy - FDS, FDP

No man's Land - previously believed

- FDS enter A1 pulley and divides into two equal half and rotate lateral and dorsal to FDP tendon [180 degree]
-



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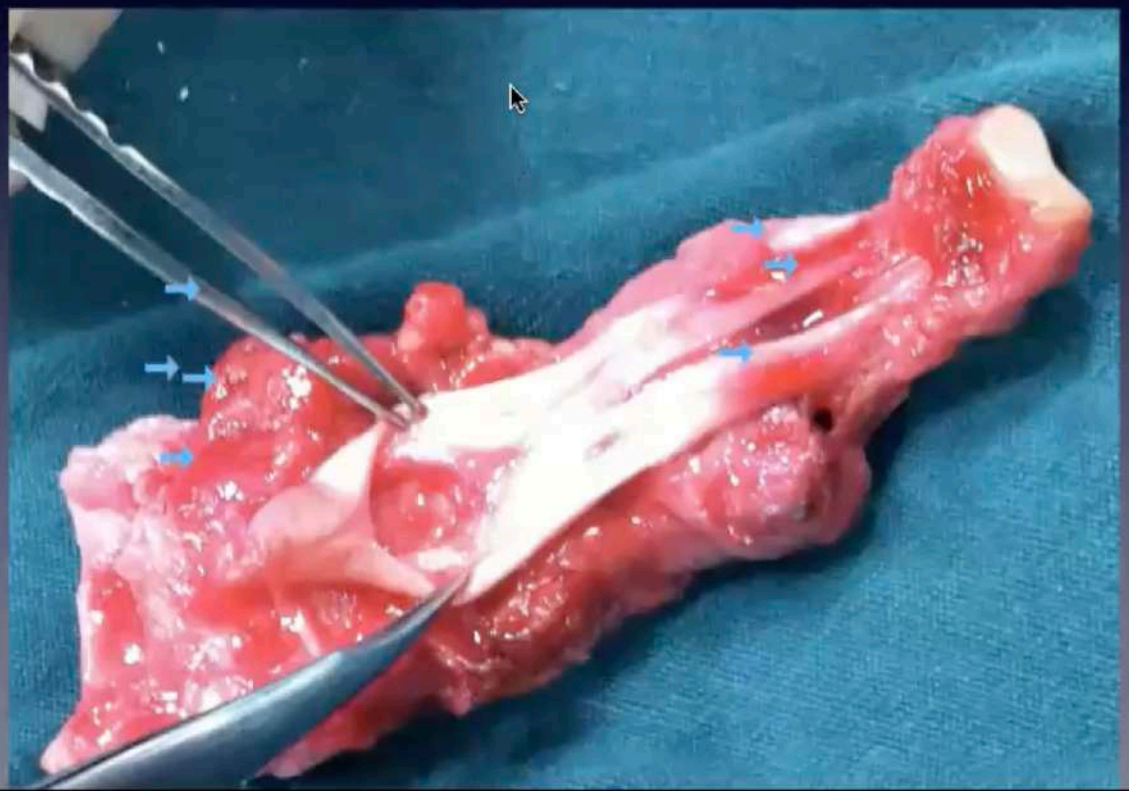
Anatomy - FDS

- At level of distal PPX or Volar plate dorsally it joins and forms chamber chiasma
-



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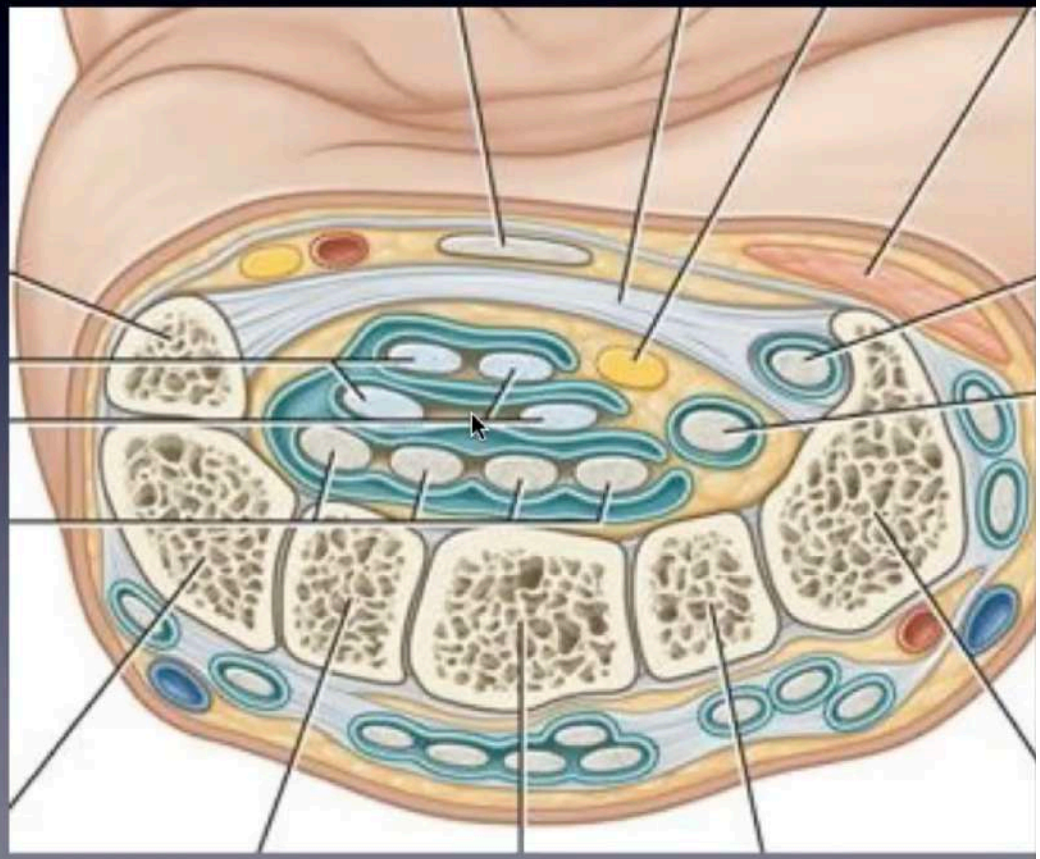
Cross section anatomy - at Wrist
Flexor Tendons

Superficial - FDS of long and ring finger

Then - FDS of little and index finger

Then all FDP and FPL



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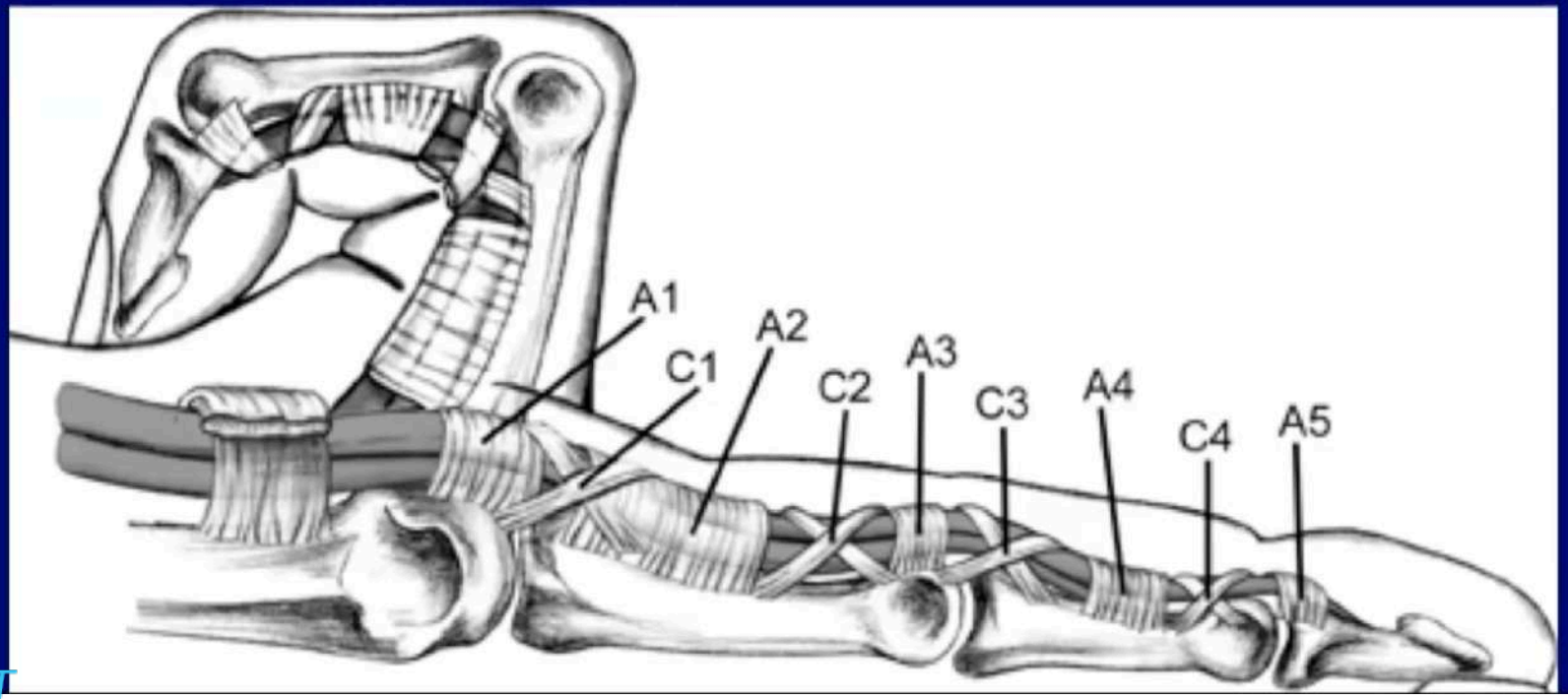
Pulleys of flexor tendon

- Annular - A1 to A5
- Cruciate - C1 to C3
- Thumb - 2 annular , oblique pulley



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Annular Pulley system - Anatomy

- Thicker and keeps tendon close to bone . Increase efficiency of tendon excursion
- Innermost layer - of hyaluronic acid for smooth gliding
- Middle layer - Thicker collagenous tissue
- Outer layer - Areolar tissue for nutrition for pulley

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Cruciform Pulley system - Anatomy

- Thinner collapsable and flexible and
- can accordion to allow digital flexion without significant deformation of annular pulley

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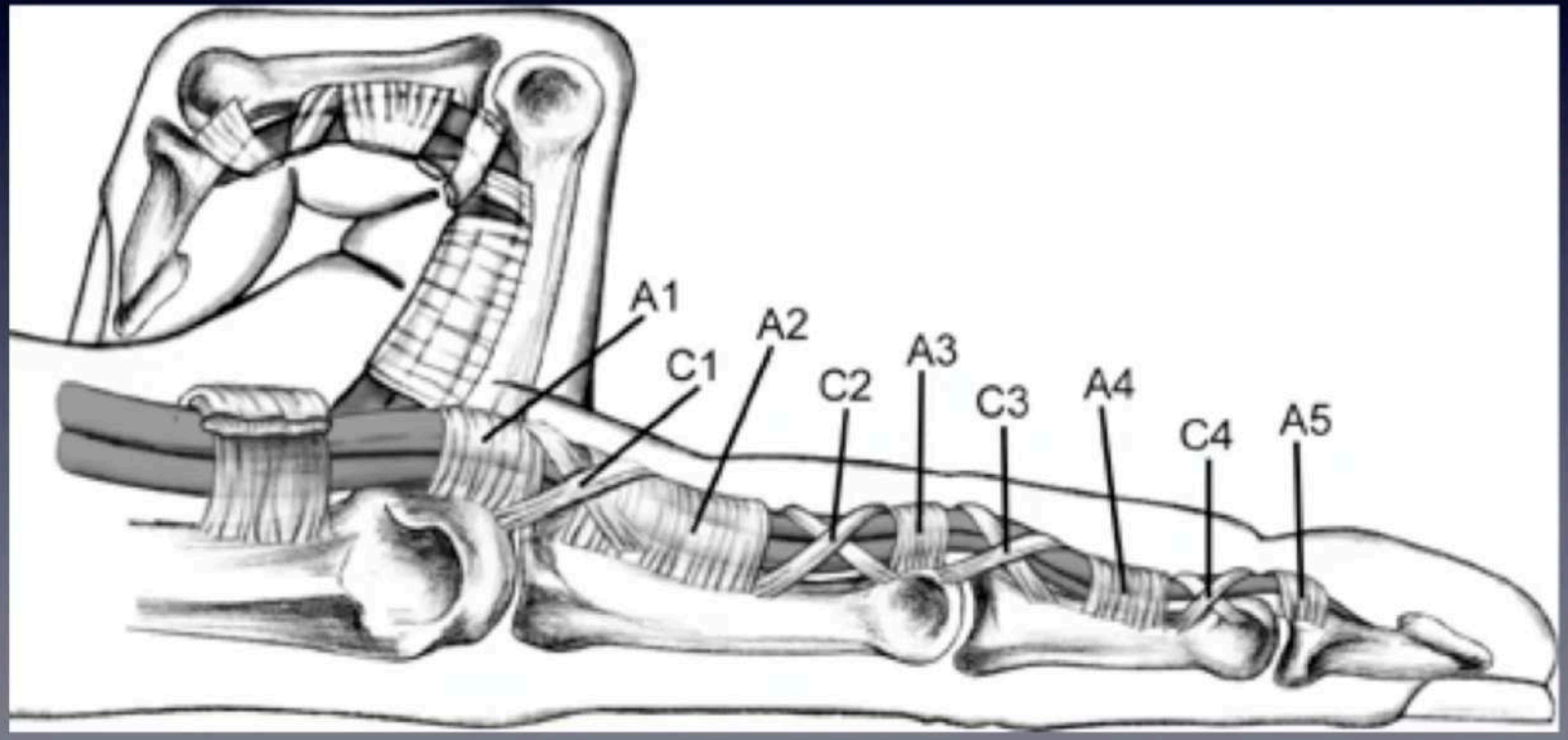
A1, A3 , A5 Annular pulley originate from palmar plate of MP PIP ,DIP joint



