Review Article

JHS(E)

Journal of Hand Surgery
(European Volume)
2021, Vol. 46(8) 813–817

DOI: 10.1177/17531934211037112
journals.sagepub.com/home/jhs
SAGE

Rehabilitation after flexor tendon repair and others: a safe and efficient protocol

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Abstract

In this review I detail the protocol that I use after flexor tendon repair and outline my experience regarding how its framework might be used for other disorders. The early passive–active flexion protocol has a sufficient number of cycles of active flexion in each exercise session, which is at least 40, and ideally 60 to 80. The frequency of exercise sessions may range from 4 to 6 a day, distributed in the morning, afternoon and evening. Increasing the number of daily sessions *without* a sufficient number of runs in each session is ineffective. In the first 2–3 weeks after surgery, active digital flexion should go through only a partial range. In weeks 4–6, the patient gradually moves through the full range. With modifications, I suggest generalization of the partial-range finger motion to therapy after treating other hand injuries. I consider partial-range active flexion a generalizable working principle for different hand disorders.

Keywords

Flexor tendons, rehabilitation, exercise session, number of motion cycles, hand disorders, partial-range digital flexion, early active motion

Date received: 18th July 2021; accepted: 19th July 2021

Over past 10 years, after I started to use a partial-range active digital flexion protocol for flexor tendon repair years earlier, I sought to determine the proper number of motion cycles for it, and to simplify the protocol and expand its use to other hand disorders. In this review I detail the protocol and outline my experience regarding how its framework might be used for other disorders.

Combined early passive-partial active flexion: a current mainstay

Early active digital flexion is currently a popular way of rehabilitation after primary flexor tendon repair. In discussion with surgeons and therapists, I found quite a few of them have not used an updated protocol; they use protocols that are 20 to 30 years old, though also called 'early active' motion. The earliest protocol differs dramatically from the current ones, resulting in outcomes of Zone 2 repairs that are not as good as those using an updated protocol.

The earliest protocol of 'early active' flexion calls for only four repetitions performed in 2-hourly intervals (Small et al., 1989), which is perhaps only a warm-up process. This protocol is also used with ten repetitions of motion hourly or 2-hourly. With this protocol, it is impossible to efficiently move the tendon, because ten repetitions would slightly decrease joint stiffness and end without sufficient digital flexion. The protocol is not greatly different from a passive flexion protocol regarding the efficiency of tendon motion.

Details of the most updated protocol

Sufficient number of runs in each session and partial-range motion in the initial weeks

The current early passive-active flexion protocol demands a *sufficient* number of cycles of active flexion in each exercise session, which is at least 40, and ideally 60 to 80. The frequency of exercise sessions is

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not as important, which may range from 4 to 6 a day. Thus, every day the patient should perform 200 to 300 cycles of active digital flexion, with the cycles divided into four to six sessions, distributed in the morning, afternoon and evening. I often instruct patients to have one session each in the morning, afternoon, before dinner and before going to sleep. They can add one or two sessions as they like, but the minimum is four sessions a day. To ensure sufficient number of runs in each session, I advise them to set a clock for 15 or 20 minutes for a session, which is much easier than counting the exact number of runs. Motion for 15–20 minutes would ensure more than 40 runs of digital active flexion. The motion can be in normal speed or slower and may include brief rest. Most patients do at least 80 digital motion cycles in 15–20 minutes.

Before starting active flexion, I stress the importance of performing a full or close-to-full range of passive digital motion for ten or more cycles, usually 10–30 cycles. That is why it is called *passive-active* motion. If very mild edema presents, the passive motion may need fewer cycles before proceeding to 40 or more cycles of active flexion.

In the first 2–3 weeks after surgery, active digital flexion should go through only a partial range, because moving through the entire flexion range is impossible to achieve comfortably in most cases, and motion over a partial range is sufficient to glide the tendon repair site. Motion through the entire range risks the repairs unnecessarily. I usually ask the patients to move through initial 1/3, 1/2 or 2/3 of the full flexion range starting from full extension. I emphasize they actively flex to a point of comfortable resistance within the partial-range, but do not set a specific goal so not to overload the tendon. In weeks 4–6, the tendon repair grows stronger, so the aim is for the patient gradually to move through the full range.

Active flexion is easier out of the splint, because a splint adds resistance to digital motion. For compliant patients, out-of-splint motion is safe and efficient. I order out-of-splint motion for most of my patients. The patients should put on the splint right after each session, where it protects the hand from inadvertent use and serves as a cautionary reminder to other people.

