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Original Article

Outcome of Early Active and Late Mobilization following Flexor Tendon Repair in Zone II of Hand

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Abstract

The functional outcome of flexor tendon injury after repair depends on multiple factors. Postoperative rehabilitation protocol plays an important role after a good repair for better functional outcomes. The aim of this study is to compare the outcome of early active mobilizations versus late mobilizations after flexor tendon repair in zone-II of hand. This Quasi-experimental (Nonrandomized control trial) was conducted from July 2018 to June 2021. Total 30 patients of flexor tendon injury in Zone-II of hand presented within 3 weeks were divided into two equal groups according to envelope technique, late mobilization (No intervention group) group- A and early active mobilization (Intervention group) group-B. All the flexor tendons were repaired with polypropylene 4/0 double strand score sutures and 6/0 epitendinous continuous sutures. In group-A mobilization started after 3 weeks and in group–B, intervention was given by active mobilization which was started at the day of operation. Buck Gramcko functional criteria and Louisville system were used for assessment of final result after 6 months of surgery. Male was predominant, M: F ratio was 3.3:1. Mean age of the respondent was 32.53±9.86 years. Dominant (Right) hand involvement was 70%. Student and service holder were the common involved group. Nearly three fourth (73%) of them had sharp cutting injury. More than half (53.10%) of the injuries were found in ring and little fingers followed by index (20.30%), middle (20.30%) and thumb (6.30%). Mean time interval between injury and operation was 11 days. Adhesion formation was the commonest complication that was 40% in group A and 20% in group B. More satisfactory outcome (87.50%) was found in group- B (Intervention group), that is patients who received early active mobilization; where the level of satisfactory outcome was less (62.50%) in group-A (Non-intervention group), that is patients who received late mobilization (p-value was significant <0.05). Early active mobilization following repair of flexor tendon in zone II of hand ensures better functional outcome with minimum complication compared to late mobilization.

Keywords: *Flexor tendon injury, zone II of hand, tendon repair, early active mobilization, late mobilization.*

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INTRODUCTION

The hand is one of the important medium of introduction to the outside world. Its unique repertoire of prehensile movements, grasp, pinch, hook-action and tactile acuity sets us apart from all other species. But intact and proper functioning flexor tendons are mandatory for any hand function.[1] Flexor tendon surgery at zone II is particularly difficult as fibro osseous sheath with pulley systems are there to prevent bow-stringing. The zone II is also important as two tendons Flexor digitorum superficialis (FDS) and Flexor digitorum profundus (FDP) pass through the fibro osseous sheath system. The two tendons maintain fairly constant relationship and that is important to prevent malfunctioning of tendons. For injured flexor tendon in the hand, the goal of treatment is recovery of functionally acceptable digital motion with intact tendon[2] Improving the results in zone II flexor tendon injuries remains a constant challenge to hand surgeons. It is now generally accepted that primary or delayed primary repair within four to six weeks should be done. Both flexor tendons should be repaired. An atraumatic technique is obligatory to minimize the formation of adhesions and scar tissues. Provided the repair has been done in a satisfactory manner, good results in zone II injuries depend on the post-operative management.[3] Optimizing the outcome

following flexor tendon repair requires a combination of factors, encompassing far more than suture bridging a severed tendon. Multiple injuries, smoking, and concomitant nerve injuries have shown to be factors leading to a less desirable outcome. Therapy with a certified hand therapist, however, results in higher patient satisfaction and range of motion scores.[4]Tendons treated with early passive digital mobilization are characterized by early epitenon proliferation and migration to the repair site. The formation of peritendinous adhesions is limited. Careful ultra-structural examination found that the gliding surface had been restored by a flattened layer of epitenon cells at 10 days after repair. In contrast, tendons treated with immobilization showed a repair response that was dominated by extrinsic mechanisms of repair. By 10 days after repair, the ingrowth of peripheral adhesions dominated the repair site. Precise tendon suture and early digital mobilization could alter the primary mechanism of tendon repair in favor of the desired mechanism.[5]The improved understanding of splinting techniques has promoted these mobilization protocols. It has been proven that postoperative immobilization leads to increased disability period, weak tensile strength, decreased final functional capacity, stiffness, and deformity. Further early postoperative mobilization leads to improved tendon healing, increased tensile strength, and decreased adhesion formation, early return of function, and less stiffness and deformity as compared to the immobilization protocol. However, as any other procedure it has its own demerits in the form of rupture of repaired tendons.[6,7,8] We conducted a study to evaluate the outcome of early active mobilization and compared with the late mobilization after repaired of flexor tendons in zones II of hand.

