IC 03: Flexor Tendon Repair: Why Research Should Change Your Practice

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Session Handouts

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How Research Changed My Practice:
Take Home Messages
Paige Fox, MD PhD

The tendon bone interface (TBI)

- After injury the unique architecture is not restored
- The normal transition zone (bone-mineralized fibrocartilage-fibrocartilage-tendon) is replaced by scar
- The scar/bone interface is weak→ repeat rupture occurs
- Bone to bone healing is best
- Anchor to the bone and residual tendon whenever possible
- Test it on the table

The Pulvertaft weave

- No failures even at high loads
- Wide tunnel for good motion
- Test it on the table
- Move the patient early to avoid scar formation
- Bulky repair → very strong, less bulky side to side alternatives

Tendon healing

- Stem cells home to injury sites but have limited penetration into the dense tendon collagen
- Native cells in and around the tendon are few
- Adhesions occur with minor trauma to the tendon
- Keep the tendon moving to fight adhesions
- Minimal touch technique
    - When repairing the tendon use techniques that minimize tendon trauma to limit injury to native cells and scar/adhesion formation
    - Limit tendon dissection to preserve tendon blood supply

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Operative Technique

Flexor Tendon Repair Postoperative Rehabilitation: The Saint John Protocol

Amanda Higgins, BSc (OT)*; Donald H. Lalonde, MD, FRCSC†

The wide awake approach to flexor tendon repairs has decreased our rupture rate by 7% by allowing us to identify and repair tendon gaps during the surgery before we close the skin.[1] Eliminating any gap with full fist flexion and extension testing during the surgery gives us the confidence to move away from full fist place and hold to true active movement as advocated by Tang.[2,3] If a patient gets a good 4 to 6 strand repair that does not gap when tested during surgery, we believe that full fist place and hold should be abandoned in favor of true active movement even when patients are sedated during surgery and do not get the benefits of wide awake flexor tendon repair.[4,5] (**See video, Supplemental Digital Content 1**, which outlines the 5 reasons we have moved toward up to half a fist of true active protected finger flexion and away from full fist place and hold for zone 2 flexor tendon injuries. This video is available in the "Related Videos" section of the Full-Text article on PRSGlobalOpen.com or available at ***http://links.lww.com/PRSGO/A292***.)

First 3 to 5 days after surgery. (**See video, Supplemental Digital Content 2**, which outlines The Saint John rehabilitation Protocol for the first 2 weeks after flexor tendon repair with 3 to 5 days of immobilization and elevation followed by passive warm ups and up to half a fist of early protected true active finger flexion. This video is available in the "Related Videos" section of the Full-Text article on PRSGlobalOpen.com or available at ***http://links.lww.com/PRSGO/A293***.)

- Patients are taught during wide awake flexor tendon repair surgery to not move their fingers at all and to keep the hand elevated at all times in these early postoperative days to avoid bleeding in the wound. Internal bleeding causes clot, and clot becomes scar. Waiting 3 to 5 days before moving lets the swelling, work of flexion, and friction decrease to minimize the risk of rupture. Collagen formation does not start until day 3, so detrimental immediate movement is not necessary.

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Video Graphic 1.
Why we do true active movement instead of full fist place and hold? See video, Supplemental Digital Content 1, which outlines the 5 reasons we have moved toward up to half a fist of true active protected finger flexion and away from full fist place and hold for zone 2 flexor tendon injuries. This video is available in the "Related Videos" section of the Full-Text article on PRSGlobalOpen.com or available at ***http://links.lww.com/PRSGO/A292***.

- Immediately after surgery, our awake patients are immobilized in a dorsal block splint with wrist up to 45 degrees of extension and hand in a comfortable position, metacarpal phalangeal joint joints in 30 degrees of flexion and IP joints in full extension.

Four days to 2 weeks (10 repetitions every waking hour).

- "You can move it but you can't use it!" is the key important hand and finger movement rule emphasized to patients at least 3 times during the flexor repair surgery and at each visit.
- Edema control through elevation of hand and gentle finger compression wrap (Coban, 3M, Hartford City, Ind. or Co-Flex, Andover Healthcare Inc., Salisbury, Mass.).
- Within dorsal blocking splint involving the wrist, patients are taught passive flexion of all digits as a "warm up" before active flexion.
- Active IP joint extension with MP joint blocked in flexion to prevent interphalangeal joint flexion contractures.