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Dual nutrition supply in zone 2

1.- Vascular perfusion and

2.- Synovial diffusion from paratenon

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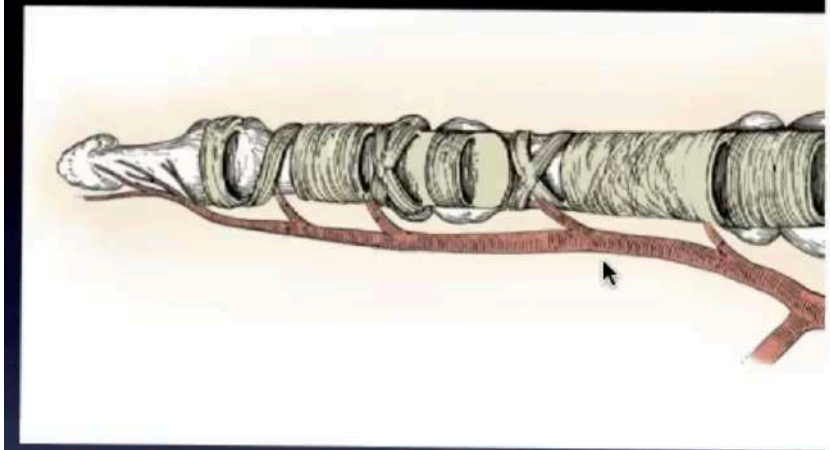
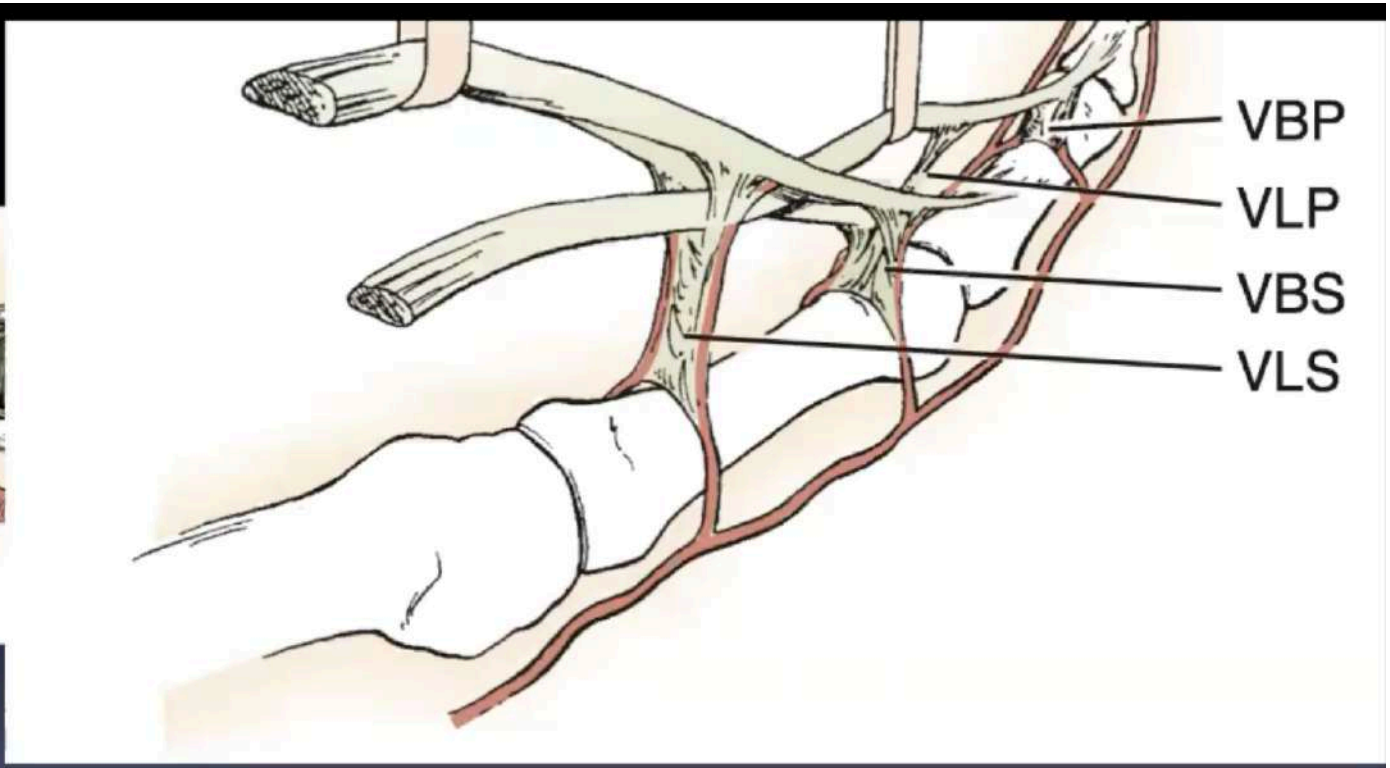
Vascular perfusion





- Vascular perfusion -
- vincular [bony insertion VB, reflected vessels from sheath VL], longitudinal vessel from palm
- VLS - arise from sheath at Ppx level , VLP - arise from FDS at level of PIP joint

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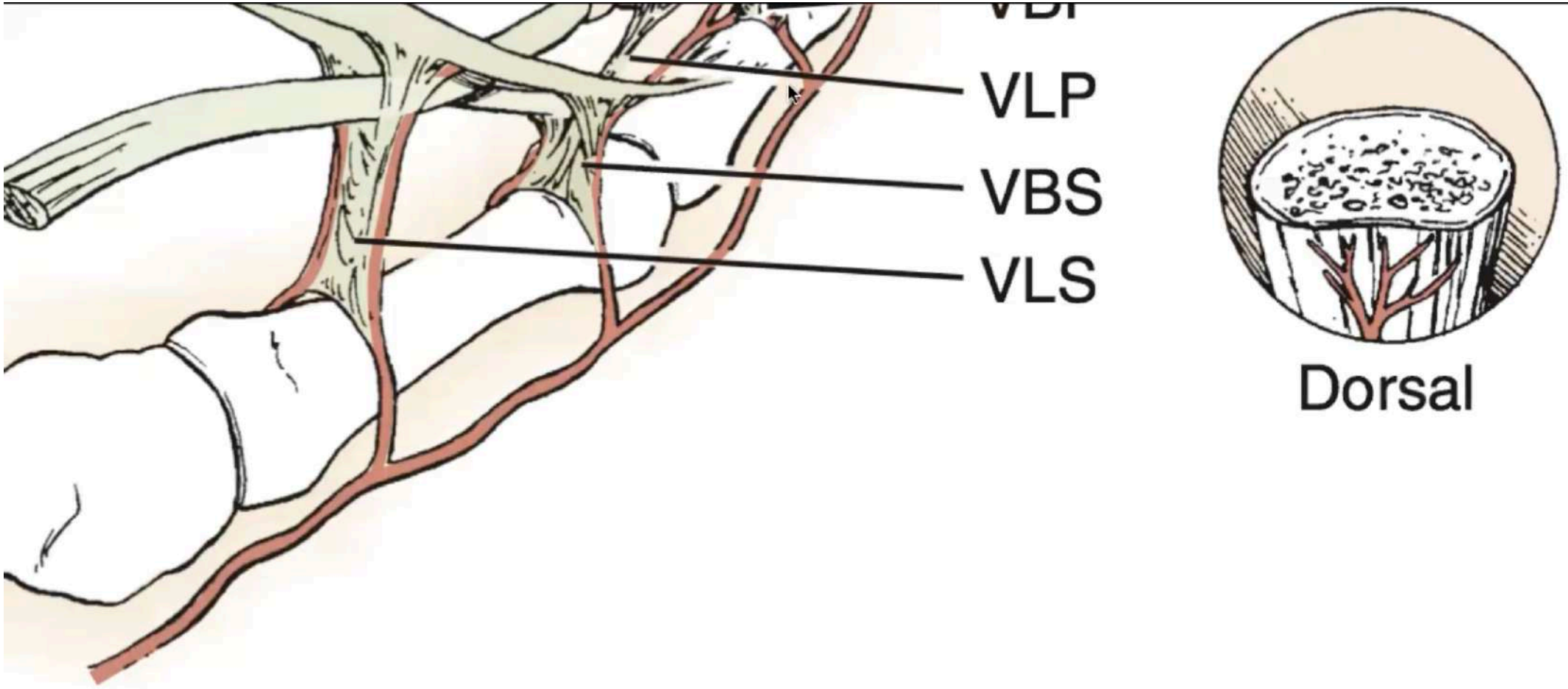

Relative avascular of palmar surface than dorsal surface

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General principles

- Repair for laceration greater than 60 %
- Reconstruct for failed repair and chronic untreated injury

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Surgical principles 1
Timing of repair

- Should be repaired within 3 weeks [ideal 2 weeks]
- Longer delay - difficulty due to tendon retraction

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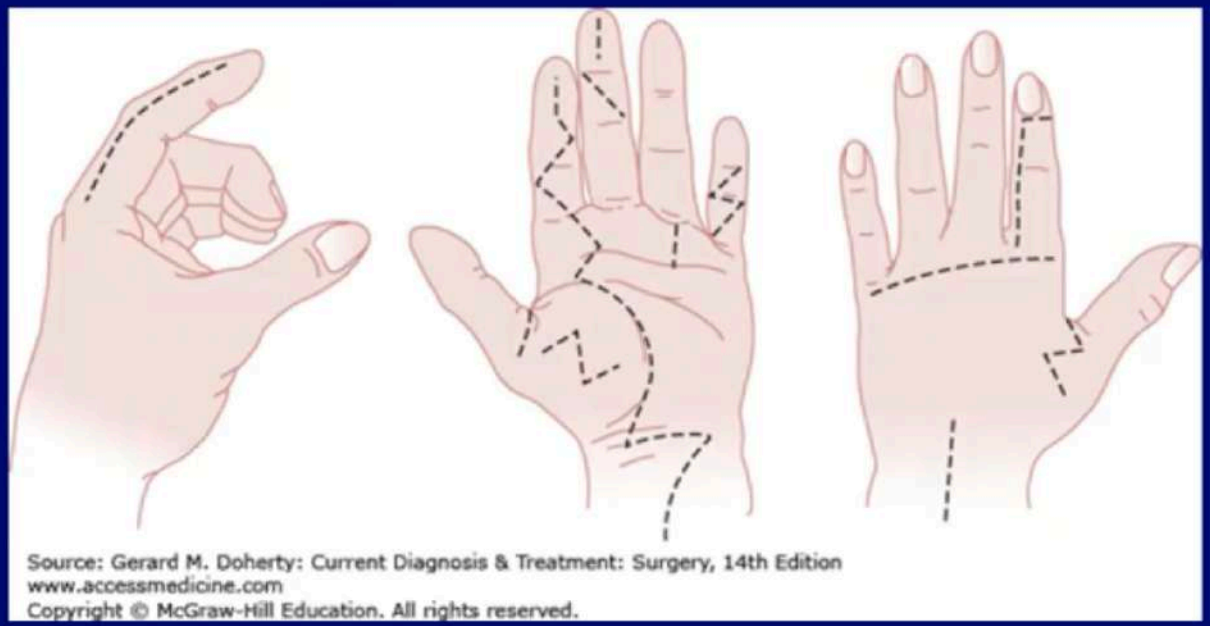
Surgical principles 2
Skin incision

- Should always cross flexion creases transversely or obliquely to avoid contracture
- Midlateral incision is preferred



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Surgical principles 3
Instruments

- Meticulous atraumatic tendon handling limit adhesion
- Non toothed forcep pick the endotendon and not epitendon
- stabilise the tendon with 25 guaze needle with 5/8 inch needle

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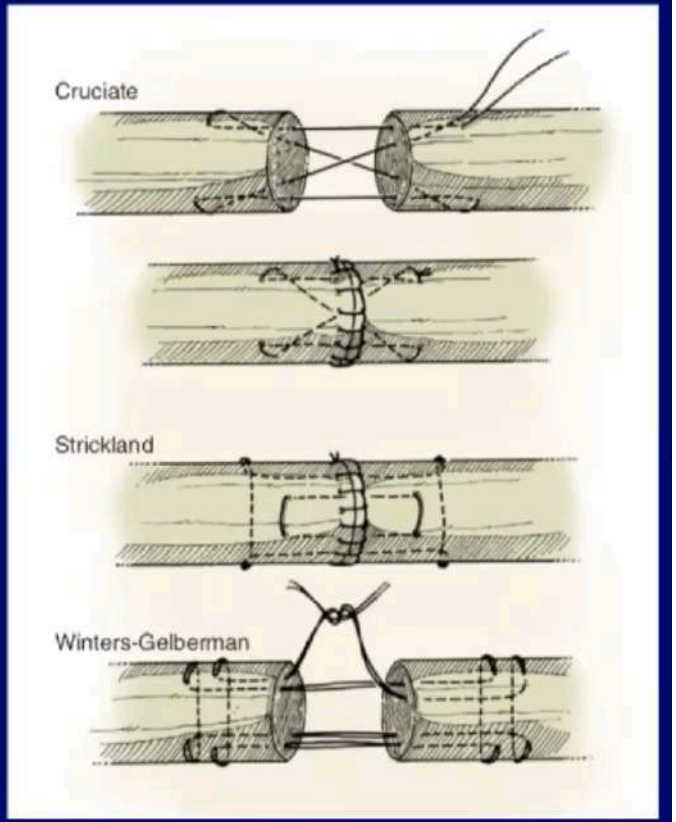
Surgical principles 4
Strength of repair

Number of suture strand that crosses the repair site is imp than number of grasping loops

4 stand core suture provide adequate strength for early active motion .



