Original Article

Comparison of Early Active and Passive Post-operative Mobilization of Flexor Tendon in Zone 2

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Objectives: Despite numerous studies, achieving the best outcome is challenging after flexor tendon repairs in zone 2. This study was done to test the hypothesis that immediate postoperative active mobilization will achieve similar outcomes to passive mobilization.

Method: Fifty fingers in 38 patients with flexor tendon repair in zone 2 were enrolled in this trial. The patients were randomly assigned to two groups: Early active mobilization and Passive mobilization. They were assessed eight weeks post-operatively. Outcomes were defined using 'Strickland' and 'Buck-Gramcko' criteria. The analysis was done according to intention-to-treat principles, using imputation for missing data.

Results: There were significant differences between the two groups ($p<0.001$). According to Strickland criteria, the results were 80% 'excellent and good' and 20% 'fair' and 'poor' in the early active mobilization group. In the passive mobilization control group results were: 40% 'excellent and good' and 44% fair and 16% poor. Mean of total active mobilization was significantly greater in the early active mobilization group.

Conclusion: The actively mobilized tendon underwent intrinsic healing without large gap formation. Increased ultimate range of motion confirmed that early active mobilization can be used after strong repair in zone two.

Keywords: flexor tendon, zone 2, early active mobilization, passive mobilization

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Introduction

Hand injuries form an important part of hospitals' accident and emergency services, and among them flexor tendons are more commonly affected (1). Despite numerous advances in our understanding of the anatomy, biomechanics, nutrition and healing of flexor tendons, repair techniques and post-operative care improvement, the results following flexor tendon repairs show relatively high rates of failure (2).

Adhesion formation that prevents tendon gliding is the most frequent cause of failure after flexor tendon repairs (3). Since the surgical management of acute flexor tendon injuries is well understood, the real problem is how to decrease or eliminate the formation of the peritendinous scarring that inhibits a freely gliding tendon. A wide range of rehabilitation approaches have been based upon this principle (4, 5). Early active mobilization of repaired tendons has been recognized as an important treatment after flexor tendon repairs for more than two decades (2). Strong repairs are needed to tolerate the tension of active mobilization (6). Current flexor tendon repair techniques consist of a multiple strand core suture to withstand the stress produced by early and in particular, active mobilization. Active mobilization generates tension and motion and offers several advantages over passive mobilization (6, 7).

Several investigations have been designed with new four-strand core suture techniques that are easy to perform. These sutures possess adequate strength to allow active mobilization (8-10).

Attempts have been made to strengthen the repairs by increasing the strands but more time is needed, an expert surgeon is required; and there is risk of adhesion formation. In spite of all the benefits of active motion, due to difficulties in performing multiple strands, passive motion is routine therapy

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after flexor tendon repairs in zone 2. We hypothesised that by using epitenon the first four strands can withstand the load of active motion and is therefore suitable to use in active mobilization.
The purpose of this study was to compare the result of active versus passive mobilization after four-strand repairs in zone 2.

Method

The study protocol was approved by the Human Research Committee of our Institution. Between 2003 & 2004 sixty-one patients with flexor tendon repairs (four-strands) in zone 2 were identified. Inclusion criteria were being ten years or older, beginning mobilization in the first week after repair and no concomitant injuries. Thirty eight patients met the inclusion criteria. After informed consent, 50 fingers from these 38 patients were equally randomized to either receive early active mobilization or controlled passive mobilization according to a computerized random-number generator.

