ORIGINAL ARTICLE

EARLY ACTIVE MOBILIZATION VS IMMOBILIZATION FOLLOWING MODIFIED KESSLER REPAIR OF EXTRINSIC EXTENSOR TENDONS IN ZONE V TO VII

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Background: The long-disputed issue of rehabilitation of extensor tendon repairs in zones V–VII has been treated with either complete immobilization or mobilization within the constraints of splint. In recent times, most authors have preferred some mobilization. Many studies have shown good results with early mobilization techniques; however, these studies have limitations. Most of these are retrospective observations. Some prospective studies are without proper controls. This study was conductive to compare the functional outcome of early active mobilization versus immobilization following repair of extensor tendons in zone V–VII. **Methods:** Functional outcome was determined by total active motion, pain and complications during rehabilitation. Total active motion (TAM) was graded by scores of the American Society for Surgery of Hand as TAM=total active flexion (MCP+PIP+DIP)–total extension deficit (MCP+PIP+DIP). A randomized control trial was conducted including 50 subjects of with extensor tendon injury exclusively in zone V–VII. Patients were divided randomly in two groups. All extensor tendon repairs (zone V to VII) were performed with modified Kessler's method. The pain and TAM was assessed during all visits in both groups except TAM in group B that was assessed after four weeks. **Results:** We found that outcome of 12% cases in Group A as excellent and no patient fell in category of fair results. While, in comparison, there was no case of excellent result in Group B. 4% cases showed fair results that were treated with immobilization. The pain score at the end of treatment, i.e., at 12 weeks were same in both the groups but, generally the score remained higher in group of EAM. There was significant difference in adhesion formation that was more in patients of immobilization group. The overall suture dehiscence was insignificant and was only 8% in each group. **Conclusion:** EAM has better outcome in terms of pain and range of motion.

Keywords: Extensor tendon injury; Zone V; Zone VI; zone VII; Early active mobilization

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INTRODUCTION

Treatment of the extensor tendon injuries has always been less debated and taken as easier job. Multiple factors contribute to such conditions like extra-synovial position of tendons, easy approach to the tendons due to thin overlying soft tissue and reaction of the tendons is lesser as compared to that of flexors. However, in contrast to this commonly believed fact, the extensor tendon injuries management is much more difficult than that of flexor tendons. There is severe tendency of extensor tendons to form adhesions because of its superficial position and close contact with the underlying bone. Adding to this, the limited excursion amplitude of these tendons, a slight shortening or lengthening may affect the overall function of the repaired tendons. Post-operative physical therapy protocol should be very carefully selected depending on the zone of injury.

Rehabilitation of extensor tendon repairs in zones V–VII has been disputed. The regimens employed for the postoperative management of extensor tendon repairs, in recent times, can be grouped into the following categories: 1) Immobilization with a static splint.[1] 2) Early active mobilization with a flexion blocking splint (EAM)[2] and 3) dynamic splinting (active flexion and passive extension).[3] A period of immobilization would logically lead to the formation of a strong fibrous union at the repair site, which has less chances of breakage.

According to various studies early mobilization has shown promising results but those studies have their own limitations. In these studies, most are retrospective, repair to multiple tendons was involved, follow up was variable, and no standard assessment criteria was followed. Appropriate controls were not used in prospective studies.[2,3]

A prospective study was conducted by Patil and Koul.[4] In this two groups were compared for results of

immobilization vs. early active mobilization. Patients with zone V to zone VII tendon injuries were taken. After this randomized trial they concluded that the patients with early active mobilization had lesser stiffness. In the group with immobilization total active motion was in 142±16 patients, whereas, in the group with active mobilization, total active motion was seen in 200±26 patients. But this significant number had decreased in six months follow up results. Both groups did not develop adhesions during the rehabilitation time. Chow, *et al.* study showed little contrasting results. Their static group had 17.1% adhesions. Whereas, there were no adhesion formation in the group using dynamic rehabilitation as it was seen in the Patil, *et al,* study. Subjects in the study of Patil experienced greater pain in early time of initiation of mobility, which were 1–2 weeks in group with EAM and 4–5 weeks in the group with no mobilization. But no categories of pain were made in the study to be used as variable for frequency or percentage. Furthermore, total amount of pain experienced by the subjects was also not compared between different groups.

