

# TRAUMATIC TENDON INJURIES

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- Tendon injuries may be obvious or subtle
- History (mechanism of injury) and PE should allow diagnosis
- X-ray usually indicated
- Ultrasound/MRI may be helpful







# History

- Galen (131-201 A.D.): in *Ars Parva*, stated that tendons composed of both ligaments & nerves, and that placing sutures in tendons would lead to pain, twitching, & eventual convulsions
- Avicenna (9th cent.): Arab surgeon, credited w/1st tendon repair
- Meekren (1682): 1st European to describe repair
- Albrecht von Haller (1752): Conclusively demonstrated insensibility of tendons, after which tenorrhaphy became accepted practice



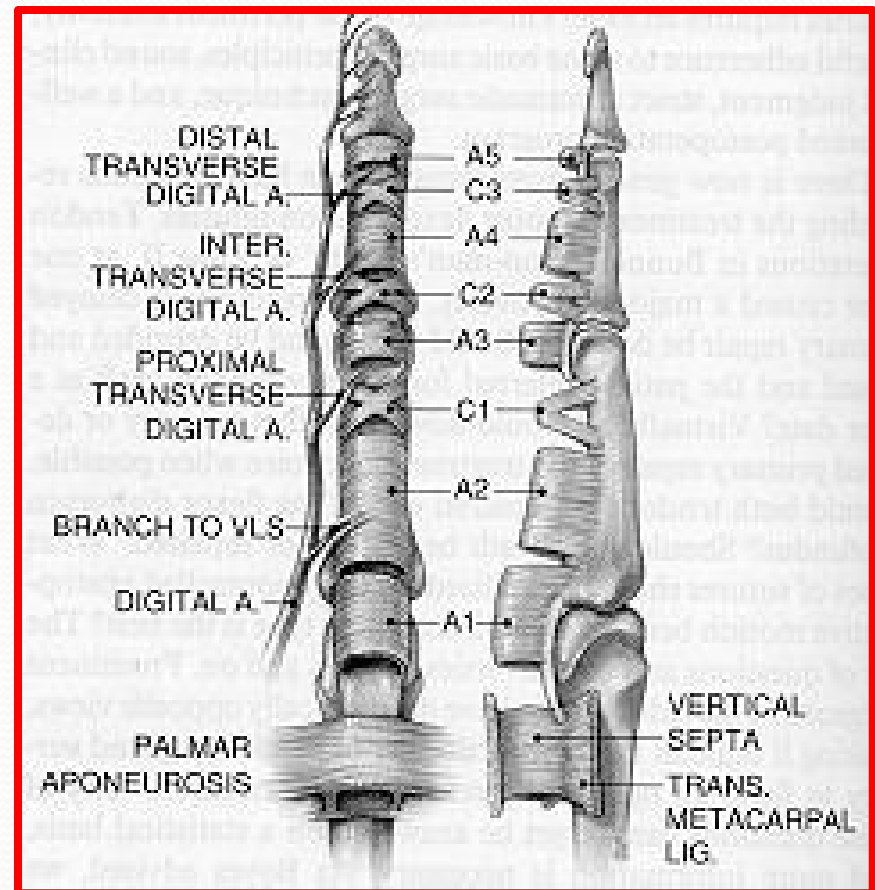
# Introduction

- **Bunnell (1918, 1956):** Because of inadequate suture materials & techniques frequent failure of primary repair strongly advised wound debridement & closure, followed by delayed tendon grafting
- **Verdan & Kleinert (1950's – 1960's):** concluded that primary flexor tendon repair superior to delayed reconstruction
- Evolution of suture & rehabilitation techniques, importance of tendon sheath & pulleys re-emphasized



# Tendon Nutrition: Vascularity

- From forearm into palm, blood supply received from segmental vessels arising from paratenon, entering the tendon & traveling longitudinally btwn fascicles
- In mid-prox. phalanx, tendons supplied by branches off digital arteries through the vincular system





# Tendon Nutrition: Synovial Fluid

- Synovial fluid, formed principally by tendon sheaths, acts as medium for diffusion of nutrients to tendons
- Variety of studies (using tracers, etc.) have shown that synovial diffusion more important (Manske, et al, J Hand Surg 3:32, 1978)





# Tendon Healing

- Previously thought that healing occurs by fibroblastic response of surrounding tissues whose own integrity has been violated
- Currently believed that tendons possess an intrinsic capacity to heal themselves without depending on extra-tendinous cells or adhesions



# Tendon Healing

- Collagen synthesis seen w/in 1st wk after tendon repair; fibers initially laid down in random, disorganized fashion
- By 8 wks., fibers reorganized into more linear pattern, w/ crosslinking
- Tensile strength of flexor tendon repair site decreases between days 4 - 10, thereafter slowly increasing to near normal by 6 wks. (re-rupture seen late as 7 wks)
- Wait 8 weeks to start resistance/strengthening



# Flexor Tendon Healing: Mobilization

- Gelberman et al: in vitro & in vivo studies showing repaired tendons subject early mobilization had consistently greater tensile strength, excursion (i.e. fewer adhesions), and ultimate function than those immobilized
- Adhesion formation associated primarily with immobilization
- Active mobilization may provide best environment
- Good **OT** critical to outcomes!