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Strength of repair - Core suture

- Example -Two strand suture technique - Kessler , Taziama
- Example - Multistrand suture technique - Strickland , Winter green , Becker , Cruciate , Savage

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Strength of repair - Core suture

- **Placement of suture knot** within or away from repair site has **not** any independent **effect on tensile strength**
- But increase of suture at repair site increase bulk , increase work of flexion and decrease surface area for repair
- **Knot placement away from repair site affect tendon gliding adversely**

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Strength of repair - No Gap formation

- Tendon healing with No gap or **gap less than 3 mm** acquire good strength 6 weeks after repair and less risk of rupture .

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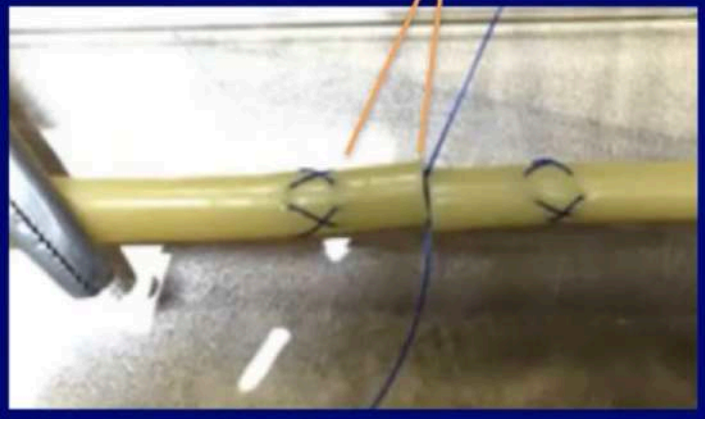
Surgical principles 5
Size of suture

- High calibre suture material [3-0 prolene] increases strength and stiffness and decreases gap formation

- Ideal suture purchase is 10 mm from cut edge flexor tendon



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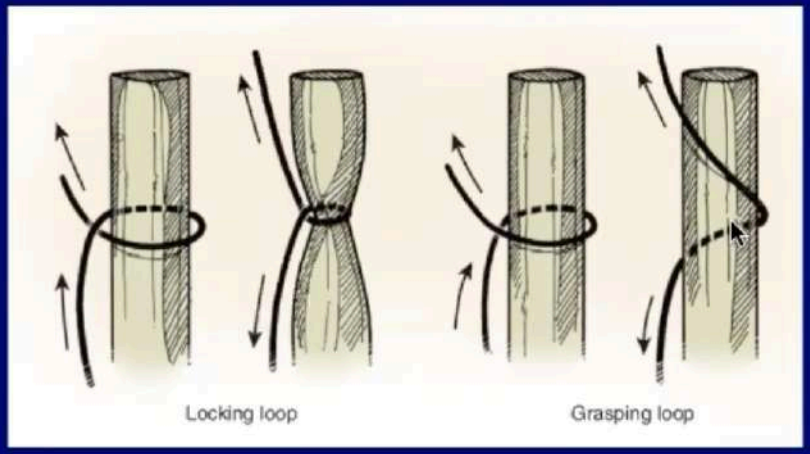
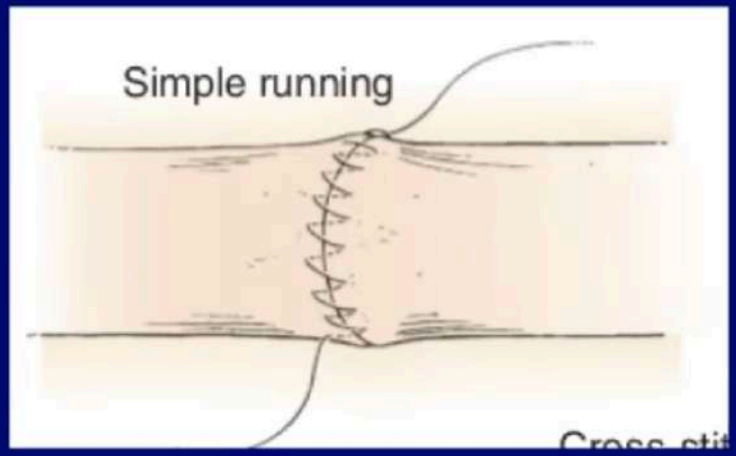
Surgical principles 6
Technique of loop repair





- Locking loop has greater time zero strength than grasping loop .

- Simple running Circumferrential epitendeneous suture with 6-0 ethilon improves tendon gliding and add 20 % strength

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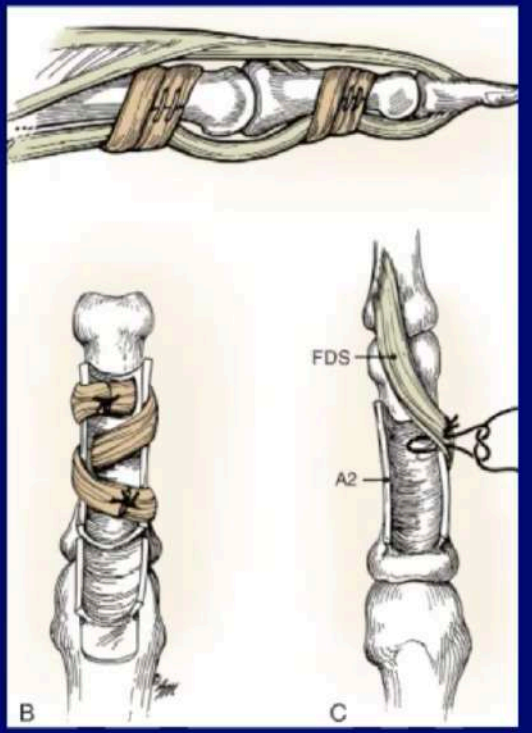
Surgical principles 7
Pulley reconstruction

- Pulley management is critical to preserve A2 and A4 and oblique pulley in thumb
- Tendon repair are weakest between post op day 6 to 20 days



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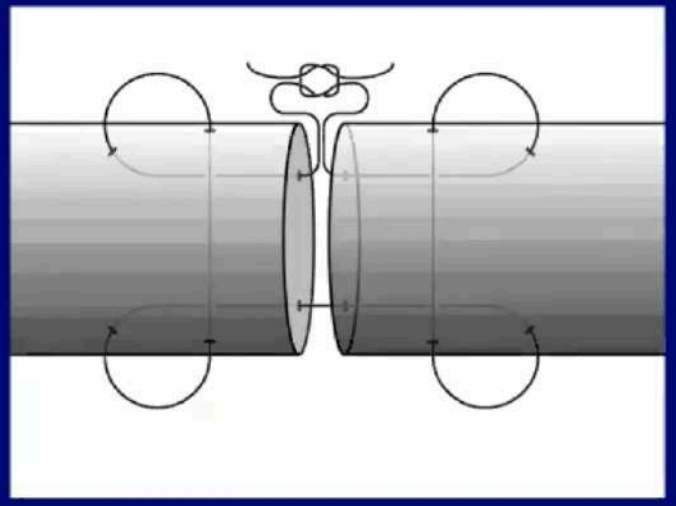
Surgical principle - 8
Practical Sequence of Repair - Deep to superficial

- **FDP FPL**
- **Then FDS**
- **Then Artery**
- **Then Nerve**
- **Then FCU ,FCR, PL**



- According to green text book theory wise
- Sequence of repair in finger- Tendon , nerve , artery
- Sequence of repair in forearm - artery , deep tendon, superficial tendons lastly the nerve

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Last and very important

- Post op rehabilitation

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Controlled Post op regime
Control the Amount of Force to repair site and promote tendon excursion

- **Rationale of Tendon excursion is to improve range of motion**
- **3-5 mm of tendon excursion is essential to prevent restrictive adhesion**
- **6- 9 mm was maximal limit of therapeutic excursion** and beyond which has no beneficial effect .
- **Rational of force to repair site is to do small amount proximal excursion of repair site and not to promote healing**
- Force applied to repair site is controlled by position of wrist and hand
- Excess force lead to tendon gap / rupture

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Rehabilitation

- Limits adhesion and leads to increase tendon excursion

- Early Active motion - Moderate force and high excursion
- Early Passive motion- Low force and low excursion
- 1. Duran
- 2. Kleinert
- 3. Mayosynergestic splint - low velocity and high excursion

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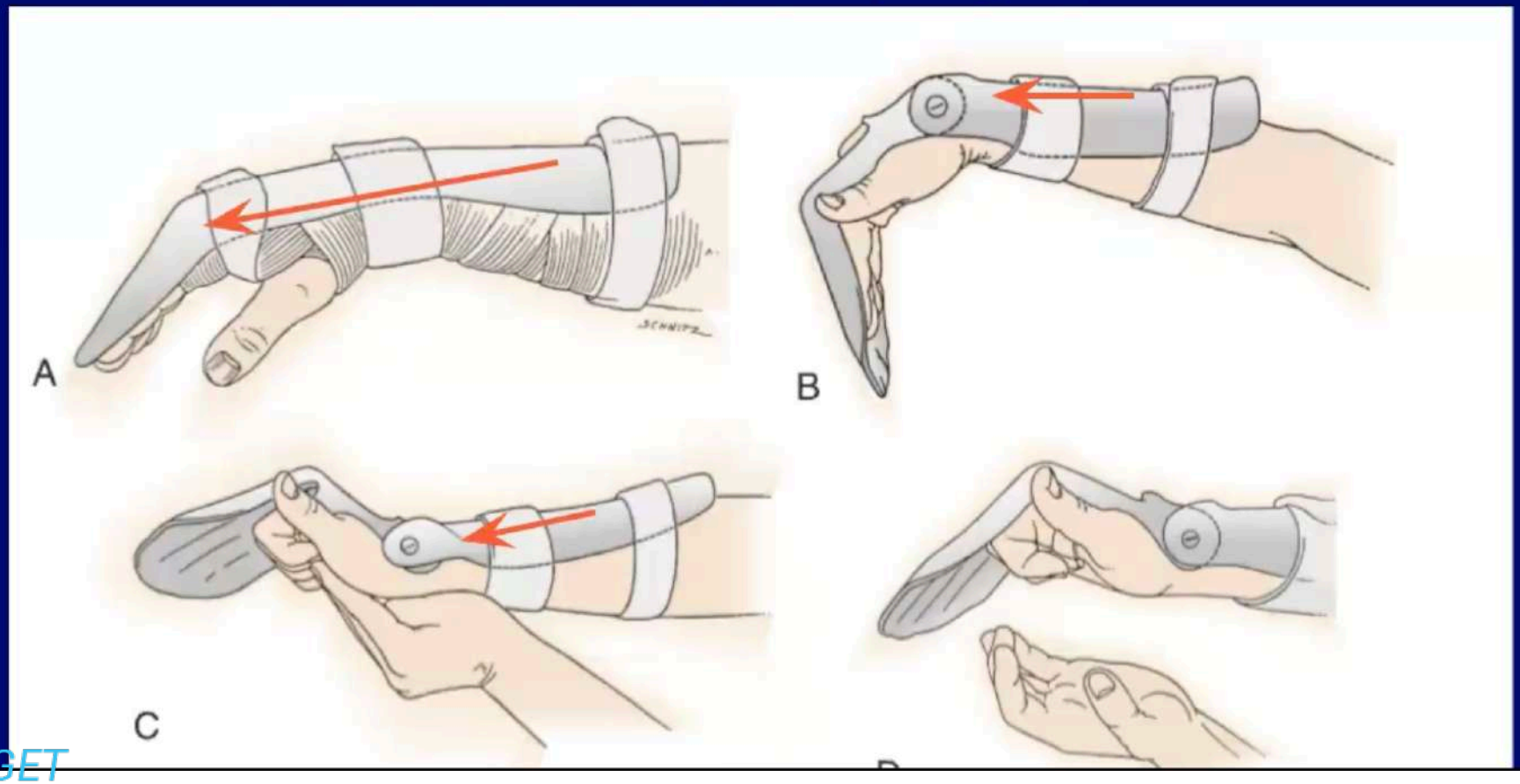
Early Active motion
Moderate force and high excursion