This prospective study compared immobilization and early active mobilization protocols after extensor tendon repair in terms total range of motion achieved and pain.

MATERIAL AND METHODS

Total of 50 patients were enrolled in this study. All patients were admitted through outdoor of Jinnah Burn and Reconstructive Surgery Centre, Lahore and referral from emergency department of Jinnah Hospital, Lahore. Total duration of study was from December 2016 to November 2017. Informed consent was taken from patients. Those fulfilling the selection criteria were included in the study. Patients of both genders, age ranging from 10 to 65 years having extensor tendon injury exclusively in zone V–VII were included. All patients who have associated flexor tendon injuries, bony fractures and nerve injuries were excluded from the study. Also, patients having infected wounds or loss of skin envelop needing soft tissue coverage were not included. Patients were divided randomly in two groups by the help of random number table. Patients were divided into two groups as Group–A following Early Active Mobilization protocol and Group–B as Immobilisation protocol.

All the patients were photographed and baseline assessment was done before initiation of treatment. Surgical protocol consisted of debridement of all nonviable tissues, exploration, and assessment of injury. All the extensor tendon repairs (zone V to VII) were performed with 4 strands modified Kessler's method using 4/0 polypropylene core suture and continuous over and over epitendinous sutures with 6/0 polypropylene material. Surgeries were performed by different surgeons following the same protocol. Immediately postoperatively, the hand was splinted with volar slab from proximal forearm to the fingertips. Measurements were taken for the custom–made padded aluminium splint and patients were discharged on the same day or the next day if the associated injuries allowed, on antibiotics and analgesics. Patients were followed up on day 3, 1st, 2nd, 3rd, 4th, 6th, 8th, 12th weeks. Pain was assessed during all visits in both groups and Total Active Motion (TAM) in group A & B was assessed at 4th, 6th, 8th and 12th weeks. Assessment was done by single assessor and was recorded in *pro forma.*

Total active motion (TAM) was graded by scores of the American Society for Surgery of Hand that categorises TAM; 100% of normal as Excellent, 75-99% as Good, 50-74% as Fair and <50% as Poor. Pain was assessed by Numeric Rating Scale (NRS-11). It is an 11–point scale for patient self–reporting of pain and is scored as 0 for no pain, 1–3 for Mild Pain (nagging, annoying, interfering little with activities of daily life (ADLs), 4–6 for Moderate Pain (interferes significantly with ADLs), and 7–10 for Severe Pain (disabling; unable to perform ADLs).

All data was entered and analysed using SPSS ver. 20. Numeric variables like age, pain and TAM were presented as mean and standard deviation. Categorical variables like complications were presented as frequency and percentage. Chi square was used to compare the complications in both groups. The mean TAM and pain measurements at each interval were compared using the t–test independent sample. A *p*-value ≤0.05 was taken as statistical significance.

All the patients, after the tendon repair, were given splint. The wrist was placed in 30º extension and interphalangeal joints in 0º. Both groups were advised different mobilization protocols. Static splint was continued for 4 weeks and was unchanged in Group B. At the end of 4th week, the splint was modified and a blocking wedge was added to the splint to allow movement of about 0–45º at MCPJ while the IPJs were left free for mobilization. Patients were advised to remove the block four times a day and mobilize their fingers and after the exercise replace the block. The splint was modified to allow 0–90º flexion at MCPJ at 6 weeks. This time the patients are advised to exercise as many times as possible. The splint was worn between the exercises. The splint was removed at 7th week in day time and allowed to do light daily activities. For another 2 weeks, night time protective splintage was continued. Heavy work was not allowed. The splint was completely removed at 8th post–operative week. At that time, patients were allowed to do routine work and passive stretching exercises were allowed. This resulted in increased range of motion.

