

## Hand Therapy Protocols

Following are representative protocols for each of the three basic approaches to flexor tendon post repair management: immobilization, early passive mobilization, and early active mobilization. Obviously, the choice between one protocol and another is a matter of assessment of the patient (i.e., compliance, ability to attend therapy regularly), the surgery (strength of suture, factors impairing healing or gliding), and the therapist (experience and skill).

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### Early Active Mobilization

**Rationale.** Repair techniques have improved vastly in recent years: We now have stronger, less bulky sutures that glide much more easily. Clearly, whenever feasible, early active mobilization is preferable to early passive mobilization. The literature is growing rapidly and contains a diversity of postoperative approaches (Stewart Pettengill KM, van Strien G: Postoperative management of flexor tendon injuries. In Hunter et al *Rehabilitation of the Hand and Upper Extremity*, Mosby, 449, 2002).

Based on studies indicating that early motion increases repair strength, most published protocols start motion at 24 to 48 hours after surgery. Halikis et al (Halikis MN, Manske PR, Kubota H, Aoki M: Effect of immobilization, immediate mobilization, and delayed mobilization on the resistance to digital flexion using a tendon injury model, *J Hand Surg [Am]*. 1997 May; 22(3): 464-72) have compared work of flexion (i.e., resistance to flexion imposed by surrounding edematous tissues) in immobilized repairs to those mobilized immediately, those mobilized at 3 days, and those mobilized at 5 days. They found that the work of flexion increased significantly in tendons mobilized immediately, whereas work of flexion increased the least for tendons initiating active mobilization at 3

days. This calls into question the assumption that immediate mobilization is crucial to a good result.

**Protocols.** Almost all protocols use a dorsal blocking splint like those used for early passive mobilization protocols. Exercises and exercise frequency vary, but all protocols protect the tendon by limiting active flexion for the first 3 to 6 weeks.

### Accelerated Active – Solomons

This protocol is being used by Solomons et al (Solomons, Rosenwasser, Diao: [Clinical Experience with a new tendon fixation device using and accelerated active motion protocol](#), pending private research) with zone 2 repairs using the Teno Fix® Tendon Repair System. Active digital flexion and extension maximum attainable to the palm are started on the first day with the goal of full flexion at 2 weeks post-operatively. The anticipated risks in this protocol are forced passive extension especially of the wrist and finger (e.g. fall on outstretched hand) and resisted flexion, potentially causing gapping or rupture of the repair.

#### Early Stage (Up to 2 weeks)

**Splint.** Wrist 30 degrees flexion, MP joints 30 degrees flexion, and IP joints straight.

**Exercise.** Days 1 through 14 post-operative, 5 active flexions and extensions every hour, with thermoplastic insert to keep IP joints extended at night and between exercises. Days 1 through 4, aim for a PDPC measurement of 3 cm. Days 5 through 14, increase to maximum unresisted flexion to achieve PDPC of 0 cm. If developing FFD of PIP joint then work harder on active extension with MP flexed. If not achieving full flexion then do place and hold exercises.

#### Intermediate Stage (2 weeks to 4 weeks)

**Splint.** Wrist 30 degrees flexion, MP joints 30 degrees flexion with IP joints fully extended.

**Exercise.** Unrestricted active flexion without resistance, aggressive passive flexion with place and hold. Active extension with and without MP joint flexed. Thermoplastic insert used at night only to keep IP joints extended.

#### Late Stage (4 weeks to 12 weeks)

**Splint.** Splint removed at 4 weeks

**Exercise.** Flexion as before, with wrist flexed, neutral, and extended. Massage scar and treat FFD's accordingly. (Note: If patient is unreliable then leave splint on to 6 weeks.)

### Allen

A method for a second rehabilitation program was completed by patients with ruptured flexor tenorrhaphies (Ruptured flexor tendon tenorrhaphies in zone II: repair and rehabilitation. *J Hand Surg [Am.]* 1987 Jan; 12(1): 18-21).

**Splint.** The wrist is set at 30 degrees and MP joints at 60 to 70 degrees with rubber band flexion traction. The splint is replaced with a wrist cuff at 3 weeks postoperative as used in the Duran protocol.

