Rehabilitation following Flexor Tendon Repairs

Philly Meeting 2018

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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

“Passive” Tendon Gliding Programs

- “Modified Duran” and “Kleinert” Programs

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

- 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
  - Lim-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

13 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

"Active" Tendon Gliding Programs

- Short Arc
  - Active Flexion
  - ¼ to ½ fist

- Place and Hold
  - Active Flexion
  - ¼ to ½ fist

"Active" Tendon Gliding

- The Nantong Experience – Jin Bo Tang, MD
  - M Tang 6 strand repair
  - Passive + short arc active fist ¼ to ½ fist 1st 2 ½ wks
  - 2nd 2 ½ wks gradually achieving full active flexion
“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

“Active” Tendon Gliding

- Saint John Program
  - Dr. Lalonde & Amanda Higgins, OT
  - 4-strand repair
  - Short arc active flexion program

Saint John – Short Arc Flexion

- Initial 2 ½ 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 ½ 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

“Place & Hold” Program

- 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
  - 4-8 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°, MPs ±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

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Hand to Shoulder
Therapy Center
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)

- **Venting Pulleys & Excision Slip of FDS**
  - Vent pulleys: ↓ WOF ≤ 30%
  - Excise slip FDS: ↓ WOF ≤ 20%

- **Minimal Force on FDP** – “Light, Active Fist”
  - Short arc = 3.0N*
  - Place & hold = 3.6N* [Edsledt & Kursa]

- **Peripheral suture** +7N (minimum)

Note: * = normal tendons, before introducing factors ↑ WOF [repair, edema, limited passive]

- **Add factors** ↑ WOF [double the newtons]
- **Safe zone**

Resistance 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
  - 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

Hand to Shoulder Therapy Center
10 Days Postop
- Tenodesis Orthosis
- Place & Hold Exercise

10 - 14 - 21 Days Postop

<table>
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<th>Time</th>
<th>MP</th>
<th>PIP</th>
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<tr>
<td>21 Days</td>
<td>X/80</td>
<td>X/90</td>
<td>X/40</td>
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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
- 6 Weeks
  - MP 0/90
  - PIP 10/90
  - DIP 0/35

- 7 Weeks
  - MP 0/90
  - PIP 10/95
  - DIP 10/40

- 8 Weeks
  - MP 0/80
  - PIP 15/100
  - DIP 10/40

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

HandtoShoulder Therapy Center
ROM  Weeks 9 – 12

<table>
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<th>Weeks</th>
<th>MP</th>
<th>PIP</th>
<th>DIP</th>
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</tr>
<tr>
<td>12</td>
<td>0/80</td>
<td>20/105</td>
<td>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 PIPJ and DIPJ 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 – 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 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 Yoshiz #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!

Boyer et al. JHS 2001
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

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 Gliding
  - Wrist tenodesis + place & hold – full flexion
  - Add... short arc active flexion with active IP joint “scratching”; advance one digit each week [flex down approach]

Risk of Rupture – Therapy

- 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

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

- Cauldfield 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!

- Notable % = Small Finger
  - 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)

Ruptures – Small Finger

- Anatomical Variances [Boyer 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

- 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]