Rehabilitation following Flexor Tendon Repairs

*Philly Meeting 2018*

Nancy M. Cannon, OTR, CHT
Indiana Hand to Shoulder Center
Indianapolis, Indiana

**Options – Flexor Tendon Programs**
- Passive Tendon Gliding
  - Modified Duran
  - Kleinert program
- Combined Passive & Active Tendon Gliding
  - Short arc motion
  - Place & hold
- No Tendon Gliding
  - Complete immobilization

**Complete Immobilization “Program”**
- Long Arm Postop Dressing & Orthosis
  - Small children
- Short Arm Postop Dressing & Orthosis
  - Clinical impression – unreliable
  - Complex surgery – prohibit early motion
  - Unable to actively participate secondary to cognitive or physical disability
  - ROM Exercises – delayed ≥ 3 Weeks

**“Passive” Tendon Gliding Programs**
- “Modified Duran” and “Kleinert” Programs

**“Passive” Tendon Gliding**
- Duran Program
  - Objective: independent tendon gliding – FDS & FDP & influence orientation of adhesions
  - Duran 3-5mm tendon gliding intraop; less postop
  - Clinical research: 17-19 days negligible passive tendon gliding
- Kleinert Program
  - Orthosis – time-consuming to fabricate
  - Concerns with flexion contractures
  - Transitioned away from orthosis & program
“Passive” Tendon Gliding Programs

- Indications:
  - Traditionally, two strand repairs
  - Surgical concerns – quality of a stronger repair [4-6-8 strands]
  - Clinical concerns – notable edema or limited passive flexion persists, unable to transition to early active program
  - Achieve passive flexion prior to early active

“Active” Tendon Gliding Programs

- Key Indications:
  - Typically, stronger repairs [4-6-8 strand]
  - Limited edema
  - Excellent passive flexion
  - Reliable patient

“Active” Tendon Gliding

- The Bern Experience
  - Lin-Tsai 6-strand repair
  - “Stop and Go” Approach
  - Algorithm – quality of the repair, edema, and patient compliance
  - Red-passive
  - Yellow-place & hold
  - Green-short arc active

“Active” Tendon Gliding Programs

- Short Arc Active Flexion
  - ⅓ to ½ fist

- Place and Hold Active Flexion

CLINICAL PRIMARY FLEXOR TENDON REPAIR AND REHABILITATION

- The Bern Experience*
- The Nantong Experience*
- The Mayo Clinic Experience*
- The Chelmsford Experience
- The Singapore Experience
- The Stanford Experience
- The Australian Experience
- The Wellington Experience

Fleming Publication 2017

Hand to Shoulder Therapy Center
“Active” Tendon Gliding

- The Mayo Clinic Experience - Peter Amadio, MD
  - 4-strand and 6-strand repairs
  - Modified Duran + Short Arc Place & Hold + Active

Rehabilitation Following Zone II Flexor Tendon Repairs
Techniques in Hand & Upper Extremity Surgery, March, 2015

“Active” Tendon Gliding

- Active “Scratching” Motion
  - Each week – actively bend down to the next digit
  - Goal directed
  - Modification by Gwendolyn van Strien, LPT, MSc

Saint John – Short Arc Flexion

- Initial 2 1/2 Weeks
  - DBO – forearm based; wrist 45° ext. MP’s 30° flexion & the IPs extended
  - PROM → short arc active flexion 1/3 – 1/2 fist

- 2 1/2 to 4 Weeks
  - DBO reduced to hand based
  - ↑ active flexion to 3/4 fist

- 4 – 6 Weeks
  - Gradually achieve full active flexion
  - 6 Weeks – discontinue orthosis

“Place & Hold” Program

- Multiple Approaches – Literature
  - With or without wrist motion
  - Partial or full passive flexion, with active hold
  - Assisted passive flexion with simultaneous active flexion through partial or full arc of motion

- Indiana Program
  - Hinged wrist orthosis
  - Synergistic, tenodesis motion combined with place and hold

Hand to Shoulder Therapy Center
Flexor Tendon Surgery & Therapy

- Many Common “Threads”...
- Yet, Individual Differences

- Surgeon’s approach – repair & other structures
- Therapist’s approach – home therapy program

Surgery → “Common Threads”