**Exercise.** For the first 3 weeks hourly gentle active flexion and extension exercises (10 repetitions) are performed in the splint with rubber band traction attached. Once in the wrist cuff, wrist AROM is initiated (intermediate stage). The program progresses to dowel gripping and unresisted weight well exercise at 5 weeks, with progressive resistive exercise as needed (late stage). Patients begin light activities at 6 weeks.

## **Belfast and Sheffield**

A group of related early active mobilization programs have been published by authors from the United Kingdom. Two similar original protocols (Small JO, Brennen MD, Colville J: Early active mobilisation following flexor tendon repair in zone 2, *J Hand Surg [Br]* 1989 Nov; 14(4):383-91 and Cullen KW, Tolhurst P, Lang D, Page RE: Flexor tendon repair in zone 2 followed by controlled active mobilisation, *J Hand Surg [Br]* 1989 Nov; 14(4):392-5) were modified subsequently by other authors. Following is one of the more detailed of the recently published versions by Gratton (Gratton P: Early active mobilization after flexor tendon repairs, *J Hand Ther.* 1993 Oct-Dec; 6(4):285-9).

### **Early Stage (Up to 4 to 6 weeks)**

**Splint.** The postoperative cast maintains the wrist at 20-degree flexion and MP joints at 80 to 90 degrees of flexion, allowing full IP extension. The cast extends 2 cm beyond the fingertips to inhibit use of the hand. A radial plaster "wing" wraps around the wrist just proximal to the thumb to prevent the cast from migrating distally. On initiation of therapy, the postoperative dressing is debulked to allow exercise.

**Exercise.** For zone 3 injuries, therapy is initiated 24 hours after repair, but zone 2 repairs are allowed to rest until 48 hours after surgery to allow postoperative inflammation to subside. Exercises, performed every 4 hours within the splint, include all digits and consist of two repetitions each of full passive flexion, active flexion, and active extension. The first week's goal is full passive flexion, full active extension, and active flexion to 30 degrees at the PIP joint and 5 to 10 degrees at the DIP joint. Active flexion is expected to gradually increase over the following weeks, reaching 80 to 90 degrees at the PIP joint and 50 to 60 degrees at the DIP joint by the fourth week. In the presence of joint stiffness, passive exercises are increased to every 2 hours. A pen could be placed behind the proximal phalanx to block the MP in flexion for greater IP active extension if flexion contractures develop.

### **Intermediate Stage (Beginning at 4 to 6 weeks)**

**Splint.** The splint is discontinued at 4 weeks if tendon glide is poor (not achieving expected goals given above), at 5 weeks for most patients, or at 6 weeks for patients with unusually good tendon gliding (full fist developing within the first 2 weeks). Three weeks after splinting is discontinued, any residual flexion contractures are treated with finger-based dynamic extension splints.

**Exercise.** The only exercise specified for this period is protected passive IP extension (with the MP held in flexion) in the presence of flexion contractures. Presumably, patients continue active flexion and extension exercises, and the program progresses from this point as it would for any tendon protocol, adding light resistance first as warranted by difficulty attaining tendon glide, and then stepping up resistance (late stage) for strengthening. Small et al. do speak of using blocking exercises to increase tendon glide at 6 weeks, and Cullen et al. initiate progressive resistive exercise and heavier hand use at 8 weeks, with full function expected by 12 weeks.

## Strickland/Cannon

**Active-hold/place-hold mobilization Strickland/Cannon.** This protocol by Strickland (Strickland, JW: Flexor tendon injuries: I. Foundations of treatment, *J AM Acad Orthop Surg* 1995 Jan; 3(1): 44-54) and Cannon (Cannon N: Post flexor tendon repair motion protocol, Indiana Hand Center Newsletter 1:13, 1993) is an "active-hold" or "place-hold active mobilization" protocol. The digits are passively placed in flexion, and the patient then maintains the flexion with a gentle muscle contraction. Patients learn to use only minimal force by practicing with the uninjured hand and also use biofeedback to monitor the strength of contraction (less than 10 mV on a Cyborg model biofeedback unit).