Surgical method

Intervention - Post operatively, the repairs were protected in a dorsal blocking splint; the wrist was positioned in 0-30 degree flexion; metacarpophalangeal (MP) joints were protected in 60-70 degree flexion and interphalangeal (IP) joints were kept in full extension in both groups. In the passive mobilization group an elastic band was attached to the finger nail for modified kleinert exercises and the patient was asked to do passive flexion with a rubber band and active extension ten times in every waking hour. For flexor digitorum profundus gliding we added a palmar pulley to the splint. The patients were asked to take off the rubber band at nights. We performed Duran mobilization in the therapy session too. This protocol was done for 3 weeks after surgery (11, 12).
In early active mobilization groups, we used Belfast and Sheffield protocols. Exercises were performed every 4 hours within the orthosis, included all digits and consisted of two repetitions each of full passive flexion, active flexion, and active extension. The first week's goal was full passive flexion, full active extension, and active flexion to 30 degrees at the Proximal Interphalangeal PIP joint and 5 to 10 degrees at the Distal Interphalangeal DIP joint. Active flexion was 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. Tenodesis exercise was done 25 times a day under supervision of a therapist (7, 12).
After three weeks the splints were changed to neutral wrists and in the 4th week they were taken off in both groups. Tendon gliding and blocking exercises were started in the 4th and 5th weeks respectively. From the 6th week we started progressive resistive exercises and if needed we used correction splints for flexion contracture in PIP joints this time onward (12).

Evaluation - At the end of the 8th week all the patients were evaluated by an independent therapist not involved in the care of the patients. Prior to the intervention, demographic information and injury-related medical history were recorded. After eight weeks finger motion was measured with a handheld goniometer. Many systems for evaluating the range of motion following flexor tendon repair have been described, but the most commonly used systems are the ‘Strickland’ and ‘Buck-Gramcko’ system. They are the most rigorous classification systems and relatively easy to apply. The Strickland system sums the degrees of active flexion at the distal interphalangeal joint and the proximal interphalangeal joint and subtracts the degrees of extension deficit. The result is compared with an ideal of 175 degrees (total active motion) (13).

Statistical Analysis - Prior to the study, it was calculated that 23 patients per group would provide 90% power to detect a 30 degree difference in the arc of flexion and extension between cohorts to reach significance with alpha set at 0.05. The target enrolment was 60 patients to cover an expected 15% to 20% rate of patient loss.
Comparison of baseline characteristics and outcome variables was done using a two-tailed independent Student t-test for continuous variables and the chi-square test for categorical variables. Significant and nearly significant variables ($p < 0.10$) were then introduced in a backward multiple linear regression analysis to account for any confounding.

Results

Recruitment and Participant Flow - Between 2003 and 2004 fifty fingers from 38 patients met the inclusion criteria from among 61 patients and were enrolled in the trial. They were then randomly assigned to either the active or passive mobilization groups. All the patients attended two months in the sessions.
Baseline Data - In the passive mobilization group there were 17 patients with 25 injured fingers. 88%

were male with a mean age of 29.52 years (SD=15.57). 36% of injured fingers were the ring finger. All the patients were right handed and 56% of injuries were in the right hand.
In the active mobilization group there were 21 patients with 25 injured fingers. 80% were male with a mean age of 21.6 years (SD = 44.5). 48% of injuries were in the right hand. 96% had right hand dominancy. The most commonly injured finger was the middle finger (36%).

Outcomes - Based on Buck-Gramcko's criteria in the passive group: 4% were excellent, 12% were good, 24% were fair and 60% were poor. However, in the active group 12% were excellent, 40% were good, 32% were fair and 16% were poor Chart 1).

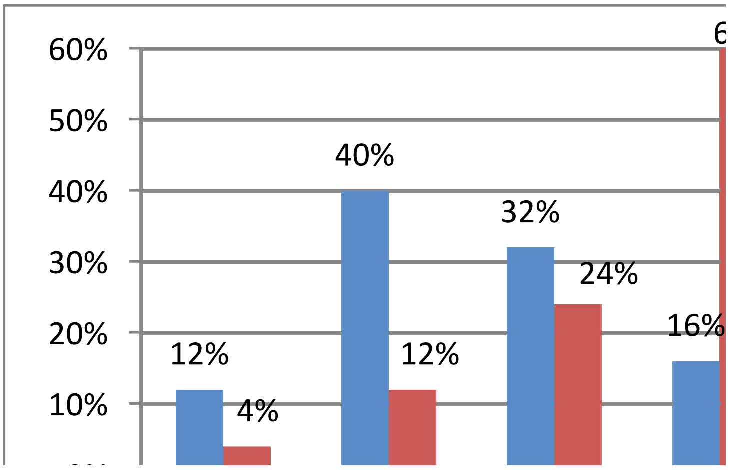

Chart 1: Frequency of total active motion in groups according to Buck-Grameko criteria

