IC73-R: Chronic Flexor Tendon Injuries within Digital Sheaths

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Session Handouts

75TH VIRTUAL ANNUAL MEETING OF THE ASSH
OCTOBER 1-3, 2020

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Delayed Repair of Flexor Tendon Lacerations in the Digital Sheath

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Disclosures: None

“No Man’s Land”
The flexor system is divided into 6 zones:

Zone 1: distal to FDS
Zone 2: fibro-osseous flexor sheath
Zone 3: origin of lumbricals from FDP
Zone 4: flexor tendons within the carpal tunnel
Zone 5: muscle-tendon junction to proximal carpal tunnel

Direct repair of flexor tendons within the digital sheath

Verdan: Primary repair of flexor tendons, 1960
Kleinert, Kutz, Ashbell: Primary repair of lacerated flexor tendons in "no man's land", 1967

?: how to best to treat flexor laceration in Zone 1 and 2 that has occurred more than two weeks ago

31 patients, 37 digits
Zone 2, FDS and FDP
Delay 1 to 21 days
TAM
Excellent: 11 (35%)
Good: 10 (32%)
Fair: 2 (1%)
Poor: 8 (26%)
Delay did not affect TAM

Purpose of this study
Review the results of repair of lacerated flexor tendons within the digital sheaths of the thumb and fingers when treatment was delayed more than two weeks
Compare these results with published reports of one stage free tendon grafts

Methods
Retrospective review
48 patients
38 injured one or more fingers
10 injured the thumb
Finger Injuries

38 patients

Zone 1: 16 pts (one pt injured 2 fingers)

Zone 2: 22 pts
12: FDP in one finger
6: FDS and FDP in one finger
1: FDS and FDP in two fingers
1: FDS and FDP in two fingers and FDP in one

Interval between injury and surgery

Thumb: 2 to 7 weeks (avg. 5.5 weeks)

Fingers: 2 to 96 weeks (avg. 8.5 weeks)

Criteria for repair

No scar contracture
Supple joints
Minimal swelling, induration
No infection
Minimal muscle contracture
Good pulley system
Repair technique

- Direct repair
  - Modified Bunnell or Kessler
  - 3-0 or 4-0 core plus 6-0 epitendon

- Advancement
  - FDP and FPL
  - Up to 1.5 cm

- Post op protocol
  - 33 pts immobilized x 3wks
  - 5 pts early mobilization

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Total Active Motion Grading Scale

<table>
<thead>
<tr>
<th>Finger</th>
<th>Thumb</th>
</tr>
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<tbody>
<tr>
<td><strong>Excellent</strong></td>
<td>&gt;220°</td>
</tr>
<tr>
<td><strong>Good</strong></td>
<td>200 to 219°</td>
</tr>
<tr>
<td><strong>Fair</strong></td>
<td>180 to 199°</td>
</tr>
<tr>
<td><strong>Poor</strong></td>
<td>&lt;180°</td>
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Bunnell and Boyes Grading Scale

Results were considered satisfactory if:

- Finger flexed to within 1 inch of the DPC
- Loss of IP extension did not exceed:
  - 45° in the index and middle
  - 60° in the ring and small

If converted to TAM, satisfactory result:

- 185° for the index and middle
- 165° for the ring and middle

(TAM 185=fair, 165=poor)
Results : Zone 1 FDP

17 repairs
9 – direct
8 – advanced

TAM
120-265, avg : 215°
Excellent : 8
Good : 6
Fair : 1
Poor : 2

Results : Zone 2 isolated FDP

13 tendons
11 - direct repair
2 – advanced

TAM : 110-270° (avg 207)
Excellent : 7
Good : 1
Fair : 1
Poor : 4

Results of 30 Zone 1 and 2 FDP injuries

Total Active Motion
Excellent : 15
Good : 7
Fair : 3
Poor : 6

Avg DIP motion : 37°
Zone 2: FDS and FDP injury

11 fingers
10 repair of FDP
1 repair FDS and FDP

TAM: 80-260° avg = 178°
Excellent: 5
Good: 0
Fair: 2
Poor: 4
2: drug addict
2: children

Results of 10 thumb flexor repairs

TAM
Excellent: 6 pts = >45°
Good: 3 pts = 31 to 45°
Fair: 1 pt = 16 to 30°
Poor: 0 pt = <16°

