Zone Specific Management of Flexor Tendon Injuries to the Hand

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In the Literature

• No one definitive rehabilitation program

• Outcomes:
  – Minimize or modify tendon adhesions
  – Promote optimal finger movement
  – Promote differential tendon glide
  – Avoid force or stress that could lead to gapping or rupture
  – Prevent deformity
  – minimize the WOF (work of flexion)
What Protocol to Use?

• Young or Unable to comply
  – Immobilization or delayed movement

• Stiff/Edematous fingers
  – Early Passive (Kleinhert, Duran, Indiana Hand Protocol)

• Good passive movement, minimal edema, strong repair, compliant
  – Early Active (Solomans, Allen, Belfast, Strickland, Silfverskiold and May, Evans and Thompson, Jin Bo Tang, Fiona Peck)
CURRENT IDEAS

• Recent literature now supports early active mobilization over purely passive regimens
• Stronger repairs have improved safety
• Local anesthesia allows testing of the repair and prevention of gapping
• Regimens must still be adapted to individual patient needs
What is Early Active Motion

  — work of flexion increased significantly in tendons mobilized after day 5, whereas work of flexion increased the least for tendons initiating active mobilization at 3 days.

  — Recommended starting rehabilitation on the 5th day when gliding resistance is lower

  — Post traumatic and postoperative oedema increases the work of flexion and therefore the load on the repaired tendon

• start motion between day 3-5.
  — Allows bleeding to stop, less bleeding less scar
  — Elevate and rest hand to help reduce edema, reduce work of flexion
Work of Flexion

- The amount of Work (force) necessary to overcome the resistance to glide:
  - Cao, Amadio et al. (JHT 2005)
  - Internal factors – related to tendon:
    - Glide-resistance between tendon and sheath
    - Curvature of flexed digit – pulley integrity (tang)
  - External factors:
    - Stiff joints
    - Edema of the hand and tendon
    - Resistance (length) of antagonists (extensors)
Passive Motion before Active Motion

• Passive motion reduces WOF
  – prevent tightening of dorsal structures and joint stiffness
  – must be performed over the entire range
  – vital part of regimen
Resistance of Digital Flexion


- Resistance to digital flexion increases over the range
- Least resistance in the first two-thirds of flexion
- Resistance increases 5 – 10 x in final third of flexion

- Increased stress of tendon around pulleys and joints

Full fist:

- Place and hold in this position may not be safe in digital repairs
- Early full range active flexion is not necessary or safe

- passive exercises before active motion
- reduction edema prior to active motion
Wrist Position

● **Savage R (1988)**

  - Examined influence of wrist position on the forces required to move the IP joints
  - Wrist extended and MP joints flexed has least flexion force
  - Slight wrist extension “like resting position” puts least tension on repairs

● **Peck F (2014)**
  - 45 degrees of wrist extension is optimal position to minimize Work of Flexion
  - For active movement programs
Zone of Injury

• Dr. Verdan’s original description
• Level of injury is described according to the position of the tendon laceration in the sheath when the digit is in extension
Zone of Injury

• Understanding the anatomy involved in each zone can help with rehabilitation planning
• Lot of focus in the literature for zone 1 and 2
• Very little evidence based literature for zone 3 to 5
Zone I Injury

• Extends from the insertion of the FDS on the middle phalanx to the insertion of the FDP on the distal phalanx
• Only 5-7 mm of glide expected of the FDP at this zone
• Surgery cannot tighten repair more than 1 cm at this level
  – Quadriegia effect
Zone 1 Injury

- Only FDP tendon will be injured
- Observe PIPJ flexion but no bend at DIPJ
- Can function without FDP
- FDP is important in power grip, FDS is absent in 21%
- A4 and A5 pulleys
Force on FDP

  - FDP: as finger moves into full flexion -> more tension on the repair
  - Tension is higher:
    - With MP’s in 90°
    - compared to MP’s in 45°.
MCP Joint Position

• Fiona Peck and Gwen Van Strien
• At 30° MCP flexion:
  • motion is initiated at the DIPj
  • encouraging differential glide
• Howell, Peck (2013)
• Wong et al (2014)
MCP Joint Position

- Flexion of MP joints puts the tendon on slack
- MP motion has no significant effect on flexor tendon excursion in zone II
- 90 degrees of flexion is difficult to achieve and uncomfortable and can cause intrinsic tightness (especially in zone III) and produces little glide in zone 1 and II.
- 30-45 degrees of MCP joint flexion is enough to attain better PIP joint flexion and produce slack to prevent rupture.