Surgical Anatomy and Biomechanics-The innervation of the FDS muscle is from the median nerve. The ulnar nerve innervates the muscle-tendon units of FDP of the ring and little fingers. The anterior interosseous branch of the median nerve innervates the FDP muscle-tendon units of the index and middle fingers and FPL of thumb. The vinculum brevis superficialis (VBS) and the vinculum brevis profundus (VBP) consist of small triangular mesenteries near the insertion of the FDS and FDP tendons. The vinculum longum to the superficialis tendon (VLS) arises from the floor of the digital sheath of the proximal phalanx. The vinculum longum to the profundus tendon (VLP) arises from the superficialis at the level of the PIP joint.[8]

Kleinert and Verdan (1983) classified the injuries of flexor tendons into five zones.

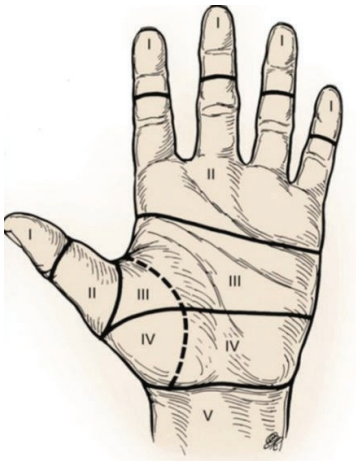
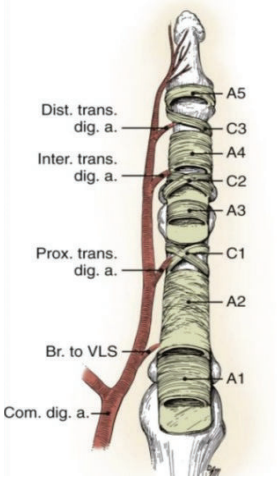


Figure- 1: *Flexor system has been divided into five zones. Zone 2, which lies within the fibro-osseous sheath, has been called "no man's land" because it was previously believed that primary repair should not be done in this zone.*[9]

Flexor zone II started from the distal palmar crease (proximal aspect of the A1 pulley) tothe insertion of the FDS tendon at the middle of the MPX, the "no man's land" because of surrounded by fibrous flexor sheathandzone I is distal to FDS insertion to up to FDP insertion. In each finger, the FDS tendon enters the A1 pulley and divides into two equal halves that rotate laterally and then dorsally (180 degrees) around the FDP tendon. The two slips rejoin deep to the FDP tendon over the distal aspect of the proximal phalanx and the palmar plate of the PIP joint at the Camper chiasm and then insert as two separate slips on the volar aspect of the middle phalanx.[3]



Figrue- 2: *Fibrous retinacular sheath, form the flexor pulleys, which can be identified as five heavier annular bands and three filmy cruciform ligaments. Distal transverse digital artery; intermediate transverse digital artery; proximal transverse digital artery; branch to vinculum longum; common digital artery.*[9]

Zones I and II of the FDS and FDP tendons are described by the fibro osseous digital sheath. Within this sheath, the flexor tendons are covered by a layer of flattened fibroblasts termed the epitenon. This specialized surface is the crucial gliding surface that must be restored for flexor tendon repair to be successful.[9]

Dynamics of flexor tendons- Excursion of a tendon can be affected adversely by extrinsic factors, such as contractures and adhesions, and enhanced by exercise and stretching. The total moment of the tendon on the joint is the product of tension and moment arm. As the moment arm increases, less tension is required to move the joint. With the moment arm kept constant, the independent variable is tension. Although tension may vary in response to muscle strength, the tension throughout the segments of the tendon cannot be changed. Tension seen by one part of the tendon is constant throughout the whole tendon. To change the force and torque seen by each joint crossed by a single tendon, therefore, the moment arm for the different joints must vary. The FDP has a different moment arm to each joint it crosses1.25cm at the wrist, 1.0 cm at the MCP joint, and 0.75 cm and 0.5 cm respectively, at the PIP and DIP joints. To move the joint through its full range of motion, the FDP must have an excursion of 1.57 cm.[10, 11]

