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Tendon Trauma: Keys to Optimal Outcomes

Rebecca Neiduski, PhD, OTR/L, CHT
Concordia University Wisconsin

Learner Outcomes

1. Examine mechanism of injury and surgical procedures to inform clinical decision-making.
2. Create rationale for post-operative positioning that facilitates safe and effective excursion of repaired structures.
3. Incorporate assessment data into treatment progression and outcomes analysis.

Objectives

1. Anatomic priorities
2. Initiation of therapy
3. Saint John Protocol
4. Progression of therapy

Anatomic Priorities

Prioritize:

- Bone
- Vascular
- Tendon
- Nerve
- Wound

What therapists need to know:

- All structures repaired
- Surgical specifics
- Perceived integrity of structures

#1: Vascular

- Questions to ask:
  - Integrity of structures?
  - Adequacy of blood supply?

#1: Vascular

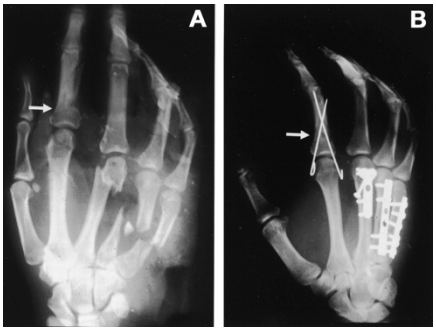
- Arterial or venous repair or graft
  - *Vein grafts as particularly fragile*
- Immediate concerns
  - Vasospasm
    - Pale due to manipulation
  - Venous insufficiency
    - Blue and tense to touch
  - Arterial insufficiency
    - White or pale

#1: Vascular

- Implications for therapy
  - Wound care and dressings
  - Temperature
    - Choice of modalities
  - Elevation/avoidance of dependent position
  - Dietary issues
    - Nicotine/caffeine
  - Orthotics and strapping
    - Avoidance of single digit

#2: Bone

- Fracture healing
  - Timeframes?
- Questions to ask:
  - Fracture classification and complexity?
  - Type of fixation?
  - Post-surgical stability?



#2: Bone

Person factors affecting fracture healing

- Age
- Emotional status
- Comorbidities and medications
  - Delay in healing associated with diabetes
- Nutritional factors, alcohol/tobacco use
  - Nicotine increases time to healing, risk of nonunion, and decreased strength of callus
- Ability and willingness to comply

Shin, 2011

#2: Bone

Factors Influencing Structural Strength

- Location of fracture
- Pattern and displacement of fracture
- Type of reduction and hardware
- Concomitant soft tissue injuries
- Functional demands of patient
- Timing and stage of healing

Feehan, 2003

#3: Nerve

- Questions to ask:
  - Tenuousness of repair?
  - Indications for protective immobilization?
  - Timing of progression towards full range of motion?

"Limited, protected postsurgical motion does not affect the results of digital nerve repair" *(Yu et al., 2004)*

- Group #1: Isolated digital nerve lacerations
  - 14 patients immobilized in PIP flexion ~21 days
- Group #2: Combined nerve and tendon lacerations
  - 12 patients mobilized at ~4 days
- Both groups with decreased sensibility BUT…no significant differences in 2PD or Semmes Weinstein between groups!

#4: Tendon

- Questions to ask:
  - Zone of injury?
  - Tendons repaired, partially lacerated, intact?
  - Number of strands?
  - Integrity of repair?

#4: Tendon

- Intrinsic healing capability of flexor tendons
- Beneficial effects of early motion
  - Increased strength and excursion
  - Fewer peritendinous adhesions

The practice of immobilization following flexor tendon repair, unfortunately not obsolete, should be replaced by early motion protocols in the vast majority of situations.