- 30° **MCP** flexion more comfortable position. **IP** joints can move more efficiently to facilitate differential tendon glide (hook position) (*Elliot 1999*)
Specific Zone 1 Injury Locations

- 3 areas FDP can be lacerated
  - Under A4 pulley
    - Scar adhesions can prevent repaired tendon from gliding through the A4 pulley
    - Passive movement of the digit to minimize stress
    - **Active DIP joint movement to achieve tendon glide**
    - Each 10 degrees of movement gives 1-2 mm of excursion
  
  **** Tang(2003) need to start movement at the DIPJ
Specific Zone 1 Injury Locations

• Distal to A4 pulley
  – If damage to volar plate can get flexion contracture.
  – May need to include extension splinting (6 weeks) and active extension exercises
  – Early passive extension of IP joints with MCP and wrist in flexion, no tension on FDP
Specific Zone 1 Injury Locations

- FDP insertion site
  - Need to reinsert tendon to the distal phalanx
  - Risk of tendon shortening and DIPJ flexion contracture
  - **Maintain passive motion of the DIPJ** (difficult to do this with a Kleinert-type program)
  - Can do active flexion with a strong repair
  - If concerned with repair strength
Zone 1 Flexor Tendon Laceration Programs

- Dorsal block splint wrist in extension (6 weeks)
- Start movement at 3-5 days post op
- Start with passive finger flexion
- Initiate active movement at the DIP joint (gentle no forceful moving)
- This will promote differential glide and minimize tendon adhesions
  - Kleinert type regimes are not suitable as DIP joint does not get enough movement

Howell J, Peck F (2013) Injury
Zone 1 Flexor Tendon Laceration Programs

• Perform active digital extension exercise to prevent PIP joint contracture
• Easier done when MCP joint is blocked in flexion
• Exercises are hourly with 5-10 reps
• Synergistic motion at 2-3 weeks surgery

Howell J, Peck F (2013) Injury
Synergistic Motion

• Simultaneous finger flexion and wrist extension followed by simultaneous finger extension with wrist flexion
• Increase excursion of both FDS and FDP and helps with differential glide between the two

Cooney, Lin, & An, 1989
Synergistic wrist motion exercises

Figure 36-18 Modified passive synergistic wrist motion protocol. A, Passive full extension of metacarpophalangeal (MCP), PIP and DIP joints with wrist at 60 degrees flexion, to pull the tendon distally. B, Passive composite flexion of the finger, keeping the wrist flexed 60 degrees. C, Slow, careful wrist extension to 60 degrees (or maximum comfortable extension), with finger remaining flexed. D, Slow, careful MCP joint extension to 45 degrees hyperextension (or maximum comfortable extension). Steps are repeated in reverse order.

(From Amadio PC. Friction of the gliding surface. Implications for tendon surgery and rehabilitation. J Hand Ther. 2005;18:112.)
Zone 1 Flexor Tendon Laceration Programs

• At 6 weeks:
  • Start stretching any residual flexion deformity
• Start night extension splinting
• Return to light activity
• Return to all activity at 10-12 weeks
Zone 1 – if not a strong repair

Zone 1 Closed Avulsion Injuries

- Controlled active motion
- Type 1 – tendon has avulsed from bone and retracted into palm
  - Potential for muscle tendon shortening
  - Neutral position of wrist
- Type 2 – tendon retracted to PIP joint level with small bony fragment
- Type 3 – remains distal to A4 pulley with large bony fragment
  - Less shortening of muscle tendon unit
  - Wrist position in splint at 10-30 extension
Zone 1 Closed Avulsion Injuries

- Jersey Finger – FDP avulsion Injuries
  - Tendon avulsed from bone with or without a bony fragment
  - Protective dorsal splint in wrist neutral or slight extension (6 weeks)
  - Passive flexion exercises
  - Early controlled active flexion, starting at the DIPJ
  - Hourly exercises (10 reps)
  - At 6 weeks – may need extension splinting to treat flexion contractures
  - Gentle passive stretching. Keep MCP in flexion to protect repair while extending IP joints
  - At 6 weeks start composite extension stretching
All Zone 1 Injuries

• Passive stretching
  – Remove hand from protective splint and position wrist and MCP joints in flexion
  – Carefully passively extend IP joints

• Active extension
  – Block the MCP joint in flexion while they actively extend IP joints.
  – Howell, Peck (2013)
Zone II Injuries