Based on Strickland's criteria in the passive motion group; 8% were excellent, 32% were good, 44% were fair and 16% were poor. In the active group 44% were excellent, 36% were good and 20% were poor; with no fair cases.
We had no rupture in either group (2).

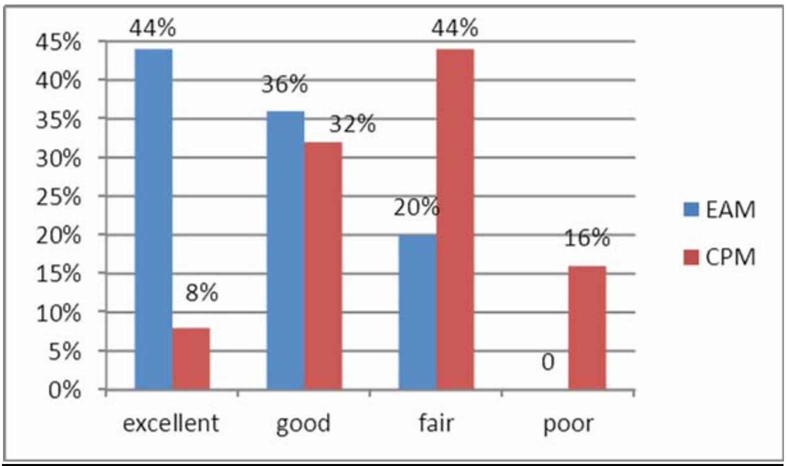

Chart 2: Frequency of total active motion in groups according to Strickland's criteria

The mean of total active motion in the passive and active groups were 116.4 and 150.2 respectively. The latter is the result of better gliding of the repaired tendon in. The confounding variables were: age (p=0.132), sex (p=0.366), number of injured fingers (p=0.79), kind of injured finger (p=0.746). The dominant hand (p=0.131) had no effect on the results. Only the type of mobilization had a significant effect on the results (p<0.001). There were significant differences between the means of total active motion in the two groups (p<0.001) (3).

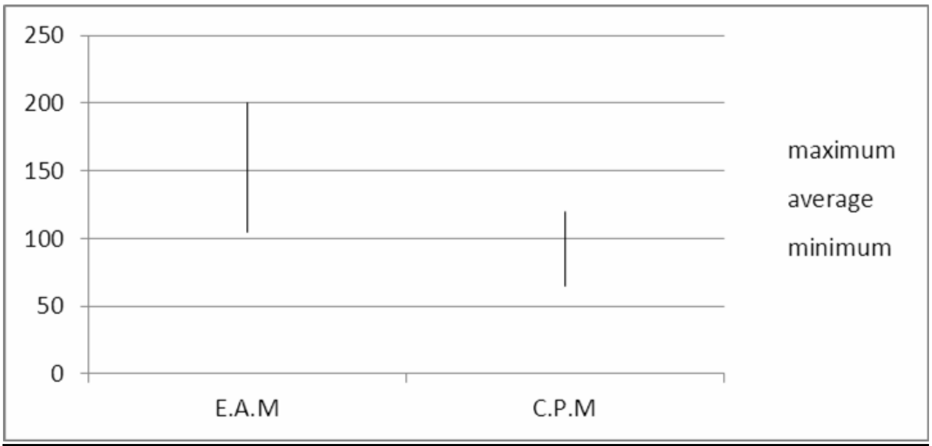

Chart 3: Mean of total active motion

Discussion

In this study, there were significant differences in total active motion between active and passive mobilization groups. This is consistent with previous studies addressing rehabilitation methods after zone two flexor tendon repairs (5).