- 1.Dorsal blocking splint limit wrist extensions
- 2.Place and hold exercise[Active] in digits



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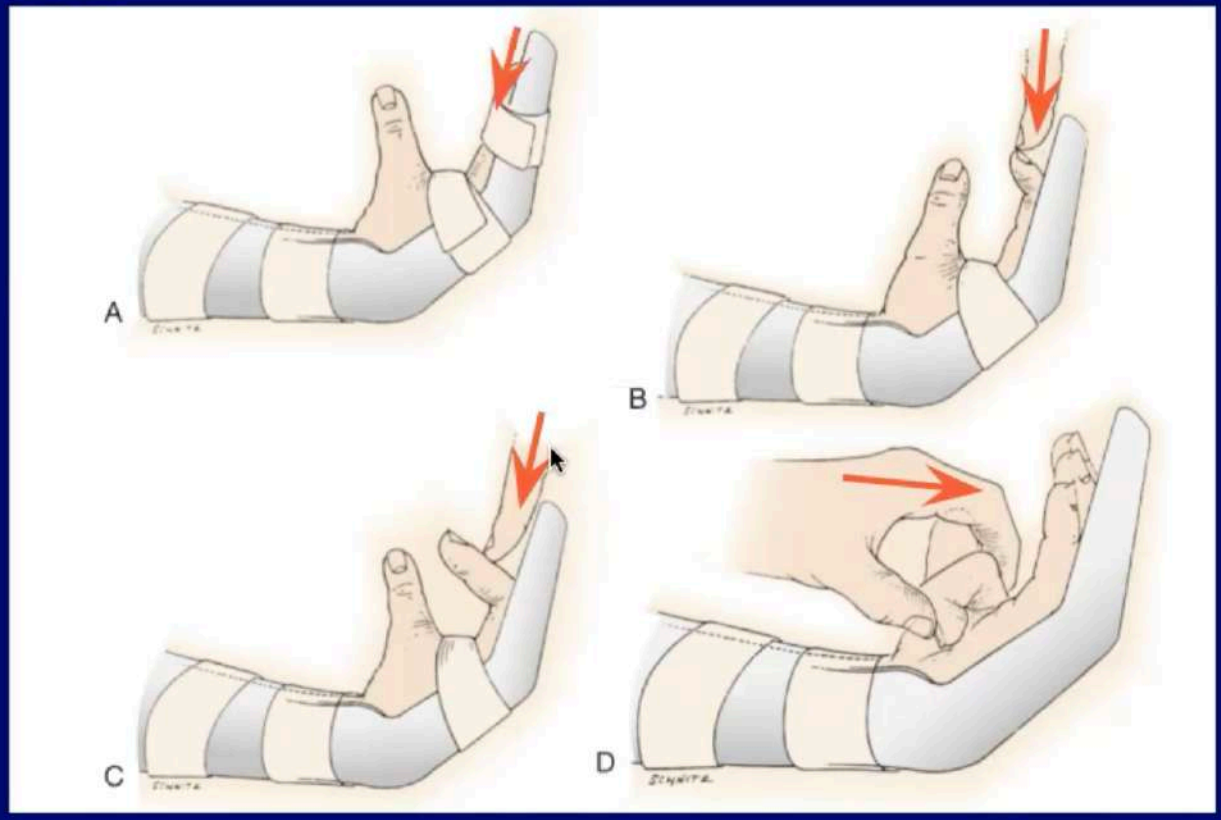
Early passive motion
Low force and low excursion

- **1. Duran** - patient assisted passive finger flexion



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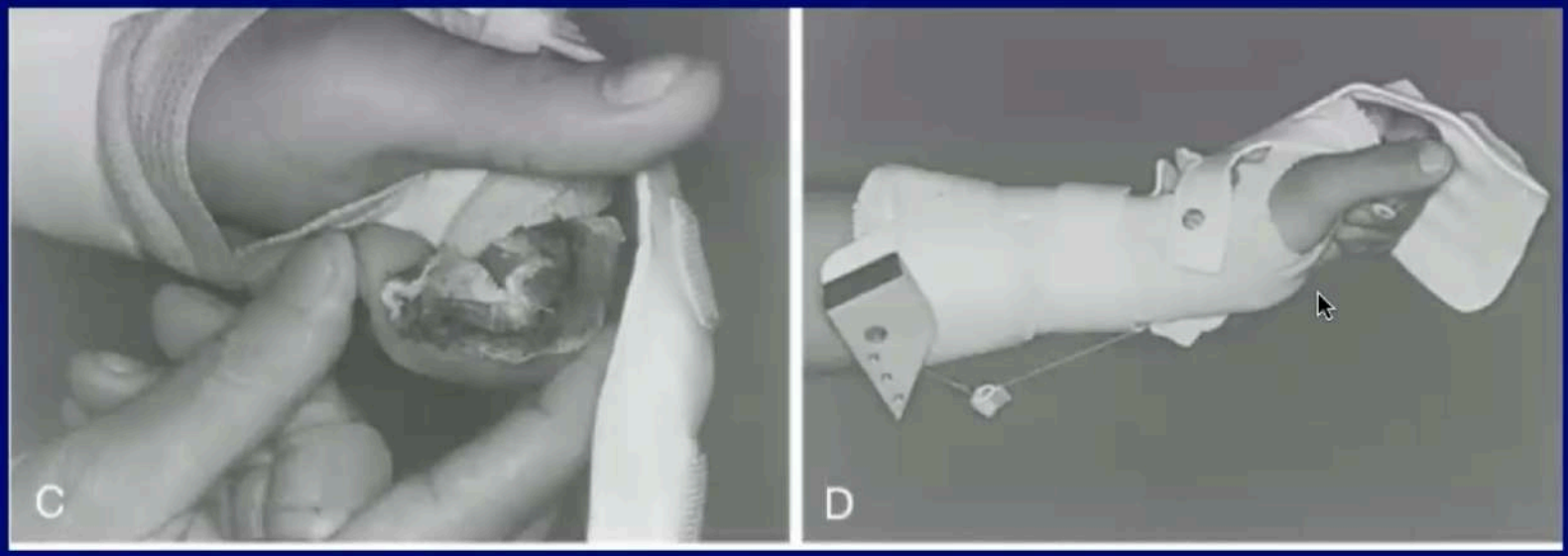
Early passive motion
Low force and low excursion

- **2. Kleinert - dynamic splint assisted passive finger flexion**



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At 6-8 weeks

- **Dorsal block splint is discontinued**

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For complicated cases

Passive mobilisation [duran regime] is continued till 4 weeks and after 4 weeks it is same as active mobilisation

- Upto 4 weeks - only passive rom exercise of DIP , PIP joint within confines of splint to allow differential excursion of tendon

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Zone 1 FDP injury - Tips

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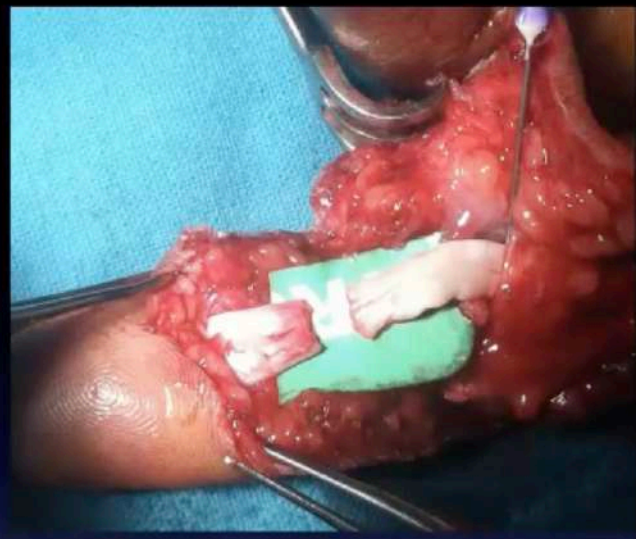
Zone 1 FDP tendon injury



- If distal FDP tendon stump is 1 cm or **more than 1 cm** - then **primary tendon repair is indicated**

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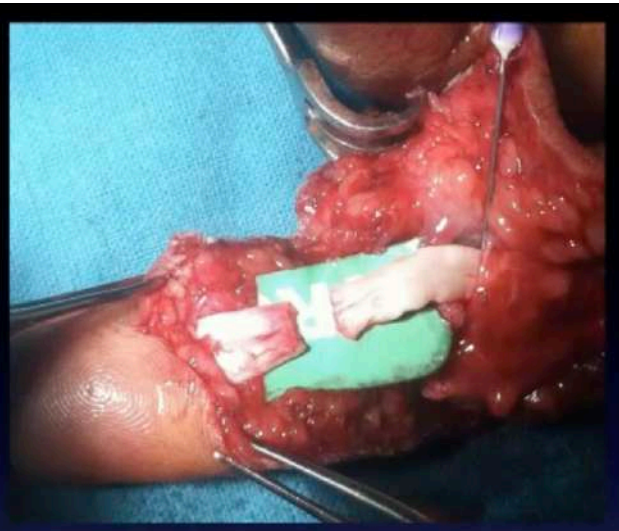
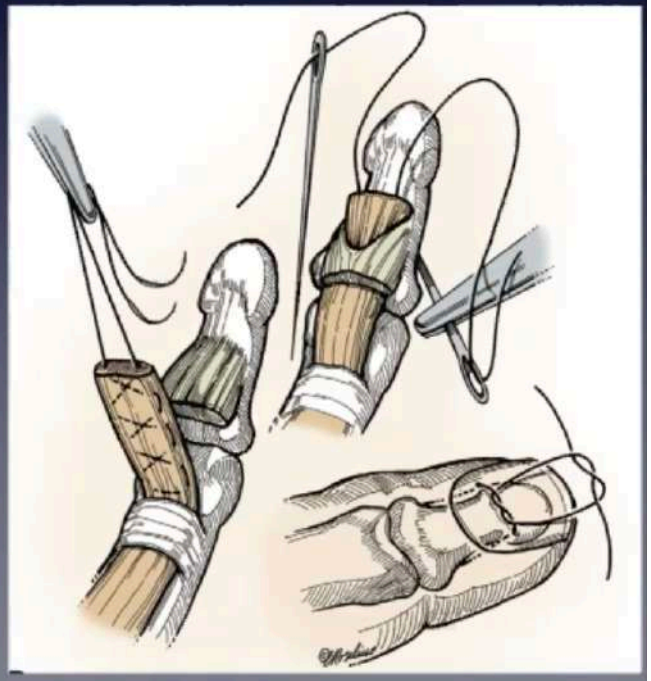
Zone 1 FDP tendon injury

- If distal FDP tendon stump is 1 cm or **less than 1 cm** - then **advancement of tendon to bone is indicated**
- **Exit the nail plate beyond the lunula**
-





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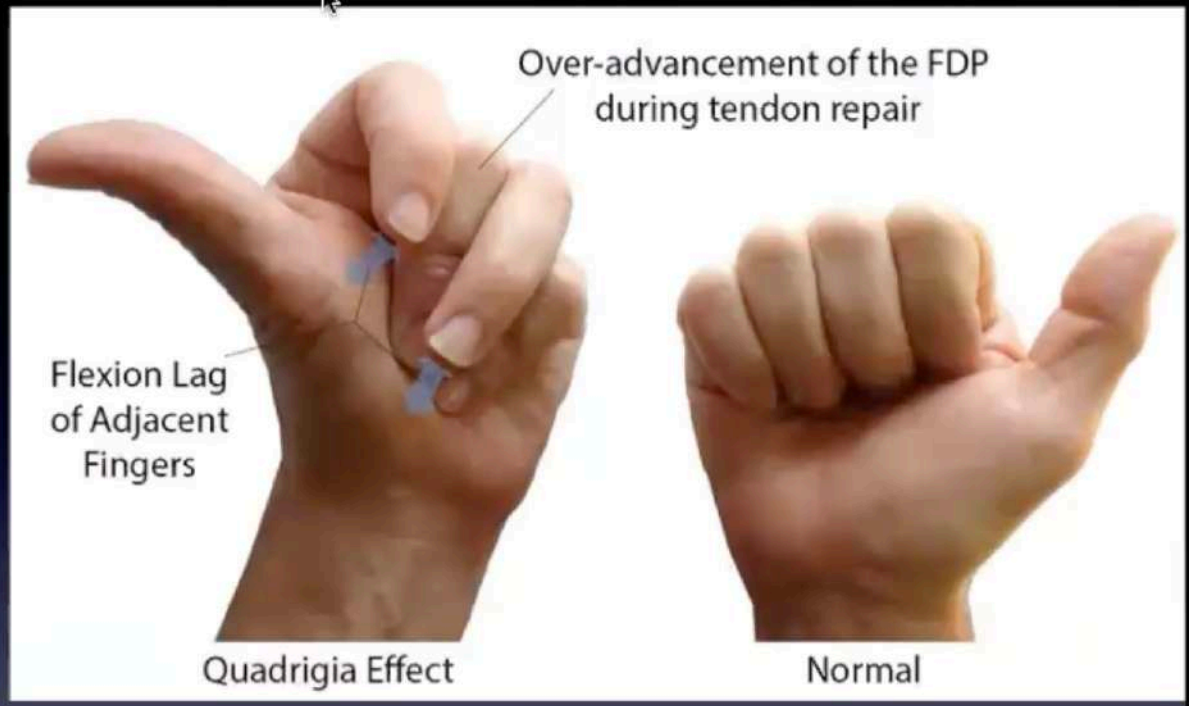
Quadragia effect