MATERIALS AND METHOD

This Quasi-experimental (Non-randomized control trial) was conducted in BSMMU, Dhaka, Bangladesh from July 2018 to June 2021. A total of 30 patients were enrolled according to the inclusion criteria (FDS, FDP and FPL injury, presented within 3 weeks of surgery, stable fracture or no fracture with minimum contamination and sharp cutting or minor laceration, age of the patients were below 50 years with good digital circulation) and exclusion criteria (Lacerated injury, stiff joints of finger, comminuted or unstable fracture and medical problems, like paralytic hand, Raynaud's disease, arthritic hand) and informed written consent was obtained.

All the flexor tendons were repaired with polypropylene 4/0 double strand score sutures and 6/0 epitendinous continuous sutures.

The patients were divided into two equal groups by closed envelop technique during admission; the late mobilization (No intervention group) group- A and early active mobilization (Intervention group) group-B. In all cases, both the FDP and FDS or FPL in Zone-II were repaired with double strands modified Kessler core suture with locking epitendinous sutures with a knot inside the repair site, using polypropylene 4-0 and 6-0 sutures respectively. Postoperatively below elbow dorsal slab was applied, maintained the wrist in neutral or up to 10^0 palmer flexion in associated nerve repaired cases, MCP joint in 60^0-70^0 flexion, PIP and DIP joint in nearly full extension. In study group B, active flexion was started on the day of operation and follows the specific mobilization protocol (appendix-I) but in the control, group-A immobilization was continued up to 03 weeks after the operation then started finger mobilization study group. Post-operative findings were noted at 1st, 2nd POD and follow-up were given at 12-14 days, 3rd, 6th, 8th, 12th and 16th weeks. Complications were noted. Finally,the outcome was evaluated at 24th weeks according to Buck-Gramco functional criteria and the Louisville systemfor assessment of tendon function.

***Statistical analysis*:** Data was compiled and analyzed with the help of SPSS Version 26.0. P value <0.05 were labeled as statistically significant. The results were expressed with 95% Confidence Interval (CI) and adjusted for known confounders. The summarized data was interpreted accordingly and then presented in the form of tables and figures. Continuous variables were expressed as mean with standard deviation and categorical variables as count with percentage.

RESULTS

Total number of respondents was 30 and total fingers involvement was 60 and thumbs involvement was 4.

Table I contains that mean age of the study populations was 32.42±6.2 years, age distribution was almost similar in all group except in age group 10-20 years, where it was 6.7%; in other groups 27% to 40%.

Table- I: Age distribution of the respondents (n=30)

	Group A	Group B	Total
Age (Years)			
10-20	1(6.7%)	2(13.3%)	3(10.0%)
21-30	6(40.0%)	3(20.3)	9(30.0%)
31-40	4(26.7%)	7(46.7%)	11(36.7%)
41-50	4(26.7%)	3(20.0%)	7(23.3%)
Mean Age (Years)	32.10±5.6	32.54±6.8	32.42±6.2

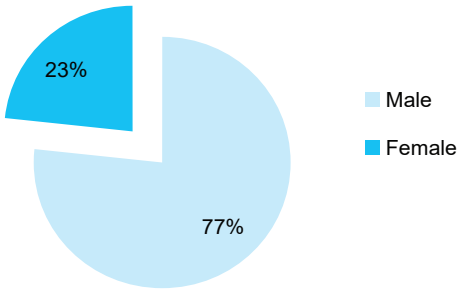


Figure- 3: *Sex distribution of the respondents (n= 30).*

Figure 3 shows the distribution of sex among the respondents, here 77% was male and male-female ratio was 7:2.

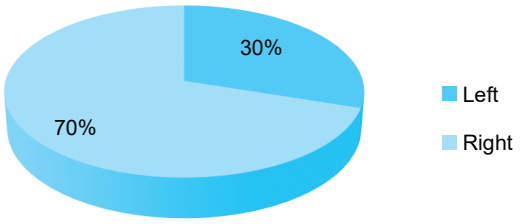


Figure- 4: *Hand involvement of the respondents (n= 30)*

Figure 4 states that right hand involvement was 70% and rest was left hand.