Avg TAM 44°
90% satisfactory

Results of one stage flexor tendon grafts for injury to FDS and FDP

Pulvertaft 1956 – 90 fingers
90% flexed to within 1.5 cm of DPC
3 graft ruptures
2 flexion contractures >30°

Boyes 1971 – 607 fingers
95% flexed within 5 cm of DPC 21 graft ruptures
14 tendolysis
33 flexion contractures >40°
If converted to TAM
85% satisfactory
72% for present study
Comparative results of free tendon graft vs delayed repair of isolated injury to FDP

McClinton, JHS, 1982
100 grafts
Avg DIP motion: 48°

Stark, JHS, 1977
25 grafts
Avg DIP motion: 37°

Present study
Avg DIP motion: 37°

Results of one stage reconstruction in thumbs

Pulvertaft (graft)
70% at least 40°

Boos (graft)
80% more than 50% of passive IP ROM (similar to Pulvertaft)

Posner (FDS transfer)
Avg: 53°

Present study
Avg: 44°
100% at least 30°

VS:
Conclusions of this study

Delayed direct flexor tendon repair for lacerations within the digital sheath may be possible several weeks or months after injury under certain circumstances.

Flexor tendon reconstruction may therefore may not be always required for delayed treatment.

Delayed repair of the FPL and isolated FDP can yield recovery equal to tendon grafting.

Results for delayed surgery for FDS/FDP lacerations are not as satisfactory but results are similar to grafting.
Flexor Tendon Single Stage Reconstruction

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ICL 73R, ASSH 2020

Case Example

13yo M, RHD
Presented 3 months after stabbing himself with pocket knife in index finger over P1
Inability to actively flex PIP and DIP
PROM
- MP - 0 - 90
- PIP - 0 - 100
- DIP - 0 - 40
History

- 1960's - flexor tendon repairs in zone II were almost exclusively performed with tendon grafts
- "No Man's Land"
- In 1967 Kleinert presented series of zone II primary repairs
- Stressed meticulous technique and early motion, changed treatment forever

INDICATIONS

1. Failure of primary tendon repair.
2. Injuries resulting in segmental tendon loss.
3. Delay in repair with proximal retraction that obviates primary repair (ill-defined time frame)
4. Significant soft tissue loss, tendon coverage issues
CONSIDERATIONS

- Age
- Mechanism and extent of trauma – crush, fractures, N/V injury, skin loss (poorer prognosis)
- Level of laceration – outside the tendon sheath better
- Comorbidities
- Patient compliance – proper patient selection is key

1. The patient should be highly motivated, able to be compliant with a rigorous postoperative regimen

2. Pre-operative Boyes classification of grade I


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<tr>
<th>Grade</th>
<th>Preoperative Condition</th>
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<td>1</td>
<td>Minimal scarring with mobile joints and ectopic changes</td>
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<td>2</td>
<td>Chronic heavy skin scarring because of injury or interventional surgery; deep scarring because of failed prior repair or infarction</td>
</tr>
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<td>3</td>
<td>Joint damage; injury to joint with restricted range of motion</td>
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<td>Nerve damage; injury to digital nerves resulting in trophic changes in finger</td>
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<td>Multiple sites of damage; involvement of multiple fingers with combination of above problems</td>
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1. The injured digit should have full PROM.
4. Scars should be supple, soft and mature.
5. Digit well perfused, at least one proper digital nerve intact.
6. The flexor tendon sheath should be intact with minimal scarring.


**TECHNIQUE - INCISION**

- Volar zig-zag vs. mid-axial
- Previous incisions may dictate

**GRAFT SELECTION**

- Intrasynovial
  - Less scarring/adhesions
- Extrasynovial
  - Easier to harvest
  - Plantars (top to plant), plantars (top to 5th)
  - Generalized flexion 5 or less

Palmaris (tip to palm), plantaris (top to 5th). (L100)
**GRAFT LENGTH**

- Critical
- Measure, wrist in neutral, the extended finger from the distal juncture to the proximal juncture
- Then add about 5 cm to allow for weaves