- Advancement of more than 1 cm of FDP tendon will do increased tension in all the digit [Quadragia effect]
- That means diminished flexion of other digits

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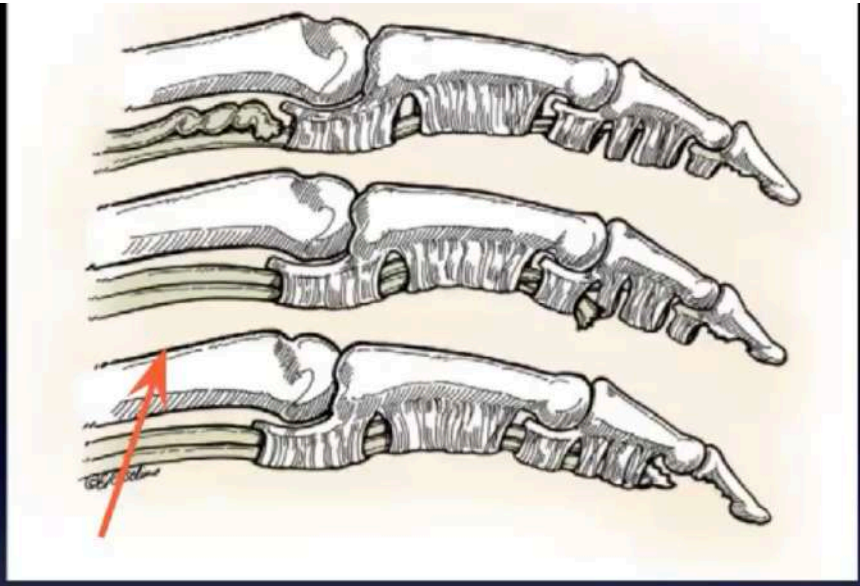
FDP avulsion injury



Type I - present at A1 pulley - no vincular supply left - urgent repair

Type II - some vincular supply left - can be delayed upto 6 week

Type III- big fracture fragment attached to tendon stump present distal to A4 pulley .

Type IV- fracture and avulsion - can be in sheath or in palm .

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Zone 2 tendon Injury - Important points

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2 weeks old FDS FDP with Neurvascular injury

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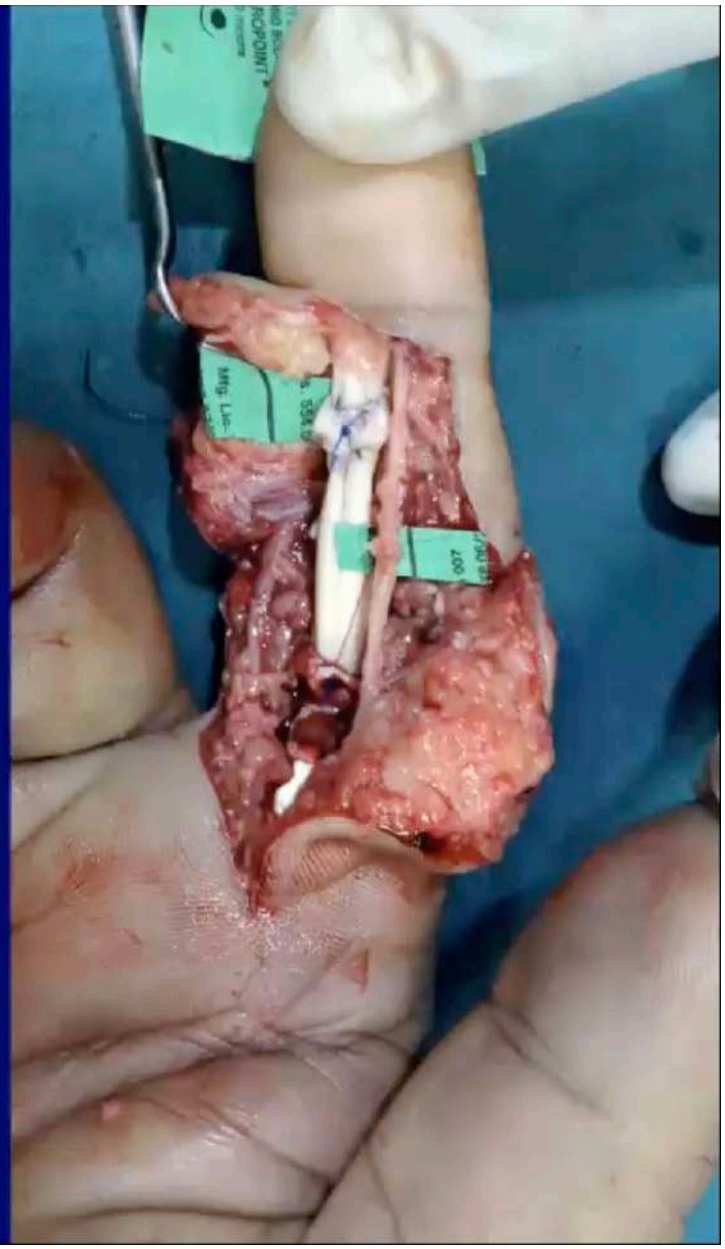
Repaired
FDS FDP, Nerve



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2 week old Failed zone 2 repair
- primary repair + pulley recon

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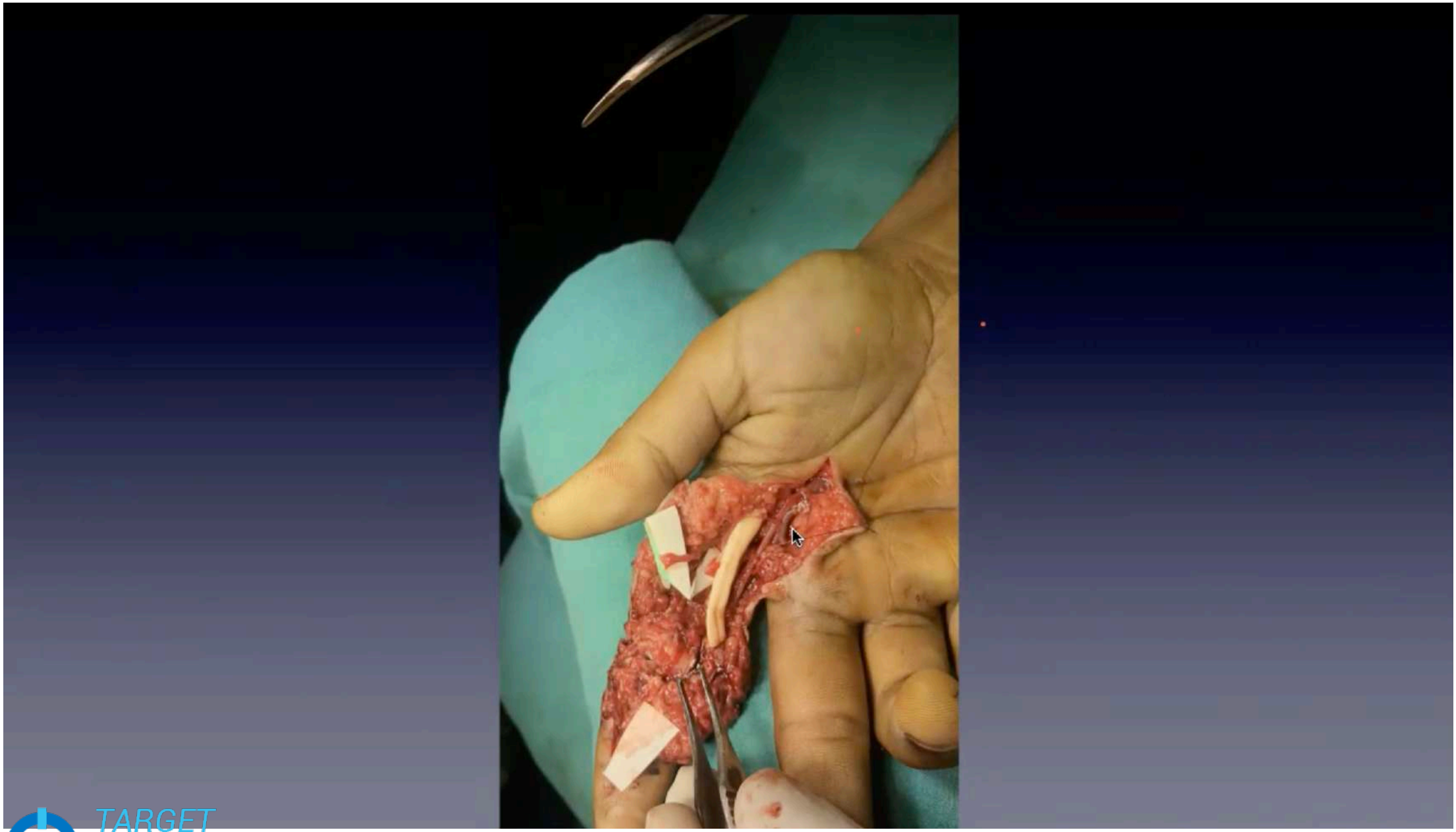

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- In some complex case where orientation of fds is not possible then do **resect one slip of fds**

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If digit is in significant flexion at time of injury then distal stump is

- **Distal to the open wound or A4** pulley when finger brought in extension
- Distal stump is brought to laceration site by passive digit flexion
-

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Proximal Tendon stump

- Proximal stump is brought to skin laceration site by -
- **Milking** ,
- **sourmellis and Mc gruther method** [pediatric feeding tube number 8] or
- direct exposure

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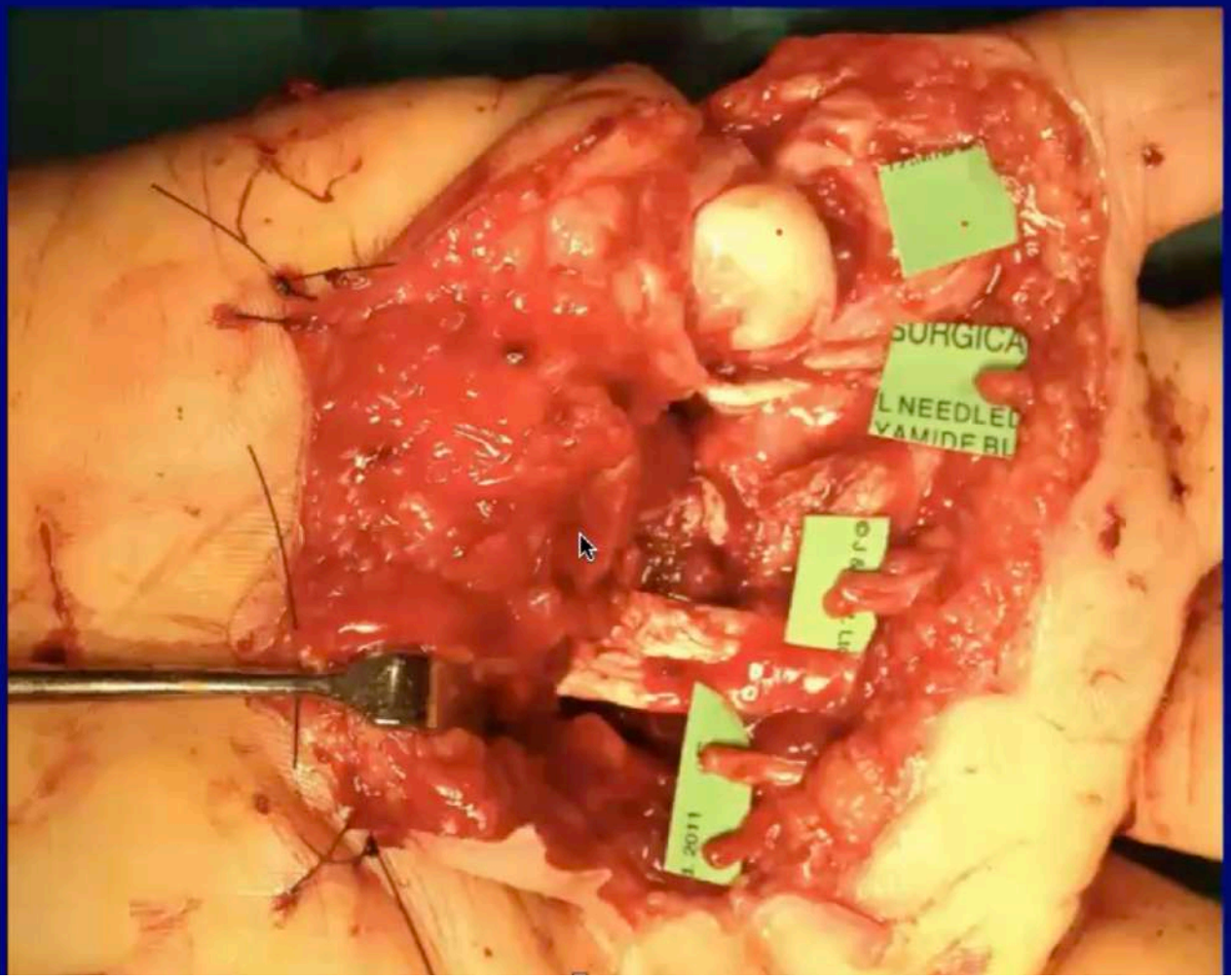
Zone 3 - with Multiple Nerve injury



