Original Article

Comparison the Range of Motion Following Early Versus Late Active Mobilization after Repairing Surgery on Flexor Tendon Injury in the Zone II: A Randomized Clinical Trial

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ABSTRACT

Background: Early or delayed mobilization of limb after flexor tendon rupture repairing has an effect on postoperative outcomes, however it is not yet clear whether early or late organ mobilization leads to more likelihood of recovery. We aimed to assess the effects of early and late active limb mobilization through rehabilitation after surgery on the range of motion and hand recovery.

Methods: This randomized clinical study was performed in Sina Hospital, Tehran, Iran in 2022 on 80 patients with flexor tendon damage in the zone II, who underwent reconstructive surgery of superficial and deep tendons. Patients were randomly (using random number table) divided into two groups that for one group, rehabilitation was done early (starting after three days, n = 53) and for the other group, rehabilitation was done late (starting after three weeks, n = 27). The patients were examined postoperatively and following occupational therapy and the range of motion of their involved joints was calculated.

Results: The means PIP extension Lag, PIP active flexion, DIP extension Lag, DIP active flexion and total active motion were all significantly higher in those patients planned for early mobilization as compared to those who considered for late mobilization(P=0.031). Such a significant difference was also revealed adjusting baseline parameters.

Conclusion: Compared to the delayed start of hand flexor tendon mobility, the early start of these activities is associated with a much greater improvement in the movement function of this tendon.

KEYWORDS
Flexor tendon injury; Zone II; Range of motion; Active mobilization

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INTRODUCTION

Restoring satisfactory finger function after flexor tendon rupture and finger repair is one of the most problematic issues in hand surgery. In this regard, many debates remain and surgical and therapeutic techniques are still evolving [1, 2]. Correct understanding of these injuries

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at the histological and biomechanical level is essential to improve the outcome of this process. The main techniques during the treatment of flexor tendon injuries are tendon suturing. But the fingers are still active during the recovery phase [3,4]. What is emphasized in this stage today is removing the immobility of the tendons from the very early stages of recovery. Early mobilization is responsible to reduce adhesion formation and resulting better quality of tendon healing [5,6]. Optimizing rehabilitation methods after surgical repair is a challenging issue. In the 1940s, Mason and Allen described immobility for three weeks after flexor tendon repairs [7]. Early mobilization of the tendons caused less adhesion and led to improved outcomes after immobilization. Early movement also led to improved healing power after surgery, which itself reduced the prevalence of tears. This phenomenon led to the emergence of different protocols after surgery, including active and passive movements [8,9]. Zone 2 starts from the proximal end of zone 1 or the insertion of the superficial flexor tendon and continues to the proximal reflection of the digital synovial sheet. Historically, this zone is called "No-Man's- Land" due to the increased risk of adhesion formation, catching tendon under the A2 pulley and tendon rupture, and poor blood supply in this area. Adhesion usually does not occur before the 10th to 14th day after repair. Also, if the patient starts moving immediately after the operation, the possibility of bleeding inside the wound and creating scar tissue increases. In the first days, the tendons and fingers are edematous, and shaking them inside the sheath leads to their wear and friction.

The rehabilitation method is not limited to these techniques and the beginning of active movements was applied early and late. The late method is the same as the early method in terms of how it is performed, and the difference is in the time of treatment, which in the early method, this time is two to three days after the operation, and in the late method, this starting time is three weeks. Choosing one of these two methods is still debated.

Therefore, we decided to investigate the effects of early and late limb mobilization through rehabilitation after surgery on the range of motion and hand recovery.

MATERIALS AND METHODS

The randomized clinical study (registered in IRCT with code: IRCT 20220617055203N1) was done on the patients with flexor tendon damage in the zone II, who underwent reconstructive surgery of superficial and deep tendons with 0-4 and 0-5 nylon thread in Sinai Hospital in Tehran, Iran in 2022. The criteria for including the subjects were sharp and simultaneous injury of the superficial and deep flexors of the fingers in zone II. Damage to one tendon or other zone, nerve damage, bone and joint damage, soft tissue defect, flexor tendon damage at several levels, extensor tendon damage and damage to both digital arteries were considered as the exclusion criteria.

All study protocols were according to ethical protocols approved by committee at Tehran University of Medical Sciences (Ethical code: 1401.027).