Lundborg & Rank, 1978, 1980; Gelberman et al., 1980-1989; Hitchcock, Light, & Bunch, 1987

#5: Wound

- Primary intention
  - *Surgical closure*
- Secondary intention
  - *Wound closes with production of connective tissue (contraction) and epithelialization*
  - *Longer healing time*

#5: Wound

- Delayed Primary Closure
- Tertiary or re-epithelialization
  - *Used when there is a significant loss of tissue and deformity or loss of function would result with skin closure*
  - Skin Grafts
  - Skin Flaps

What not to wait for…

- Edema
  - Gliding resistance proportional to area and severity of edema; reduced with gentle motion
  - Observation of edema should inform the range, frequency, and speed of exercise
    - *Cao et al., 2005-2008*

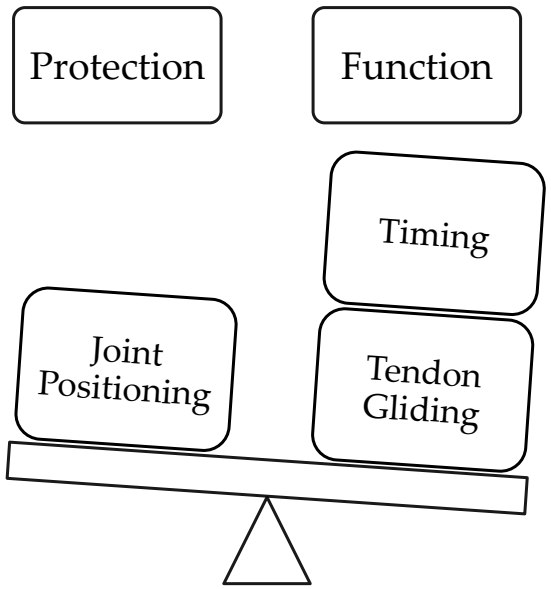
What not to wait for…

- Bony healing
  - Functional and physiologic stresses increase quality and rate of healing
    - *Feehan, 2003*
  - Statistically significant decrease in number of days to achieve functional range of motion in patients who started active range of motion at one week post-op
    - *Valdes, 2009*

Best case scenario…

- Close-packed position
  - Optimal position for immobilization
  - Ligaments maximally taut
  - Joint surfaces maximally congruent
  - Joint spaced minimized

  - *Wrist extension, maximal MP flexion, digital PIP/ DIP extension, thumb palmar abduction and MP/ IP extension*



"The ultimate goal of both the surgeon and therapist is to minimize and modify peritendinous adhesions and promote optimal tendon glide. At the same time the tendon repair must be protected from excessive stress in order to avoid gapping or rupture."

Peck, 2014

Initiation of Therapy

Questions

1. Post-operative timing?
2. To wrap or not to wrap?
3. Which "protocol"?

Post-operative timing?

Work of Flexion (WOF)

- Work necessary for active flexion
- Influenced by intrinsic and extrinsic factors
  - Surface friction, bulk of the repaired tendon, tendon adhesions, mass of the digit, joint stiffness, soft tissue resistance, and resistance of the antagonistic musculature
- Gliding resistance
  - Decreased on day 5
  - Increased at day 7 with notable adhesions and stiffness
- **Optimal initiation of early motion at day 4-5**

Cao et al., 2005-2008; Tanaka et al., 2003; Zhao et al., 2004-2005

To wrap or not to wrap?

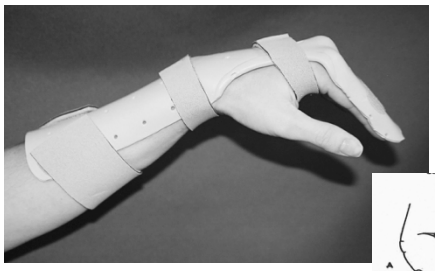
Buonocore et al., 2012

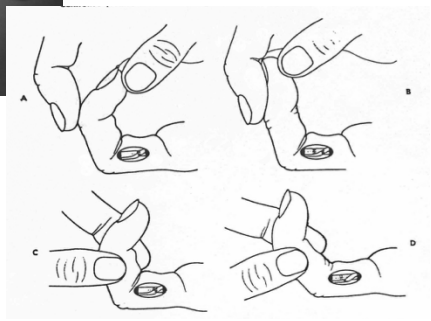
- Cadaveric study of edema and "self-adherent wrap"
- Without wrap
  - Moderate edema: 23% increase in WOF
  - Severe edema: 71% increase in WOF
- Wrap
  - Significant increase in WOF in all digits
- **Suggest attention to edema and removal of adherent wrap prior to exercise**

Which "protocol"?