**TECHNIQUE**

- Excise remaining tendon within zone 2 (keep pulleys- A4 probably not critical)
- Leave 1 cm of FDP to augment repair
- Leave 2 cm of FDS to help prevent PIP joint hyperextension deformity
- Pass tendon graft, proximal to distal using pediatric feeding tube/any catheter

**TECHNIQUE**

- Distal Repair first!
- Suture through or around bone to a button
- 4 mm distal to lunula, 2 mm from midline
- Tendon to tendon
- Micro suture anchors
- Weaker of two junctions
TECHNIQUE

- Slightly overtension normal cascade - better too tight than too loose
- Fingers are more flexed as move ulnarily
- Pulvertaft weave to FDP
- 3 passes, 90 deg, 3-0 suture

TECHNIQUE

- Proximal juncture outside of sheath
- Palm - Just distal to lumbrical origin, excise lumbrical only if scarred
- Pull lumbrical distal during repairs, suture to itself
- Can excise A1 pulley
- Forearm-used if palm or lumbrical are damaged, need plantaris (preferred)

TIPS

- Reconstruct only one tendon in each finger
- Rarely sacrifice an intact FDS tendon (small finger possibly)
- Ensure proper graft tension. Triple check this. Use “stay suture” until certain!
- Close Digital incision before proximal juncture
POST-OP REHABILITATION

- OT starts POD 2-3
- Static dorsal blocking splint, wrist in neutral, MP joints 45 degrees of flexion, IP joints extended
- PROM starts immediately
- Week 2-3, start place and hold (strong repairs!)
- Week 4, start AROM and blocked ROM
- Week 6, splint removed, start light resistance

FDS intact, FDP reconstruction...

- Most patients adapt well, especially if DIP doesn't hyperextend
- If no weakness or DIP joint instability, can perform a DIP joint tenodesis or fusion
- Surgery - RARELY NEEDED
- Young patient who needs DIP joint flexion (e.g. guitarist), ulnar digits for power grip, and in fingers with limited active PIP joint flexion

FDS intact, FDP reconstruction...

- Thinner graft is best (plantaris) and passed through FDS decussation
- No need to resect a FDS slip
- Early active ROM protocols to minimize adhesions
- Schneider published that many patients needed tenolysis despite careful patient selection- be careful!
Case Example

- Since 13 y/o and only 3 months post injury:
- Able to remove FDP and FDS while not damaging pulleys
- Pediatric feeding tube used to pass PL
- Was mature, complaint with rehab
- Good result

THANK YOU
Staged Flexor Tendon Reconstructions

pseudo-sheaths to reduce scarring and adherence of grafts

- celloidin tubes (Leo Mayer - Hospital for Joint Diseases - JBJS 1936)
- vitallium
- glass
- stainless steel rods
- silicone rods
  - smooth, flexible (main advantage) and stable to heat (300°F) and cold (-100°F)

“Transplantation of Tendons Through Preformed Gliding Channels”
Joseph Milgram - Bulletin of HJD 1984

“Formation of Tendon Sheath by Silicone Rod Implants”
Bassett and Carroll - JBJS 1963
- Hunter rods far superior - dacron fibers in the silicone
- sutures do not “cut through” rod when attaching to FDP stump

- proximal end of rod in forearm must be under fascia
  - rod must glide freely with passive flexion and extension of finger
  - should not buckle

- silicone rod sutured deep to FDP remnant (or volar plate)

• passive finger motions begin 1-2 days post-op
  • must be careful with DIP passive extension
    - periodic x-rays to determine rod has not detached

stage 2:
• when swelling resolved and passive mobility restored
• approx. 10-12 wks. - can be longer - even 6 months

• proximal end of rod in forearm must be under fascia
  - rod must glide freely with passive flexion and extension of finger
  - should not buckle
• tendon graft should span from fingertip into forearm
  • tenodesis effect of wrist motions ↑ absolute amplitude (approx. 2.5 cm)
  • effective amplitude more important than absolute amplitude

  • order of preference for donor tendon for 2nd stage
    # 1 - plantaris
    # 2 - long toe extensor (2nd, 3rd or 4th)
      - not EHL or 5th toe (has no short extensor)
    # 3 - palmaris longus (PL)
      - long enough for a thumb to extend into forearm
      - not long enough for a finger