Patients were randomly (using random number table) divided into two groups that for one group, rehabilitation was done early (starting after three days) and for the other group, rehabilitation was done late (starting after three weeks). A single protocol called place hold was performed for both groups. Demographic information of the patients was collected by a resident. Then, patients were all operated by a single surgeon and were referred to an occupational therapist for rehabilitation, according to the random division done in the early or late method. The patients were examined postoperatively and following occupational therapy and the range of motion of their involved joints was calculated using a goniometer. Finally, after completing the occupational therapy, total active motion (TAM), Strickland's functional status, flexion gap and extension lag were also reported by the occupational therapist.

SPSS 22 (IBM Corp., Armonk, NY, USA) was used to analyze the data. The quantitative data shown the mean and standard deviation (mean ± SD) and for qualitative variables as percentage and frequency. t test or Mann-Whitney test was used to compare the quantitative variables of two groups. Comparison between qualitative variables was also done applying Chi-square test or Fisher's exact test. The multivariable linear regression model was used to compare study outcomes between the two protocols with considering the baseline parameters. Differences between groups were noticeable when $P<0.05$.

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RESULTS

Overall, 80 patients were enrolled, so that 53 cases were treated early and 27 cases were treated with delayed mobilization after surgery. As shown in Table 1 regarding baseline characteristics, baseline parameters were similar between the two groups.

The outcome of movement following early and late active mobilization are summarized in Table 2. In this regard, the means PIP extension Lag, PIP active flexion, DIP extension Lag, DIP active flexion and Total active motion were all significantly higher in those patients planned for early mobilization as compared to those who considered for late mobilization. However, in terms of TAM grade, excellent condition was revealed in 30.2% and 18.5%, good condition in 17.0% and 14.8%, fair condition in 39.6% and 37.0% and poor condition in 13.2% and 29.6% with no difference between the two groups ($P = 0.310$).

Base on the multivariable linear regression models, difference was revealed in PIP extension Lag (beta = -8.293, $P = 0.002$), PIP active flexion (beta = -17.258, $P = 0.001$), DIP extension Lag (beta = -4.989, $P = 0.001$), and DIP active flexion (beta = -17.565, $P = 0.006$). Finally, in similar multivariable linear regression model, the difference in TAM between the two groups showed a significant difference (beta = -21.541, $P = 0.046$).

DISCUSSION

The time of leaving the immobility of the organs related to the flexor tendon of the hand, or the so-called mobilization, can have potential effects on the movement function of the relevant organ. Therefore, early or delayed organ mobilization has an effect on the outcomes after surgery, but it is not yet clear whether early organ mobilization leads to more organ recovery or delayed mobilization. What is clear from many evidences is that moving the organ related to the flexor tendon as quickly as possible leads to a faster recovery of the movement function of the hands, but based on some evidence, there is also the possibility of dissociation of the surgical excision site or the risk of increased complications after surgery. What we discussed in the present study was the evaluation and comparison of limb movement function after flexor tendon injury surgery in two states of early and delayed mobilization. What was clear from the results of this study was the superiority of early

Table 1: Baseline characteristics in subgroups with early and late mobilization

Characteristics	Early mobilization	Late mobilization	P value
Male gender, %	50 (94.3)	21 (77.8)	0.055
Involved limb			0.218
Right	18 (34.0)	13 (48.1)	
Left	35 (66.0)	14 (51.9)	
Dominant limb			0.594
Right	49 (92.5)	24 (88.9)	
Left	4 (7.5)	3 (11.1)	
Type of involved finger			0.256
Index finger	15 (28.3)	8 (29.6)	
Middle finger	13 (24.5)	6 (22.2)	
Ring finger	12 (22.6)	5 (48.5)	
Small finger	13 (24.5)	8 (29.6)	
Mean time between trauma and surgery, d	4.92±3.72	5.04±4.11	0.902

Table 2: Movement outcome after surgery in subgroups with early and late mobilization

Characteristics	Early mobilization	Late mobilization	*P* value
Mean PIP extension Lag	8.49±10.31	0.37±1.33	0.001
Mean PIP active flexion	89.72±13.21	72.04±19.33	0.001
Mean DIP extension Lag	8.81±5.45	0.19±0.63	0.001
Mean DIP active flexion	50.00±19.41	35.67±23.02	0.004
Mean Total active motion	126.42±34.68	107.15±37.51	0.031

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mobilization in improving the motor and functional outcomes of the flexor tendon after surgery. In fact, the evaluation of functional movement indicators including active movements of this tendon after the repair of traumatic injury showed that the recovery of these active movements is more achieved in cases with the early onset of movement than the late onset of movement. Therefore, the time of starting motor activity in this tendon after surgery can be a potential factor in its optimal function return. Of course, considering that the two study groups were significantly different in terms of some background parameters such as demographic characteristics, we used regression models to adjust these background characteristics as well, which still witnessed more improvement and recovery of the flexor tendon in cases were early with mobilization.