### Early Stage (Up to 4 weeks)

**Splint.** Two different splints are used. A dorsal blocking splint is worn most of the time, with the wrist at 20 degrees of flexion and MP joints at 50 degrees. The exercise splint has a hinged wrist, allowing full wrist flexion, but wrist extension is limited to 30 degrees. Full digit flexion and full IP extension are allowed, but MP extension is limited to 60 degrees.

**Exercise.** Every hour, patients perform the Strickland version of modified Duran exercises (15 repetitions of PROM to the PIP and DIP joints and the entire digit) in the dorsal blocking splint, followed by 25 repetitions of place-hold digit flexion in the tenodesis splint. The patient extends the wrist actively with simultaneous passive digit flexion and actively maintains digit flexion for 5 seconds. The patient then relaxes and allows the wrist to flex and digits to extend within the limits of the splint.

### Intermediate Stage (From 4 to 7 or 8 weeks)

**Splint.** Tenodesis splint is discontinued. Patient still wears dorsal blocking splint except for tenodesis exercises.

**Exercise.** The tenodesis exercises continue every 2 hours with 25 repetitions followed by 25 repetitions of active flexion and extension exercise for wrist and digits, avoiding simultaneous wrist and digit extension. FDS gliding also may be added. At 5 to 6 weeks, blocking and hook fists may be added if needed to improve tendon gliding.

### Late Stage (Starting at 7 to 8 weeks)

**Splint.** The splint is discontinued.

**Exercise.** Progressive resistive exercise is initiated. The patient gradually

resumes activities of daily living, with no restrictions by 14 weeks. FPL is moved more aggressively than digit flexors (putty exercises are initiated by 7 weeks), and flexors to the small finger are moved the least aggressively, in the light of the authors' clinical observation that repairs of these tendons are the most prone to deformation and rupture.

## **Silfverskiold and May**

These protocols (Silfverskiold KL, May EJ: Flexor tendon repair in zone II with a new suture technique and an early mobilization program combining passive and active flexion, *J Hand Surg [Am]*. 1994 Nov; 19(1): 53-60) are similar to the previously discussed early passive mobilization protocol, but have added an active-hold component. The wrist is splinted in neutral instead of 30 to 45 degrees of flexion, but the splint is otherwise identical to the early passive mobilization protocol (MP joints in 50 to 70 degrees flexion and splint extending only to the PIP joints). Exercises are similar to those outlined for the four-finger program, but after using the uninvolved hand to push the fingers of the involved hand into full flexion, the patient uses an active muscle contraction to maintain flexion of the involved fingers for 2 to 3 seconds. The program is progressed in the same manner as the four-finger protocol.

## **Evans and Thompson**

Evans and Thompson (Evans RB, Thompson DE: The application of force to the healing tendon, *J Hand Ther*. 1993 Oct-Dec; 6(4):266-84) have examined the biomechanical aspects of early active-hold mobilization using the concept of "minimal active muscle-tendon tension" (MAMTT), the minimal tension required to overcome the viscoelastic resistance of the antagonistic muscle-tendon unit.

Note that this is not a protocol, but a set of guidelines to be used by a therapist in planning treatment. The therapist must know the strength of the suture, recognize any unusual factors such as severe edema, and decide whether this approach is appropriate. He or she must consider the anticipated potential drop in tensile strength of the repair between day 5 and day 15 and adapt the program accordingly.

The MAMTT exercises are performed only under a therapist's supervision, while the patient follows an early passive mobilization program at home (a dorsal blocking splint and rubber band traction into flexion are used). For MAMTT exercise, the splint is removed. The wrist is passively placed in 20-degree extension and the finger passively flexed to 83 degrees at the MP joint, 75 degrees at the PIP joint, and 40 degrees at the DIP joint. The patient is then asked to maintain the position with as gentle a muscle contraction as possible. The force of the muscle contraction is measured with a small (less than 150 g) Haldex pinch gauge. A loop of string passes perpendicularly around the gauge arm of the pinch meter and around the finger tip. The patient flexes the finger with a force of 50 g or less.

## **Early Passive Mobilization**

**Rationale.** If applied with care, early passive mobilization (starting within a few days of repair) has been shown to produce superior results, apparently because early

mobilization inhibits restrictive adhesion formation, promotes intrinsic healing and synovial diffusion, and produces a stronger repair, preventing the decrease in tensile strength of repairs noted in immobilized tendons reported in literature.