- Strong, Quality Repair + ↓ Gliding Resistance
  - 4-6 strand repairs
  - Peripheral running suture
  - 3-0 suture material
  - Venting of the Pulleys
  - Excision – Slip of the Superficialis
  - Intraop Testing – Tendon Repair & Tendon Gliding through Pulleys
    - Ideal – wide awake approach – active motion

Therapy → “Common Threads”

- Therapy Initiated 3-5-7 Days Postop
  - Prioritize edema control/passive flexion
  - Passive ROM prior to Active Motion
    - Progressively ↑ tension on the repair over time
  - Protective Orthosis
    - Wrist extension ≤45°, MP ≤45° flexion, IPs 0°
  - Discontinued 6 weeks postop
  - Exercise Orthosis
    - Hand based or no orthosis

Hinged Wrist Tenodesis Orthosis

- Transitioning to Hand Based or No Orthosis
  - Partial FDP repairs
    - 6-strand repairs [not small fingers]

Therapy → “Uncommon” Thread

- Arc of Active Flexion Weeks 2 & 3
  - Short arc active flexion
    - Place & hold full arc active flexion
Short Arc and Place & Hold Exercises

- Strong Repairs
  - 4 strand: ± 28N (2mm gapping)
  - 6 strand: ± 42N (2mm gapping)
  - 3-0 suture material: + 10-15N
  - Peripheral suture: +7N (minimum)
  - Ventril Pulleys & Excision Slip of FDS
    - Vent pulleys: ↓ WOF ≤ 30%
      - tendon gliding 3.5mm
    - Excise slip FDS: ↓ WOF ≤ 20%
      - tendon gliding 2.5mm

Short Arc and Place & Hold Exercise

- Minimal Force on FDP – “Light, Active Fist”
  - Short arc = 3.0N*
    [Evans/Thompson/Greenwald/Edsfeld & Kursa]
  - Place & hold – 3.6N* [Edsfedt & Kursa]
    Note: * = normal tendons, before introducing factors ↑ WOF [repair, edema, limited passive]
  - Add factors ↑ WOF [double the newtons]
  - Safe zone

Resistence Levels

- 6 Strand
- 4 Strand
- 2 Strand

Hand Clinics - 2013
- Sean Clancy, OTR, CHT & Daniel Mass, MD

Short Arc and Place & Hold Exercise

- Bunching at Tendon-Pulley Interface with End Range Flexion
  - Repair strength less under angular tension
  - Breaking strength M-Tang repair (2mm gap)
  - Linear tension = 46N Angular = 36N
    [Wang et al, JHS Brit/Eur 2003]

Short Arc and Place & Hold Exercise

- Quality Outcomes – Literature
  - Active motion
  - Limited or no ruptures

Clinical Experience – Extremely Favorable
- Dr. Tang’s program
- St. John program
- Mayo Clinic program
- Indiana Program
- Among others...

Therapy Program – Customize

- Current Therapy Programs – Guidelines
  - Extremely valuable
  - NOT an absolute of treatment

Individualize each Home Program
- Orthosis [protective & exercise]
- Specific exercises
- Timelines
Case Example – Indiana Program

- 24 y/o Male, Lacerated Left Ring Finger
  - FDP, radial slip of the FDS and RDN
- Surgery 17 Days Post Injury
  - Profundus repair – 6 strand (4-0 suture material)
  - RDN repaired
  - Radial slip FDS – excised
  - A4 pulley collapsed – FDP repaired outside the pulley
  - A5 pulley vented 2mm

Considerations – Therapy Program

- **Favorable Considerations – Surgery**
  - Simple laceration – 6-strand repair
  - Excised slip of FDS
  - Vented A5 pulley
  - Skilled hand surgeon
- **Favorable Considerations – Therapy**
  - Limited edema – 5mm ↑ opposite digit P1
  - Full passive flexion
  - Patient – “seemed reliable”
  - No pertinent medical history (delayed healing)

Considerations – Therapy Program

- **Unfavorable Considerations**
  - Delayed surgery [17 days]
  - No A4 Pulley
    - [potential disadvantage for active DIPJ flexion]
  - Lived 1½ hours away – limited therapy visits

Initial Appointment – 7 Days Postop

- Dorsal Blocking Orthosis
  - Wrist 15° extension
  - MPJs 60° flexion, IPJs extended
- PROM – Modified Duran

