Flexor and Extensor Tendon Injuries of the Hand

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Anatomy

- Zone 1: FDS insertion to FDP insertion
- Zone 2: Zone 1 to proximal part of A1 pulley
- Zone 3: Zone 2 to distal edge of flexor retinaculum
- Zone 4: Within carpal tunnel
- Zone 5: Proximal to carpal tunnel
- Thumb T1: FPL insertion to A2 pulley
- Thumb T2: Zone 1 to distal part A1 pulley
- Thumb T3: Zone 2 to carpal tunnel

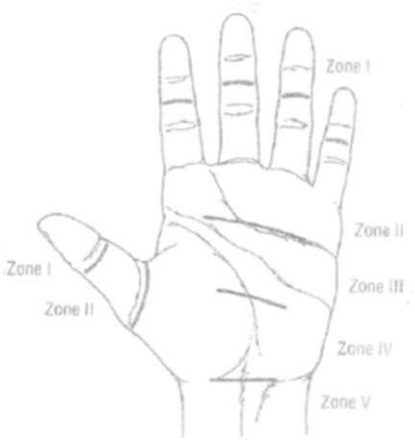

FIGURE 6.1
Flexor tendon zones

Pulleys

5 Annular, 3 Cruciform
Fibrous annular pulleys prevent bowstringing
A2 and A4 most important
Cruciate pulleys are thin and provide flexibility
Tendon repairs through C1 and C2

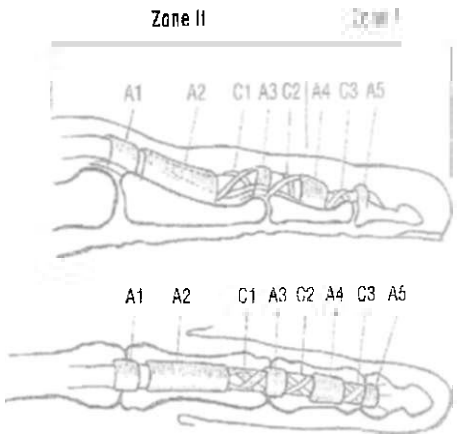

FIGURE 6.2
Annular (A) and cruciform (C) pulleys of the flexor tendons

Tendon Nutrition

- Extra-synovial : forearm – palm
  - paratenon
- Synovial : Carpel Tunnel & digital flexor sheath
  - vincular arterial system
  - diffusion from synovial fluid
  - additional supply from distal oseous attachments

Watershed areas (Lundborg) :

- FDS under the A2 pulley
- FDP under the A2 pulley and A4 pulley

Intrinsic repair response

- Lundborg and Rank (1978) – intra-synovial flexor tendons initiate intrinsic repair response after tendon transection
- Gelberman et al (1980s) – studied effect of early digital mobilization following flexor tendon repair in zone 2
  - immobilized: ↓ linear tendon excursion
    formation of peritendinous adhesions (extrinsic tendon repair)
  - mobilized: ↑ linear tendon excursion (intrinsic repair response)
    Early restoration of gliding surface by day 10

Stages:

1. Inflammatory phase (0 – 14 days)
2. Reparative phase (2 – 6 weeks):
3. Remodeling phase (> 6 weeks):

Inflammatory phase (0 – 14 days):
Fibrin clot forms at repair site
Macrophage and leukocyte migration
Phagocytosis
Growth factors (bFGF) peak
Cells from epitenon proliferate and migrate to repair site
Gliding surface restored
Strength of repair is related to strength of suture

Reparative phase (2 – 6 weeks):
Intense collagen production – mostly type 1
Gradually orient themselves along the axis of tensile forces
Epitenon cellular ingrowth fills repair site gap
Neovascularization
Strength increases at 2 weeks post-op
Repair site strength still principally related to the suture strength & material

Remodeling phase (> 6 weeks):
Collagen fibers smooth and uniform
Collagen fibers are remodeling to be oriented parallel to the longitudinal axis
Increased repair site strength

Extrinsic repair response

- Dominated in the immobilization group
- By 10 days after repair, the in-growth of peripheral adhesions dominated the repair site

Surgical principles

Operating room, loupe magnification
GA or regional anaesthesia
Tornıquet
Meticulous tissue handling (Bunnell)
Bruner type (zigzag) or midlateral incision, incorporate original lacerations
Identify & protect neurovascular bundles
Avoid devascularization of skin flaps
Locating tendon ends:
- haemorrhage within tendon sheath
- 'milking' proximal to distal
- grasping exposed interior substance of tendon stump with fine toothed forceps
- pre-op ultrasound

- Avoid blind passage of instruments into tendon sheath – promote intrasynovial adhesions
- If proximal tendon is retracted & inaccessible, retrieve by distal – proximal passage of small feeding catheter

- 20G needle placed 1-2cm prox + distal to transected ends to stabilize ends for repair
- Protect annular pulleys, especially A2 and A4
- Do repairs through C1 and C2
- Reconstruct sheath where possible

Surgical technique

No man's land

Attributed to Bunnell 1934
Zone 2
Discouraged primary repair in this zone
The preferred treatment was free tendon grafting
Kleinert reported excellent results with primary suturing in 1967
Then it was believed that only FDP should be repaired in zone 2.
Now, in experienced hands, it is believed best to repair both FDS and FDP (FDS first)