**Protocols.** There are two basic types of early passive mobilization protocols based on the work of Kleinert (Kleinert HE, Kutz JE, Cohen MJ: Primary repair of zone 2 flexor tendon lacerations, *AAOS symposium on tendon surgery in the hand*, St Louis, 1975, Mosby) and on that of Duran and Houser (Duran R, Houser R: Controlled passive motion following flexor tendon repair in zones 2 and 3, *AAOS symposium on tendon surgery in the hand*, St Louis, 1975, Mosby). Each protocol has many variations on these two approaches described in literature. In both approaches, a forearm-based dorsal blocking splint, applied at surgery, blocks the MP joints and wrist in flexion to place the flexor tendons on slack, and the IP joints are left free or allowed to extend to neutral within the splint. Dynamic traction maintains the fingers in flexion to further relax the tendon and prevent inadvertent active flexion. The dynamic traction may be provided by rubber bands, elastic threads, springs, or other devices; the traction is applied to the fingernail either by placing a suture through the nail in surgery or by gluing to the fingernail a dress hook, Velcro, a piece of soft leather or moleskin, or the rubber band itself.

## Duran and Houser

### Early stage (from 0 to 4.5 weeks)

**Splint.** The wrist is held in 20 degrees of flexion and the MP joints in a relaxed position of flexion.

**Exercise.** Duran and Houser determined through clinical and experimental observation that 3 to 5 mm of glide was sufficient to prevent formation of firm tendon adhesions; the exercises (6 to 8 repetitions twice a day) are designed to achieve this. With MP and PIP joints flexed, the DIP joint is passively extended, thus moving the FDP repair distally, away from an FDS repair. Then with DIP and MP joints flexed, the PIP is extended; both repairs glide distally away from the site of repair and any surrounding tissues to which they might otherwise form adhesions.

### Intermediate stage (from 4.5 weeks to 7.5 or 8 weeks)

**Splint.** After 4.5 weeks, the splint is replaced with a wrist band to which rubber band traction is attached.

**Exercise.** Active extension exercises begin within the limitations imposed by the wrist band. Active flexion (blocking, FDS gliding, and fisting) is initiated on removal of the wrist band at 5.5 weeks.

### Late stage (starting at 7.5 to 8 weeks)

Resisted flexion waits until 7.5 to 8 weeks. The program is upgraded in the same manner as described in the section on Immobilization. The patient begins gentle blocking exercises for isolated FDP and FDS glide. Blocking exercises are performed four to six times a day, with 10 repetitions, in addition to the passive exercise and active differential flexor tendon gliding introduced in the previous

stage. After 1 week, if active flexion has not improved, the program is upgraded to include towel walking (flexing fingers individually in turn to gather a towel on a flat surface), light pick-ups, and gentle putty squeezing (no more than 10 repetitions with the lightest putty).

In another week, sustained grip activities may be added, followed by light-resistance grip exercisers, putty scraping, and use of heavier putty. The patient also may be instructed to begin lifting heavier objects at home (e.g., a quart of milk). The tendon that is gliding well does not need that additional resistance. Smoothly gliding tendons should not receive even light resistance until 7 or 8 weeks, and most tendons are not ready for heavy resistance (e.g., lifting more than 10 pounds, using heavy putty) and manual labor job simulation until 10 to 12 weeks.

### **Modified Duran Approach**

This is to apply a dorsal protective splint (40 to 50 degrees at the MP joints and from 20 degrees of extension to 20 degrees of flexion at the wrist, with the IP joints allowed to extend to neutral in the splint) but to omit the rubber band traction and strap the IP joints in extension between exercises or at night. Patients perform passive individual and composite flexion and extension, active composite extension exercises (manually blocking the MP in greater flexion for more complete active IP extension), and the passive flexion and extension exercises advocated by Duran and Houser. In therapy only, the splint is removed for careful protected tenodesis exercises (passive or assisted simultaneous wrist flexion and finger extension, alternating with simultaneous wrist extension and finger flexion).

### **Kleinert**

The original protocol is no longer used much in the original form. More recent adaptations are summarized following.