- Involves both FDS and FDP glide in the flexor sheath
- From A1 pulley to the insertion of the FDS
- Used to be no man’s land
  - But now we can get good results
Zone II Injuries

- Adhesions between:
  - FDP and FDS
tendon and sheath
tendon and bone
tendon and vascular structures
- Both slips of FDS repaired – increase of gliding resistance
Zone II Injuries

• If only one slip repaired
  – Adherence to unrepaired slip
  – Catch on edge of A2 pulley
  – Impede tendon glide

• Tendons may retract into palm
  – Tight repair
  – Joint contracture

• Damage to pulley
  – A1, A2, and A3 pulleys
  – Bowstringing
Zone II Injuries

• Concentrate on:
  – Restoring tendon glide but avoid rupture
  – Regain differential glide of the FDS and FDP
Zone II Injuries

• Encouraging differential glide is very important
  – MCP joints 30 degrees flexion, initiate movement at the DIPJ
• PIP Joint motion only will allow for adherence between tendons
• Want to avoid making DIP joint flex at end range
• Tang(2003) J Hand Surg
Zone II Injuries

• Pulley injury can complicate tendon glide
  – Want to initiate active motion at the DIP
• joint and gently increase digital flexion from this point
• To do this, position wrist in 10-30 degrees of extension and MP joints in 30 degrees of flexion
• MCP Joint flexion at 60-70 degrees, active motion can not be initiated at the DIPJ
Zone II Injuries

- Wrist position at 10-30 degrees of extension
- MCP joint at 30 degrees of flexion
- Start passive and active movement at 3-5 days post-op
- Passive digital flexion first
- Hourly active IP joint flexion 10 reps (lead with DIP Joint)
- NO FORCED flexion ******
- Avoid place and hold until full active flexion achieved
Zone II Injuries

• Increase range of flexion over 5 weeks
• Perform active digital extension exercise to prevent PIP joint contracture
• Easier done when MCP joint is blocked in flexion
• Synergistic motion at 2-3 weeks surgery

Take a look at:
Tang (2009)
Howell, Peck (2013)
Wong et al (2014)
For active movement protocols
Zone II Injuries

- At 6 weeks:
- Start stretching any residual flexion deformity
- Start night extension splinting
- Return to light activity
- Return to all activity at 10-12 weeks
EXERCISE TRICKS from Gwen Van Strien

Scratch over dorsum of fingers uninjured hand to encourage DIP (FDP) motion
Active flexion → NOT place-hold

Easy way to control too much flexion

Making sure patient doesn’t go to fast

Focus on DIP— awareness on how to move

Idea from Gwen Van Strien
Synergistic Motion Using the Manchester Short splint for Zone II flexor tendon repairs

- Manchester Short Splint
- Allows wrist motion during active program
- Controlled wrist extension (45 degrees)
- Reduce work of flexion
- Greater tendon excursion
- Safe
Zone II Injuries

• Active Programs
  – Howell, Peck (2013)

• Passive Programs
  – Not Kleinhert (can’t initiate movement at DIPJ
  – Modified Duran
  – Passive synergistic movement program
  – Indiana Hand Protocol
ZONES 1 AND 2
preventing IP flexion contractures

- Prevention of flexion deformity at the IP joints is paramount
- Volar gutter splints may be safely applied at night and worn in conjunction with the dorsal splint
Zone III Injuries

- Distal border of the carpal tunnel and the A1 pulley of the flexor sheath.
- Common digital nerves, vessels, FDP and FDS, the lumbricales and interossei.
- Adhesions between tendons, lumbricales and interossei, fascia and skin.
Zone III Injuries

• Good prognosis because does not include the flexor sheath
• Both FDP and FDS should be repaired
• Delayed repair can occur as proximal end on FDP is held by lumbricle origin
Zone III Injuries

• Lacerations to mid palm:
• Injury to one or more flexor tendons
• Injury to intrinsic muscles  
  – claw deformity
• Common digital nerves
Zone III Injuries

- Dorsal block splint for 6 weeks
- Wrist 10-30 degrees of extension
- MCP joints in 30 degrees of flexion (if no nerve or intrinsic involvement)
- MCP joints in 60-70 degrees with nerve or intrinsic involvement (Want to avoid claw deformity)
- Watch for MCP joint flexion deformity due to palmar scar
- Place MCP joints in more flexion during exercise periods to facilitate IP joint extension and prevent joint contractures