I do not instruct the patient to place the opposite hand vertical to the palm of the repaired hand as a set goal for the finger to reach. This goal is particularly difficult for a repaired little finger to achieve. Comfortable digital flexion increases in later runs of a session. The other hand crossing the palm interferes with the later runs.

The rationale behind the partial-range active flexion over the initial flexion range is that the curvature of the flexor tendons is smoothest with the fingers mildly flexed (Wu and Tang, 2013, 2014). From full finger extension to moderate flexion, the tendons are subjected to minimal bending forces. However, the extreme flexion subjects the tendons to a great bending force, which may easily rupture the repair (Tang et al., 2001, 2003) (Figure 1).

Wrist position is not important and the hand can be in resting position

The exact wrist position in the splint is not important, neither is the length of the splint over the forearm. I make the splint to cover the distal 1/3 of the forearm. The splint extends distally to the tip of the digits and protects the digits in a resting position. Because the patient removes the splint to move for 1–2 hours each day, there is less chance of joint stiffness due to splinting. A comfortable hand position in the splint is a primary consideration. A neutral or slightly flexed or extended position of the wrist suffices. I put the metacarpophalangeal (MP) joints in mild or moderate flexion and interphalangeal joints in extension or minimal flexion, which lessens tension on the repaired tendon and allows digital extension, and the digits rest in the resting position.

A plaster splint versus thermoplastic splint

I mould a dorsal plaster splint in the operation room and use it for protection continuously throughout the weeks after surgery. I do not change it to a thermoplastic splint, because a plaster splint, well-padded with cotton and covered by a stocking, is comfortable and free of sharp edges. The patient can unwrap the elastic bandage over this splint easily. The fingers can mostly be covered by the bandage, which protects the fingers securely. A thermoplastic splint is fine, but I prefer a plaster one.

Wearing a thermoplastic splint may increase the difficulty of little finger movement. I did see one tendon ruptured in a little finger during active flexion, because the thermoplastic splint was slightly curved and restricted little finger motion. Care should be applied to avoid this risk.

I instruct my patients directly at the first postoperative clinic visit, which is usually 4 to 7 days after surgery. The digital motion is initiated after the visit. I often ask the patient to record a voice memo or a smartphone video while I teach them the protocol, which I have described above. The explanation takes only 5 to 10 minutes, therefore I see no need to go through therapists. Because the motion is simple to demonstrate, most uncomplicated patients do not need formal therapy.