Modified Duran

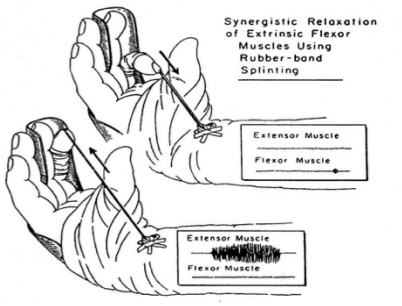
Duran & Houser, 1975





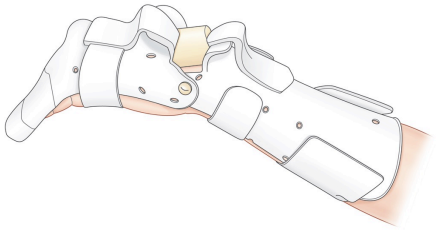
Kleinert

Kleinert et al., 1975; Chow et al., 1988



Indiana

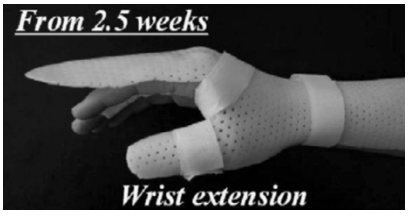
Strickland & Cannon, 1993



- Prior to week 4
  - Synergistic place and hold exercises in splint
- Week 4
  - Synergistic place and hold exercise out of splint
- Week 5
  - Composite flexion and extension of wrist/hand
- Week 6
  - Isolated PIP and DIP flexion

Nantong

Tang, 2007



- First 2.5 weeks
  - Wrist flexion
  - Active motion progressed through the first two thirds of full range of digital motion
  - Avoids the higher levels of anatomical resistance observed in the final third
  - Conservative wrist position maintained for the first 2.5 weeks while the patient is focused on full extension to the dorsal block as opposed to composite flexion

Mass & Saint John

Coats et al., 2005; Clancy & Mass, 2013; LaLonde, 2013, 2016

- Wrist in 20-30° extension
- MP joints positioned between 60-75° flexion
  - Allows the benefits of synergistic motion while avoiding the complicated fabrication of a dynamic orthosis
- Mass:
  - Active motion through "available range"
- LaLonde
  - "Mid-range" true active flexion
  - NOT place and hold

Manchester Short Splint

Peck, 2014

- http://www.ifssh.info/ezine.html
- Zone 1 and 2: "robust 4 strand repairs"
- Compliant patients with uncomplicated repairs
- Allows 45° wrist extension
- MP joints in 30° flexion
  - Edematous finger creates increased WOF
  - "Placing MP joints in excessive flexion will bias motion to the PIP joint and force the patient to attempt DIP joint flexion at the end of range, thereby increasing WOF" (p. 34)

Manchester Short Splint

Peck, 2014

- Start at 4th or 5th postoperative day
- Start with passive motion to decrease WOF
- Initiate motion from the DIP to optimize differential glide
- Confine early active motion to the "outer range" or first third
- Facilitate maximal PIP and DIP extension

Early full range of flexion is not necessary or safe and care should be taken if using a 'place and hold' regimen, that patients are not required to put a great effort into holding a full fist position. 'Place' is a passive action but 'hold' requires an unmeasured active force and in an oedematous finger the position of the tendons within the sheath system is not predictable.

Manchester Short Splint

Peck, 2014

- 62 forearm-based
- 40 Manchester short

- Significantly less flexion contracture at PIP at 6 and 12 weeks
- Significantly greater arc of flexion at DIP
- Greater proportion of excellent/good results

Saint John Protocol & Video

Saint John Protocol

Higgins & LaLonde, 2016

- Wide awake local anesthesia no tourniquet (WALANT)
  - Therapist present during surgery, educating patient
  - Keep hand elevated with no movement for 3-5 days
  - Dorsal blocking orthosis fabricated: up to 45° wrist extension, MP joints 30° flexion, IPs fully extended
- Four days to 2 weeks
  - "You can move it but you can't use it"
  - Edema management with adherent wrap
  - Passive motion warm up
  - Active IP extension with MP blocked in flexion
  - True active flexion 1/3 to 1/2 fist; motion initiated at DIP

Saint John Protocol

Higgins & LaLonde, 2016

- 2 to 4 weeks
  - Dorsal block orthosis shortened to Manchester Short Splint
  - Active synergistic exercises initiated; advance carefully from midrange to full fist with wrist in 45 degrees extension
  - Continue active IP extension with MPs in flexion
- 6 weeks
  - Discontinue protective orthosis
  - Digit extension orthoses as needed
  - Relative motion flexion orthosis as needed during functional tasks