# Emergency Room Care

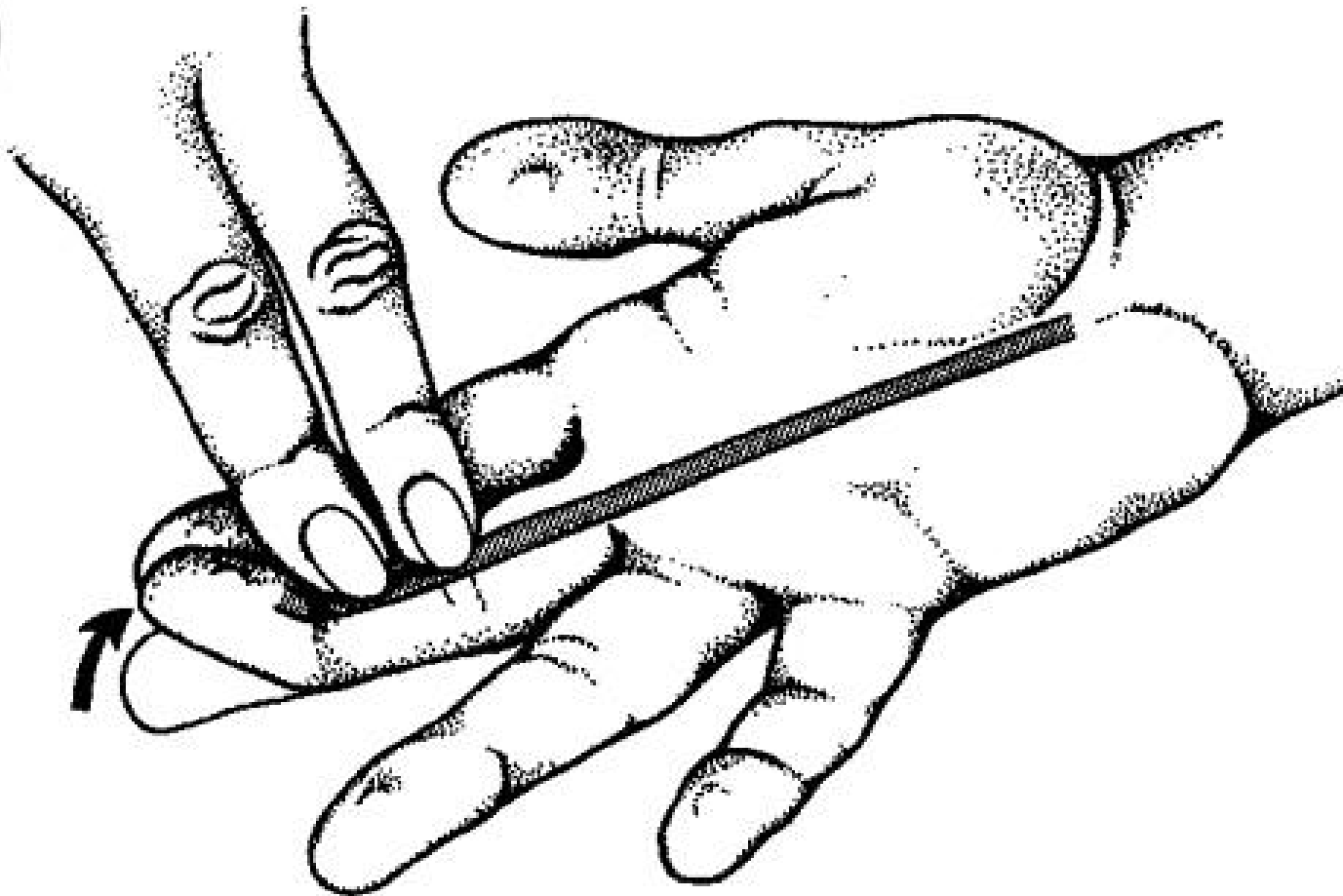
- Irrigation and debridement of the wound
- Wound closure
- Update tetanus immunization
- Administer oral antibiotics
- Early referral for purpose of repair
  - Within 2 weeks ideal (4 weeks generally upper limit for primary repair)
  - 1 week for FDP avulsion injuries



# Inspection for Wounds/Scars

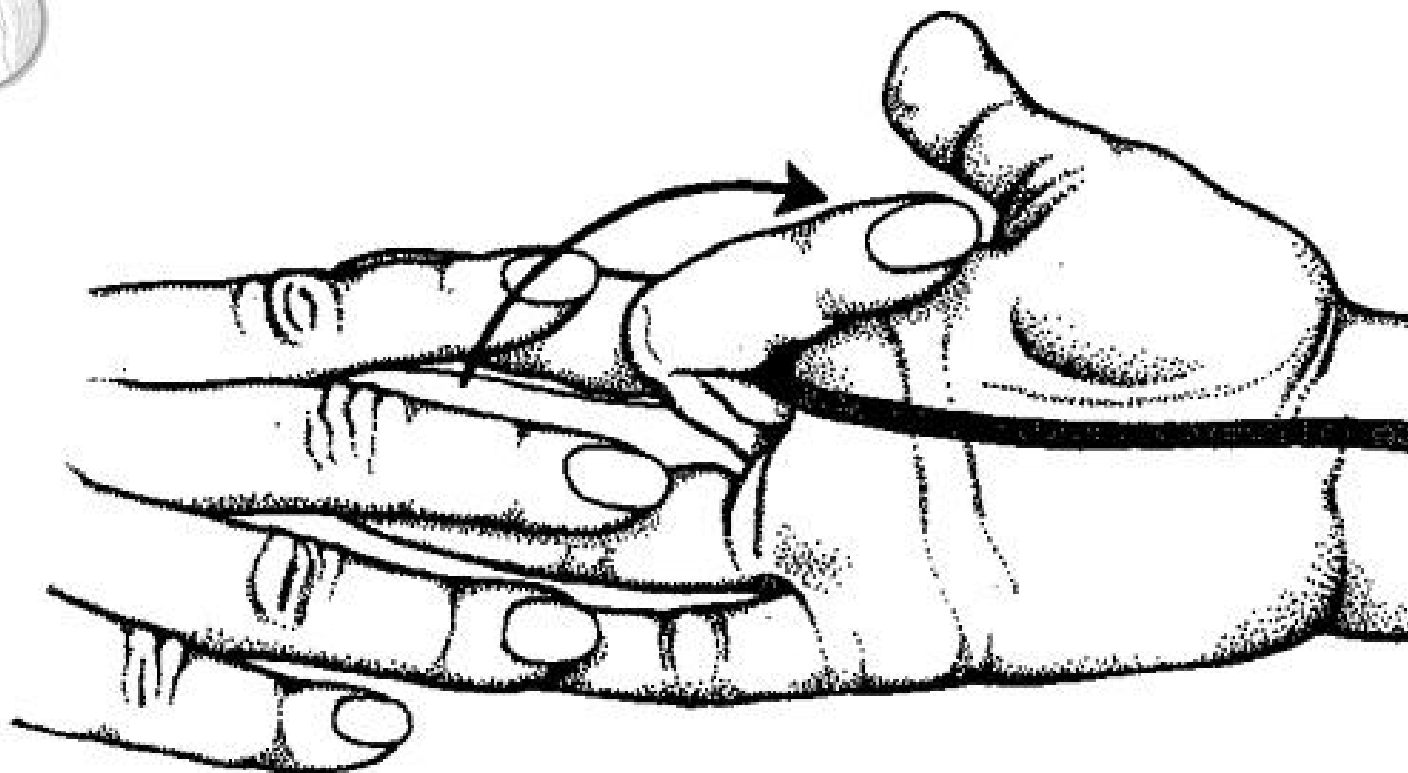
- Note size and location of any acute wounds
- Can often predict likelihood of tendon damage just based upon location of wound & resting posture finger
- Painful digital flexion is suggestive of partial tendon injury