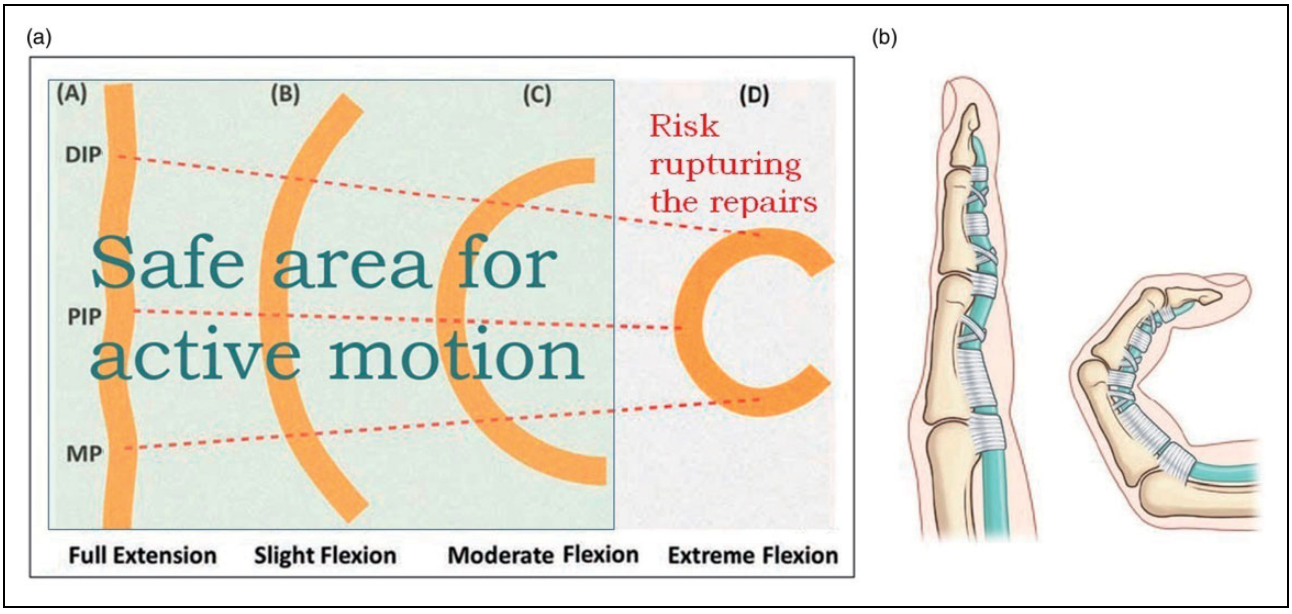

Figure 1. (a) (A) At the full extension of the finger, the tendon shows physiological curves within the digital flexor sheath. (B) When the finger is slightly flexed, the curvature of the tendon is small and smooth. The tendon sustains a small amount of bending force. (C) When the tendon is increasingly flexed, the tendon curvature increases and the bending force increases accordingly. (D) At the extreme of digital flexion, the tendon gliding arc becomes nearly circular, and the tendon is the easiest to disrupt. Therefore, the safe range of active digital motion is from full extension to moderate flexion. (b) Active flexion between two shown positions is in the safe range.
MP: metacarpophalangeal joint; PIP: proximal interphalangeal joint; DIP: distal interphalangeal joint.

Three or 4 weeks after surgery, I instruct the patient to gradually increase active flexion aiming for a full or close-to-full range of active flexion, with passive motion more specifically targeted at any finger joints if there is stiffness. Such exercises need to continue for at least 3 to 4 weeks. The splint is not needed after 6 weeks for most patients. After week 6, I sometimes urge patients to wear a splint only when they go outside, which prevents unintentional use or injury. For residual joint stiffness at this stage, therapists are a great help.

Considerations

In previous writings I have given slightly different numbers of runs – a range of 20–30 times of active flexion after 10–30 times of passive motion – for each exercise session, which indicates correctly executed cycles, usually with the therapists, and consideration for allowing room for users to individualize the programme with a range (Tang, 2007, 2018a, 2018b; Tang et al., 2012, 2017). The protocol – called Nantong regime – is used in different units where surgeons perform strong surgical repairs and vent the pulleys according to current guidelines. They obtained consistent outcomes, with zero ruptures or ruptures only in exceptional patients who did not follow instructions (Pan et al., 2019, 2020, Tang et al., 2017, Zhou et al., 2017). The required number of runs indeed varies among patients according to trauma severity and structures involved.

I have observed that very reliable patients tend to do more cycles of motion, while some others do fewer than instructed or have inefficient runs. For the patients coming from a diverse background, a slight increase in the cycles of motion in a session offsets the influences and provides a safety margin. This increase is easy and safe. It is clear to me that the minimum of runs in a session is better set at a slightly higher number. Minimum of 40 runs of active flexion in one session should be clearly instructed to the patient for exercise *at home*. This is a key element in the protocol. It is very clear to me that increasing the number of daily sessions *without* a sufficient number of runs in each session is useless, because each session would end up with only being a warming up process.

There is no set limit in the duration of each session and the frequency of sessions in one day. The patients can do more runs as they wish, but I explain to the patient each session should not need to exceed 30 minutes, because a longer session is unnecessary and may tire the patient, leading to less care regarding the force exerted and therefore be more risky.

Many sessions a day or hourly exercise is similarly unnecessary.

After flexor tendon repair in Zone 4 and 5, the motion can be modified according to the number of the tendons repaired, being less aggressive generally. For tendon repairs with concomitant soft tissue loss or a phalangeal fracture, the same protocol is used, but the patient actively flexes the fingers over a smaller range and motion is slower and under therapists' close guidance and delicate adjustment. Adhesions occur in some patients, and motion range after 6 to 8 weeks of rehabilitation may still not be ideal. For these patients a relative motion splint and other methods are useful (Lalonde, 2021). For secondary tendon reconstruction, fewer motion sessions are necessary, and motion can be started during the second or third week after surgery.

Protocols for extensor tendons, hand fractures and other conditions

With proper modifications, I suggest generalization of the partial-range finger motion to therapy after treating other hand injuries, because amply reducing digital joint stiffness or gliding the tendon does not need full motion; rather *sufficient* repetitions of *partial* motion.

