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RESEARCH ARTICLE

Retrospective evaluation the results of the repair of flexor tendon injuries in the hand using a combination of epitenon first suture technique and controlled early active mobilization

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Abstract:

Background: The response of healing tendons to mechanical load varies depending on anatomic location. Flexor tendons require motion to prevent adhesion formation, yet excessive force results in gap formation and subsequent weakening of the repair. The study evaluates the effect of early active mobilization (EAM) and the use of epitenon-first suture repair after flexor tendon surgery in the hand.

Patients and Methods: A retrospective analysis of collected data was performed of 40 patients receiving primary flexor tendon repair in the hand from in 2017, during which time 51 fingers were treated. Exclusion criteria were finger revascularization, age younger than 20 years, rehabilitation by means other than EAM, and missing information data. The analysis of EAM results under the rehabilitation protocols was conducted using t-tests. The rupture rate and the assessment of adhesion/infection were defined as endpoints.

Results: There was a statistically significant difference between the total active motion values (TAM) of the EAM protocols one year after surgery using the epitenon-first suture technique. The rupture rates were 5%, which were not statistically different.

Conclusions: This study showed a favorable effect of EAM protocol on TAM a year after surgery. The percent rupture rate was clinically insignificant.

Key words: Hand, flexor tendon repair, early active mobilization, rupture rate, adhesion formation.

1 | INTRODUCTION

Flexor tendon injuries are common and usually result from penetrating trauma. The highest incidence occurs in males and those aged 20 to 29 years, with 25% of acute cases being due to work-related injuries. (1) Advances in our understanding of tendon biology, healing, suture properties and design, and repair techniques have led to improved outcomes in these important and potentially life-altering injuries. Despite extensive data on the surgical approach, rehabilitation protocols are still a current topic of discussion.

Immobilization is useful when treating children, non-compliant patients, and co- occurring intra-articular fractures. The positive effect of mechanical loading on tendon Development and homeostasis is evident from a number of studies. (2-4)

Recent studies indicate that early active mobilization helps improve postoperative range of motion by preventing restrictive adhesions. (5-6) Manske, Gelberman, and others (7-8) have shown that the flexor tendons of the hand, which require long pathways to function, are usually surrounded by synovial sheaths. The function of the synovial investment is to provide a low-friction sliding system and to surround the tendon with a fluid medium that provides it with nutrients, and tendon healing occurs by both intrinsic and extrinsic pathways, via sequential phases of inflammation, cell proliferation, and remodeling. (9-10) The mechanical properties of tendons are largely based on type I collagen fibers arranged in dense, parallel rows. This arrangement creates an elastic fabric with high tensile strength in the direction of the fiber orientation. (11) Efficient repair of long and sheathed tendons (e.g., flexor tendons) often depends on preventing gaps from forming at the repair site and maintaining tendon gliding. There is ongoing debate about the proper postoperative rehabilitation strategies for tendon repair after flexor tendon repair in hand.(12) Immobilization after flexor tendon repair results in fibrous adhesions between the tendon and its synovial sheath, which can significantly limit the range of motion leading to a reduction in repair strength (13) since full unloading has been shown to restrict the organization and structure of the healing tendon and reduce the mechanical properties of the unloaded tendon.(14-16)

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2 | OBJECTIVE

The purpose of this work is to evaluate the late postoperative outcomes of repair of flexor tendon injuries of the hand using a combination of "Epitenon - First" suture technique (17) and controlled early active mobilization.

Patients and methods:

This study is a retrospective case series. It was reviewed and approved by the local regulatory authority, and all patients gave written informed consent for the procedure. Data from 40 adult patients with flexor tendon injuries of the hand admitted to the causality unit of Alexandria Main University Hospital who underwent surgery for fresh traumatic flexor tendon tears of the hand were retrospectively collected in 2017. The patients included in the study were operated upon using the "Epitenon First" suture technique. (17) A total of 51 fingers were rehabilitated using an early active mobilization protocol.

Exclusion criteria:

Patients who were younger than 18 years or older than 60 years and had concomitant fractures, joint injury, soft tissue defects, extensor tendon injury, or patient in need for vascular repair were excluded from the study. Flexion work, grip strength, rupture rate, and adhesion formation were evaluated. Flexion work was assessed by the physiatrist who evaluated the results using a goniometer and a jamer dynamometer. Grip strength was measured three times in the injured hand with the elbow supported in 90 of flexion and the wrist held in a neutral position. The mean value was expressed as a percentage of the mean value in the healthy hand.