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Supplemental digital content is available for this article. Clickable URL citations appear in the text.

Video Graphic 2.
First 2 weeks after flexor zone 2 tendon repair. See video, Supplemental Digital Content 2, which outlines The Saint John rehabilitation Protocol for the first 2 weeks after flexor tendon repair with 3 to 5 days of immobilization and elevation followed by passive warm ups and up to half a fist of early protected true active finger flexion. This video is available in the "Related Videos" section of the Full-Text article on PRSGlobalOpen.com or available at ***http://links.lww.com/PRSGO/A293***.

- True active flexion up to one third to half of a fist; initiating movement at the distal interphalangeal joint (active hook fist).
- No tension, painful or forceful movement. We encourage our patients to be off all pain medicine and follow pain guided hand therapy before starting true active movement.

Two to 4 weeks. (**See video, Supplemental Digital Content 3**, which outlines The Saint John rehabilitation Protocol in the 2 to 4 weeks after flexor tendon repair with progressive flexion, short Manchester splinting, and synergistic motion. This video is available in the "Related Videos" section of the Full-Text article on PRSGlobalOpen.com or available at ***http://links.lww.com/PRSGO/A294***.)

- Dorsal block splint is shortened to Manchester short splint.[4]
- Active synergistic exercise program in the Manchester short splint.
- Patients work toward half to full active fist position and up to 45 degrees of wrist extension.
- Continue full IP joint extension with MP in full flexion.
- Work toward achieving full fist position by 6 weeks.

Six weeks. (**See video, Supplemental Digital Content 4**, which outlines The Saint John rehabilitation Protocol for the remaining 4 to 8 weeks after flexor tendon repair. This video is available in the "Related Videos" section of the Full-Text article on PRSGlobalOpen.com or available at ***http://links.lww.com/PRSGO/A295***.)

- Manchester short splint discontinued.
- Patients can start to use the hand for light activity.
- Start palm-based or digit extension splints at night if needed to correct IPJ flexion contractures. Relative motion flexion orthoses during daytime activity are also helpful.

Video Graphic 3.
Two to 4 weeks after flexor zone 2 tendon repair. See video, Supplemental Digital Content 3, which outlines The Saint John rehabilitation Protocol in the 2 to 4 weeks after flexor tendon repair with progressive flexion, short Manchester splinting, and synergistic motion. This video is available in the "Related Videos" section of the Full-Text article on PRSGlobalOpen.com or available at ***http://links.lww.com/PRSGO/A294***.

Video Graphic 4.
Four to 8 weeks after flexor zone 2 tendon repair. See video, Supplemental Digital Content 4, which outlines The Saint John rehabilitation Protocol for the remaining 4 to 8 weeks after flexor tendon repair. This video is available in the "Related Videos" section of the Full-Text article on PRSGlobalOpen.com or available at ***http://links.lww.com/PRSGO/A295***.

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Repaired Flexor Tendon Excursion with Half a Fist of True Active Movement Versus Full Fist Place and Hold in the Awake Patient

Clifton Meals, MD*; Donald Lalonde, MD, FRCSC†; Gilles Candelier, MD‡

Wide awake flexor tendon repair permits observation of freshly repaired tendons moving actively and passively in comfortable tourniquet free unsedated patients. We present videos of true active flexion versus full fist place and hold (FFPH) immediately after tendon repair so the viewer can see how the tendons move when we simulate postoperative rehabilitation in the awake patient.

The videos demonstrate that half a fist of true active movement provides 5–15 mm of smooth normal gliding of repaired profundus tendons in 10 fingers and 1 flexor pollicis longus in a thumb in 10 patients (**See** video, Supplemental Digital Content 1, which displays 4 fingers showing a range of 5–10 mm of profundus repair glide. Buckle and jerk with FFPH simulation is clearly shown in one of the tendons. This video is available in the "Related Videos" section of the Full-Text article at PRSGlobalOpen.com or at ***http://links.lww.com/PRSGO/A973***; **see** video, Supplemental Digital Content 2, which displays 3 fingers showing a range of 6–11 mm of profundus repair glide. This video is available in the "Related Videos" section of the Full-Text article at PRSGlobalOpen.com or at ***http://links.lww.com/PRSGO/A974***; **see** video, Supplemental Digital Content 3, which displays 2 fingers showing 14 and 15 mm of FDP repair glide. One thumb showing 12 mm of FPL repair glide. This video is available in the "Related Videos" section of the Full-Text article at PRSGlobalOpen.com or at ***http://links.lww.com/PRSGO/A975***).