Testing for flexor digitorum profundus musculotendinous function

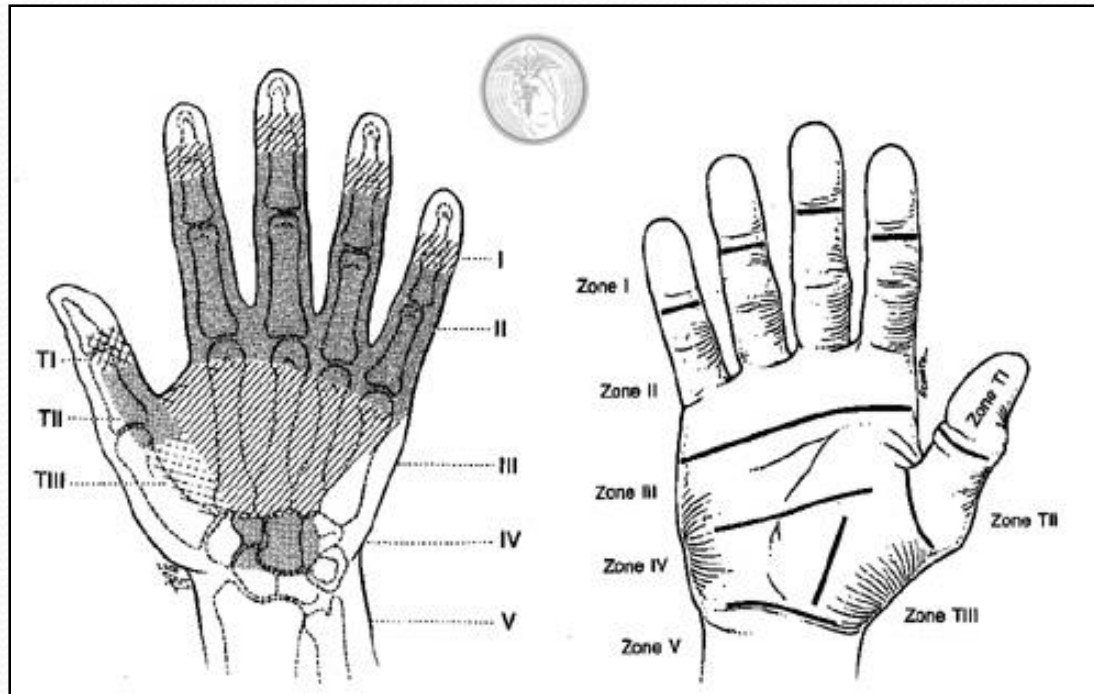




Testing flexor digitorum superficialis  
musculotendonious function

# Zones of Flexor Tendon Injury

- Zone I
- **Zone II**
- Zone III
- Zone IV
- Zone V



The classification of flexor tendon injuries  
using zones of the hand





# Repair Fundamentals

- Zone II flexor tendon repair
  - Restore anatomy
  - Minimize tendon handling to avoid adhesions
  - Create a smooth repair that allows gliding of the repair site
  - Perform a repair that is strong enough to allow an early active motion rehabilitation method



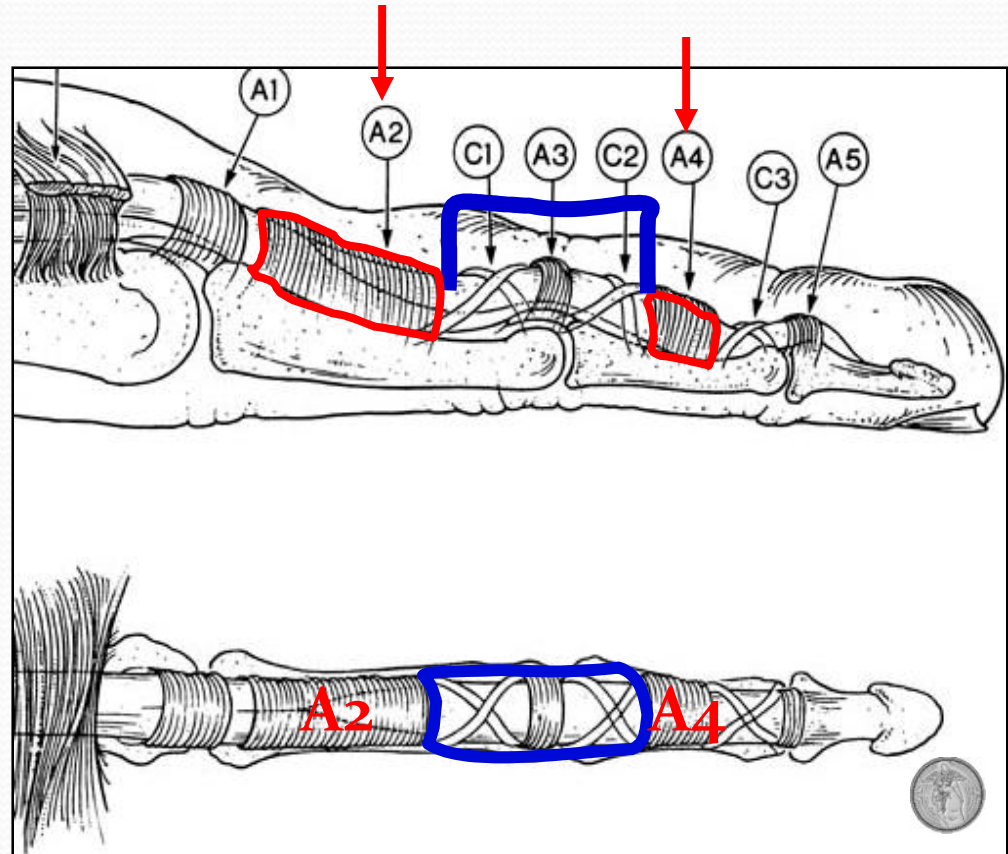
# Flexor Tendon Repair

- Should be done in the operating room
- Incorporate the existing laceration into surgical approach
- Focus on atraumatic tissue handling
- Choose a tendon repair method based on intra-operative findings and the anticipated rehabilitation method
- Start rehabilitation as soon as practical following repair