#### **Early stage (from 0 to 3 weeks)**

**Splint.** In the original Kleinert protocol, the dorsal blocking splint blocked the wrist in 45 degrees of flexion and the MP joints in 10 to 20 degrees. Rubber band traction was directed to the fingernail from the wrist or just proximal to the wrist.

**Exercise.** Every hour, the patient actively extends the fingers to the limits of the splint 10 times, allowing the rubber bands to flex the fingers.

#### **Intermediate stage (from 3 weeks to 5 weeks)**

**Splint.** The rubber band from the injured digit is attached to a wrist band from 3 weeks through 5 weeks.

**Exercise.** All active movement so the wrist and hand are encourage, although the injured digit is still tethered through 5 weeks. At five weeks, gentle active flexion may begin.

## Late stage (starting at 6 weeks)

Resisted exercise begins.

## Variations on early passive mobilization

Prevention of PIP flexion contractures. When the fingers are maintained in PIP flexion with dynamic traction, PIP flexion contractures often result. One solution is to remove the traction at night and strap the fingers in IP extension. A static PIP extension splint may be inserted between the dorsal blocking splint and the dorsum of the finger to address this problem when it first develops.

Studies have shown that rubber bands offer increasing resistance because finger extension stretches the elastic further, Burge and Brown (Burge PD, Brown M: Elastic band mobilisation after flexor tendon repair; splint design and risk of flexion contracture. *J Hand Surg [Br]* 1990 Nov; 15(4):443-8) found that this increase could be moderated by use of a palmar pulley or by positioning the MP in no more than 20 degrees of flexion,

Another proposed solution is to change the means of dynamic traction within the splint design. In the Washington regimen, two rubber bands are used, one of which is cut in half so that it forms a single strand. Before performing active extension exercises, the patient detaches proximally the intact rubber band so that only the single strand elastic resists extension, making full extension easier to achieve. The finger rests in complete flexion to the distal palmar crease (DPC) when not exercising.

## Achieving maximum passive tendon excursion.

McGrouther and Ahmed (McGrouther DA, Ahmed M: Flexor tendon excursions in "no man's land," *Hand* 1981 Jun; 13(2): 129-41) found that complete excursion of the FDP tendon and differential excursion between FDP and FDS could be accomplished only through flexion of the DIP; later this principle also was found to be true for the FPL. In other words, to achieve glide of a repair, it is necessary to flex the joints distal to the repair. This and other studies suggest that early passive mobilization programs should incorporate the greatest possible degree of flexion in the IP joints. In the standard dynamic flexion splint as first designed by Kleinert, the rubber band traction is directed from the wrist or distal forearm to the fingernail. This flexes the MP joint and, to a lesser extent the PIP joint, but leaves the DIP in virtual extension. Standard practice with zone 2 FDP injuries has been to adding a palmar pulley to redirect dynamic traction and thus fully flex the DIP joint.

## Four-finger method.

May et al (May EJ, Silfverskiold KL, Sollerman CJ: Controlled mobilization after flexor tendon repair in zone II: a prospective comparison of three methods, *J Hand Surg [Am]* 1992 Sep; 17(5): 942-52) describes an early passive mobilization protocol that is a variation of the Kleinert protocol they call the "four-finger" method.

**Splint.** The dorsal splint extends only to the PIP joints to ensure that PIP

extension is not limited, with the wrist at 30 – 45 degrees of palmar flexion, and the MP at 50 – 70 degrees of flexion. All four fingers are included in traction, even if not injured. A thicker rubber band is used to ensure maximum passive flexion, and manual pressure to all four fingers is used to attain the final degrees of passive flexion during exercise. Patients are instructed to use the uninvolved hand to decrease resistance from the rubber bands by pulling them distally during the active extension part of the exercises. The splint is removed at 4 weeks.

**Exercise.** 10 active IP joint extensions hourly beginning on the first to third postoperative day. At night, the rubber bands are detached, and a volar component is added holding the IP joints in extension. Upon splint removal, unassisted active flexion/extension is begun. At 6 weeks, gentle resistive flexion exercises are started, progressing to blocking of the PIP joint at 8 weeks postoperative. Unrestricted activity is usually achieved at 10 to 12 weeks after the operation.

