Flexor Tendon Injury

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History

- 131 AD – Galen - describes tendons and nerves as one. Advised against repair.
- 980 AD – Avicenna – describes tendon repair
- 1889 – Codivilla of Bologna – preserve the digital sheath
- 1918 – Bunnell – Advised against repair in “no man’s land”. Recommended grafting.
- 1967 – Kleinert – Primary repair in “no man’s land”
- 1967 – Bruner – Zigzag incision
- 1970 – Hunter - flexor tendon reconstruction
- 1970s – Kessler, Tajima – suture techniques

Anatomy

- **Flexor Digitorum Superficialis**
  - Origin: medial epicondyle, UCL, coronoid, proximal ulna and radius
  - Insertion: Middle Phalanx
  - Innervation: Median N.
- **Flexor Digitorum Profundus**
  - Origin: Prox ¾ of ulna and inteross membrane
  - Insertion: Proximal aspect of distal phalanx
  - Innervation: AIN = IF, MF; Ulnar N. = RF, SF
Anatomy

• Relationships
  – FDS: deep to pronator teres, FCR, PL, FCU
  – FDP: deep to FDS
  – FDS divides at mid forearm
    • Superficial: MF, RF
    • Deep: IF, SF
  – Carpal Tunnel: 9 tendons + median n.

Know the Zones
Anatomy

- Flexor Sheath
  - 5 Annular, 3 Cruciate
  - Affords efficiency, gliding, protection
- FDS divides within A1
- Rotates around and dorsal to FDP
- Reunites at Camper’s chiasma
- Separates again and inserts on middle phalanx

Tendon Healing

- 3 Phases
  - Inflammatory Phase: 48 to 72 hours
  - Fibroblastic: 5 days to 4 weeks
  - Remodelling: up to ~4 months
- 2 Mechanisms
  - Extrinsic
    - Scar and adhesions
  - Intrinsic
    - Healing within the tendon
    - Fewer adhesions
Tendon Nutrition

Tendon Healing

• Adhesion Formation
  – Direct tendon and sheath injury and repair
  – Injury to synovial sheath
  – Poor blood supply and ischemia
  – Immobility
  – Gapping

Tendon Healing

Numerous studies to minimize adhesions
- Oral: steroids, antihistamines, NSAIDS
- Topical: 5-FU, TGF-beta, PDGF, IGF, BMPs, beta-aminoproprionitile, hyaluronic acid, collagen solutions
- Physical: silicone, polyethylene, Adcon-T gel, interposed sheath flaps

Tendon Repair

• The Ideal Repair!!!
  - easy placement of sutures in the tendon
  - secure suture knots
  - smooth juncture of tendon ends
  - minimal gapping at the repair site
  - minimal interference with tendon vascularity
  - sufficient strength throughout healing to permit application of early motion stress to the tendon
Tendon Repair

- A few questions:
  - Core suture number?
  - Suture size?
  - Grasping or locking?
  - Dorsal or volar?
  - Epitendinous suture?
  - Sheath repair?

Tendon Repair

- Core suture number
  - The strength of a repair is roughly proportional to the number of core sutures
  - 6 strand repairs are more resistant to failure, but technically difficult and may damage tendon.
  - 4 strands with newer materials are easier, yet strong enough for controlled rehabilitation.


Timing of Tendon Repair

• Primary Repair
  – within 12 hours of injury
  – Usually with clean wound or N/V injury

• Delayed Primary Repair
  – Within 12 hours to 10 days
  – No difference when compared to emergent repair

• Secondary Repair
  – After 10-14 days
  – Will lead to shortening of the tendon

Core Repair

• Knots outside repair site stronger
• 4-6 strand core
• 3-0 or 4-0 braided poly
• Looped or single
• Strong suture techniques
• Decrease gap formation
• Allow early active motion

Rehabilitation

• Early Passive Motion
  – Wrist and MCP flexion
  – PIP and DIP extension
  – Controlled Motion
    • Active finger extension
    • Passive finger flexion
Rehabilitation

• Kleinert
  – Dorsal blocking splint
  – Rubber bands to maintain flexion
  – Active Extension
  – Passive Flexion

• Modification of Kleinert
  – Palmar bar to redirect forces and allow greater DIP flexion

Rehabilitation

• Duran and Houser
  – Patient controlled passive flexion
  – Requires greater patient compliance

Rehabilitation

• Strickland - Active-hold / Place-Hold
Rehabilitation

• Advances in materials and repairs have allowed for more aggressive protocols
• Increase risk of rupture with aggressive active mobilization
• Osada et al (2006)
  – 6 strands repairs and early active flexion
  – 26/27 Excellent or Good
  – No ruptures

Tendon Reconstruction

• Age
  – Younger patients do better
  – Compliance issues with children
• Cause of injury
  – Outcome worse with: crush, fracture, infection, N/V injury, skin loss
• Zone of injury
  – Zone 2 and 4 more difficult to rehab
• Comorbid conditions
  – Diabetic, smoker, RA, etc.

Graft Options

• Palmaris Longus
• Plantaris
  – Good for multiple grafts or long grafts
• Long toe extensors: middle 3 toes
• Toe Flexors
• EIP, EDQ
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Two-Stage Tendon Grafting

• Stage 1:
  – Excise flexor tendons, keep distal FDP
  – Transect FDP at level of lumbral origin
  – Transect FDS at musculotendinous junction
  – Reconstruct pulleys if needed
  – Pass graft spacer and fix distally

• GOAL: PASSIVE FLEXION
  – Start motion within 1 week
  – Graft will develop pseudo-sheath over 3 months

Two-Stage Tendon Grafting

• Stage 2
  – Release distal end of rod
  – Attach graft to proximal end of rod and pull graft distally
  – Attach graft to distal phalanx
  – Tension and fix graft proximally to FDP
Zone 2 Flexor tendon Preparation Tips

- Mechanism of injury
- Associated injuries (Artery, nerve, bone, etc)
- Surgical timing (< 3 wks)
- Location (hospital vs surgery center)
- Surgical planning
  - (suture, tendon passage, nerve, micro)
- Anesthesia (General, Block, WALANT)
- Hand therapy
Repair tips

• Mastery of anatomy & meticulous surgical technique
• Atraumatic tendon handling
• Ragged edges removed with scalpel or tendon cutting device
• Venting or release of selected pulleys
• Strong suture techniques
• Decrease gap formation
• Allow early active motion