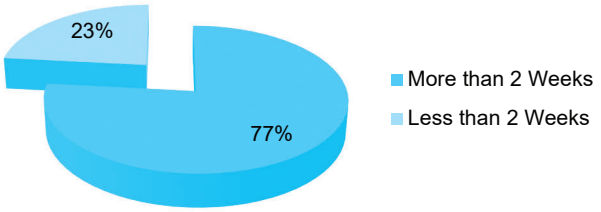


Figure- 5: *Distribution of time interval between injury and operation.*

Figure 5 illustrates that time interval between injury and operation was less than two weeks was 77% of patients where more than two weeks but within three weeks was 23%.

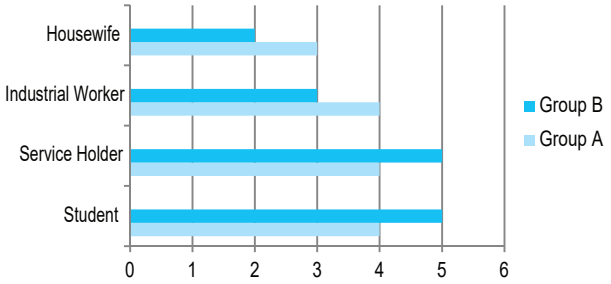


Figure- 6: *Distribution of the respondents according to occupation (n=30).*

Figure 6 shows taht distribution of occupation, among the patients of group-A (non- intervention) group A- industrial worker, service holder and students were almost the same member that was around 26% and remaining 20 was housewife in group B- service holder and students were 33% in each.

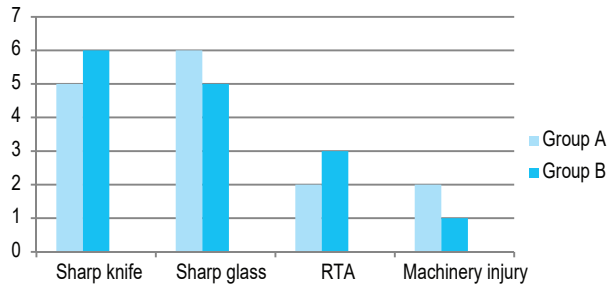


Figure- 7: *Distribution of the patients according to causation of injury (n=30)*

Figure 7 shows the distribution of the patients according to causation of injury, here 5,6,2 and 2 injuries were due to knife, sharp glass, RTA and machinery cause respectively. In group 6,5,3 and 1 were due knife, sharp glass RTA and machinery causes respectively.

Sharp weapon- glass cut or sharp knife (73%) was the most common form of injuries, that was significant ($p<0.05$) comparison with RTA and machinery injuries (27%).

Table II contains the distribution of injured fingers. Thumb index, middle, ring and little fingers injury was found in group A.3,7,6,10,6 and in group-B 1, 6,7,9 respectively

Table- II: Distribution of the patients according to the involvement of the fingers (n=64)

Involved Digit	Group A (n=32)	Group B (n=32)	Total n=64	p value
Thumb	3 (9.4%)	1 (3.1%)	4 (6.3%)	
Index	7 (21.9%)	6 (18.8%)	13 (20.3%)	
Middle	6 (18.8%)	7 (21.9%)	13 (20.3%)	
Ring	10 (31.3%)	9 (28.1%)	19 (29.7%)	0.20
Little	6 (18.8%)	9 (28.1%)	15 (23.4%)	

Table III presents the complications after repair, adhesion formation, superficial infection, contracture and rupture were found 6, 3, 4,2 in group A and 3, 1, 1, 2 in group B respectively.

Table- III: Distribution complications after repair (n=64)

Complications	Group A (Late Mobilization) (n=32)	Group B (EAM) (n=32)	P value
Adhesion formation	6(18.75%)	3 (9.38%)	0.045
Superficial infection	3(9.4%)	1(3.13%)	0.041
Contracture	4 (12.5%)	1(3.13%)	0.032
Rupture	2(6.25%)	2(6.25%)	-

Table IV shows that composite flexion, extension deficit, total active motion(TAM) and Buck Gramcko score were more in group study group B, compared to group control group-A. The p-value was <0.05 in every category, which is statistically significant. According to Louisville grading excellent and good result was found in 7 (21.9%) and 13 (40.6%) patients respectively in group A. Excellent and good result was found in 16 (50.0%) and 11 (34.38%) respectively in group B. Regarding complications- adhesion formation, superficial infection, contracture and rupture were more in late mobilization group.