Technique of tendon repair:

Primary tendon repair was performed using the "epitenon first" suture technique. (17) A method in which the epitendinous suture is placed first before the core suture, as follows: After exposing the fibro-osseous sheath, the tendon ends were brought together without tension by inserting a small needle through the proximal tendon and sheath. Minimal debridement of the tendon was performed when necessary. Using 6-0 polypropylene (Prolene, Johnson & Johnson Medical, New Brunswick, NJ) on a rounded needle, an epitendinous suture was placed at the furthest point from the posterior wall. It was then continued circumferentially around the tendon. This minimizes handling of the tendon by allowing the assistant to "follow" the suture in progress. After the repair of the back wall is completed, the repair of the front wall is performed. returned to the original suture and tied to itself.

Next, a longitudinal incision was made in the tendon with the No. 11 blade approximately one centimeter proximal or distal to the tenorrhaphy site. Using 4-0 polypropylene (Prolene, Johnson & Johnson Medical, New Brunswick, NJ) on a rounded needle, the needle was inserted through the slit and across the tenorrhaphy site. An interlocking suture was placed at the medial or lateral edge of the tendon, and the needle was passed across the anterior half of the tendon. Another locking suture was placed and the needle was passed back across the tenorrhaphy site, leaving the anterior half of the tendon. A second transverse pass was made, and after a locking suture from the outside, the needle was passed out into the slit. In this way, the knot was buried in the substance of the tendon. After five overhand knots, the suture was cut flush with the tendon and the repair was complete.

Post-operatively:

All patients underwent controlled early active active mobilization under the close supervision of a hand therapist at Alexandria Main University Hospital. Active movement was started from day one. As follows: With the splint in place, the patient actively stretches all fingers against the elastic band to achieve the full extension range of the MCPJ, PIPJ, and DIPJ. By pulling back the rubber band, the patient passively returns to the flexed position. Patient over presses MCPJ, PIPJ and DIPJ. The patient removes the splint under the supervision of the surgeon or hand therapist, actively makes a fist, then relaxes and actively extends the hand with all fingers, which is repeated twice. The surgeon or hand therapist blocks FDP function of the sound fingers and the patient is asked to perform 5 active FDP flexions. Then the surgeon or hand therapist blocks the FDS function and asks the patient to perform 5 active FDP flexions. The surgeon or hand therapist maintains passive extension in all finger joints by straightening the joints while the flexor tendon rests in a relaxed position. The surgeon or hand therapist maintains passive flexion of all finger joints by over-pressing the joints into flexion. Finally, the patient is asked to perform active movements in all joints of the upper limbs (shoulder, elbow, and wrist). Under no circumstances should the patient fully stretch the affected tendon(s). The patient continues to resist until 7 weeks after surgery. The patient removes the splint except for physiotherapy treatments.

3 | RESULTS

A retrospective review of surgical reports and a functional evaluation were performed by examination of 51 flexor tendon injuries in different zones of the hand in 40 patients. All patients were treated by primary repair within the first 24 hours. thirty-six (90%) were males and 4 (10%) were females.

The age of the patients ranged from 19 to 58 years with a mean of 34.7 years. Of the 51 digits, 31 cases (77.5%) of transected tendons were in the zone II, second most in zone III; 7 cases (17.5%), and least in zone I; 2 cases (5%), while no cases occurred in the IV zone.

There were isolated complete FDP on 2 fingers and complete FDP tears associated with partial and/or complete FDS tears on 40 fingers. Only one case showed an isolated FDS tear, the FPL tendon was torn in 8 cases. Table 1 showed the patients- injury related data

The results were accurately evaluated clinically with the ruler and goniometer, maximum grip strength was also measured using a Jamar dynamometer. Grip strength was measured three times on each hand with the elbow supported in 90° of flexion and the wrist held in a neutral position. Results were evaluated using the original Strickland criteria. (10) Statistical analysis of the results was performed using the chi-square test and Student t test. A P value of 0.05 or less was considered to indicate a significant difference.