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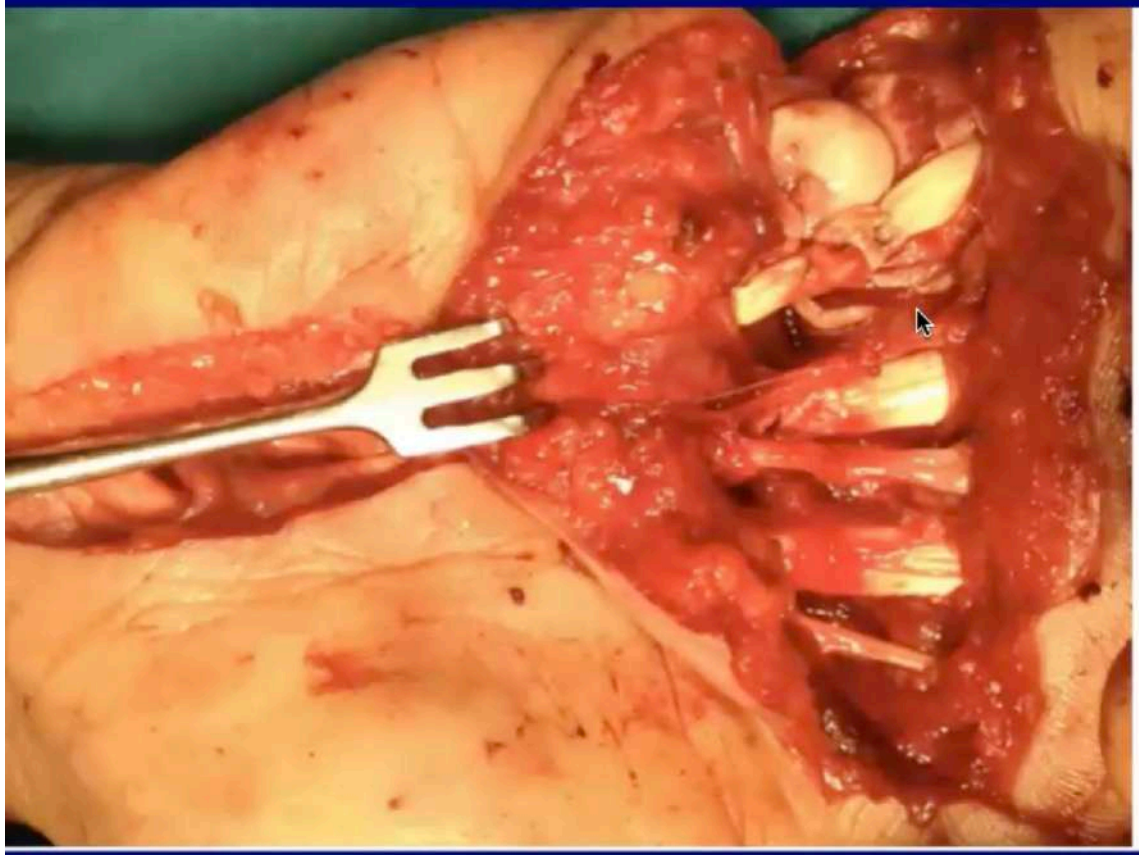
Multiple nerve injury



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Multiple Nerve injury
8 months follow up

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8 months follow up

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Zone 5 flexor tendon injury - Tips

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Zone 5

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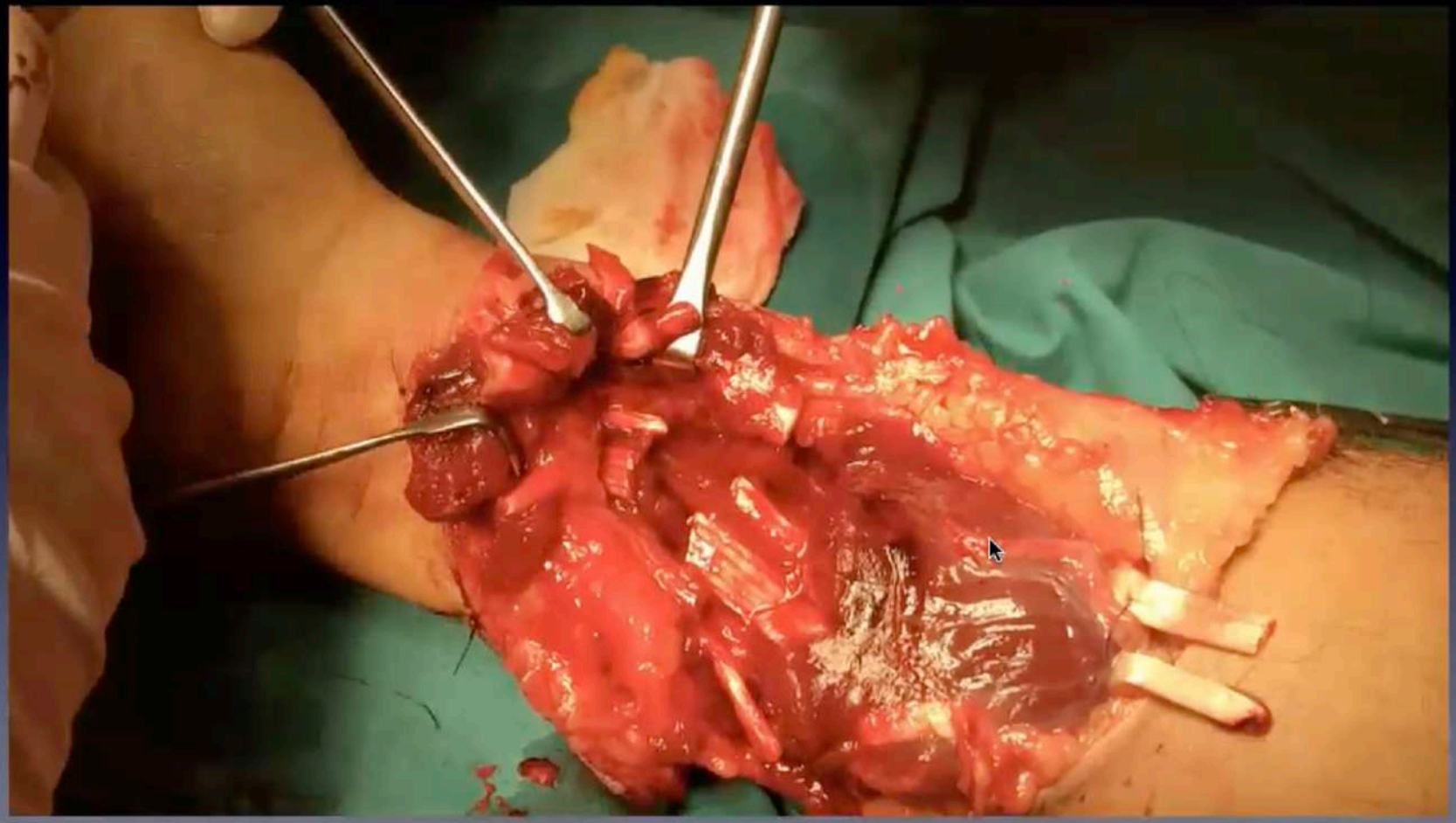

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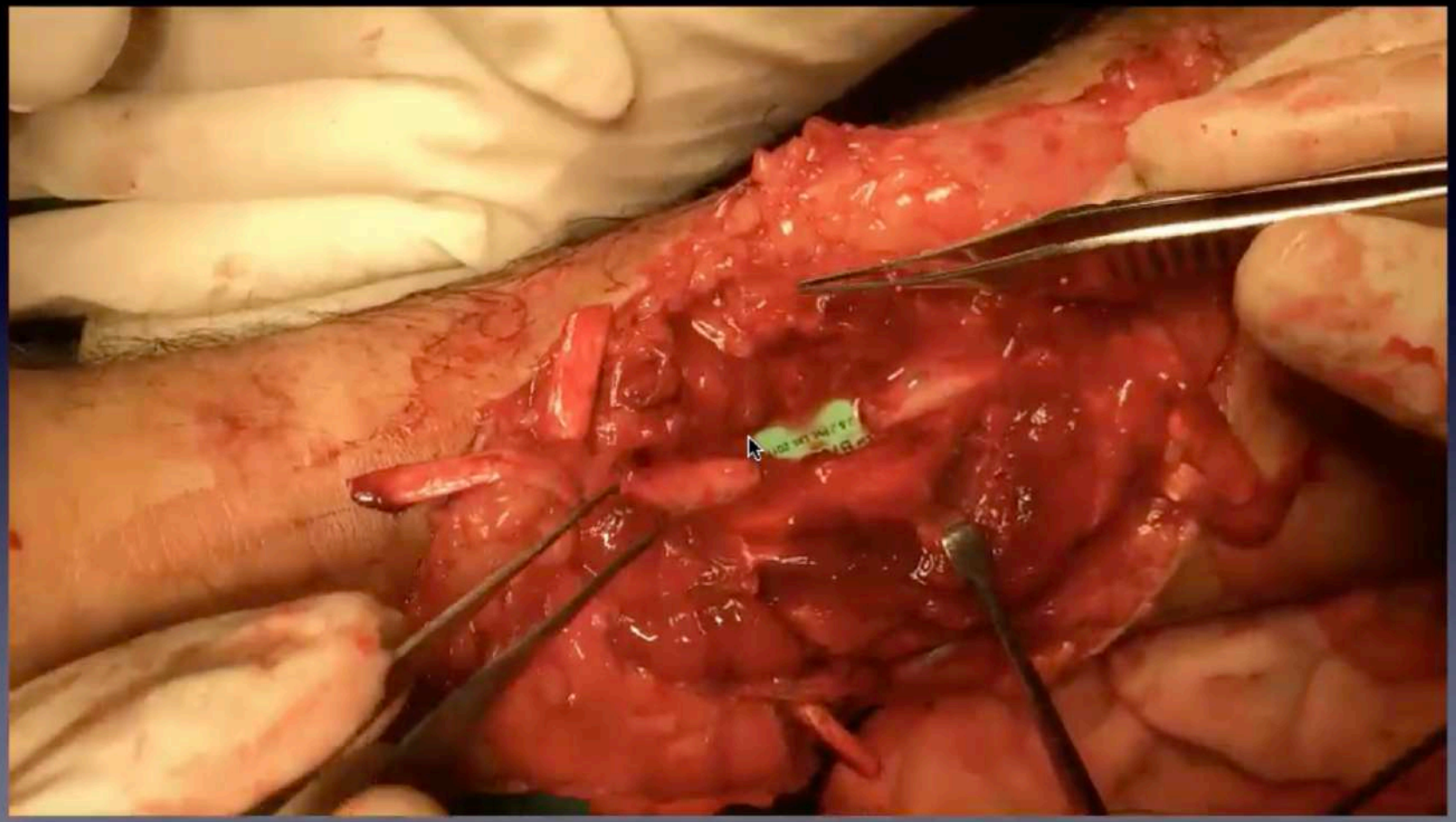

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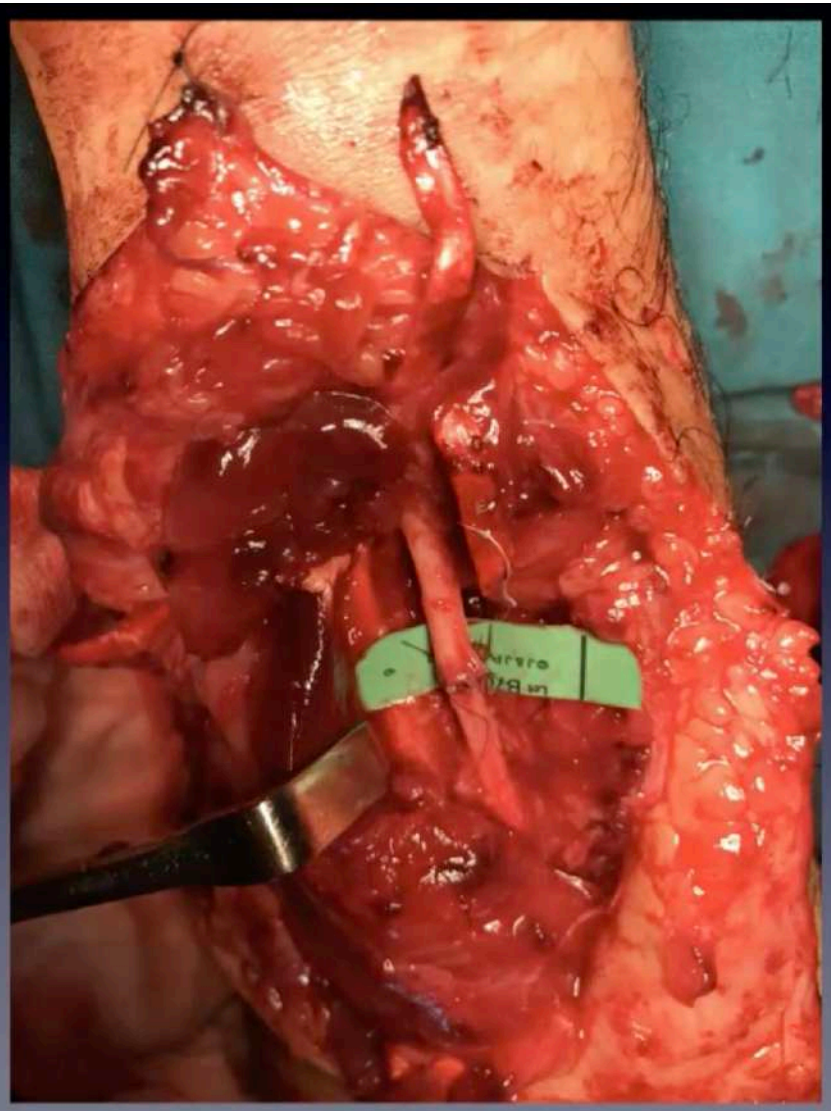