Howell, Peck (2013)
Zone III Injuries

• Start passive and active movement at 3-5 days post-op
• Passive digital flexion first
• Hourly active IP joint flexion 10 reps (lead with DIP Joint)
• NO FORCED flexion ******
• Avoid place and hold until full active flexion achieved

Howell, Peck (2013)
Zone III Injuries

• Increase range of flexion over 5 weeks
• Perform active digital extension exercise to prevent PIP joint contracture
• Easier done when MCP joint is blocked in flexion
• Synergistic motion at 2-3 weeks post surgery
Zone III Injuries

• At 6 weeks:
  – Start stretching any residual flexion deformity
  – Start night extension splinting
  – Return to light activity

• Return to all activity at 10-12 weeks
Zone III Injuries


• Proximal zone III injuries, because of tendon adhesions may have limitations with composite digital flexion and limited isolated digital flexion and extension.

• Distal zone III injuries, may see flexion contractures of the digit and reduced flexion glide distally in the finger because of adhesions and not easily gliding past A1 pulley.
Zone III Injuries

• Chinchalkar SJ et al. Zone III flexor tendon injuries – A proposed modification to rehabilitation. JHT 2015, 28:3:319-324.

• Proximal zone III
  – Initially wrist positioned in 30 degrees of flexion in dorsal block splint, increasing in extension 10 degrees each week
  – MCP joint in 60 degrees of flexion
  – Passive tenodesis exercise
  – Isolated active digital extension (other fingers in passive flexion position)
Zone III Injuries

• Distal Zone III
  – Wrist in 25 degrees of flexion and gradually increase until wrist in neutral within splint
  – MCP joints in 60 degrees flexion and increase MCP extension by 10 degrees each week
  – 4-8 weeks post repair: wrist flexion with digital extension exercise
  – 8 weeks post repair: resisted finger extension
Zone IV Injuries

- Carpal tunnel
- Flexor tendons are covered by the transverse carpal ligament
- Median and Ulnar nerves, ulnar artery and superficial arch
- Adhesions to synovial sheaths, to adjacent tendons, to nerves, transverse ligament, skin.
- Adhesions between tendons limits differential glide
Zone IV Injuries

• Early active motion is most desirable
• But ... wrist extension can put tension on nerve repairs
  – Neutral or slight flexion wrist position
  – After two weeks gradually extend wrist position in splint to achieve better tendon glide
Zone IV Injuries

• Nerve lacerations will result in intrinsic muscle paralysis
• MCP joints positioned in more flexion
  – Severe clawing (60-70 degrees flexion)
  – Helps with active IP joint extension and flexion
  – Facilitate tendon motion
• Active finger flexion
• Differential tendon glide exercises
• At 2-3 weeks start synergistic motion exercises
Zone IV Injuries

• Prolonged splinting can cause intrinsic muscle tightness.

Bunnell-Lister Test for Intrinsic Tightness

• MCP joint held in slight extension while examiner moves the PIP joint into flexion – if can’t be flexed, intrinsic or joint capsule tightness

• Place MCP joint in a few degrees of flexion to relax intrinsics – if joint can now flex, then it was intrinsic tightness

• If when MCP joint placed in flexion still can’t flex PIP – then it is a joint capsule tightness or contracture.
Zone IV Injuries

- Dorsal block splint for 6 weeks
- Wrist neutral position (if nerve involvement) (2-3 weeks gradually extend position)
- MCP joints in 30 degrees of flexion (if no nerve or intrinsic involvement)
- MCP joints in 60-70 degrees with nerve or intrinsic involvement (Want to avoid claw deformity)
- Place MCP joints in more flexion during exercise periods to facilitate IP joint extension and prevent joint contractures

Howell, Peck (2013)
Zone IV Injuries

• Start passive and active movement at 3-5 days post-op
• Passive digital flexion first
• Hourly active IP joint flexion 10 reps (lead with DIP Joint)
• NO FORCED flexion ******
• Avoid place and hold until full active flexion achieved
Zone IV injuries

• Increase range of flexion over 5 weeks
• Perform active digital extension exercise to prevent PIP joint contracture
• Easier done when MCP joint is blocked in flexion
• Synergistic motion at 2-3 weeks surgery
Zone IV Injuries

• At 6 weeks:
  • Start stretching any residual flexion deformity
  • Start night extension splinting
  • Return to light activity
  • Return to all activity at 10-12 weeks