+ Modified Synergistic Exercise

- Passive Tendon Gliding
  - 1st - forearm neutral – tabletop
  - 2nd composite passive flexion followed by...
  - 3rd passive MP joint extension while maintaining PIP and DIP joint flexion

Modified Synergistic Exercise

- Amandio & Tanaka
  - Generates passive tendon gliding
  - Negligible force on FDP 1.7N
  - No gapping at the repair
  - Prevents buckling of the profundus with PROM
10 Days Postop
- Tenodesis Orthosis
- Place & Hold Exercise

ROM 10 -14 -21 Days Postop
- 10 Days: MP X/60, PIP X/50, DIP X/20
- 14 Days: MP X/85, PIP X/80, DIP X/30
- 21 Days: MP X/80, PIP X/90, DIP X/40

Note: X = no active/passive extension

Therapy Program – 3 Weeks Postop
- AROM within Dorsal Blocking Orthosis

Therapy Program – 4 Weeks Postop
- Discontinued Tenodesis Orthosis
- AROM – No Orthosis

ROM – 4 Weeks Postop
- MP 20/65
- PIP 40/85 -5
- DIP 20/35 -5
- Trapping!
- Heated Ultrasound followed by Exercise

ROM – 5 Weeks Postop
- No Change in Active PIP or DIP Joint Flexion
  - Early, gentle blocking
  - Blocking orthoses

Hand to Shoulder Therapy Center
**Therapy Program – 5 Weeks Postop**
- Blocking Exercises – MPJ & PIPJ slightly flexed
  - PIPJ and DIPJ

**Therapy Program – 5 Weeks Postop**
- Blocking Orthoses

**5 Weeks Postop**
- Place & Hold Exercise – Hook-Fist Position
  - MPJs extended; IPJs flexed

**ROM Weeks 6 – 8**

<table>
<thead>
<tr>
<th>6 Weeks</th>
<th>7 Weeks</th>
<th>8 Weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP 0/90</td>
<td>MP 0/90</td>
<td>MP 0/80</td>
</tr>
<tr>
<td>PIP 10/90</td>
<td>PIP 10/95</td>
<td>PIP 15/100</td>
</tr>
<tr>
<td>DIP 0/35</td>
<td>DIP 10/40</td>
<td>DIP 10/40</td>
</tr>
</tbody>
</table>

Note: passive PIP & DIP extension (10)

**Therapy Program – 6 Weeks Postop**
- Discontinued Dorsal Blocking Orthosis
- Hand Based Blocking Orthosis – Day

**Therapy Program – 7 & 8 Weeks**
- Gentle Resistance
  - Soft putty – cylinder shape
- Passive Digital Extension
  - PIPJ only
  - No composite extension
- Safety Pin Splint
  - Not including DIPJ

Hand to Shoulder Therapy Center
**ROM Weeks 9 – 12**

<table>
<thead>
<tr>
<th>9 Weeks</th>
<th>11 Weeks</th>
<th>12 Weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP 0/90</td>
<td>MP 0/85</td>
<td>MP 0/80</td>
</tr>
<tr>
<td>PIP 25/95</td>
<td>PIP 20/100</td>
<td>PIP 20/105</td>
</tr>
<tr>
<td>DIP 10/45</td>
<td>DIP 10/50</td>
<td>DIP 15/55</td>
</tr>
</tbody>
</table>

Note: passive PIP & DIP extension (10)

**Discharge Appointment**

- Final ROM
  - MP 0/80
  - PIP 10 (5)/110
  - DIP 10 (10)/60
- Strickland Criteria – Excellent 150°-175°
  - TAM = 150°

**Outcomes – Past 10 Years**

- Zone II Repairs
- 4 & 6 Strand Repairs
- Results – Original Strickland Criteria
  - TAM active PIP and DIP motion
    - Excellent: 85%-100% ≥ 150°
    - Good: 70%-84% 125° to 149°
    - Fair: 50% to 69% 90° to 124°
    - Poor: Less than 50% ≤ 89°

**Outcomes – Short Arc**

- Tang et al. Hand Clinics 2017
- 121 Digits
- 6-Strand M-Tang Repair + Peripheral Suture
- 3 Centers – Multiple Surgeons
- Therapy – Passive & Short Arc Flexion
  - Orthosis – optional for exercise
- Averaged 85% Excellent/Good Category
- 1 Rupture .8%