Table- IV: L Specific digit-wise functional outcome according to Buck Gramcko Grade (n=64 fingers) at 24 weeks.

Involved Digit	Group -A					Group -B				
	Total	Excellent	Good	Fair	Poor	Total	Excellent	Good	Fair	Poor
Thumb	3	1(33%)	1(33%)	1(33%)	0	1	1(100%)	0	0	0
Index	7	2(28%)	3(42%)	2(28%)	0	6	3(50%)	2(34%)	1(17%)	0
Middle	6	1(17%)	2(34%)	2(34%)	1(17%)	7	4(42%)	2(28%)	1(14%)	0
Ring	10	4(40%)	5(50%)	1(10%)	0	9	5(55%)	4(44%)	0	0
Little	6	1(17%)	0	3(50%)	2(34%)	9	3(33%)	3(33%)	2(22%)	1(11%)
Total	32	9(28%)	11(34%)	9(28%)	3(9%)	32	18(56.25%)	10(31.25%)	2(6.67%)	2(6.67%)

Table V states that in group-A, out of 3 thumbs, the excellent, good and fair result was 33% in each. In the index finger out of 7 fingers, 28% had excellent, 42% had good and 28% fingers had fair results. In the middle finger, out of 6 digits, 34% had good and fair in each but excellent and poor results were 17% in each. In the ring finger, excellent result had 40%, good had 50% and fair result was 10% digit. In the little finger, excellent result had 17%, fair had 50% and poor had 34% digits. In group B, all the thumbs had excellent results, in the index finger, 50% had excellent, 34% had good and 17% fingers had fair results. In middle finger, 56% had excellent, 28% had good and 14% had fair results. In the ring finger, excellent result had 55%, good had 44% and no fair or poor results. In the little finger, excellent and good had 33% in each, fair had 22% and poor was 11% digit only.

Table- V: Comparison of final functional outcome according to Buck Gramcko and Louisville Grading (n=64).

	Group A (n=32)	Group B (n=32)	P value
Buck Gramcko Grade			
Satisfactory (Excellent+Good)	20 (62.5%)	28 (87.5%)	0.016
Unsatisfactory (Fair+Poor)	12 (37.5%)	4 (12.5%)	
Louisville Grade			
Satisfactory (Excellent +Good)	20(62.5%)	27(84.38%)	0.020
Unsatisfactory (Fair+Poor)	12(37.5%)	5(15.62%)	

Table VI presents that in late mobilization group satisfactory result was (62.5%) in both Buck Gramcko and Louisville grading criteria but in early active mobilization group satisfactory result was 87.5% according to Buck Gramcko grading and (84.38%) according to Louisville grading.

Table- VI: Rehabilitation protocol/Early Active mobilization (EAM) protocol. 12

Day 1 to 28	Splint	:	Dorsal splint with wrist 00-50 dorsiflexion MCP 700 flexion and IP full extension.
	Exercises	:	Shoulder, elbow, supination/pronation promoted.
	Hand	:	10times/session and 3session/day.
	Step 1	:	Try to active extension of all fingers, gaining extension at IP and MCP joints blocked only by a splint.
	Step 2	:	Active flexion of all fingers to possible flexion position without a forceful effort.
	Step 3	:	Passively flex the fingers at MCP and IP joints with the help of other hand, gradually increased the range of passive flexion

Table- VI (Cont'd): Rehabilitation protocol/Early Active mobilization (EAM) protocol

4-8 weeks	Splint : Intermittant, volar splint with wrist 100 _ 150 palmar flexion, MCP 700 flexion and IP extension, removed during exercise, scar mobilization done.
	Exercises : Shoulder, elbow and wrist exercises continued.
	Hand : 10 times/session and3 sessions/day. Block FDP of all fingers and isolated FDS function, and block FDS of all fingers and do isolated FDP contraction. Actively make fist, curling of all fingers into flexion, release and open actively extending to full extent.
8-12 weeks	Volar splint in 150-250 dorsiflexion, MCP 500-700 flexion, IP full extension (used only as night splint).
	Scar mobilization continued.
	Power grip allowed; ball exercises five times each session.
	Resume light work, food, drinking, button, knots, etc.
	Avoid heavy work.
12-14 weeks	No splintage.
	Stop scar mobilization.
	Power grip continue.
	Resume to daily household work but avoid heavy work.
	Exercise : Hand- continued same as above with an increased frequency of 50 times per session and 5 sessions per day.

