Maximizing Functional Outcomes after Flexor Tendon Repair

Presented by
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Disclosure: I DO NOT have a financial relationship with any commercial interest.
Issues today are the same as they were 75 years ago:

- Tendon adhesions
- Loss of motion (both in flexion and extension)
- Tendon gapping (can lead to increased scar, weaker tendon & insufficient excursion)
- Risk of rupture
Surgical technique changes

- Shorter splints
- Wrist position/wrist inclusion
- Decreasing MP flexion in splint
- Early AROM/Out of splint AROM
- Relative motion flexion splinting

(Chung 2017)

What’s Trending/
Hot Topics
(Tang 2018)
TREATMENT PLAN

Clinical Judgement

Experience

Evidence
Phases of Healing

- Inflammatory (0-1 week)
- Fibroplasia/proliferative phase (1-6 weeks)
- Remodeling (around 4 weeks)
Surgical techniques and terminology

- Type of repair
- How many strands
- Peripheral suture?
- Pulley venting?
Rehabilitation Goals

- Increase passive joint motion
- Increase tendon glide w/ lowest force (incremental controlled stress)
- Decrease edema
- Prevent adhesions, gapping, rupture
- Patient education
Post-op Options

Immobilization

Early Passive Motion (EPM)
- tendon “buckle” vs. true gliding?

Early Active Motion (EAM)
- Goal: Increase glide, Decrease work of Flexion
- Tenodesis: most amount of glide (3.5 mm), least amount of tension compared to other motions (Savage 1988; Lieber et al, 1996)
Benefits of Early Motion

- Tendon adhesions decreased if tendon allowed 3 mm of glide (Duran et al, 1976)
- Increased nutrition to the tendons via synovial diffusion (Amadio, Jaeger & Hunter, 1990)
- Reduces inflammation
- Encourages collagen fiber alignment
Early Passive Mobilization: 1970’s

- Based on work of Kleinert (1967) and Duran & Houser (1975)

- 3-5 mm glide sufficient to prevent adhesions

- Modified Duran: DBS: wrist 30 deg, MPs 70. Passive flexion, active extension to roof of splint.

- Kleinert: DBS, digits held in flexion with rubber bands. Passive flexion, IP extension against rubber band resistance
Early Active Mobilization

- With EPM, tendency for tendon to “buckle” – how much glide actually occurring?

- Goal: Increase glide, Decrease work of Flexion

- Tenodesis: most amount of glide (3.5 mm), least amount of tension compared to other motions (Savage 1988; Lieber et al, 1996)

- Terminology varies: should look for “true active flexion” (Nieduski 2019)
<table>
<thead>
<tr>
<th>POST-OP</th>
<th>SPLINT</th>
<th>EXERCISE</th>
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<tbody>
<tr>
<td>Day 4</td>
<td>DBS wrist neutral to 45 deg ext, MPs 30 deg flex, IPs straight</td>
<td>True active flexion, 1/3 to ½ fist (in splint) Active IP extension w MP flexed</td>
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<td>2-4 weeks</td>
<td>Manchester short splint, blocking wrist to 45 deg ext</td>
<td>Active synergistic AROM in splint Increase active fist: ½ -2/3</td>
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<td>4-6 weeks</td>
<td></td>
<td>Work towards full fist by week 6</td>
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<td>6-8 weeks</td>
<td>Short splint D/Ced Can initiate pm ext splinting if flexion contracture RMFS daytime if needed</td>
<td>Start to use hand for light activity</td>
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Early Passive-Partial Active Flexion Protocol
(Tang 2021)

Update to the Nantong Protocol: “wrist position unimportant”
Full passive flexion 10-30 cycles
EAM ½ fist or within comfortable range: “point of comfortable resistance”
40-80 cycles of AROM minimum of 4x/day: recommends setting a timer for 15 minutes
Manchester Splint  (Wong & Peck, 2014)

**Wrist:** extension to 45 deg is optimal position to dec forces from extensors (MAMTT) (Evans & Thompson 1993)

**MPs:** flexed to 30 deg: excessive MP flexion will bias motion to PIPs, forcing DIP to flex at end range
Relative Motion Splinting

- Relies on “quadrigia effect” of 1 muscle belly/4 tendons for FDP
- Affected digit placed in relative flexion compared to unaffected digits
- Limits tension placed on repair site/decreased elongation of FDP
- Encourages active PIP extension/↓rate of PIP flexion contractures
- Functional hand use is allowed earlier: “move it, and (progressively) use it”

Henry & Howell 2020; Newington 2022
Work of Flexion

- Work required of repaired tendon to actively flex
- Force going through repair site can’t exceed strength of repair
- Will lead to gapping, rupture
- Must also take into consideration: edema, scar, joint stiffness, wrist position/extrinsic extensors, bulk of repair

(Skirven & DeTulio 2023)
Figure 1. (a) (A) At the full extension of the finger, the tendon shows physiological curves within the digital flexor sheath. (B) When the finger is slightly flexed, the curvature of the tendon is small and smooth. The tendon sustains a small amount of bending force. (C) When the tendon is increasingly flexed, the tendon curvature increases and the bending force increases accordingly. (D) At the extreme of digital flexion, the tendon gliding arc becomes nearly circular, and the tendon is the easiest to disrupt. Therefore, the safe range of active digital motion is from full extension to moderate flexion.