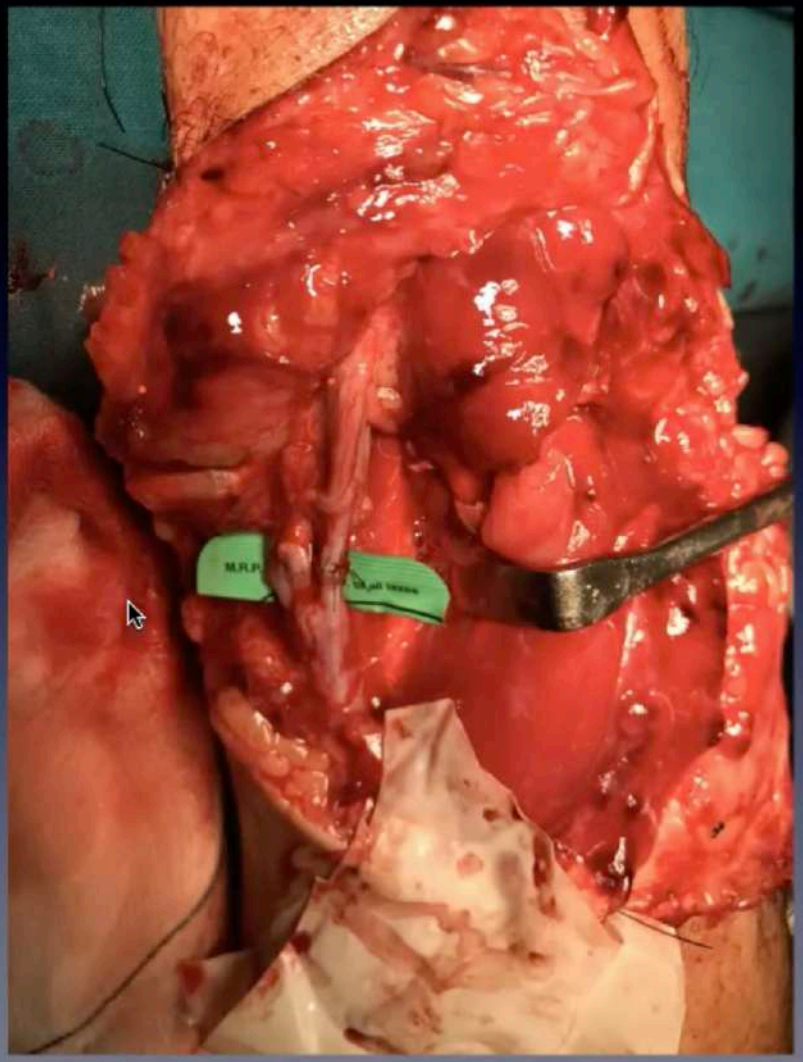

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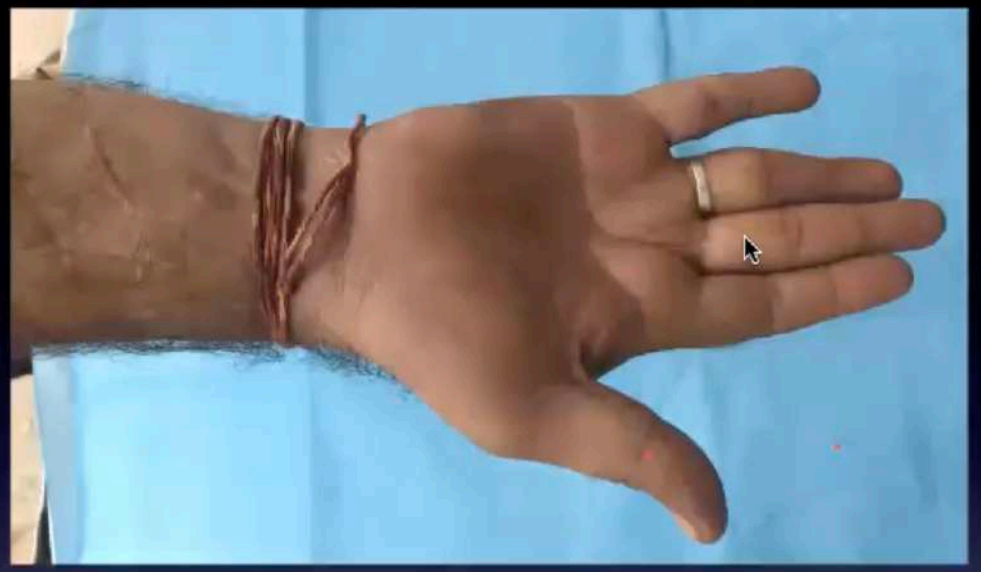

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Complication

- **Rupture** - Repeat repair is better if rupture is 3 weeks post op. beyond this tendon graft is better .
- **Adhesion** - Tenolysis is considered at least 4 - 6 month post op

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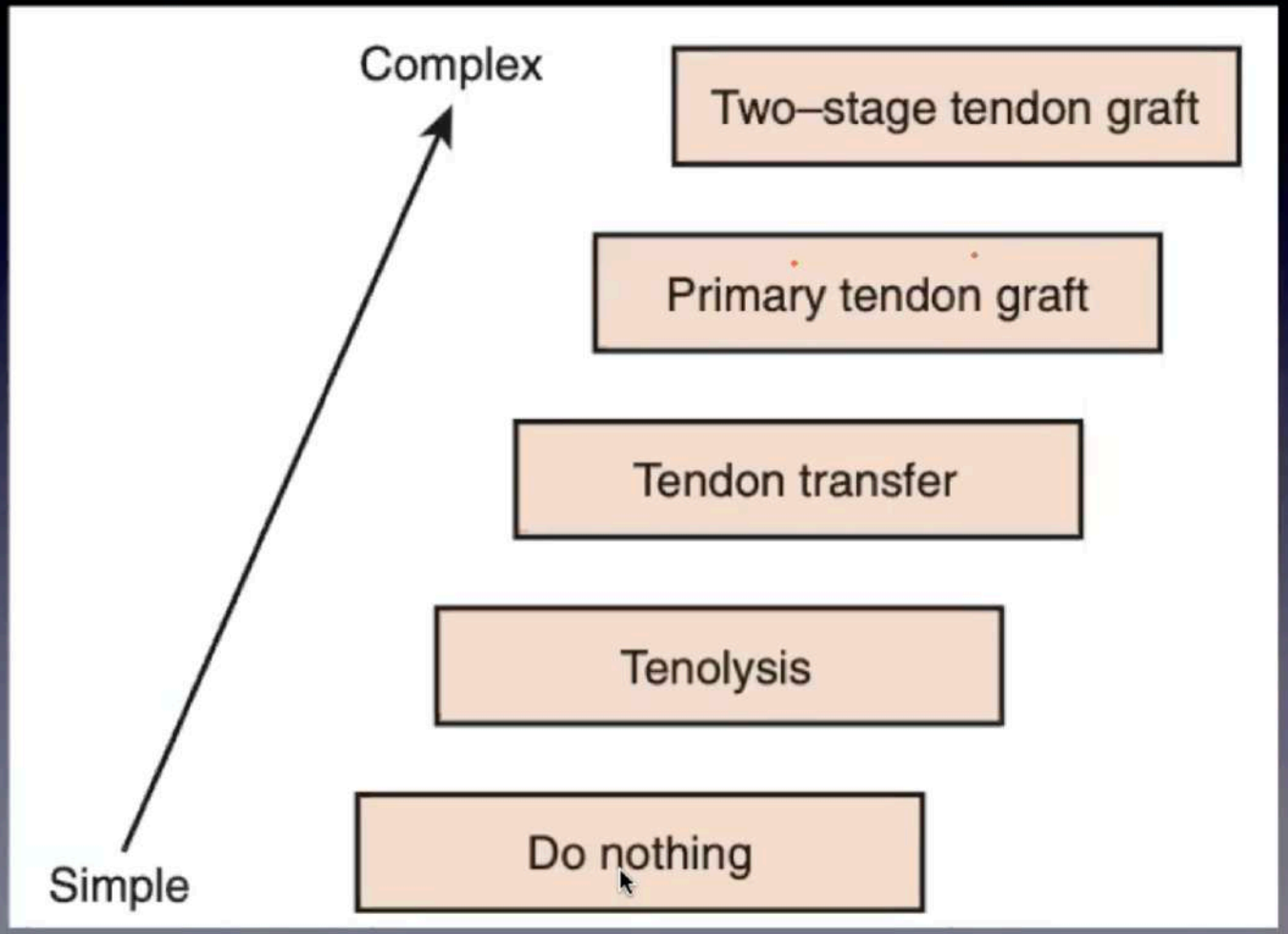
Ladder of reconstruction



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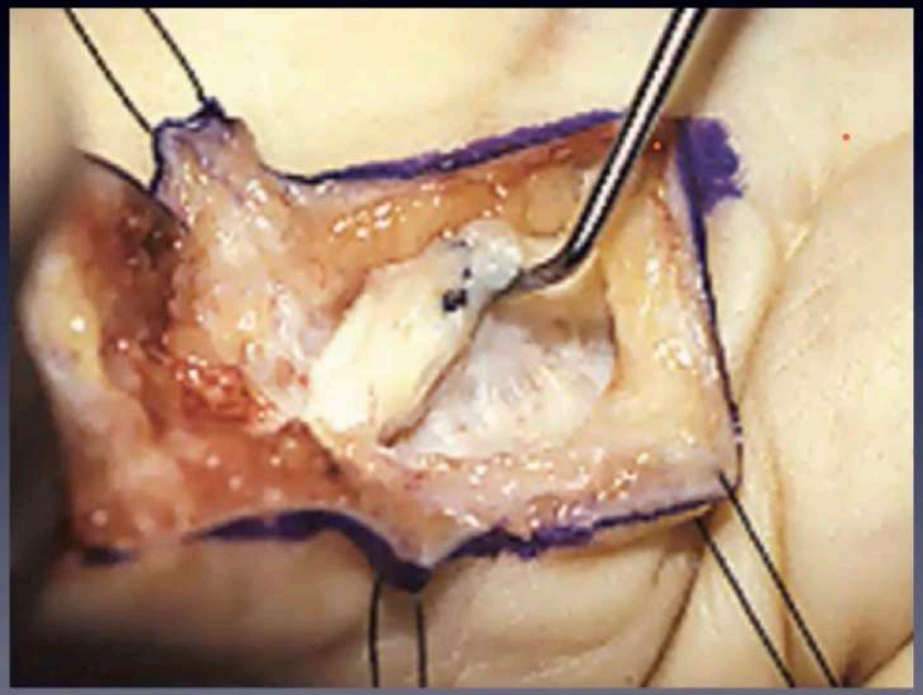
Tenolysis - Localised area of tendon adhesion



- Patient progress plateaued and substantial difference exist between active and passive ROM

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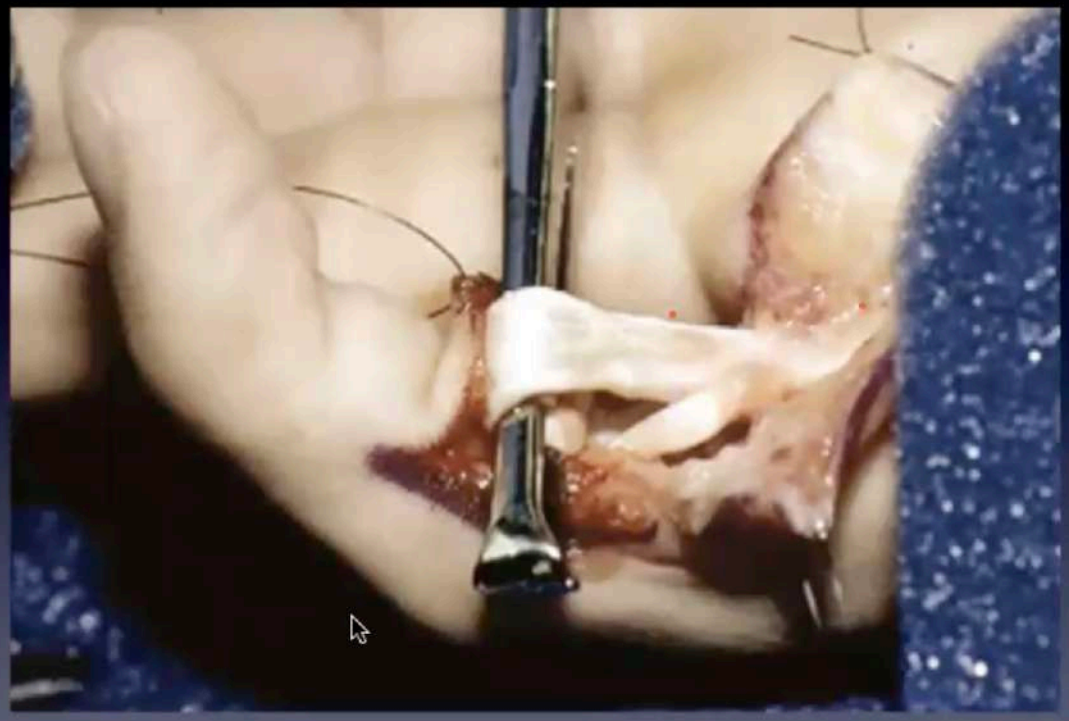
Good Tendon excursion after Tenolysis



- **Whitaker recommended -Traction flexor check method** - to pull involved tendon by separate incision at wrist for estimating range of motion of joint and additional benefit of breaking up of adhesion if left .