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A Caveat About Staged FTG's

“Intratendinous Ruptures of a Flexor Tendon Graft Many Years After Staged Reconstruction: A Report of 3 Cases”


• 3 clinical cases:
  – 2 grafts ruptured 12 years post surgery
  – 1 graft ruptured 24 years post surgery

• at surgery, caliber of ruptured tendons was the same as caliber of the original graft - Wolff’s law does not appear to apply to FTG’s

• patients should be alerted to the possibility of late ruptures, even many years later

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• prior to stage 2 – be certain rod in place – can usually palpate end of rod in forearm with passive finger motions - confirm with a lateral x-ray of finger
  • at exam prior to scheduling stage 2, prox. end of rod not palpable
  • x-ray of hand – rod not visible
  • x-ray of forearm showed the entire rod
  • he had been playing touch football

• at surgery, harvest the autogenous tendon graft first before exposing proximal end of rod – the graft determines the location of junction site with the motor
  – only a plantaris or toe extensor* will span from forearm to fingertip
  (* toe extenders often interconnect and may not be of adequate length)
  – PL graft – junction will be in the palm for a finger
Boyes’ pre-operative classification

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Indications for Staged Reconstructions:

1. Severe scarring of tendon sheath
2. Flexion contracture of PIP
3. Volar instability of PIP
4. Nerve damage - anesthetic finger
5. Severe scarring of volar skin and subcu. of finger
6. Multiple fingers

Clinical Examples:

1. Severe Scarring of Tendon Sheath
   - pulley reconstructions required in almost all cases
Pulley Reconstruction: techniques

- Double or triple loop
  - Tendon graft wrapped 2 or 3 times around finger at multiple sites often interferes with ext. tendon mechanism

- Belt loop of volar plate
  - Often too tight and location only at PIP joint - not optimal

- Distal slip FDS
  - Location also only at PIP joint - not optimal

- Fibrous rim
  - Less complicated technique than in diagram that requires most of sheath being intact and a long “shoe-lace” graft
  - Requires a short segment of previously lacerated tendon - can use ½ thickness - tendon segment sutured to one side of rim
    - Silicone rod placed in finger - tendon sutured to other side of fibrous rim
    - One 4-0 nylon suture at each corner of graft inserted obliquely to pull tendon taut
  - Reconstruct all 3 annular pulleys (A-1, A-2, and A-4)
    - A-1 as important as A-2

- Through bone method - applicable for thumb - not fingers
  - Hole in base of prox. phalanx to reconstruct oblique pulley (most important pulley)
  - In a finger, hole in prox. phalanx for A-2 pulley has greater risk of fracture

- FPL bowstring - no sheath
  - Graft (FPL) then phalanges, around FPL and sutured to itself at level of oblique pulley

- Post-op - improved IP flexion
26 y/o female: 3 failed operations
1. 1º repairs both tendons 7 yrs. ago
2. FTG 5 yrs. ago
3. tenolyses 2+ yrs. ago

- scarred tendon
- no tendon sheath
- 3 pulleys reconstructed +
silicone rod

12 wks.: passive ROM restored

- stage 2: no plantaris or toe ext. of sufficient length
- PL harvested first followed by incision in palm
  where junction to FDS of adjacent ring was sutured

post-op – stage 2

20 y/o male: lac. FDP left ring >2 yrs. ago
- no treatment at time of injury
- professional musician - difficulty playing guitar

Reconstruction of FDP with intact FDS:
2-stage procedure necessary due to scarring and no pulleys
- A-2 pulley reconstructed distal to FDS decussation (arrow)
Division of Hand Surgery
Department of Orthopedic Surgery

second stage - rod replaced with plantaris tendon
• junction with motor in forearm

post-op – stage 2

2. Flexion Contracture of PIP

42 y/o male:
failed 1st repairs FDS + FDS index lac. 2 yrs. ago
- PIP rigid flexion contracture
- no improvement with therapy and use of static progressive ext. splint
- sensibility intact

42 y/o male:
failed 1st repairs FDS + FDS index lac. 2 yrs. ago
- PIP rigid flexion contracture
- no improvement with therapy and use of static progressive ext. splint
- sensibility intact
- PIP capsulectomy + pulley reconstructions + silicone rod
- with severe PIP flexion contractures alert patient to post-op numbness that can be permanent due to traction on digital nerves