(b) Active flexion between two shown positions is in the safe range.

MP: metacarpophalangeal joint; PIP: proximal interphalangeal joint; DIP: distal interphalangeal joint.
Forces on the Tendon

• Mean strength of 4 strand repair: 49-85N, 8 strand 82N

• Place/hold: significantly higher forces on FDS with wrist 30 deg flex compared to neutral

• Active flexion: Significantly higher force on FDP w/ full fist

• Isolated FDP/FDS (blocking): Highest forces recorded, FDP

• Tenodesis: mean forces FDP: 2.8N/FDS: 2.7N

(Edsfeldt 2015)
# Effects of Edema:

*(Cao and Tang)*

<table>
<thead>
<tr>
<th>Moderate edema adds 7N of force</th>
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<tbody>
<tr>
<td>Severe edema adds 9N force</td>
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<tr>
<td>Minimum of 6 reps needed to decrease force, WOF by 30% (?)</td>
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<tr>
<td>NSAIDS: may decrease adhesions, but also may reduce strength of repair (Kulick et al)</td>
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<tr>
<td>Leave the coban on!</td>
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When to start therapy?

Ideally: pre-op for splint and pt education

- Exercises are initiated pod 3-5
- Edema control as soon as possible
  - Mod/max edema increases resistance
  - coban
Splint

- **Wrist**: slight ext
- **MPs**: flexed
- **IPs**: Splinted straight, but strapped in loosely. IPs unstrapped at night
Home Exercise Program: #1

#1: PROM to affected digits to warm up the joints and decrease friction and the work of flexion (WOF)
Isolated Passive Glide
Home Exercise Program #2:

• True active flexion: 1/3 - 1/2 fist initially, progress to full fist by week 6
Home Exercise Program #3: MP Flexion, Active IP extension
Tenodesis
Exercise frequency

- min of 10 reps, 5-6x/day
- Should be the last thing they do before going to bed, 1st thing when they wake up
“Think like a chef”

• DIP: 1mm glide for every 10 deg
• PIP: 1.3 mm for every 10 deg *(McGrouther & Ahmed 1981)*
• Strickland’s Percentage:

\[
\frac{\text{Active PIP + DIP flexion minus ext lag}}{\text{175 (AAOS norms)}} \times 100
\]
Issues to watch for

- Decreased tendon glide/adhesions: active vs passive
- Digit “trapping” (can be addressed with buddy strap with foam)
- Edema
- IP flexion contractures
- Compensatory motions

• Increased joint stiffness
• Increased adhesions
Trapping:
Functional Motions to Increase ROM:

- “Spinning” wine glass
- Manipulating cell phone
- Be Creative!
• Treatment algorithm based on tissue response \( (\text{Groth, 2004}) \)
TENDON GLIDING EXERCISES

OPEN PALM

DUCK / ROOF TOP

STRAIGHT FIST

FULL FIST

HOOK FIST
Blocking exercises: volar or lateral support

(Osanami 2020)

Found to have decreased WOF with lateral support

Volar support may increase tendon resistance
Splints to gain motion
Adherence to precautions

- Up to 67% of patients remove DBS for ADLs or are non-compliant (removing velcro to perform task, etc) (Sanford 2008; Kaskutas & Powell, 2013)
- Non-compliance associated with increased rupture rate.
- Adherence higher in 1st few weeks post-op, then gradually decr over time
- Home instruction: what not to do, how to modify activity to perform safely
Patient Personality Profile

- **The overachiever**: "the more I exercise, the faster I’ll recover" increased swelling, gapping, rupture
- **High strung**: only performs exercises in the presence of the therapist
- **Too cool for school**: “I don’t really need to wear this splint”
- **Uncoordinated**: difficulty understanding exercise technique

- **Therapist personality profile**: Newer or less experienced may be hesitant to advance pt appropriately. Older therapist may be stuck in old ways
Less research on FPL repair

FPL mechanics inherently different than FDS/FDP

Greatest glide occurs w isolated IP flexion (MP at 0)

IP flexion 35 deg w wrist neutral produces 1.3N force (*Rappoport, 2015*)
References


Chung B, Chiu DT, Thanik V. Relative motion flexion splinting for flexor tendon lacerations: proof of concept. Hand. 2017 1-4


References


Thank you!

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