Extensor tendon repairs

After extensor tendon repairs (except in Zone 1), the motion can be used safely because active motion through a partial range of the digits or the wrist does not overload the repair. The motion can start in the second or third week after surgery.

Phalangeal and metacarpal fractures

After surgery or splinting for the fractures, the patient starts partial-range active flexion beginning in the third or fourth week. Only mild finger joint stiffness is present in most patients, which disappears within weeks of starting motion. I find no need to move the fractured hands in the first two weeks, which causes pain and risks re-displacing the fracture.

Not immobilizing unrelated joints with the splint is a key. The splint should only be beyond one joint distal to the site of fracture. For example, the dorsal splint for a metacarpal fracture should not extend to the proximal interphalangeal joint, leaving this joint entirely movable and the MP joint free to perform partial active flexion from mild to full flexion, for 4–6 daily sessions with each session lasting 15 or 20 minutes (Xing and Tang, 2014).

Ligament repairs of MP or interphalangeal joints

After surgery, the patient starts the partial-range active flexion in the third or fourth week, and aims at full range of active flexion after week 5.

Overall, I find no evidence to support a very early start of active motion for these disorders, except for a repaired flexor tendon in the sheath area. Depending on structures involved, *delayed early active motion*, starting at the late half of week 2 or in the third week, makes the therapy easier and safer, and the patient more comfortable, without impairing treatment outcomes. I consider early active motion is the motion starting in the first week or the early half of week 2.

The ranges of starting time for active motion that I use are summarized in Figure 2, with exact time decided with consideration of individual conditions. I use *delayed early active motion* except primary flexor tendon repairs, and have not found functional impairment due to the delay.

The partial-range active motion can be used for a spectrum of disorders and varying conditions. The partial-range motion can be in a range from mild to moderate flexion, not starting from full extension. This is used in patients with delayed flexor tendon repair with marked tension.

Summary and remarks

I use the partial-range active flexion protocol as an early framework of rehabilitation of flexor tendon injury and later for other injuries in patients not needing the help of a therapist. This framework simplifies my philosophy in preventing joint stiffness and formatting rehabilitation protocols. I use this framework to explain to the patient easily and to adjust the protocol details according to the specifics of each case regarding structures involved and treatment performed.

This approach may be particularly meaningful when therapists are unavailable. Worldwide, only a small percentage of patients with hand trauma have the luxury of therapist-assisted therapy. A simple, safe and efficient therapy framework is thus valuable and imperative for patients and surgeons in those regions. After observing my patients for more than 10 years and using this protocol and its extensions, I recommend this framework.