3. Volar Instability of PIP

31 y/o male: 2 failed operations
1. 1st repairs lac. both tendons + volar capsule PIP joint 7 yrs. Ago
2. tenolyses

Problems: volar instability PIP + no active flexion

- capsular repair (prox. volar plate) + reconstruct pulleys + silicone rod
Stage #1: post-op 6 months:
- full passive ROM + volar PIP stability restored

Stage #2: post-op

4. Nerve Damage - anesthetic finger
(often a contraindication to staged reconstruction)

44 y/o female:
- ripping injury (power saw) 6 months ago
- tendons and nerves cut – finger anesthetic
- NYC Park Avenue “socialite”

- surgical options:
  1. amputation (procedure of choice for a laborer)
  2. fuse IP joints + nerve grafts
  3. reconstruct flexor tendon + nerve grafts (sural)
5. Severe scarring of volar skin and subcutaneous tissues of finger

- A tendon graft will not glide under severely scarred skin or under a free skin graft
- Requires good “cover” - skin + subcutaneous tissues

36 y/o male: 2 failed operations
# 1. 1º repair FDP 6 yrs. ago
# 2. tenolyses 5½ yrs. ago

Problems: scarred and contracted finger
- Sensibility intact

Options:
1. Fuse PIP: resect sufficient bone dorsally to overcome contracted volar skin
- Result is a little finger that is truly “little”

2. Reconstruct flexor tendon: much more complicated
- Must resurface volar surface: skin + subcu. tissue (pedicle)
- dense fibrotic skin excised + pulleys reconstructed
- alert pt. to post-op numbness due to traction on nerves
- cross finger pedicle flap provided padded skin

- post-op stage 1 (4 months)
- post-op - stage 2

6. Multiple Fingers
- results decrease exponentially with each additional finger requiring reconstruction
23 y/o male:
- hand caught in meat tenderizing machine 3 months ago
- FDS and FDP disrupted in middle and ring
- FDP in little intact but scarred – limited excursion

1st priority – restore passive ROM – therapy + splints (static progressive, then dynamic)

- tendon grafts cannot restore active motions to stiff fingers

- PO stage 1: silicone rods middle / ring
  + tenolysis FDP little (regained full flexion little)

- stage 2: rods replaced with both plantaris tendons

When 3 or 4 fingers require staged reconstructions

Objective: simply restore functional active arcs of PIP motions
(alternative are PIP fusions – perhaps also DIP fusions)

- achieving even 20° - 30° of active PIP motions preferable to absence of any motions with fusions
Operative procedure different when 3 or 4 fingers involved:
- proximal ends of rods end in the palm and not forearm

Reason:
- patient may not have 3 or 4 tendons to span from fingertips into forearm - plantaris tendons may be absent and toe extensors may not be of sufficient length

35 y/o staged reconstruction for 3 fingers

Stage 1: rods end in the palm and sutured into FDP tendons (fish-mouth) with fingers in slight flexion
• prevents rods from poking into median nerve with passive finger flexion and decreases amount of buckling

Stage 2: 4 months later – junction of grafts and motors in palm
post-op. stage 2 (arcs of motion approx. 50°)
Staged FTG for Thumbs:

**stage 1:** same as for a finger (reconstruct pulley + silicone rod)
- oblique pulley (not A-1) is most important in thumbs

**stage 2:** two options:

1. **FTG** (PL will reach from thumb into forearm)
   - problem: FPL muscle has likely undergone a contracture that will limit excursion of the graft
   - FPL muscles more likely to undergo contractures than FDS or FDP muscles
   - reason: FDP tendons do not retract as much - held by lumbrical
   - < 1cm of excursion of FPL

2. **tendon transfer** (FDS middle or ring finger)
   - advantages of a transfer over a graft:
     1. transfer has normal excursion
     2. no sutures between graft and motor in forearm
     3. FDS inserted directly into distal phalanx

Reference:
- Flexor Superficialis Tendon Transfers to the Thumb: Alternative to Free Tendon Graft for the Treatment Of Chronic Injuries within the Digital Sheath
  Posner, MA. Journal of Hand Surgery 1983
“Man was given the hand because he was given spirit”
Aristotle