Tendon Repair
WHAT’S NEW IN HAND SURGERY?

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DISCLOSURES

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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 MCP joint
- Zone 6: over metacarpals
- Other (7, 8, 9): proximal
• Zone 1 Injury
  • Loss of active DIP extension
    • Mallet Finger Subtypes
      • Tendinous
      • Bony
• Closed Zone 1 - Tendinous Mallet Finger
  – **Full time** extension splinting for 6-8 weeks
    • PIP joint mobilization
    • Dorsal Splints
    • Better extension but more skin irritation
  – Volar splints
    • Less effective but fewer skin complications
• Results – Closed treatment
  – Crawford, *J Hand Surg* 1984

• 62 patients

• Excellent/good results

• <10 deg. loss of extension in 79%

• Fair and poor results in patients with delayed treatment or improper use of splint
• Complications – Closed treatment
  – Rate ~ 45%
  – Transient skin problems (maceration, ulceration, tape allergy).
  – Many complications with dorsal aluminum splints.
  – Skin blanching at 50% of passive DIP hyperextension (avg 14°).
• Open Zone 1 Injuries
  • Operative treatment is recommended by most authors
  • +/- transarticular K-wire in full extension
• Extensor Tendon Suture Methods
  – For more distal injuries (zones 1-4) the tendon is flat
    • Figure of 8 repair or mattress suture repair
  – As the caliber thickens (zones 5-8)
    • Core suture method
• Zone 2,4 Injuries – most common due to laceration
  – Acute Zone 2,4,6
    • Lateral band, EDC laceration
    • Can excise one lateral band without losing extension
    • May repair with 4-0 non-absorbable suture
    • Aftercare is identical to mallet
  – Chronic Zone 2 with swan neck deformity
    • Spiral oblique retinacular ligament reconstruction
• Zone 3 Injuries
  – Central slip injury
    • Leads to loss of active PIP extension
    • If palmar subluxation of lateral bands Boutonnière deformity develops
    • Flexion of the PIP
  – Hyperextension of the DIP
    • Can occur within one week
Zone 3 extensor injury - Physical Examination

- Patient p/w pain over the dorsal PIP, loss of 15-20° active PIP extension with wrist and MP joints flexed
- Weak extension of the middle phalanx against resistance
- + Elson test = central slip rupture
- Loss of passive flexion of the DIPJ with the PIPJ extended
Zone 3 extensor injury - Treatment
  - Splint PIP in neutral for 6-8 weeks
  - Allow DIP active flexion (helps approximate ruptured tendon ends)
  - Can use serial casts or K-wire fixation when needed
- Open Zone 3 Injuries
  - Patient who maintains active PIP extension against resistance
    - Active motion
    - Close follow up
  - Patient with active PIP extension, but weak against resistance
    - Extension splint 3-4 weeks
    - Close follow up
  - Patient with extensor lag
    - Open repair with 3-O braided suture
    - May require microsuture anchor if injury at the central slip insertion
• **Chronic Zone 3 Injuries**
  - **Stage I:** Supple boutonnière deformity
    - Active extension therapy + extension splinting
  - **Stage II:** Fixed boutonnière deformity (Contracted lateral bands)
    - Trial of active extension therapy + extension splinting
    - Tenotomy: release the lateral bands distal to the central slip
    - Maintain the spiral oblique retinacular ligament
    - Allows central slip to relax, but maintains DIP extension
  - **Stage III:** Fixed boutonnière deformity - joint degeneration
    - May require arthroplasty or fusion
• Boutonnière Deformity - Repair
Boutonnière Deformity - Repair

Extensor tendon

Attenuated tendon
• Boutonnière Deformity - Repair

Removal of attenuated tendon
Boutonnière Deformity - Repair

Repair of tendon, centralization of lateral bands
Boutonnière Deformity - Treatment of Chronic Injuries

- Repair with repositioning of the lateral bands (+/- [staged] PIP contracture release)
- Fowler’s terminal tenotomy
- PIPJ arthrodesis
Rehabilitation

- Passive
- Early Active
STIFFNESS FOLLOWING EXTENSOR TENDON REPAIR

- Loss of MCP, PIP or DIP flexion can be due to:
  - Loss of tendon excursion
    - Shortening
    - Adhesions
  - Joint contracture
- Restoration of functional range of motion may require multiple procedures
Extensor Tendon Loss/Reconstruction

- Spiral Oblique Retinacular ligament
- Fowler Release
- Turnover Flap from Zone 4
- EIP
Extensor Subluxation

- Centralization
- Lumbrical
- Junctura
- EIP
- Sagittal Band Repair
Flexor Tendon Repair
• Goals in Flexor Tendon Repair
  – Prevent gap formation
  – Prevent adhesions
  – Allow differential gliding between FDS and FDP tendons
  – Allow gliding under pulleys
  – Perform a repair of adequate strength to allow early rehabilitation
  – Allow for full functional recovery
• Strickland (JAAOS 1995)
  – Ideal repair
    • Sutures easily placed in tendon
    • Secure suture knots
    • Smooth juncture of tendon ends
    • Minimal gapping at the repair site
    • Minimal interference with tendon vascularity
    • Sufficient strength throughout healing
• Anatomy
  – Zones on injury - FDP
  I  Distal to FDS insertion
  II  Proximal aspect of flexor sheath to FDS insertion
  III Lumbrical origin to proximal aspect of flexor sheath
  IV  Carpal tunnel
  V  Proximal to carpal tunnel