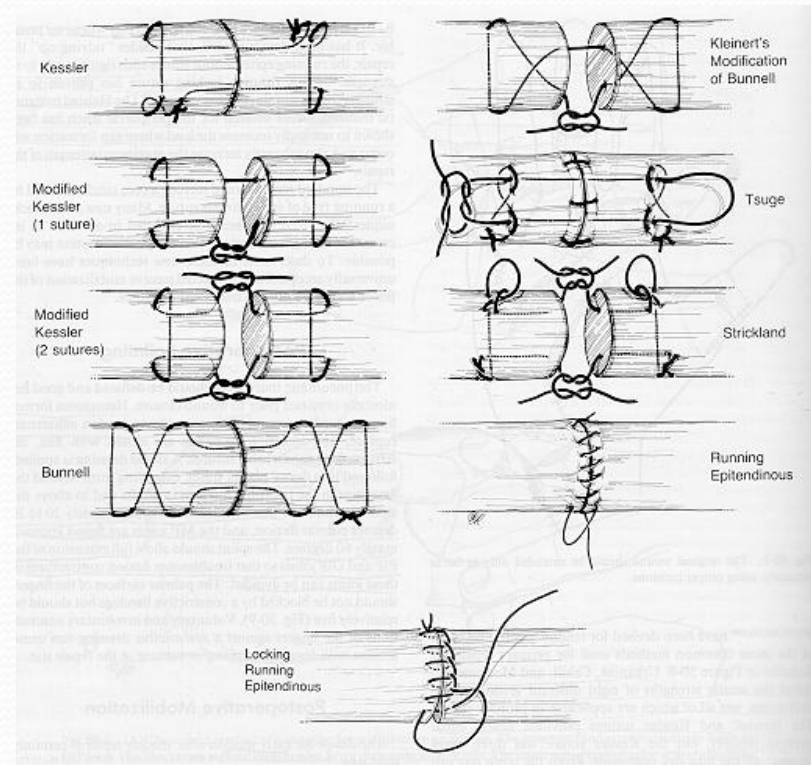
# Surgical Approach

- Preserve **A2** and **A4** pulley
- Use cruciate pulley windows (**A3**)
- Raise flap of C1, A3 and C2 for exposure
- Preserve rim for possible later repair of sheath



# General Considerations: Suture Techniques

- Suture material:
  - braided non-resorbable: nonreactive, pliable, strong
- Multiple suture techniques have been developed,
- Many different studies looking at in vivo and in vitro strengths of various techniques, with little agreement
  - One technique has not been unequivocally accepted as the best



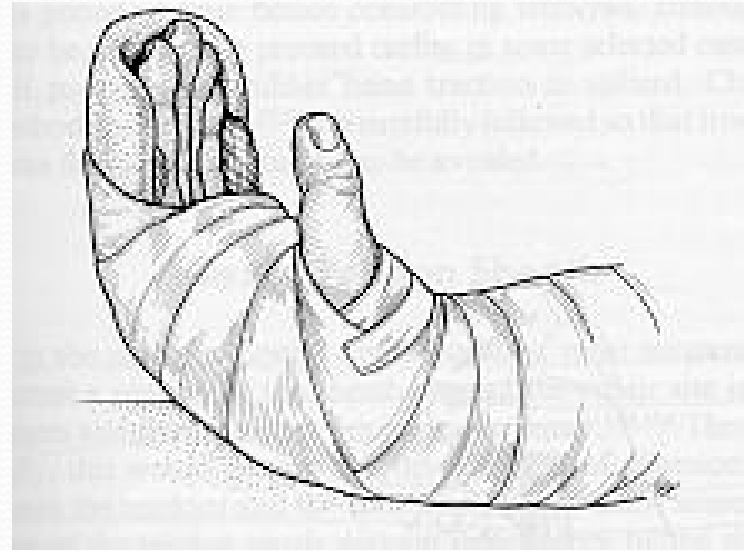


# Primary & Delayed Primary Repair

- While primary repair is theoretically preferable, delayed primary may be performed without adversely affecting the end result (Green & Niebauer, JBJS, 1974)
  - In some cases, delayed primary repair may be possible 6 weeks or more after injury
  - In others, it may be impossible only 2 weeks after injury
  - Therefore, have alternative plan (e.g., tendon grafting) in mind if repair found intra-operatively to be impossible

# General Considerations: Post-Operative Mobilization

- Based on data showing improved outcomes with early motion, immediate post-operative passive mobilization advocated.
- Variety of protocols
  - Duran & Houser demonstrated that 3-5 mm extension motion sufficient to prevent adhesion formation





# Partial Tendon Lacerations

- Unlikely need to repair lacerations under 50%
  - Address triggering and tendon sheath
- 50%-75% lacerations probably repair
  - Consider epitendinous only repair
- Repair if greater than 75%
  - Include core suture

# FDP Insertion Avulsion

- Common, esp. in athletes
- First described by von Zander (1891)
- Typically occurs in young males when playing football / rugby
  - While attempting to grasp a jersey, FDP eccentrically contracts as opponent pulls away, extending finger





# FDP Avulsion

- Frequently a delay in treatment unless active DIP joint flexion tested specifically
- Vast majority involve ring finger, possibly because of weaker profundus tendon insertion in ring finger (Manske & Lesker, Hand, 1978)



# FDP Avulsion: Classification (Leddy &

Packer, J Hand Surg 2:66, 1977)

- Type I (least common): Tendon retracts all the way into palm beneath A1 pulley, vincula rupture, synovial fluid nutrient diffusion interrupted
  - No active DIP flexion, excellent PIP flexion
  - Tender mass in palm
  - Reinsertion within 7-10 days before tendon contracts



# Complications

- Re-rupture: 3-15%, usually within 2-3 wks of repair, occasionally as late as 7 weeks
- Adhesions / loss of ROM: occurs to some degree in nearly all pts.; >64% of pts had total loss of greater than 25 deg.