• If not favorable for early active
  – Kleinhert, modified Duran or passive synergistic mobilization
Zone V Injuries

- Flexor musculo-tendon junction in forearm to proximal border of the transverse carpal ligament
- Median and Ulnar nerve and radial and ulnar arteries
Zone V Injuries

• Adhesions to skin and fascia
• Interdinious adhesions not as much of a problem
• Paratenon is a loose connective tissue and adhesions tend not to be as restrictive
• BUT adhesions can occur so active differential tendon glide exercises are preferred.
Zone V Injuries

- Wrist tendons only
  - Dorsal block splint only
    - the MCP joints, rest of fingers can be free
  - Wrist in neutral or slight flexion
  - Start active wrist motion at 3 weeks
  - Can use hand for light activity but avoid forceful movements until 6-8 weeks
Zone V Injuries

- Tendon and nerve injuries
- Wrist in neutral or slight flexion for 2 weeks
  - Gradual extension of splint after this (10-20 degrees)
- MCP joints in flexion (60-70 degrees)
  - Facilitate finger flexion
  - Inhibit claw deformity
  - Allow IP joint extension
- Not much issue with free IP joint movement
- Passive extension exercises to prevent IP joint contracture
Zone V Injuries

- 6 weeks of dorsal block splint
- If loss of composite finger extension
  - Palm based or forearm extension splinting may be required
- Anti claw splints may be required for several more months
Flexor Pollicis Longus Injury

- Zone I – insertion of the FPL
- Zone II- neck of metacarpal to the neck of proximal phalanx
  - Involves flexor sheath
- Zone III – area of the thenar muscles
- Zone IV – Carpal Canal
- Zone V- musculotendinous junction to the proximal edgeof the carpal canal
FPL Injury

- Only one tendon
- Only one viniculum
- No lumbricles
- Lacerations to zone I and II usually retract to the palm or wrist
- Zone 1 and 2 are most common injuries and are reported most in literature
FPL Injuries

• Rupture rates increased when active motion applied to 2 strand repairs.
• Evidence support use of active motion programs with multistrand repair
• Passive motion techniques still used if there is any concern with active motion
FPL Injuries

• Wrist in neutral position
  – Wrist in extension can put tension on the repair
  – Wrist in extension makes active extension at IP joint harder to achieve

• Controlled active motion
  – Isolate movement to the IP joint
FPL Injuries


• Same principles as finger flexors, active movement with staged increases

• Passive flexion, active extension first

• Active flexion of thumb to middle finger tip first week

• Active flexion of thumb to ring tip second week

• Third week, actively flex thumb as far as possible without undue force
FPL injuries

• Advocate for wrist neutral, slight ulnar deviated position
  – Less angle at CT
• Thumb flexes when fingers flex to grip
• Include dorsal block to fingers, keep fingers strapped when thumb strapped.
FPL Injuries

- Judy Colditz – Clinical Pearl #15
- Only FPL flexes IPJ
- Other muscles stabilize CMC and MP joints
- Tendon adherence following repair can limit distal tendon glide
- Prevent CMC and MP from moving, to allow more glide distally

Consider:

Strong repair gentle IP joint blocking exercises
Worrisome repair: IP joint only place and hold exercise (Colditz)
Gradually add MP and CMC joint flexion
Zone T2 FPL

- 4 strand repair in Zone T2
- Isolated IP motion is safe for both passive and active exercise
- Wrist in 30 degrees extension during passive IP motion
Zone T2 FPL

- Simulated active IP motion produced forces within the SEZ (1.3 N – 7N)
- Actively flexing an isolated IP joint 35-40 degrees while maintaining a neutral position wrist, CMC 30 degrees abduction and MCP joint 0 degrees.
- This will safely and effectively move FPL tendon at least 2 mm in zone T2
- Need clinical outcomes to validate passive and active methods
- Lower stress protocols may be more suitable for patients with impaired healing or repairs under tension.
All Zones of Injury

• Sensory re-education techniques
  – Nerve injury present
• Motor planning activities
• Functional re-organization of the somatosensory cortex
• Preservation of cortical representation

Individualized programs

• We can control the amount of stress and amount of excursion with each individual repair
• Crush injuries (high adhesions but poor repair strength) – low stress, high excursion program
  Passive Synergistic Program
• Strong repair – early active motion and synergistic motion
• Good repair (but non compliant patient or poor history of healing) low stress, low excursion program (modified Duran, but with wrist in slight extension at certain zones, Evans protocol etc)
Thank You!