Flexor tendon repair
• Approaches
  – Preserve A-2 and A-4 pulleys
  – Use cruciate pulley windows (C1, A3, C2)
  – Raise flap of C1, A3 and C2 for exposure
  – Repair between A-2 and A-4 pulleys
• Approaches
  
  – Venting (partial release) of the A-2 and A-4 pulleys up to 50% can be used to facilitate exposure and allow tendon gliding following repair (Mitsionis et al, JHS 1998)
• Repair Technique
  – The finger will need to be flexed to allow delivery of the distal stump of the FDP into the wound
  – Core suture
  – Epitendinous suture

Courtesy of Martin I. Boyer, MD
OPTIMAL SUTURE TECHNIQUE

• Found in Dictionary between Dragon and Unicorn
• 4 to 6 Strand Core 7-10 mm Purchase
• Knots Outside Stronger
• Palmar Entry, Less Vascular
• 3-0 Braided Polyblend
• Fiberwire/Stainless Steel Stronger
• 6-0 Epitenon 2mm Purchase
• Strickland Repair
  – Four strand repair
    • Uses two sutures
    • Modified Kessler outer stitch
    • Horizontal Mattress or modified Kessler inner stitch

Courtesy of Martin I. Boyer, MD
• Cruciate Repair
  – Four strand repair
    • Single suture
    • Modified as locked suture if desired or with placement of knot inside repair
• Modified Becker/MGH Repair
  – Four Strand Repair
• Excellent for FDS repair after decusation (Miller, *JHS 2000*) or distal FDP repair (Gelberman, *JOR 2002*)
• Six Strand Repair
  – Savage
  – Tsai
  – Tsuge
  – These are technically difficult, but strong and can be used with early active motion protocols
• Epitendinous Repair
  – Sutures placed in the periphery, circumferentially in a running fashion
  – Increases repair strength by 10-50%
  – Tidies repair site
  – Allows better gliding under pullies
  – Prevents gapping
• Distal FDP Repair
  – If less than 1 cm of distal stump present, use a multi strand repair in the proximal tendon and advance it into bone, repair with button over the distal nail or bone anchors
• Distal FDS Repair
  – A modified Becker/MGH type of repair works well (Miller and Mass, *JHS 2000*)
  – Excision of one slip of FDS to improve gliding reduce work of flexion
  – Vincula can provide up to 93% flexion of PIP joint (Stewart *JHS 2007*)
• Partial Tendon Lacerations
  – Lacerations involving greater than 70% are repaired similar to complete lacerations
  – Lacerations between 50 and 70% can be repaired with an epitendinous suture only
  – Lacerations involving less than 50% should be debrided to smooth edges
• Flexor Sheath Repair?
  – There is no evidence that sheath repair improves outcomes, but this may be useful when it improves tendon gliding.
Platelet Rich Plasma

- Promote More Rapid Healing
- Up Regulate Transforming Growth Factor Beta
- Decrease Interleukin 1 Associated with Inflammation
Tendon Gliding/Adhesions

- Hylan G-F 20
- PXL01
• Rupture
  – Rupture in a compliant patient warrants exploration and re-repair
  – In this situation, excision of the FDS may be indicated, depending on operative findings
• Flexor Tenolysis
  – Must have good passive motion of all affected joints
  – Therapy must have reached plateau (no further progress in with motivated, compliant patient)
  – Usually considered around 4-6 months
• **Flexor Tenolysis**
  
  – Early rehabilitation, depending on operative findings, to minimize further adhesions
  
  – This may involve full active motion or frayed tendon protocol with place and hold
Tendon Reconstruction

- Single Stage  Intrasyrovial vs Extrasynovial
- Two Stage  Silicone Rod, Tendon
• One Stage Grafting and **Pulley** Reconstruction
  – Donor tendon
    • Intrasyovial
    • Toe flexors
  – Extrasynovial
    • Palmaris
    • Plantaris
    • Toe extensors

*Courtesy of Martin I. Boyer, MD*
• Two Stage Grafting
  – First stage involves silicone rod insertion and pulley reconstruction to create a new sheath
  – Second stage involves placement of tendon graft into sheath created by silicone rod approximately four months later
• Two Stage Grafting
  – Silicone rod is exposed distally, tendon graft is sutured to rod proximally and graft is pulled through newly formed sheath
• Conclusions
  – Repair both FDP and FDS tendons in zone II
  – Consider excision of one slip of FDS to improve tendon gliding
  – At least four strand repair with core and epitendinous sutures
  – Early rehabilitation
  – Early Active if Repair Strength Adequate
Questions

• Which of the following epitenon suture techniques has the lowest tensile strength?
  • A. Interlocking Horizontal Mattress
  • B. Cross-stitch
  • C. Interlocking Cross stitch
  • D. Silverskiold
  • E. Simple Running
  • (E)
Questions

• In a zone 2 FDS laceration the intact vincula tendinum can be responsible for proximal joint flexion of up to what percent of normal?
  • A. 10%
  • B. 33%
  • C. 50%
  • D. 74%
  • E. 93%
  • (E)
THANK YOU!

San Diego Museum of Man

INSTRUMENTS OF TORTURE