Photograph:

Photo, A-B: Per-operative photo *C-E: Post operative at 24 weeks*

Photograph (A-E): Per-operative and post operativephotograph. Repair of FDS and FDP of Middle, Ring and little fingers and FDP of Index finger followed by EAM started at day of operation. Follow up at 24 weeks

Photo, F-H: Per-operative photo *I-J: Post operative at 24 weeks*

Photograph (F-J): Pre, per and 24 weeks postoperative photo of repair of FDS and FDP of Index, Middle, Ring and little fingers at zone-II followed by Late mobilization started at 21 days.

DISCUSSION

A flexor tendon injury in zone-II is a serious and complex injury, occurring commonly in young males of the working class and an excellent outcome depends on multiple factors. A delayed diagnosis, a poor suture technique, or an inappropriate rehabilitation regime can lead to deformity and disability. In most cases, the injury involves both tendons, which can cause significant morbidity to patients due to loss of grip and other functions if not repaired properly. The added benefits of a primary/delayed primary repair and early active mobilization are decreased rehabilitation time, adhesion formation, and rupture rate, and increased healing rate with adequate tensile strength.[12] The mean (± SD) age of the study population in group A was 32.50(± 11.34) years and in group B was 32.53(± 8.53) years. Most of the patients belong to 31-40 years age group. Flexor tendon injury in zone II is more common among the working age group, and common occupations were industrial worker, housewife, service holder and student. Male was the predominant (23/30, 6.7%) gender in this study, and dominant right-hand involvement was 70% 0f patients. Regarding etiology, 73.33% (22/30) of injury was accidental in nature by sharp weapons such as knives or broken glass. Machinery injury was 10% (3/10) and road traffic accident-related injury was only 16.67% (5/30), these result is correlated with otherstudy.[12,13,14] Ring and little finger involvement was more 53.1% (34/64) and thumb affected was less than only 6.4% (4/64), similar toother studies.[7,15] Results after a flexor tendon injury repair are inversely proportional to the delay in the repair of the tendons. The added benefits of a primary/delayed primary repair are decreased rehabilitation time, adhesion formation, and rupture rate, and increased healing rate with adequate tensile strength. 23(76.67%) of patients were operated on within 2 weeks of injury but the remaining 7(23.33%) of cases were operated on after 2 weeks. 14/64 (21.88%) digits had associated digital vessel injury and 21/64 (32.81%) digits had associated digital nerve injury that was also similar to the results.[12,14] Regarding complications, adhesion formation 9/32 (28.13%), superficial infection 4/32 contracture 4/32 (12.50%) and tendon rupture 3/32 (9.37%) were significantly more in the late mobilization group, compared with the early active mobilization group, 4(12.50%), 2(6.25%), 1(3.12%), 2(6.25%) respectively. Few of the adhesion digits improved with physiotherapy but 5 digits in the group A were treated with tenolysis after 6 months but no cases in the EAM group needed tenolysis and rupture cases were treated by tendon reconstruction and found satisfactory results. Our results were comparable with the study conducted by Strickland and the results of group B (study group) were similar to the result with Sainiet. al.; Trumble et.al.[12,16,17] In our study, we observed that the early rehabilitation group exhibited the lowest resurgery rate (6.25%), and also used fewer rehabilitation resources, on the other hand, resurgery ratein late rehabilitation groups was 21.88% (5-tenolysis and 2-tendon reconstruction) and took more time also for rehabilitation. Early controlled mobilization 1 week after surgery increased tendon tensile strength, avoided large callus formation, and reduced tendon adhesion.18 By contrast, continual immobilization during the fibroblastic phase resulted in disorganized cross-links among newly formed collagen fibres, leading to the contracture of ligaments, joint capsules, and volar plates.[19,20] A meta-analysis summarized the complication rates following flexor tendon repairs: the risk of tendon rupture was 3.6% for early passive motions and 5.3% for early active motions, compared with 16.0% for those receiving immobilization.[21] A study revealed that even 5 days of immobilization can cause substantial loss in skeletal muscle mass and strength, as well as with activation of the catabolic molecular signaling pathway. These disadvantages might not affect the resurgery rate directly but might compromise hand function and slow down the recovery, thus increasing healthcare resource usage.[12, 22] At 24 weeks follow upmean composite flexion was 189.68 ± 22.35 degree in late mobilization group and 201.25±21.66 degree in EAM group. Extension deficit was 36.87±16.15 degree in group A and 22. 38±12.43 degree in group B. Total active motion 163.13± 17.27 degree in group A and 192.19 ± 17.27 degree in group B. Buck Gramcko score was 9.66±3.51 in group A and 12.78±2.65 in group B. Excellent and good was graded as satisfactory and fair and poor was graded as unsatisfactory outcome. According to Louisville Grade, in the late mobilization group excellent, good, fair and poor results were found in 7(21.9 %), 13(40.6%), 9(28.1%) and 3(9.4%) digits respectively.12 In the early active mobilization group, excellent, good, fair and poor result were found in 16(50.0%), 11(34.38%), 4(12.50%) and 1(3.13%) digits respectively. There was a significant functional improvement in the early active mobilization group 84.38%, compared to the late mobilization group, 62.50%. According to Buck Gramckoscore, satisfactory results (excellent and good) were 62.5% (20/32) in late mobilization group, but 87.5% (28/32)in the EAM group, that is statistically significant. In finger-wise function, the little finger functional