# Tenolysis

- Surgical release of flexor tendons from their restricting adhesions
- Indicated when passive flexion significantly exceeds active flexion at a joint, suggesting restriction of flexor tendon excursion by adhesions
- Prerequisites: healed Fxs; full passive ROM (no joint contractures); “tissue equilibrium; compliant/motivated patient





# Tenolysis

- Timing: Controversial, based on conflicting animal and clinical data
  - Not before 3 mos, possibly not until 6 mos.
- Some advocate performing the procedure under local anesthesia, allowing the pt to actively flex the digit intra-operatively to assess tendon excursion
- Technically demanding

# Tenolysis

- Early (within 12 hours) aggressive therapy must be initiated
- Significant complication rate, especially tendon rupture in the post-operative period
  - Pt should be prepared for ultimate tendon grafting if primary repair impossible

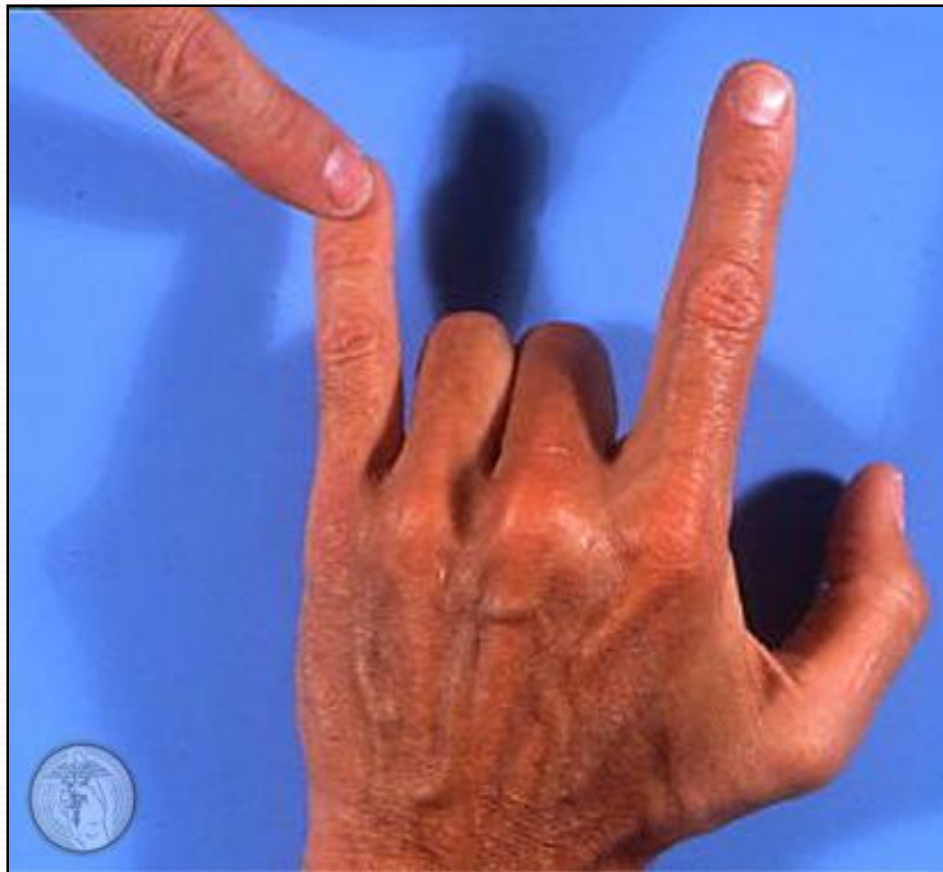


# Flexor Tendon Reconstruction (Failed Repair)

- **Two stage**
  - Silicone rod insertion and pulley reconstruction, followed by second stage graft
  - Procedures are done approximately 3-6 months apart