Five to 15 mm with half a fist is sufficient to keep the tendons gliding while they heal. We know from the work of Jin Bo Tang that the last half of a full fist is where the greatest risk of rupture exists because of increased friction and work of flexion.[1]

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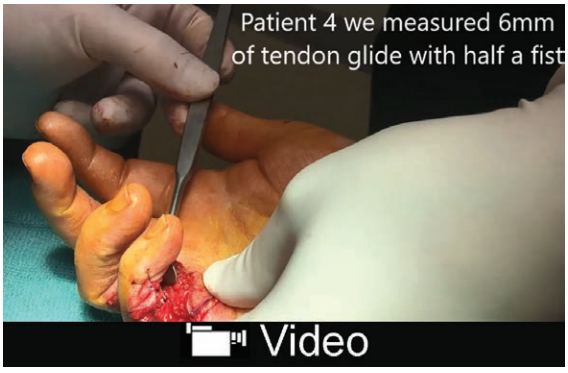
Video Graphic 1. See video, Supplemental Digital Content 1, which displays 4 fingers showing a range of 5–10 mm of profundus repair glide. Buckle and jerk with FFPH simulation is clearly shown in one of the tendons. Two of the fingers had A4 vented and one of the fingers had both A3 and A4 vented. None of the fingers had clinically significant bowstringing with full fist active movement during or after the surgery. This video is available in the "Related Videos" section of the Full-Text article at PRSGlobalOpen.com or at ***http://links.lww.com/PRSGO/A973***.



Video Graphic 2. See video, Supplemental Digital Content 2, which displays 3 fingers showing a range of 6–11 mm of profundus repair glide. One of the fingers had A3 + A4 vented. None of the fingers had clinically significant bowstringing with full fist active movement during or after the surgery. This video is available in the "Related Videos" section of the Full-Text article at PRSGlobalOpen.com or at ***http://links.lww.com/PRSGO/A974***.

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Supplemental digital content is available for this article. Clickable URL citations appear in the text.

Video Graphic 3. See video, Supplemental Digital Content 3, which displays 2 fingers showing 14 and 15 mm of FDP repair glide. One thumb showing 12 mm of FPL repair glide. One of the fingers had A3 + A4 vented. The other finger had A4 vented. None of the fingers had clinically significant bowstringing with full fist active movement during or after the surgery. This video is available in the "Related Videos" section of the Full-Text article at PRSGlobalOpen.com or at ***http://links.lww.com/PRSGO/A975***.

After flexor tendon repair, popular forms postoperative rehabilitation are (1) true active movement[2]; (2) (FFPH)[3]; and (3) Kleinert rubber band passive flexion with active extension.[4] FFPH involves passive flexion of the fingers into a full fist followed by the patient actively holding the flexed position. It is assumed that passively flexing the fingers results in full excursion of the tendons. FFPH simulation in the wide awake patient shows us that passive finger flexion does not always result in full tendon flexion. The tendon can stop gliding and buckle part way through full passive fist flexion (**Supplemental Digital Content 1**). When the patient is then asked to hold the finger in full flexion, the tendon jerks into full flexion from its passively buckled position. We feel this jerky movement may predispose the repair to rupture.

Our observations and experience lead us to believe that half a fist of true active movement provides enough smooth normal profundus gliding, and that risky full fist flexion is not required. FFPH can result in buckling of the tendon followed by jerking into flexion. We therefore prefer up to half a fist of true active movement in our rehabilitation. It provides excellent results.[2,5] We recommend that only half a fist of passive flexion be performed if therapists use place and hold.

The videos also demonstrate 5 clear examples of vented A4 pulleys with no clinically significant bowstringing with full fist flexion on the operating table. Those patients also had no clinically significant bowstringing postoperatively.

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Wide Awake Flexor Tendon Repair in the Finger

Donald Lalonde, MD, FRCSC,* Amanda Higgins, BSc (OT)†

Wide awake flexor tendon repair means no tourniquet and no sedation tendon repair under pure local lidocaine and epinephrine finger and hand anesthesia.