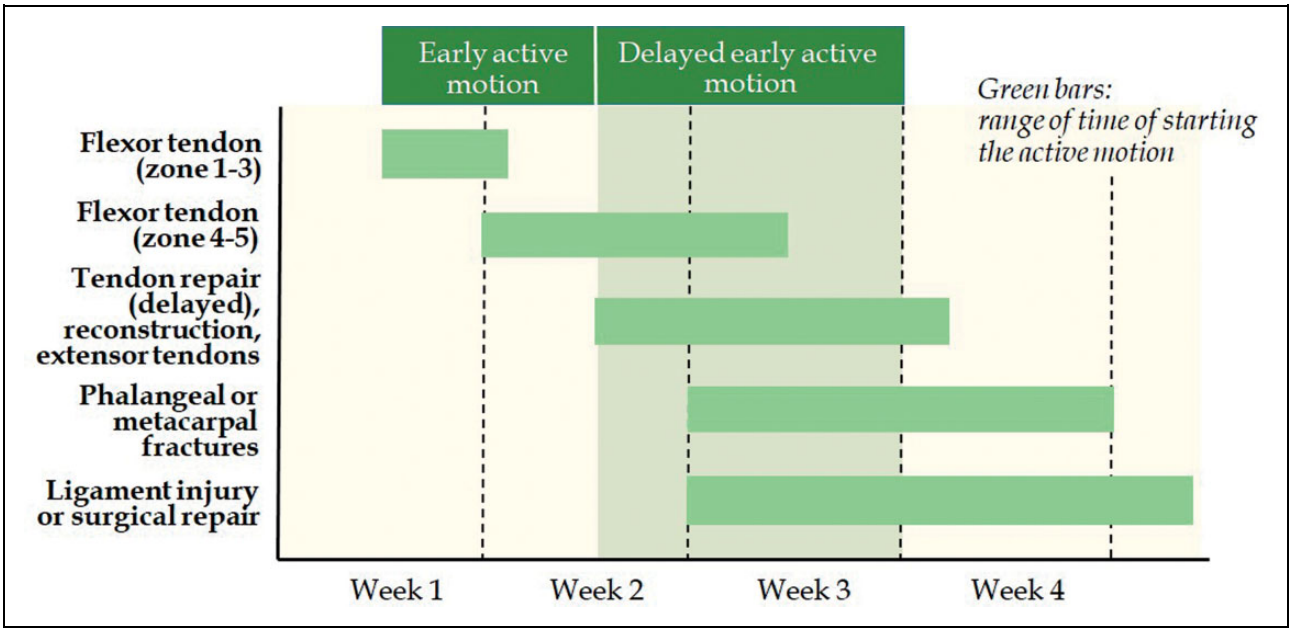

Figure 2. The ranges of *starting* the partial-range active motion are indicated with green bars, which differ in each category of disorders. The exact timing is decided within the timeframes with consideration of individual conditions.

This framework may also be useful to the therapists, likely serving as one general way to design and simplify motion exercise for the hand. In the past, some therapy protocols have been overly complicated, such as dynamic motion after extensor tendon repairs, which was found to be unnecessary. I have never used place and hold exercises. What I instruct the patient is natural hand motion, though some need assistance of the opposite hand. There are still complex therapy protocols in use that do not have supporting evidence. Natural design of the hand allows comfortable motion in many patients. Complex protocols can be replaced with much simpler ones. The simplification begins with recognizing some generalizable working principles. The partial-range active flexion may be one of them.

Declaration of conflicting interests The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding The authors received no financial support for the research, authorship, and/or publication of this article.

References

Lalonde D. Preferred methods which are against traditional teachings. J Hand Surg Eur. 2021, 46: 327–330.

Pan ZJ, Pan L, Fei Xu Y. Infrequent need for tenolysis after flexor tendon repair in Zone 2 and true active motion: a four-year experience. J Hand Surg Eur. 2019, 44: 865–6.

Pan ZJ, Pan L, Xu YF, Ma T, Yao LH. Outcomes of 200 digital flexor tendon repairs using updated protocols and 30 repairs using an old protocol: experience over 7 years. J Hand Surg Eur. 2020, 45: 56–63.

Small JO, Brennen MD, Colville J. Early active mobilisation following flexor tendon repair in Zone 2. J Hand Surg Br. 1989, 14: 383–9.

Tang JB. Flexor tendon repair and reconstruction. In: Neligan PC, Chang J (Eds.) *Plastic surgery*, 5th Edn. Philadelphia, Elsevier, 2018b: 188–226.

Tang JB. Indications, methods, postoperative motion and outcome evaluation of primary flexor tendon repairs in Zone 2. J Hand Surg Eur. 2007, 32: 118–29.

Tang JB. New developments are improving flexor tendon repair. Plast Reconstr Surg. 2018a, 141: 1427–37.

Tang JB, Cao Y, Xie RG. Effects of tension direction on strength of tendon repair. J Hand Surg Am. 2001, 26: 1105–10.

Tang JB, Tan J, Xie RG. The Nantong experience. In: Tang JB, Amadio PC, Guimberteau JC, Chang J (Eds.) *Tendon surgery of the hand*. Philadelphia, Elsevier, 2012: 138–52.

Tang JB, Xu Y, Wang B. Repair strength of tendons of varying gliding curvature: a study in a curvilinear model. J Hand Surg Am. 2003, 28: 243–9.

Tang JB, Zhou X, Pan ZJ, Qing J, Gong KT, Chen J. Strong digital flexor tendon repair, extension-flexion test, and early active flexion: experience in 300 tendons. Hand Clin. 2017, 33: 455–63.

Wu YF, Tang JB. Tendon healing, edema, and resistance to flexor tendon gliding: clinical implications. Hand Clin. 2013, 29: 167–78.

Wu YF, Tang JB. Recent developments in flexor tendon repair techniques and factors influencing strength of the tendon repair. J Hand Surg Eur. 2014, 39: 6–19.

Xing SG, Tang JB. Surgical treatment, hardware removal, and the wide-awake approach for metacarpal fractures. Clin Plast Surg. 2014, 41: 463–80.

Zhou X, Li XR, Qing J, Jia XF, Chen J. Outcomes of the six-strand M-Tang repair for Zone 2 primary flexor tendon repair in 54 fingers. J Hand Surg Eur. 2017, 42: 462–8.