outcome was less satisfactory comparison with other digits, that was 66,67% (6/9)in the EAM group, and only 17% (1/6) in late mobilization group. Chow et al. (1988), Saini et.al. (2010), and Hung et al. (2005) results were good to excellent in 77% of zone II flexor tendon repair with early mobilization protocol which is comparable to our study.[12,23,24,25]

CONCLUSIONS

Early active mobilization following primary repair of the flexor tendon in zone II of hand ensures better functional outcome with minimum complication compared to late mobilization.

LIMITATION

- Randomization was done by envelop technique of this RCT and 80% of follow up was strictltly maintain.
- All patients were collected in this study from a single tertiary level hospital which does not reflect the whole country.
- Respondents were included up to 3 weeks but if it would be within 5 days that reflect better results
- Rehabilitation could not strictly supervised.

Conflict of Interest

No conflict of interest, this study was conducted by self-funding at the department of Orthopaedics, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh.

Level of Evidence: Level II (Randomized Control Trail but follow up level was about 80% and Hand therapy was not supervised properly)

REFERENCES

1. Blom A, Warwick D, Whitehouse M.R.Apley's system of orthopaedics and fractures: Injuries of the hand. 10thed. CRC Press; 2017:815-825.
2. Strickland JW. Development of flexor tendon surgery: twenty-five years of progress. J Hand Surg Am. 2000;25 (2):214-235. doi:10.1053/jhsu. 2000.jhsu 25a0214
3. Kleinert HE. Report of the committee on tendon injuries. J Hand Surg Am. 1989;14(2 Pt 2):3816.
4. Hein C, Wilton P, Wongworawat MD. Review of Flexor Tendon Rehabilitation Protocols Following Zone II Repair. Critical Reviews in Physical and Rehabilitation Medicine. 2015;27 (1):11-18. doi:10.1615/critrevphysrehabilmed.2015013919.
5. Klein MB, Yalamanchi N, Pham H, Longaker MT, Chang J. Flexor tendon healing in vitro: effects of TGF-beta on tendon cell collagen production. J Hand Surg Am. 2002; 27(4):615-620. doi:10.1053/jhsu. 2002.34004.
6. Kessler I. The "grasping" technique for tendon repair. Hand. 1973; 5(3):253-255. doi: 0.1016/0072-968x(73)90038-7
7. Silfverskiöld 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; 19(1):53-60. doi: 10.1016/0363-5023(94)90224-0.
8. Thurman RT, Trumble TE, Hanel DP, Tencer AF, Kiser PK. Two-, four-, and six-strand zone II flexor tendon repairs: an in situ biomechanical comparison using a cadaver model. J Hand Surg Am. 1998; 23 (2):261-265. doi:10.1016/s0363-5023(98)80124-x.
9. Wolfe SW, Hotchkiss RN, Pederson WC, Kozin SH, Green DP, Hotchkiss RN Green's operative hand surgery: Flexor Tendon Injury; 6th ed. Elsevier; 2011:189-211.
10. Goodman HJ, Choueka J. Biomechanics of the flexor tendons. Hand Clin. 2005;21(2):129-149. doi:10.1016/ j.hcl.2004.11.002.