**Outcomes – Short Arc**

- Zhou X., et al JHS European 2017
- 54 Digits
- 6-Strand M-Tang Repair + Peripheral Suture
- Therapy
  - Passive flexion
  - Short arc flexion 1/2 to 2/3 full active flexion
- 80% Excellent or Good Category
- No Ruptures

**Outcomes – Place & Hold**

- Trumble et al. JBJS American 2010
- 4-Strand Repair + Peripheral Running Suture
- Indiana Program [Modified Duran/Place & Hold]
- 54 Digits
- Averaged 156° Excellent Category
- Rupture Rate: 3.8% [two small fingers]
Outcomes – Place & Hold

- Rajappa et al., Journal of Orthopaedic Surgery 2014
- 6-Strand Triple Kessler Repair
- 12 Digits Zone II
- Place & Hold Program
- 83% Excellent Category
- No Ruptures

Outcomes – Place & Hold

  - Pilot Study Comparing Two Early Active Motion (EAM) Regimens for Surgically Repaired Flexor Tendons, Zone I – IV; Wrist Synergistic EAM vs. Modified Belfast Static Wrist EAM
- 11 Digits – Zone II [Synergistic EAM Program]
- 2-Strand & 4-Strand Repairs
- 100% Excellent or Good [10 Excellent, 1 Good]
- No Ruptures

Outcomes – P&H + Short Arc

- Savvidou & Tsai
  - J Hand & Microsurgery Jan-June 2015
- 51 Digits – FDS & FDP Repairs
- 6-Strand Double Loop + Peripheral Suture
- Passive – Place & Hold – Short Arc Motion
- 81% Excellent or Good Category
- Rupture Rate 1.9%

Outcomes – Active Fisting

- Moriya et al., JHS (E) 2014
- 6-Strand Yoshizhu #1 Repair
- 41 Digits
- Kleinert Program + Active Hold + Active Fisting
  - Note: hospitalized first 3 weeks
- 82% Excellent or Good Category
- Rupture Rate: 5.1%

Ruptures – Literature

- Average 4%
  - Mutual goal – 0%
- Majority – Patient Compliance
  - Not following instructions (both good and bad reasons)
  - Not wearing orthosis
  - Using their hand normally
  
  **Careful patient selection...**
  **Clear written & verbal instruction**

Ruptures – Literature

- Notable % in Small Finger
- Outcomes
  - 526 Zone I & II FTRs – 4% ruptures – 41% small finger [Harris et al. JHS 1999]
  - 37 Zone II ruptures – 51% small finger [Dowd et al. JHS, 2006]
- Anatomy
  - Diameter FDP 42% smaller
  - Dorsal/volar length 38% less
  
  **NO blocking to small finger!**

Hand to Shoulder Therapy Center
Risk of Rupture – Surgery
- Quality of the Repair
  - Challenge – crush injury
  - Challenge – jagged laceration
- Two Strand Repairs
  - Risky – early active flexion program
- Core Suture too Loose
  - Risks gapping & bunching of the repair

Avoiding Flexor Tendon Repair Rupture with Intraoperative Total Active Movement Examination
PRS Sept. 2010
Higgins, Lalonde et al.

Risk of Rupture – Therapy
(Extremely small % clinician judgment or therapy program)
- Lacking Information – Repair & Strength
- Forceful Blocking Exercises
- Initiating Active Exercises Early – before Edema ↓ and Full Passive Flexion Achieved
- Patient NOT Exercising – NOT Progressing
  - Advancing exercises too aggressively
- Palpable or Auditory Crepitus Present
  - Avoid isolating an individual digit

So... which surgery & which therapy?
- Wide Awake Procedure
  - M-Tang 6-Strand Repair
- Passive Tendon Gilding
  - Modified Duran passive exercises [FDS and FDP]
  - "Modified" modified synergistic exercise
- Active Tendon Gilding
  - Wrist tenodesis + place & hold – full flexion
  - Add... short arc active flexion with active IP joint “scratching”; advance one digit each week [flex down approach]

Closing Thoughts...
- Home Program – Comfortable & Confident, Customize
- Prioritize Edema Control - Postop Drsg. ± 5 Days
- Prioritize Passive Motion 1st – active 2-3 days later
- Patient Demonstrate Exercises – every visit
- Measure every Visit – active flexion PIPJ and DIPJ
  - Adjust home program ⇒ no gains active flexion
- Patient Education Vital — highlight the precautions

Enjoy treating patients with flexor tendon repairs!