We did a quantitative comparison between the early and late groups, and the total active motion in the early group was 126.42 degrees and in the late group was 107.15 degrees. The difference between the two groups was 19 degrees, which was significant. Therefore, quantitatively and according to Strickland's criteria, the early group was placed in the Good category and the late group was placed in the Fair category.

Most studies and evidence support early mobilization instead of delaying it in achieving better flexor tendon surgical recovery, although some have not found a difference between the two forms in improving the function of the limb and tendon. In the study by Sara Chevalley et al, no significant difference was observed between the studied groups in this regard, including the range of motion, grip strength, shoulder and hand score, ABILHAND questionnaire score, and Purdue Pegboard test [10]. In another study, in the beginning of early active movement from the third day after the operation, the results of the operation were reported in 71% of patients with injuries of the second region and 77% of patients with injuries of other regions as good to excellent [11]. In the early onset of flexor tendon motor activity, 67% of patients with damage to the long flexor thumb reached an excellent score in terms of the amount of active movement, and 22% of patients with superficial and deep flexor damage of the fingers reached an excellent score and 74% to got a good score [12]. In the early onset of flexor tendon movement, among 115 patients with flexor tendon injury, complications occurred in only four cases, including one case of secondary tear, one case of infection, and two cases of adhesions requiring tenolysis. In this study, no special relationship was found between the time of injury and operation, sex, involved area, flexor tendon, nerve damage and improvement of tendon function [13]. In the study of Fujihara et al, immobility for more than 3 weeks significantly worsened the results. Early active movement protocol and wiring improved postoperative results. Accordingly, that early motion protocols with rigid osteosynthesis are superior to pinning [14]. In Pan et al study, in early active ankle motion following flexor tendon repair, 87% of fingers achieved good or excellent function [15]. In response to the concerns regarding the complications caused by the early onset of movements related to the flexor tendon, it was also determined that even a small number of superficial sutures is enough to maintain and prevent complications after the premature start of limb movement activity, and in this case the protocol used will be completely safe.

Anesthesia was performed as a regional block and repair of the deep flexor tendon of the fingers as 4 strands with 4-0 nylon thread as the main suture so that the knot is placed inside the tendon repair site, and then epitendinosus suture with 5-0 nylon thread as well as tendon repair The surface flexor of the fingers is performed as an X-suture with 5-0 nylon thread in each surface tendon slip, and at the end of the operation, an extension-flexion test is performed. Also, if necessary, during the repair of the tendon, we opened and didn't sew pulley A1 and C1. Sometimes and if needed, we opened A4 by 25%. We did not open pulley A2. The rehabilitation protocol followed by surgery in both groups was "Place Active Hold": Wrist 0 to 10 degree flexion, metacarpophalangeal joints 70 to 90 degrees flexion, and interphalangeal joints are placed in a splint in full extension. Weeks 1 to 3: Simultaneously with the reduction of edema, retrograde massage along with elevation, then passive flexion movements of all fingers and then active extension up to the splint limit were performed. Then, passive flexion movements of all fingers, active holding for 3 to 5 seconds, and then active extension to the splint limit were performed, and the range of movements is completed by the end of the third week. Active flexion movements depend on the conditions of edema, pain, and the ability of active holding from week 2 to 4, It can start. In the 4th to 6th week, splint

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is removed and blocking and gliding exercises are performed along with other previous exercises. In the 7th and 8th week, active and passive resistance and stretching exercises are performed. These exercises were performed daily and several times a day.

CONCLUSION

Compared to the delayed start of hand flexor tendon mobility, the early start of these activities is associated with a much greater improvement in the movement function of this tendon.

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CONFLICTS OF INTEREST

None declared.

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