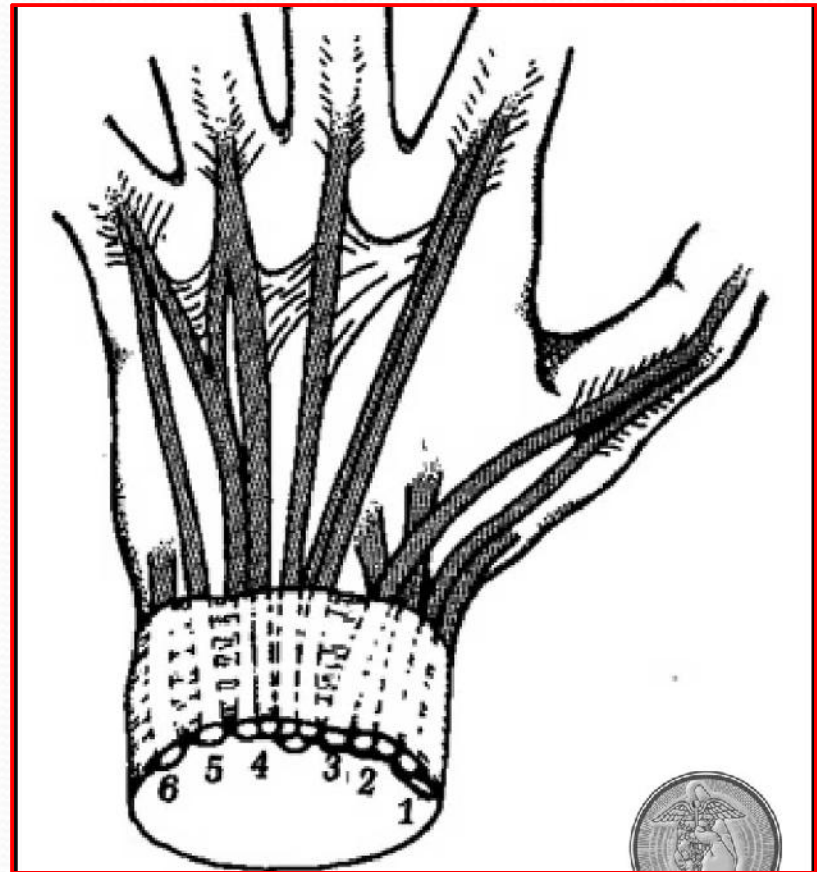
# Extensor Injuries





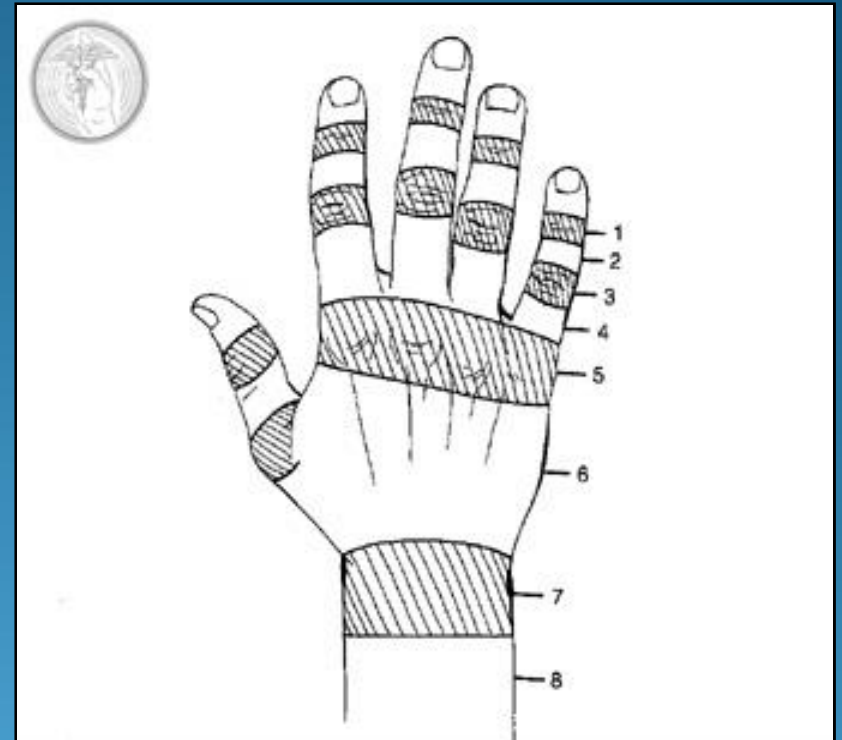
# Extensors at the Wrist

- Wrist encompasses six discrete dorsal compartments that contain the extensor tendons



# Zones of Extensor Tendon Injury

- Zone 1: terminal tendon
- Zone 2: triangular ligament
- Zone 3: central slip
- Zone 4: over proximal phalanx
- Zone 5: over metacarpal phalangeal joint
- Zone 6: over metacarpals
- Other (7, 8, 9): proximal



Zones of extensor tendon injury





# Extensor Tendon Injuries

- Occur following dorsal hand or digit laceration
- Also commonly occur by avulsion of the tendon from its site of insertion by blunt trauma

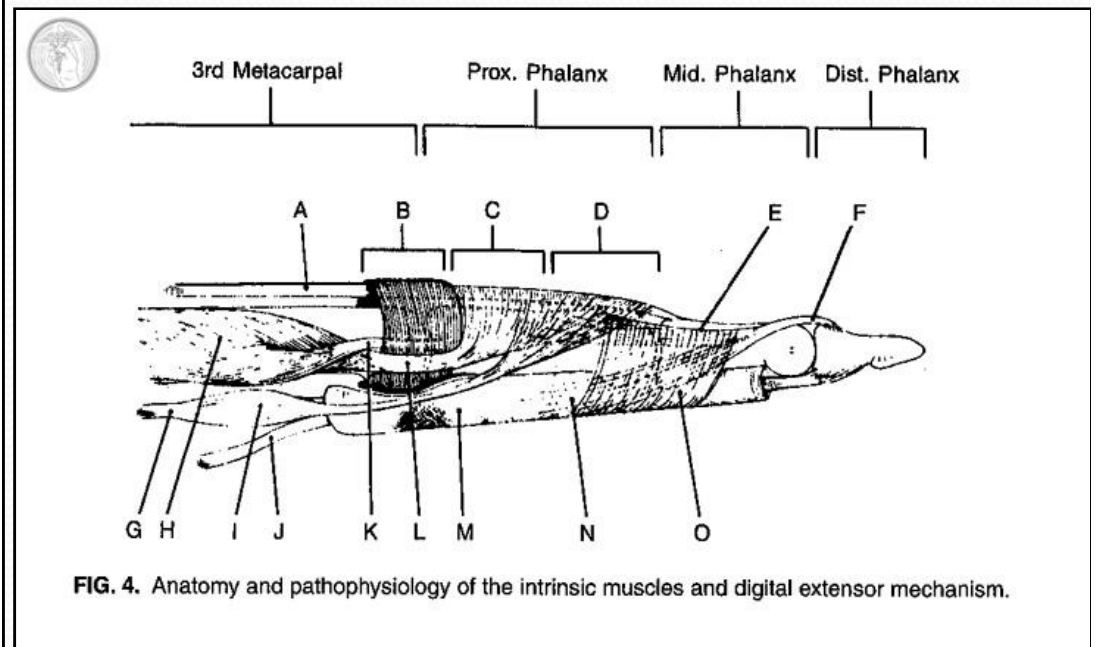
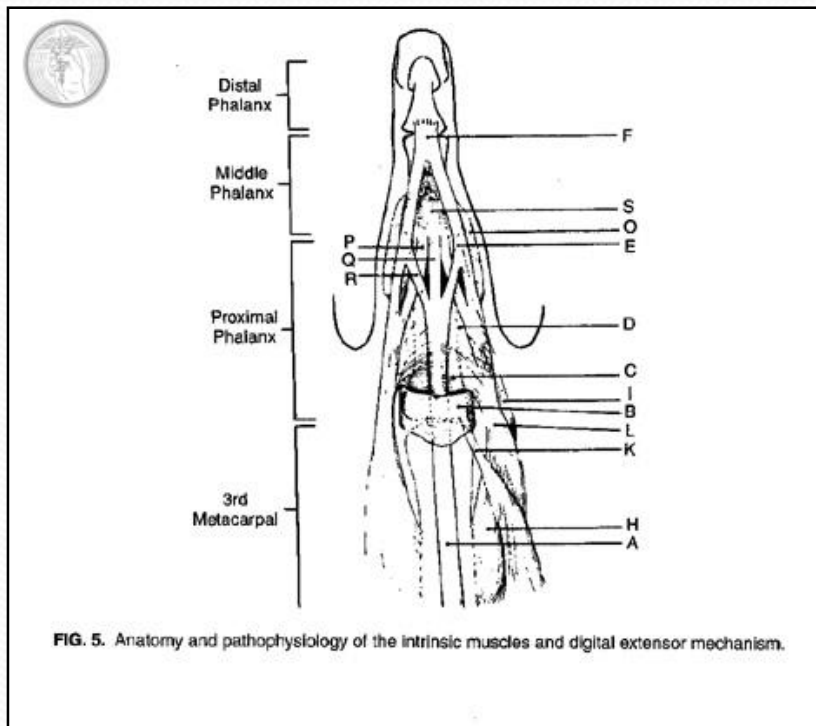