11. Hansen JT. Netter's anatomy coloring book. Saunders/Elsevier; 2010.
12. Saini N, Kundnani V, Patni P, Gupta S. Outcome of early active mobilization after flexor tendons repair in zones II-V in hand. Indian J Orthop. 2010 Jul; 44(3):314-21. doi: 10.4103/0019-5413.65155.
13. Manninen M, Karjalainen T, Määttä J, Flinkkilä T. Epidemiology of Flexor Tendon Injuries of the Hand in a Northern Finnish Population. Scand J Surg. 2017; 106 (3):278-282. doi: 10.1177/14574 96916665544.
14. Moriya K, Yoshizu T, Tsubokawa N, Narisawa H, Matsuzawa S, Maki Y. Outcomes of flexor tendon repairs in zone 2 subzones with early active mobilization. J Hand Surg Eur Vol. 2017;42 (9):896-902. doi: 10.1177/1753193417715213.
15. Riaz M, Hill C, Khan K, Small JO. Long term outcome of early active mobilization following flexor

tendon repair in zone 2. J Hand Surg Br. 1999;24(2):157-160. doi:10.1054/jhsb.1998.0175.

16. Trumble TE, Vedder NB, Seiler JG 3rd, Hanel DP, Diao E, Pettrone S. Zone-II flexor tendon repair: a randomized prospective trial of active place-and-hold therapy compared with passive motion therapy. J Bone Joint Surg Am. 2010;92(6):1381-1389. doi:10.2106/JBJS.H.00927.
17. Small JO, Brennen MD, Colville J. Early active mobilisation following flexor tendon repair in zone 2. J Hand Surg Br. 1989;14(4):383-391. doi:10.1016/0266-7681(89)90152-6.
18. Lolah MA, Elsakka DM, Samy MA, Hanot MG. Comparative study between early mobilizations vs late mobilization after flexor tendon repair in the hand. Menoufia Medical Journal. Apr 2020; 33(2):683.
19. Kyle JB, Eyre-Brook AL. The Surgical treatment of flexor tendon injuries in the hand: Results obtained in a consecutive series of 57 cases. British Journal of Surgery. 1954;41(169):502-511. doi:10.1002/bjs.18004116912.
20. Boyes JH, Stark HH. Flexor-tendon grafts in the fingers and thumb. A study of factors influencing results in 1000 cases. J Bone Joint Surg Am. 1971; 53 (7):1332-1342.
21. Matev I, Karagancheva S, Trichkova P, Tsekov P. Delayed primary suture of flexor tendons cut in the digital theca. Hand. 1980; 12(2):158-162. doi: 10.1016/s0072-968x(80)80007-6.
22. Salvi V. Delayed primary suture in flexor tendon division. Hand. 1971; 3 (2):181-183. doi:10.1016/0072-968x(71)90042-8.
23. Nielsen AB, Jensen PO. Methods of evaluation of the functional results of flexor tendon repair of the fingers. J Hand Surg Br. 1985;10(1):60-61. doi:10.1016/s0266-7681(85)80018-8.
24. Chow JA, Thomes LJ, Dovelle S, Monsivais J, Milnor WH, Jackson JP. Controlled motion rehabilitation after flexor tendon repair and grafting. A multi-centre study. J Bone Joint Surg Br. 1988;70 (4):591-595. doi:10.1302/0301-620X.70B4.3403603.
25. Hung LK, Pang KW, Yeung PL, Cheung L, Wong JM, Chan P. Active mobilisation after flexor tendon repair: comparison of results following injuries in zone 2 and other zones. J Orthop Surg (Hong Kong). 2005;13 (2):158-163. doi:10.1177/230949900501300209.