## Immobilization

**Rationale.** Early mobilization protocols are appropriate for alert, motivated patients who understand the exercise program and precautions. For this reason, immobilization may be desired for patients younger than 10 years of age, those with cognitive deficits, and those who for any other reason are clearly unable or unwilling to participate in a complex rehabilitation program. Some tendons also must be immobilized to protect other injured structures. It may be difficult to mobilize these repairs later on because of heavy adhesion formation.

**Protocol.** The following protocol is based on that developed by Cifaldi Collins and Schwarze (Cifaldi Collins DC, Schwarze L: Early progressive resistance following immobilization of flexor tendon repairs, *J Hand Ther* 4:111, 1991) and is designed to provide guidelines for sufficiently aggressive therapy after mobilization.

### Early stage (from 0 to 3 or 4 weeks)

**Splint.** The dorsal forearm-based postoperative splint or cast holds the wrist in 10 to 30 degrees of flexion, the MP joints in 40 to 60 degrees of flexion, and the IP joints in full extension. The splint is worn 24 hours a day except for therapy visits one to two times a week, when the splint may be removed by the therapist.

**Exercise.** One or two times a week, the splint is removed by the therapist for gentle protected PROM. The therapist holds adjacent joints in flexion while extending and flexing each joint. Often, after prolonged protection in MP flexion, patients develop intrinsic tightness. Therefore, in addition to protected isolated ROM of all joints, protected intrinsic stretch exercises are performed (wrist flexed maximally while MP joints are held in neutral and IP joints are gently flexed passively). After the sutures are removed and the incision is well healed, the scar is massaged. As the scar heals, massage may help control both skin and tendon adhesions.

### Intermediate stage (starting at 3 to 4 weeks)

**Splint.** At 3 to 4 weeks, the splint is modified to bring the wrist to neutral (0 degrees). The patient is taught to remove the splint hourly for exercise.

**Exercise.** With the wrist at 10 degrees of extension, the patient performs 10 repetitions of passive digit flexion and extension, followed by 10 repetitions of active differential tendon gliding exercises (hook fist, straight fist, and then full fist). For the Cifaldi Collins and Schwarze protocol, the exercises incorporate tenodesis: The wrist extends when the digits flex and flexes when the digits extend, increasing the excursion attained.

After 3 or 4 days of these exercises, tendon function is evaluated. The therapist measures active and passive flexion, totaling the degrees of flexion achieved at MP and IP joints for total active and passive flexion. If there is a discrepancy of more than 50 degrees between total active and total passive flexion, poor gliding and heavy adhesion formation are assumed and the patient is moved on to the next phase of therapy. If the discrepancy is less than 50 degrees, the patient continues with the current phase of therapy until 6 weeks after repair.

### Late stage (starting at 4 to 6 weeks)

**Splint.** The dorsal blocking splint is discontinued.

**Exercise.** The patient begins gentle blocking exercises for isolated FDP and FDS glide. Blocking exercises are performed four to six times a day, with 10 repetitions, in addition to the passive exercise and active differential flexor tendon gliding introduced in the previous stage. After 1 week, if active flexion has not improved, the program is upgraded to include towel walking (flexing fingers individually in turn to gather a towel on a flat surface), light pick-ups, and gentle putty squeezing (no more than 10 repetitions with the lightest putty).

In another week, sustained grip activities may be added, followed by light-resistance grip exercisers, putty scraping, and use of heavier putty. The patient also may be instructed to begin lifting heavier objects at home (e.g., a quart of milk). The tendon that is gliding well does not need that additional resistance. Smoothly gliding tendons should not receive even light resistance until 7 or 8 weeks, and most tendons are not ready for heavy resistance (e.g., lifting more than 10 pounds, using heavy putty) and manual labor job simulation until 10 to 12 weeks.

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1. Hunter JM, Mackin, EJ, Callahan AD: **Rehabilitation of the hand and upper extremity**, Chapter 27 *Postoperative management of flexor tendon injuries*, 431, 5th Edition, Mosby, St. Louis, 2002.
2. Solomons M, Rosenwasser M, Diao E: [Clinical Experience with a new tendon fixation device using and accelerated active motion protocol](#), pending private research.