# Closed Injuries

- More likely to be overlooked or misdiagnosed
- Distinguish from ligament injuries/fractures
- X-rays
- Consider ultrasound/MRI




# Anatomy of the Extensor Apparatus



# Principle

- A more predictable result, in terms of full active digital flexion and extension (ie no extensor lag at either the DIP or the PIP joints) may be expected if the tendon heals without formation of a repair site gap



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- Even a small gap formation at the extensor tendon repair site leads to digital extensor lag
  - Early diagnosis and treatment of injury of the *extensor* mechanism is as important as the treatment of *flexor* tendon injuries
  - If external splints cannot keep the digit immobilized effectively, consider trans-articular fixation with K-wires and/or tendon repair

# Loss of Terminal DIP Extension

- Mallet Finger
  - Swan-neck deformity





# Closed Injuries

- Zone 1: Tendinous Mallet
  - Loss of terminal extension of the DIP
  - Usually as a result of forced flexion of the DIP
  - Splint DIP in extension for 6-8 weeks
    - Then 6-8 weeks night-time splinting
  - Either a dorsal or a volar splint is acceptable
  - Consider pinning if patient can't tolerate splint
    - ?earlier RTW

# Closed Injuries

- Zone 1: Tendinous Mallet Treatment
  - Continuous splinting for 6 weeks
  - Monitor the patient for skin problems





# Closed Injuries

- Zone 1: Bony Mallet
  - Mallet injury that is associated with a fracture of the distal phalanx
  - Diagnosis confirmed by the appearance on lateral radiograph
  - Generally do well with splinting (4 wks.)
  - May require surgical repair if there is palmar translation of the distal phalanx

# Loss of Active PIP Extension

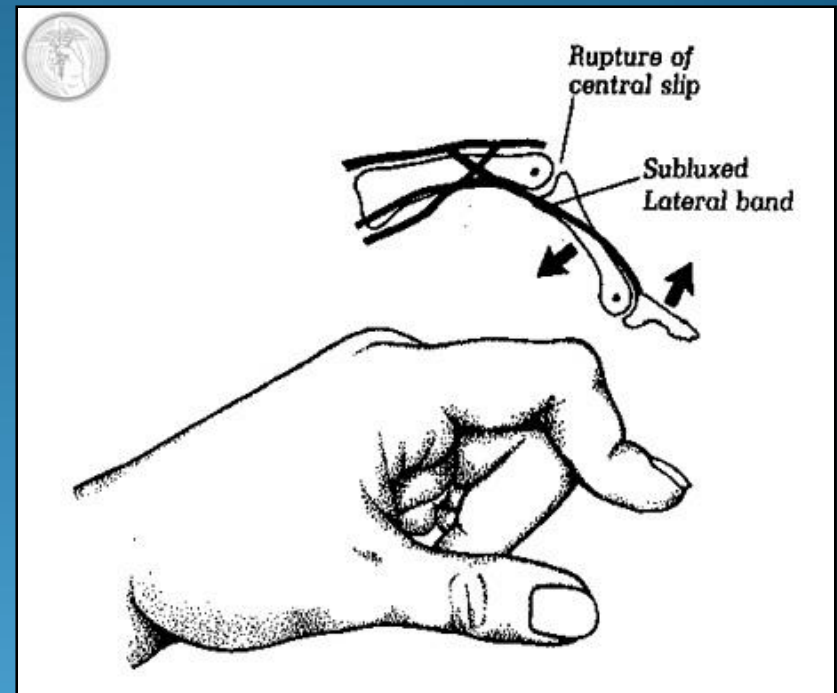
- Boutonniere Deformity





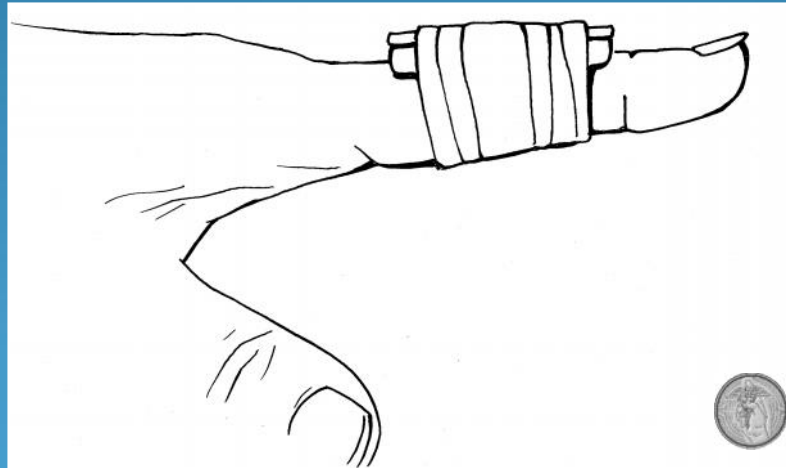
# Closed Injuries

- Zone 3
  - Central slip injury/avulsion
  - Boutonniere deformity (flexion of the PIP and hyperextension of the DIP) develops if lateral bands subluxate palmar to axis of rotation of PIP joint
  - The majority of patients can be treated with closed reduction and extension splinting of the PIP joint



# Closed Injuries

- Zone 3
  - Central slip injury/avulsion
  - Treated by splinting the PIP joint in extension for 6 weeks
    - Active DIP flexion exercised with the middle phalanx 'blocked' is done during the period of immobilization





# Stiffness Following Tendon Repair

- Incomplete flexion of the MCP, PIP and DIP joints may develop following a dorsal injury from loss of tendon excursion or from joint contracture
- Restoration of full digital flexion and extension may require greater than one surgical procedure



# Extensor Tendon Adhesions

- Peritendinous adhesions limit tendon excursion
- Early intensive post-op occupational therapy is important to maintain the range of motion obtained at surgery
- Digital stiffness following extensor tendon repair or healing can often be treated successfully with outpatient hand therapy
- Extensor tenolysis may be useful to regain digital flexion as well as digital extension





# Approach to the Stiff Finger

- Treatment is Elective (Choose patients carefully)
  - Compliant patient
  - Pain controllable- narcotics, NSAIDs
  - Employer's understanding
  - Have focused GOALS: Restore power grip? Restore active extension? Restore hand's ability to get into tight spaces?