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Indication - Single stage tendon grafting

- **Segemental loss**
- **Delayed presentation** - 6 weeks
-

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Obtaining tendon graft

- PL
- Plantaris
- Long toe extensors , flexors
- Extensor digitorium proprius- EI , EDM
-

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Principle of Tendon Grafting

- Place only one graft in each finger
- Never sacrifice intact FDS
- Use graft of small calibre

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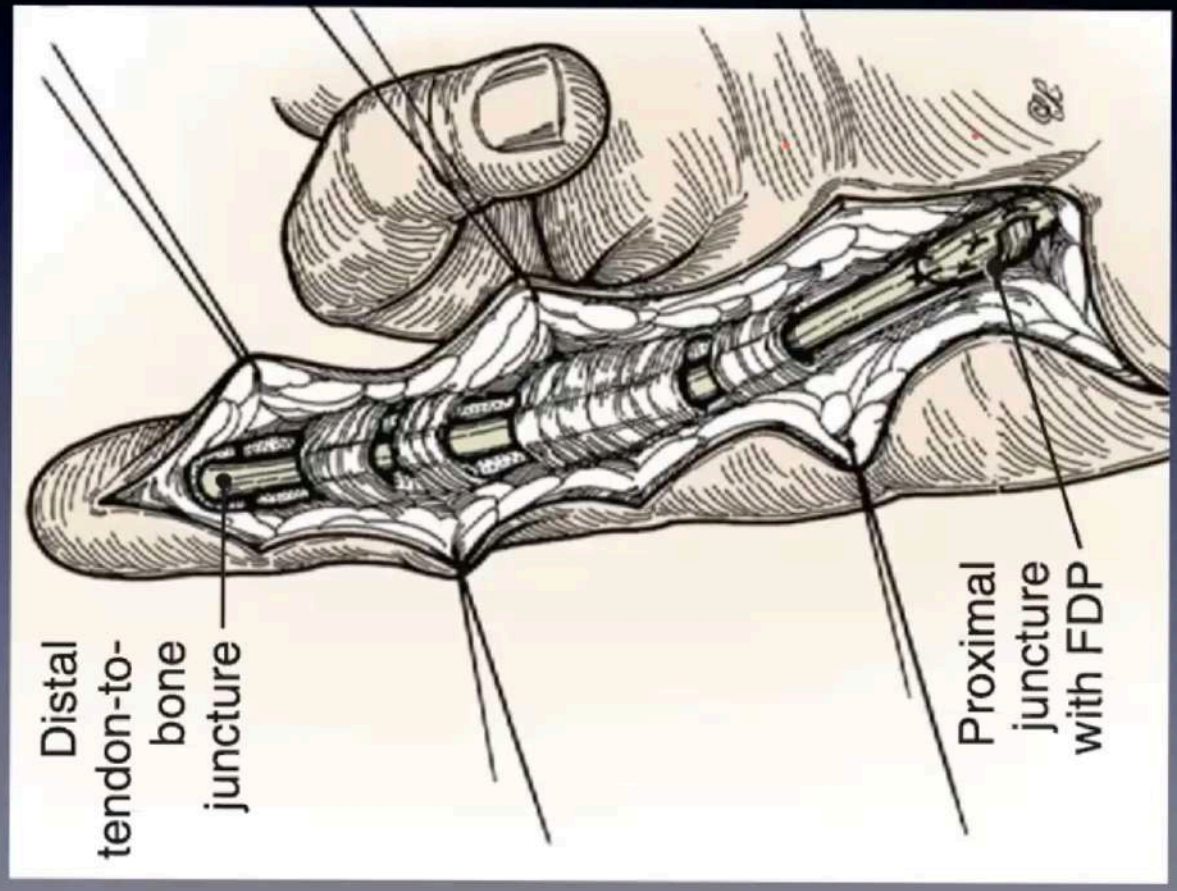
Principle of tendon grafting

Flexor tendon graft - Distal and Proximal juncture are outside confines of flexor sheath



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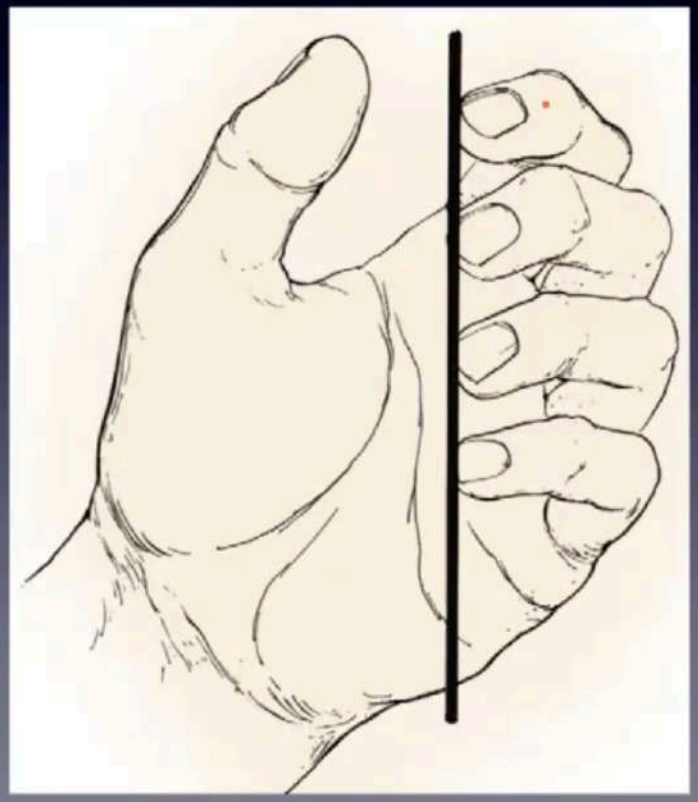
Principle of tendon grafting

Determining Tension in reconstructed flexor tendon - wrist in neutral ,each finger is in slightly less flexion than ulnar side



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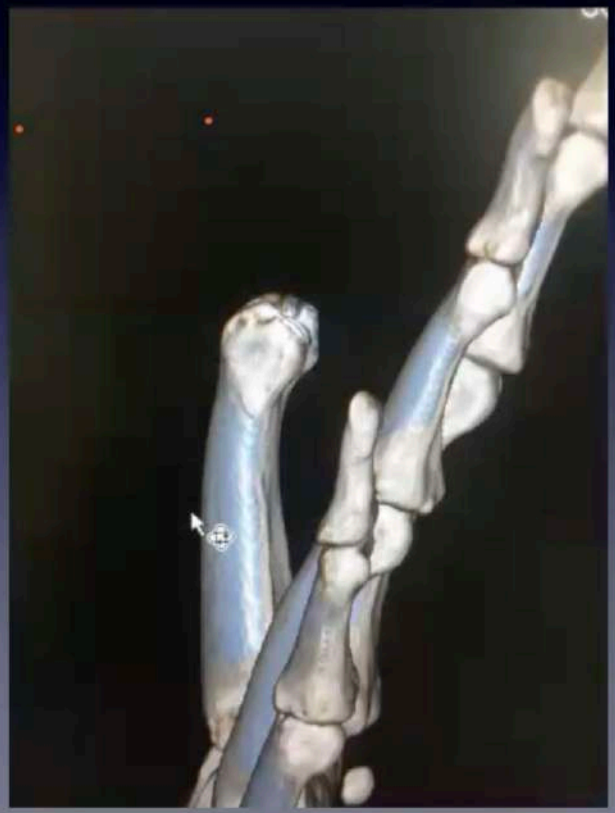
Delayed presentation - 6 week old FDS tendon injury



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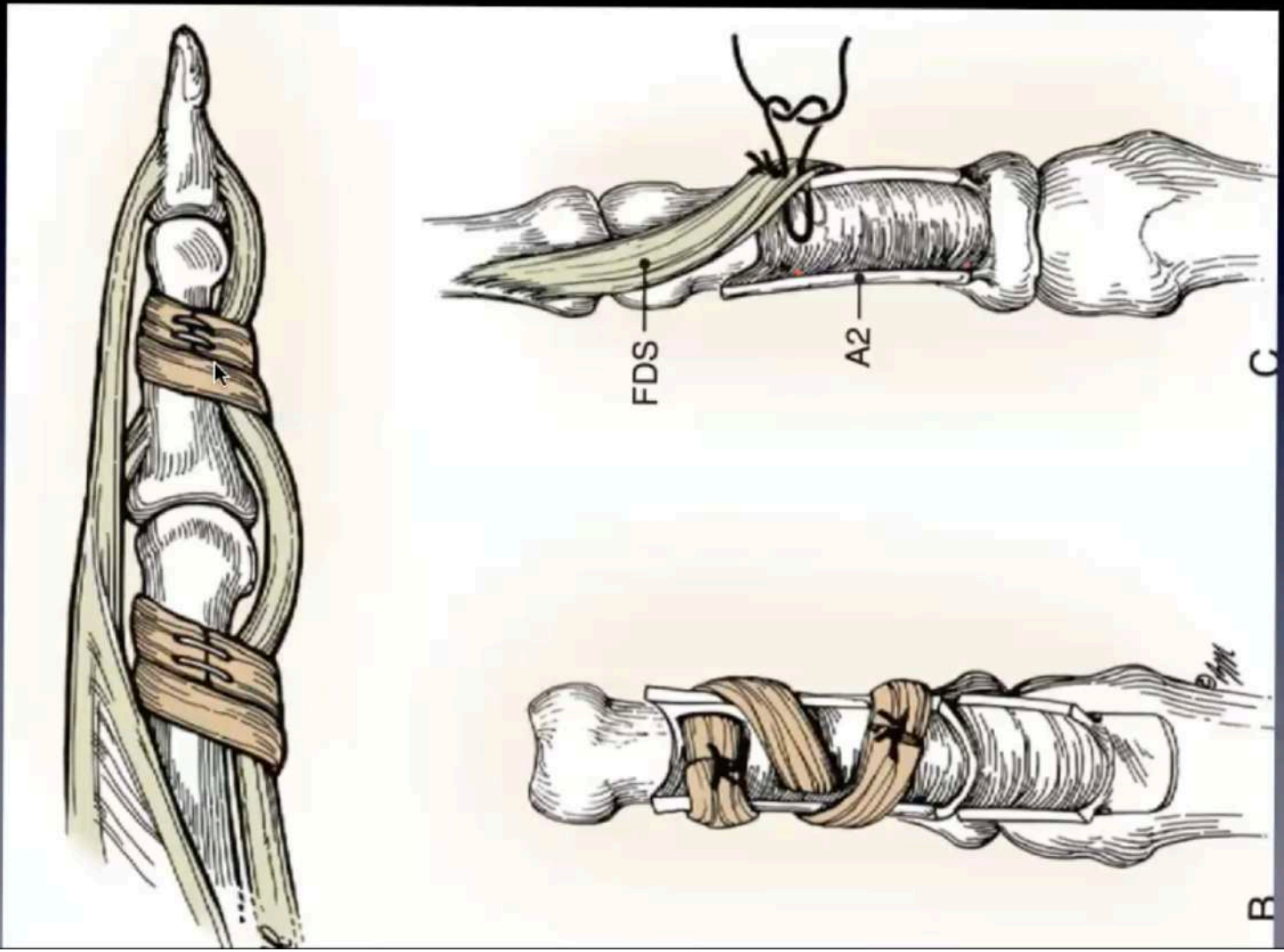
Types - Pulley reconstruction



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