Suturing material

- Braided polyester fiber 3/0 or 4/0 most popular
- Flexibility & ease of handling
- Minimal mechanical trauma to tendon
- Allow early digital mobilization

Repair methods

- Core sutures: greatest tensile strength – multiple sites of tendon interaction
  - Kessler/ modified Kessler, Bunnell
  - newer – Tajima, Strickland
- At least 4 strand core suture
- Dorsal placement of core suture
- Locking better than grasping
- Knot placement does not have an effect on tensile strength but placement away from the repair ↓ tendon glide

- Multistrand positives:
  - Less gap formation
  - Less tendon ruptures
- Multistrand negatives:
  - Technically more difficult
  - Tendon thicker
  - Increased gliding resistance

Epitendinous sutures

- ↓ repair site bulk
- ↑ tensile strength
- Bite of 25% of diameter of tendon

Obliquely lacerated tendons

- Change from modified Kessler (grasping) repair to locking Kessler repair
- Lengthen the longitudinal strands

Partial tendon lacerations

- General consensus that lacerations of less than 60% of the tendon substance should not be repaired
- Potential complications:
  - triggering
  - entrapment
  - late rupture
- Beveled edge can be trimmed

Annular pulley injuries

- A2 and A4 pulleys should be repaired or reconstructed if they are deficient
- Reconstruction can be done by using a free tendon graft or part of the extensor retinaculum

Rehabilitation

- Surgical technique and quality of repair likely attributes to only 50% of end result success
- Different rehab protocols – no method guarantees successful outcome in all pts

- Early moblization following tendon repair:
  - stimulates tendon healing
  - minimises adhesions
- Controlled motion of healing tendon
  - improves tensile strength
  - improves gliding
- Tendon excursion of 3 – 5 mm required to prevent firm adhesions (Duran & Houser)

- Rehabilitation should be individualized:

1. Type of injury
2. Quality of repair
3. Compliance of patient
4. Patient's insight

Rehabilitation – Methods

- Early Passive Motion Fingers splinted in flexion – rubber band traction
- Pt instructed to extend fingers actively for 5sec
- Repeated 10 X / hour
- Bands left unattached at night & during alternating periods – prevents flexion contractures of IPJ's

- Warn pts against passive extension of wrist & fingers

- Dorsal splint:

- wrist: approximately 20 degrees flexion
- MCPJ's: approximately 40 – 70 degrees flexion
- IPJ's: full extension

- Negatives:
- -Significant loss of PIPJ extension
- -Poor mobiliser of the DIP joint if used without distal palmar bar

Early Active motion

- Dependant on - strong repair
  - early referral to OT
  - pt comprehension & compliance

Wait 3 – 5 days – avoid fresh bleed & adhesions
Dorsal blocking splint
Initial passive flexion & extension – overcome stiffness
'place & hold' exercises: finger placed in flexion & held for 5sec
Gentle active flexion +/- 14 days post op

Rehab – wk 5-6

- Splint removed for hand wash, lotion or hand cream, scar tissue massage
- Active movement with minimal resistance
- Splint remoulded – more wrist ext
- Paraffin wax or U/S – reduce joint stiffness
- Tendon gliding exercises

Rehab – wk 7 - 12

- Dorsal splint worn at night
- Activities against resistance introduced
- Return to light duty
- Return to normal duty by wk 12
- No contact sport for another 4 wks

Complications of Flexor tendon repair

- **Gap formation** - due to:
  - breakage of suture material
  - inadequate suture method
  - poor immobilization
  - excessive prox muscle pull

(Lindsay & Thompson)

- > 3 mm: No significant repair-site tensile strength increase between 3 – 6 weeks
- > 3 mm: Gap filled with fibrosis
- > 3 mm: Gap progressively increased in size till tendon eventually ruptured

Less gap formation with multistrand, multigrasp suture methods – 4 strands being optimal

Tendon rupture
50% because of pt non-compliance
May present like infection
Prompt re-exploration and repair

Infection

Flexion contractures
Prompt recognition
NB: Extend PIP's and DIP's fully and regularly during exercises
Addition of palmer bar to dorsal splint

Bowstringing
Triggering

Extensor Tendon Rehab

- Dynamic Splinting with early passive motion
  - D5 post-op – dorsal dynamic extension splint
    (wrist 40-45° ext, MCPJ rests at 0°) + palmar block
  - allows controlled flex of MCPJ 0 - 30°
  - achieve gliding of repaired tendon
  - passive flex of IPJ's through FROM within splint
    - 3 – 4 wks post-op palmar block removed - ↑ MCPJ flexion & tendon excursion allowed
  - initially fingers ext with short lever arm (IPJ's flexed)
  - wrist in slight flex (wrist flex synergistic with finger ext)

- Passive splinting with early active motion
  - D3 – 5 post-op, hand placed in volar splint
    (wrist 40-45° ext, MCPJ 20-30° flex)
  - 'place & hold' exercises in the splint
  - progress to active ext of MCPJ from 30-0°
  - splint worn for 4 wks then shortened
- Either treatment regime may still lead to ext tendon adhesions over MC
- Early oedema control, digital scar massage, early motion prevent adhesions