Range of motion:

Complete range of motion was recovered in 13 digits, and final range of motion was rated excellent or good in 47 (92.14%) digits, mean active range of motion of the IP joint without 2 ruptures was 181.2727 +7.025 degrees, and recovered range of motion was poor in 4 (7.86%) digits. Table 2 showed the results of the range of motion according to the original Strickland criteria.

Extension deficit:

The mean+(SD) composite DIP and PIP extension deficit was 15.96+14.49 degrees.

Grip strength:

The mean value of grip strength in the injured hand was expressed as a percentage of the mean value in the uninjured hand and was 86.587+12.987.

Rupture rate:

In 2 cases (5%), early rupture occurred in the first 3 weeks after surgery, coinciding with maximal softening of the tendon. The rupture was corrected by immediate exploration and re-repair. Early rupture did not prove to be a significant problem in the study.

Adhesion formation:

Adhesion formation occurred in 2 cases, both suffered from severe infection in the first postoperative month, and both patients required tenolysis until the ninth month. They were operated by releasing the FDS and simple tenolysis of the FDP of the finger.

4 | DISCUSSION

Factors affecting the outcome of primary flexor tendon repair in the hand include tendon rupture, adhesion formation, contracture of the PIP joint, severity of trauma, surgical skill, and quality of postoperative rehabilitation. (18) Many authors define the ideal rehabilitation protocol after flexor tendon repair as one that promotes intrinsic tendon healing, optimizes tendon glide by minimizing adhesion formation, and restores a functional range of motion without significant forces that could compromise the repair.(19-20) Rehabilitation protocols can be divided into controlled passive motion, and controlled active motion. There is still no absolute consensus or 'gold standard' for the optimal mobilization strategy. (21)

In the systematic review by Starr et al (22), passive motion protocols showed a statistically significant reduced risk of tendon rupture. In discrepancy, range of motion was significantly advanced in cases rehabilitated with early active protocols. Advances in surgical repair techniques and materials have led rehabilitation protocols evolving toward early active mobilization. (6,23-26)

Mobilization of the tendon in the synovial sheath reduces adhesion formation, strengthens injured tendons compared to immobilization, and improves cell activity and collagen deposition at the repair site. (13) In our study, 47 (88.68%) digits showed excellent to good results and 6 (11.32%) digits were poor with early active mobilization with a reduced rupture rate of 5% compared to 7-8% (other regimens). Regardless of the rehabilitation protocol, the postoperative rupture rate may be 4-6%. (22,27-28)

Thurman (29) compared the strength between a two-, four-, and six-strand technique and found that the two/ four-strand technique with modified Kessler/Tajima repair and epitendinous suture provided sufficient strength to prevent rupture without increasing the volume of the repaired tendon by increasing tensile strength. In our study, the injured tendons were repaired using the epitenon first suture technique, which provides adequate strength to the repair and prevents bulk at the tenorrhaphy site, allowing smooth gliding within the flexor tendon sheath. Several studies reported that tendons respond to mechanical signals in a variety of situations, including post-injury and post-surgical periods. In general, some controlled loading is optimizing for the healing process. However, excessive loading has a negative effect on the tendon, leading to injury and impaired healing after repair. (30-33) Although clinical evidence for specific rehabilitation protocols is limited, this study may contribute, among other things, to develop logical approaches for postoperative rehabilitation.

5 | CONCLUSION

The results of this study show that early active motion was associated with significant improvement in active range of motion, greater interphalangeal joint motion, smaller flexion contractures, and higher patient satisfaction. The risk of rupture was also not increased with early active treatment.

Table (1): Patient- injury related data:

Age(mean in years)	34.7
20-30	12
31-40	24
41-50	2
51-60	2
Sex	
Male	36
Female	4
Dominant hand injured	29
Tendon injured	
Isolated FDP	2
FDP+FDS	40
Isolated FDS	1
FPL	8
Multiple digit injuries	11
Digit injured:	
Little	12
Ring	11
Middle	8
Index	14
Thumb	6

Table (2) Evaluation of results according Strickland's criteria (Strickland's original classification system)

Grade	% of return	Degrees	Number of patients
Excellent	**85+**	**150+**	39 (76.47%)
Good	**70-84**	**125-149**	8 (15.67%)
Fair	**50-69**	**90-124**	2 (3.92%)
Poor	< 50	< 90	2 (3.92%)
Total			**51**
Mean+SD of Strickland Formula Values			85.99+ 14.14
t-test			0.12 NS

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