Saint John Protocol

Higgins & LaLonde, 2016

- Higgins & LaLonde, 2016
- http://journals.lww.com/prsgo/pages/articleviewer.aspx?year=2016&issue=11000&article=00026&type=abstract

- Video
- http://journals.lww.com/prsgo/pages/videogallery.aspx?videoId=79&autoPlay=true

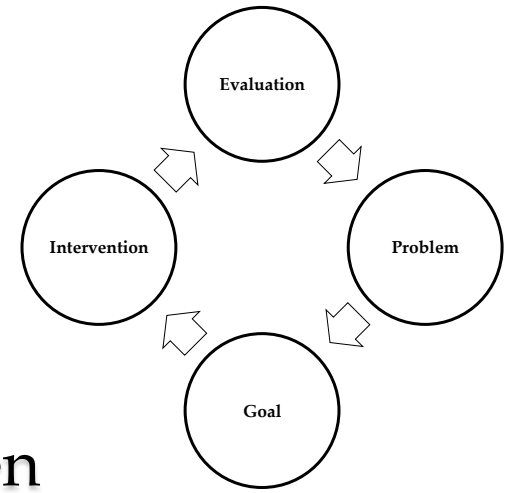
Progression of Therapy

Finding the right balance

Too much motion = rupture
Not enough motion = adhesions

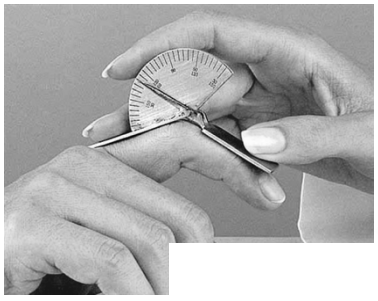
Data-driven rehabilitation

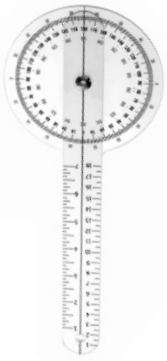
- Therapist demonstrates clinical reasoning based on a careful and comprehensive assessment strategy.
- Intervention decisions are clearly linked to reliable and valid measurements and re-evaluation is considered fundamental to support effectiveness.
- Continuation and cessation of treatment are contingent upon analysis of objective data.

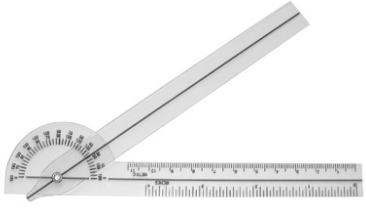


Data-driven rehabilitation

Collecting data







Strickland's Percentage

$$\frac{\text{Active PIP + DIP flexion – extension lag}}{175°} \times 100$$

= % of normal active PIP and DIP motion

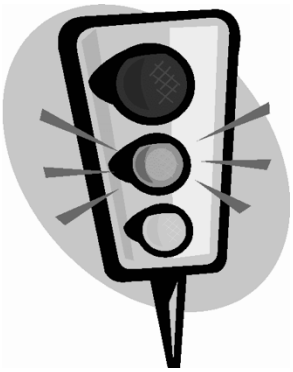
Strickland & Glogovac, 1980

Strickland's Percentage

Excellent	85-100%
Good	70-84%
Fair	50-69%
Poor	<50%

Treatment Progression

- If adhesions are significantly limiting tendon gliding
  - **PROGRESS** treatment
- If tendon gliding is good
  - **PROTECT** the tendon from resistance and potential rupture for a longer period of time



Saint John Protocol

data-driven…

- Day of surgery
  - Keep hand elevated with no movement for 3-5 days
- Day four to five post-op
  - Dorsal blocking orthosis fabricated: up to 45° wrist extension, MP joints 30° flexion, IPs fully extended
  - "You can move it but you can't use it"
  - Edema management with adherent wrap (REMOVE for exercise!!!)
  - Passive motion warm up
  - Active IP extension with MP blocked in flexion
  - True active flexion 1/3 to 1/2 fist; motion initiated at DIP
  - MEASURE active motion at all joints except MP extension
    - Calculate Strickland's percentage