Outcomes – Bern Experience
- Active Motion [short arc or place & hold]
  - 50 digits
  - Lim-Tsai 6 strand repair + peripheral suture
  - 78% excellent or good results
  - 4% rupture
- “Stop & Go” Approach
  - 26 digits
  - Same repair (Lim-Tsai 6 strand)
  - 62% excellent or good
  - 4% rupture
Outcomes – Short Arc
- Peck et al., Hand Therapy 2014
- 4-Strand Kessler or Adelaide + Peripheral
- Forearm Based
  - 76 digits
  - 29% excellent or good
  - Ruptures 3.9%
- Wrist Based
  - 45 digits
  - 49% excellent or good
  - Ruptures 4.4%

Outcomes – Short Arc
- Giesen et al., JHS European Feb. 2018
- 27 Digits
- 6-Strand M-Tang Repair – No Peripheral Suture
- Passive + Short Arc Active Flexion
- 89% Excellent to Good
- No Ruptures

Outcomes – Short Arc + P&H
- Sandow & McMahon JHS(E) 2011
- 4-Strand, Single Cross Grasp Repair
- Passive + Place & Hold [short arc to full arc] and no wrist motion
- 43 digits
- 67% excellent or good category [mean 127°]
- Rupture Rate: 3.9% [two pts., non-compliant]

Outcomes – Place & Hold
- Hoffmann et al. JHS(E) 2008
- Lim/Tsai repair – 6-strand
- Kleinert/Duran Passive + Place & Hold
- 51 digits
- 78% excellent or good category
- Rupture Rate: 2% [one patient]

Outcomes – Full Arc
- Caulfield et al. JHS(E) 2008
- 416 Digits Zones I - IV
- 4-Strand Strickland Technique + Peripheral
- Passive + Full Arc Active Flexion within DBO
- 72% and 73% Excellent to Good
- Ruptures 2% [1 infection; 7 non-compliance]

FLEXOR TENDONS RISK OF RUPTURE
**Ruptures – Literature**

- Tang Sub Zone 2B "Black Box"
  - Dowd et al. JHS British 2006

- 76% of ruptures in zone 2B **Be cautious!**

**Ruptures – Literature**

- Notable % = Small Finger
  - 526 Zone I & II FTRs - 4% ruptures - 41% small finger (Harris et al. JHS 1999)

  **The etiology of acute rupture of flexor tendon repairs in zones 1 and 2 of the fingers during early mobilization**

  **The results of immediate re-repair of zone I and II flexor tendon repairs which rupture**

  - Dowd et al. JHS, 2006

**Ruptures – Small Finger**

- Anatomical Variance (Boyce et al., JHS 2001)
  - Diameter of FDP smaller 42% compared to I-R

- Dorsal/volar length 38% less

- Challenge – Post Repair Glide through Narrow Pulleys

- Notable Edema → Persists
  - ↑ WOF – gliding resistance

  **NO blocking to small finger!**

**Risk of Ruptures – Surgery**


- 122 of 148 Tendon Repairs Evaluated
  - 85 FDS & FDP Repairs – Ottawa patients

  - 37 FDS & FDP Repairs – Saint John patients

- 2-Strand > 4-Strand Repairs (retrospective study)

- Passive + Place & Hold & Short Arc Active

- Wide awake procedure - address gapping/bunching secondary to the core sutures being too loose

- Rupture Rate 3.3% [non-compliant patients]

**Risk of Rupture – Clinical Perspective**

(Extremely small % clinician judgment or therapy program)

- Not Knowing – Repair Strength [2mm gapping] & Quality

- Not Considering – Patient’s Medical History
  - Influence healing (e.g. smoker, diabetic)

- Performing Active Motion against Resistance
  - Edema or limited passive flexion [excessive WOF]

- Blocking Exercises
  - Against resistance or the 1st exercise session/day

**Risk of Rupture – Clinical Perspective**

(Extremely small % clinician judgment or therapy program)

- Palpable or Auditory Crepitus

- Avoid isolating an individual digit

- Progressing Patient too Quickly
  - In presence of excellent active motion

- Permitting Tight, Sustained Grasp against Counterforce, once Strengthening Initiated

- Tennis, golf, work activities, gardening tools

- Limited Patient Education [written-verbal]