In 1989 Small et al documented a series of patients who were managed with the 'Belfast regime' of early active motion which allowed protected active flexion of repaired tendons and stated that it is a safe approach to manage injurers in zone 2 (7). But it needed strength repairs. Current flexor tendon repair techniques consist of a multiple strand core suture to withstand the stress produced by early and in particular, active mobilization. Active mobilization generates tension and motion and offers several advantages over passive mobilization (4). Several investigations have designed new four-strand core suture techniques that are easy to perform and possess adequate strength to allow active mobilization (14-16). The epitenon first technique, was first described by Sanders (17). There are four advantages of using this technique: the forceful handling of tendon is minimized, enlargement of the tenorrhaphy is minimized, sutures are buried in the tendon and the repair provides more strength than the popular Kessler suture.

Early active motion can shorten healing time and reduce the weakness occurring ten days postoperatively that is due to contracture of the repaired site versus the only folding of repaired tendon seen in passive motion (18). Many investigations showed that at least a four-strand repair is necessary for active motion (8, 10, 19).

Small et al treated 98 patients with early active mobilization with modified Kessler repair and a running peripheral suture; 77% had excellent and good results and 9% experienced rupture (20).

With the early passive mobilization method, Singer and Malloon (1988) (1) achieved 80% excellent or good results. Mclean (21) reported 66% excellent and good and Strickland (1987) (22) also achieved 83% excellent and good results with the early active motion program.

Savage and Risitano (1989) (23) achieved 69% excellent and good results in zone 2 tendon laceration. Cullen et al (1989) (7), Small et al (1989) (20) and Elliot (1994) (16) have also reported 78%, 77% and 79% excellent and good results after flexor tendon repair with active motion.

In our study we observed a clear difference between the results achieved in the two groups. The passive groups had 40% excellent and good outputs while the active group had 80% such cases.

Early active motion prevents extrinsic healing that restricts gliding (24). In contrast it facilitates intrinsic healing that creates more power in the suture area.

Active motion, with activates contraction of the repaired sites provides synovial fluid release in the repaired area, thus resulting in better nutrition and less adhesion formation (12).

The immobilized tendon showed significant reduction in both gap formation and ultimate strength during the first seven days, which was probably caused by softening of the tendons' ends.

The immobilized tendon healed by an inflammatory response from the tendon sheath. This caused a large tendon callus and extrinsic adhesion which interfered with restoration of the smooth gliding surface.

Previous studies of repair processes of mobilized tendons have observed that epitenon cells migrate in to the depth of the repair site and produce new collagen fibres (25).

So use of early active motion can change the result of flexor tendon repairs but it generates more tension than passive motion in repair sites. Passive motion generated 1-9 N where as active motion provided 1-29 N against no resistance, 15-50 N against moderate resistance. Considering the oedema in repair sites, the strength of the sutures should be increased. The ultimate strength of the traditional Kessler core suture plus running peripheral stitch was only 28 N, that cannot withdraw tension generated in active motion (26, 27).

Increasing the number of suture strands or locking during surgery increase the tensile strength of sutures (28, 29). Several recent studies have demonstrated that epitenon suture gives additional strength to the repair (30). The epitenon first technique was found to be 22% stronger than the modified Kessler technique (31) and can tolerate tension of active motion.

Conclusions

In our study with no rupture and mean of total active motion, we showed that it can be a safe method for performing active motion to have better results in no man's land than passive. Taking into account the mean total active motion and that rupture did not take place, so we may recommend early post-operative active mobilization as a safe tendon rehabilitation method, and also conclude that it yields better results than passive mobilization.

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