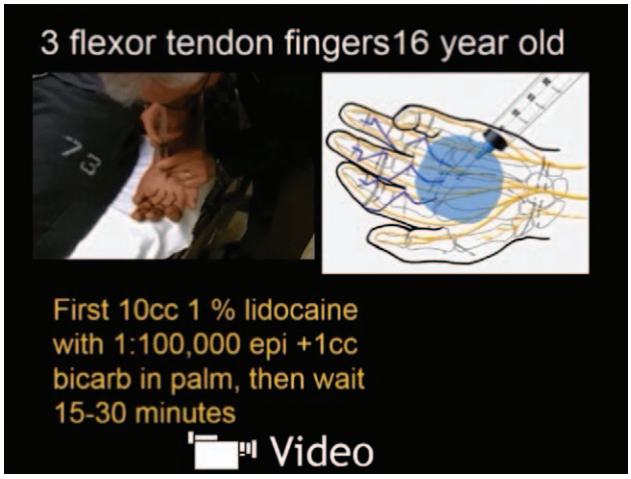
The 5 main advantages of doing the repair this way in the unsedated patient are as follows: (1) fewer postoperative ruptures happen because intraoperative testing of the tendon repair reveals gaps in 7% of cases that are repaired before skin closure.[1] (2) These repairs get less tenolysis because intraoperative testing of the repair guides the surgeon to vent pulleys that impede full flexion or extension of the finger.[2] (3) Surgeons educate the lucid patient during the surgery, so he understands how to avoid rupture and getting stuck.[3] (4) Intraoperative flexor tendon repair testing guides the surgeon in the decision to maintain a superficialis repair or resect a superficialis slip.[4] (5) Seeing full active flexion and extension with no gap during the surgery empowers the surgeon to allow up to half a fist of true active postoperative flexion (not place and hold) 3 to 5 days after surgery.[5]

LOCAL ANESTHESIA

Inject lidocaine with epinephrine (buffered 10:1 with 8.4% bicarbonate) everywhere you plan to dissect. Inject slowly from proximal to distal to decrease injection pain (**See Video 1, Supplemental Digital Content 1**, which displays a preoperative patient and local anesthetic injection. This video is available in the "Related Videos" section of the full-text article on PRSGlobalOpen.com or at ***http://links.lww.com/PRSGO/A212***). Wait 30 minutes or more after the last injection to give time for maximal epinephrine vasoconstriction in the finger.

OPERATIVE TIPS

See Videos 2 to 4, Supplemental Digital Content 2, which demonstrates dissecting the skin flaps and exposing the sheath. This video is available in the "Related Videos" section of the full-text article on PRSGlobalOpen.com or at ***http://links.lww.com/PRSGO/A213***). **See video, Supplemental Digital Content 3**, which demonstrates how to retrieve tendon



Video Graphic 1.
Preoperative patient and local anesthetic injection. See video, Supplemental Digital Content 1, which shows details of how to inject local anesthesia for wide awake flexor tendon repair. This video is available in the "Related Videos" section of the full-text article on PRSGlobalOpen.com or at ***http://links.lww.com/PRSGO/A212***.

Video Graphic 2.
Dissecting the skin flaps and exposing the sheath. See video, Supplemental Digital Content 2, which shows the dissection of skin flaps and exposure of the sheath of the patient introduced in Video 1. This video is available in the "Related Videos" section of the full-text article on PRSGlobalOpen.com or at ***http://links.lww.com/PRSGO/A213***.

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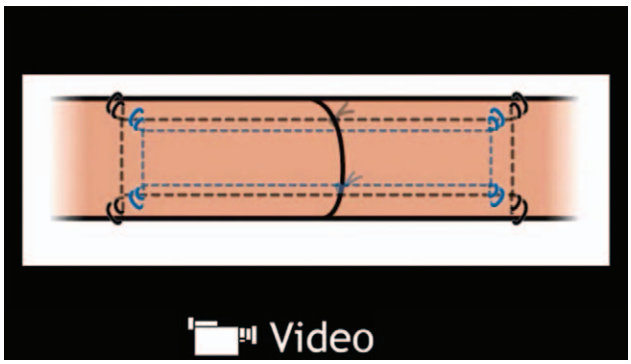
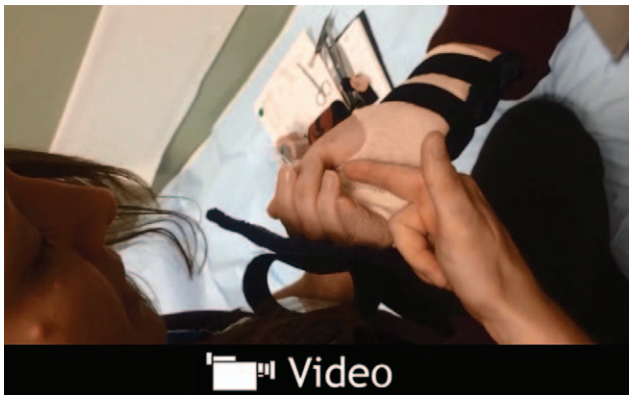
Video Graphic 3.
Retrieving the tendon ends. See video, Supplemental Digital Content 3, which demonstrates how the surgeon gets the patient to extend the finger to relax the flexor tendon and let it come distally in the sheath by pushing it with Adson forceps through sheathotomies. This video is available in the "Related Videos" section of the full-text article on PRSGlobalOpen.com or at ***http://links.lww.com/PRSGO/A214***.