Data-driven rehabilitation

	Day 4	Day 7	Day 10	Day 14
MP	NT/73	NT/82	NT/83	NT/83
PIP	-11/56	-7/62	-7/66	-5/72
DIP	-6/27	-5/34	-5/37	-4/45
Strickland's	37.7%	48%	52%	61.7%
	Poor	Poor	Fair	Fair
Progression?	Initiate active flexion 1/3-1/2 range and active extension with MPs blocked	Continue flexion; emphasize extension	Progress to synergistic flexion with Manchester Short; emphasize extension	Continue flexion and extension; monitor PROM in extension

Exercise	Excursion	Force
Passive protected extension	3-8mm distal	200-300gm
Place and hold synergistic flexion with active wrist extension	26/33mm proximal	900gm
Active straight fist	28/27mm FDS proximal	1100gm
Active hook fist	13/24mm differential proximal	1300gm
Active composite fist	24-26/32-33mm FDP proximal	400-4000gm
Active, isolated PIP flexion	~13mm FDP proximal	900gm
Active, isolated DIP flexion	~6.5mm FDP proximal	1900gm

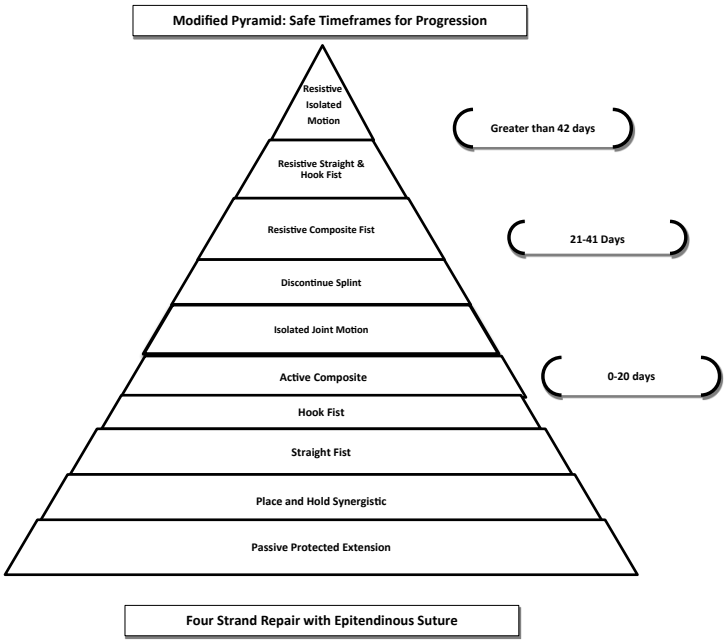
Saint John Protocol

- 17.87mm digital excursion
- Lower forces with wrist extension
- More glide based on wrist position?

Manchester Short Splint

- First 1/3 range
- Focus on DIP initiation

- 11.9mm digital excursion
- PLUS high levels of proximal glide at the wrist



After day 14…

Continue to use data to inform progression:

- Transition synergistic motion out of orthosis
- Add tendon gliding exercises; especially in cases of multi-trauma we need to ensure that the tendons can glide past one another and other repaired structures
- Make sure that discontinuation of the protective splint comprises a "step" in the process with careful education
- Add isolated joint exercises only as needed

Learner Outcomes

1. Examine mechanism of injury and surgical procedures to inform clinical decision-making.
2. Create rationale for post-operative positioning that facilitates safe and effective excursion of repaired structures.
3. Incorporate assessment data into treatment progression and outcomes analysis.

Thank you!

rvdh04@gmail.com

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Management of Upper Extremity Trauma

http://www.occupationaltherapy.com/hand-therapy

Mon 2/6	Understanding Multi-Trauma Hand and Upper Extremity Injuries Carol Recor, OTR/L, CHT
Tues 2/7	Wrist Detective: Investigating Traumatic Wrist Injuries Rachel Pigott, OTR/L, CHT
Wed 2/8	Management of Upper Extremity Nerve Injury Christine Novak, PhD, PT
Thurs 2/9	Occupational Therapist's Management of Upper Extremity Burns Nora Barrett, MS, OTR/L, CHT
Fri 2/10	Tendon Trauma: Keys to Optimal Outcomes Rebecca Neiduski, PhD, OTR/L, CHT