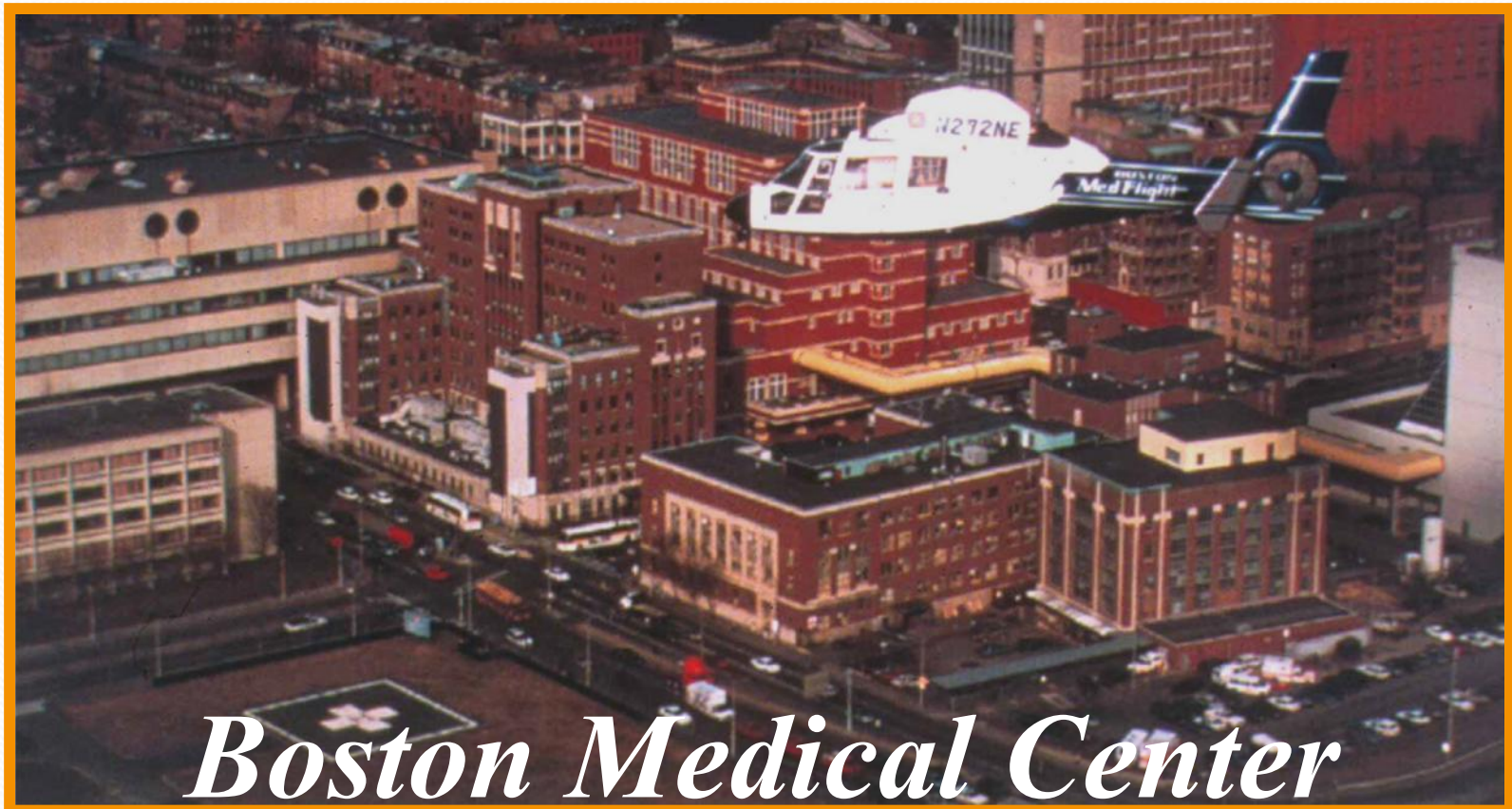


# Summary

- Early diagnosis of traumatic tendon injuries helpful
- Compliant patient/appropriate OT as important as surgery for achieving good outcome
- Full recovery often prolonged even in ideal situation
  - There are no shortcuts
  - Employer should be aware

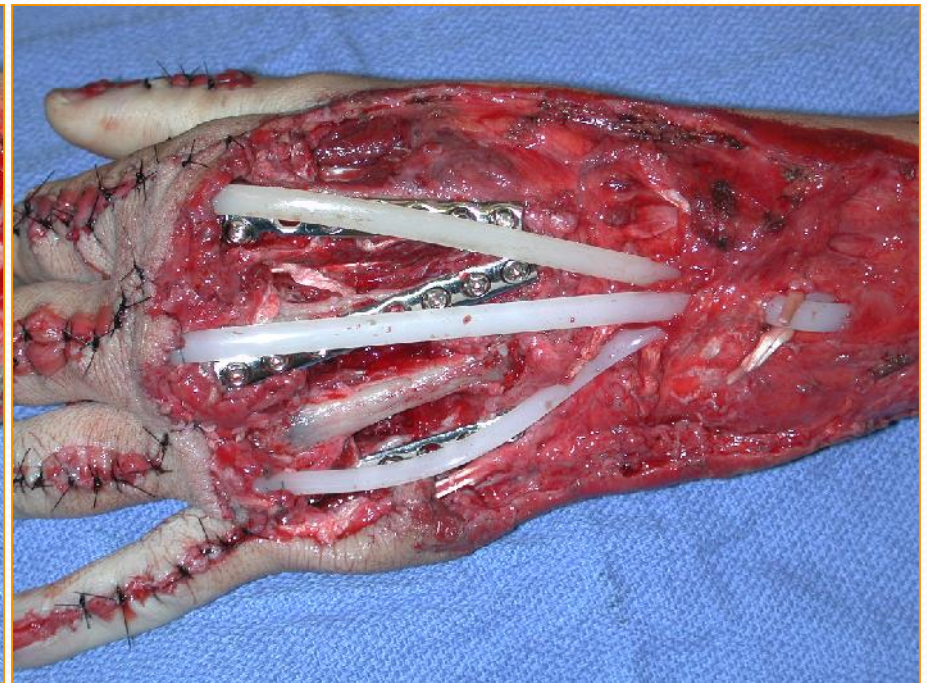


# Thank You!





## F/U to 1<sup>st</sup> Case



Multiple MCP Fxs & Tendon Loss



Plates & Hunter Rods





← Groin Flap for Coverage



↑  
Result