Video Graphic 4.
Suture the tendon and intraoperative patient education. See video, Supplemental Digital Content 4, which observes the step by step suturing of the tendon through sheathotomies, venting of the A4 pulley, intraoperative testing of the repair, and patient education during the surgery. This video is available in the "Related Videos" section of the full-text article on PRSGlobalOpen.com or at ***http://links.lww.com/PRSGO/A215***.

ends. This video is available in the "Related Videos" section of the full-text article on PRSGlobalOpen.com or at ***http://links.lww.com/PRSGO/A214***). **See video, Supplemental Digital Content 4**, which demonstrates how to suture the tendon and intraoperative patient education. This video is available in the "Related Videos" section of the full-text article on PRSGlobalOpen.com or at ***http://links.lww.com/PRSGO/A215***).

- Repeatedly, test full active patient flexion and extension of the finger after each core and epitenon suture to make sure that there is no gap and that the repair fits through the pulleys. Repair any gaps and vent pulleys as required to get a full range of motion before skin closure. This is like testing blood flow in a vascular anastomosis to ensure function before skin closure.
- Have the patients extend the finger if you feel them pull against you as you retrieve the tendon. Extension generates reflex relaxation of flexor muscles.



Video Graphic 5.
Postoperative therapy. See video, Supplemental Digital Content 5, which displays the postoperative therapy, demonstrating early protected true active flexion and extension (as opposed to place and hold) and final result with patient of Videos 1 and 2. This video is available in the "Related Videos" section of the full-text article on PRSGlobalOpen.com or at ***http://links.lww.com/PRSGO/A216***.

- You do not need cautery. Bleeding stops by the time you sew back the skin flaps to expose the sheath.
- Surgeons can repair tendons in minor procedure rooms outside the main operating room in daytime hours.
- Involve hand therapists in patient teaching during surgery.

POSTOPERATIVE THERAPY

See Video 5, Supplemental Digital Content 5, which displays post operative therapy. This video is available in the "Related Videos" section of the full-text article on PRSGlobalOpen.com or at ***http://links.lww.com/PRSGO/A216***.

- Immobilize and elevate the hand until swelling, friction, and work of flexion is gone (3–5 days).
- Initiate up to half a fist of true active movement (not place and hold).

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IC03: Flexor Tendon Repair: Why Research Should Change Your Practice

How My Research Changed My Practice

Martin I. Boyer, MD, FRCS(C)

I. How our basic research informed my decision to not focus on applied force to the repair site during rehabilitation of intrasynovial flexor tendon repairs
II. How our basic research informed my decision to instead focus on intraynovial repair site excursion of the repair site during rehabilitation of intrasynovial flexor tendon repairs
III. How Tang's (and others') research informed my decision about the treatment of the sheath and pulley system during surgical approach to repair intrasynovial flexor tendons
IV. How our (and Manske's) basic ex-vivo and in-vivo research informed us that a minimum of a four strand core suture is necessary for the application of clinically relevant in vivo force and excusrion during rehabilitation
V. How our research demonstrated that repair site separation of 3mm or greater at three weeks leads to a flattening out of the repair site ultimate strength accrual curve, and could explain why tendons that seem to be rehabilitating really well rupture late!

Citations

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2. Silva et al JOR 1999 17(5) 777-83
3. Tang 2014 JHS 39(11) 2300-7 among others
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5. Gelberman RH et al JBJS 1999 81(7) 975-82

Speaker has not provided a handout for this presentation