The initial splint for the Group A patients was same as that of Group B patients. At 1st or 2nd post-

operative day, the splint was changed to include only the involved fingers. At 3rd or 4th day, blocking wedge was added to allow 0–30º flexion. The patients were advised to do range of motion at metacarpophalangeal joints from 0–30º three times a day for 10 minutes. The interphalangeal joints were kept immobile. This was continued for 1st week. The splint was adjusted to allow motion of 0–50º in the second week. The frequency of exercise was increased to four times a day. Further increase in range of motion to 70º was allowed in 3rd week. Also, the frequency was increased to 5 times daily. At this time the splint was modified to free the interphalangeal joints to allow free movements of these joints. The angle was increased to 90º at 4th week to allow full range of motion at MCPJ and IPJ. The frequency was increased to 6 times a day for 10 minutes. The splint was used in between the periods of exercise. The blocking wedge was removed in day at 5th/6th weeks to allow free, unrestricted movement of fingers within the protective splint. At 7th weeks, same protocol was advised as for Group B patients. Both groups were assessed at the end of 12 weeks for range of motion and pain.

RESULTS

Fifty Subjects were recruited for the study. Mean age of subjects was 26.0 (SD 11.1). Mean age among Early Active mobilization (EAM) was 24.1 years (SD 8.8 years). Mean age among Immobilization group (IM) 28.0 (SD 13.0). In Early Active mobilization (EAM) group 23 (92%) were male and 2 (8%) were female and in IM Group 21(84%) were male and 4(16%) were female. The mean pain score at baseline was 6.3 (SD 2.8), mean pain score in Early Active mobilization (EAM) was 4.6 (SD 2.4) and Immobilization group (IM) mean pain score was 7.9 (SD 2.1). Mean pain score at 4 weeks was 3.9 (SD 3.0) and pain score in Early Active mobilization (EAM), mean was 1.6 (SD 2.3) and in Immobilization group (IM) mean pain score was 6.2 (SD 1.5). Mean pain score at 6 weeks was 2.2 (SD 2.2) and in Early Active mobilization (EAM) Mean pain score was 7 (SD 2.0) and in IM Mean pain score was 3.7 (SD 1.2).

Mean pain score at 8 weeks was 1.0 (SD 1.6) and in Early Active mobilization (EAM) Mean pain score was 0.5 (SD 1.8) while in Immobilization group (IM) Mean pain score was 1.6 (SD1.1). Total pain score Mean value at 12 weeks was 0.1 (SD 0.4) while Mean pain score in Early Active mobilization (EAM) was 0.0 and SD was 0.4 and in Immobilization group (IM) Mean pain score was 0.1 (SD 0.5). Mean Total active motion (TAM) at baseline was 261.3 (SD 8.0) while in Early Active mobilization (EAM) Mean TAM was 263.8 (SD 7.9) and in Immobilization group (IM) mean total active motion (TAM) was 258 (SD 7.3). Mean Total active motion (TAM) at 4 weeks was 161.3 (SD 27.5) while in Early Active mobilization (EAM) mean Total active motion (TAM) was 183.2 (SD 13.8) and Immobilization group (IM) mean Total active motion (TAM) was 139 (SD 19.1). Total TAM at 6 weeks was mean 185.7 (SD 28.0). While in Early Active mobilization (EAM) mean Total active motion (TAM) was 207.0 (SD 17.0) and Mean TAM in IM was 164.5 (SD 19.5). Mean Total active motion (TAM) at 8 weeks was 212.6 (SD 22.3) while in Early Active mobilization (EAM) mean Total active motion (TAM) was 229.8 (SD 12.2) and in Immobilization group (IM) mean total active motion (TAM) was 195.4 (SD 16.1). Mean Total active motion (TAM) at 12 weeks mean was 243.6 (SD 7.1) while in EAM Mean TAM was 255.4 (SD 9.9) and in Immobilization group (IM) mean Total active motion (TAM) was 231.8 (SD 14.4).

Outcome among subjects in both groups was; 46 (92%) had a good outcome, 3 (6%) was excellent, 1 (2%) was fair. Outcome was compared among groups. In Early Active mobilization (EAM) 22 (88%) had a good outcome, 3 (12%) had excellent outcome. In Immobilization group (IM) group 24 (96%) had good outcome and 1 (4) had fair outcome. Chi-square test was applied to assess the association between outcome and group. (X2= 4.087, p=>.05).

In EAM group patients with age <30 years, 2 (10%) had excellent outcome and 18 (90%) had good outcome as compared to Immobilization group where 16 (94%) had good outcome. (Chi-square 2.893, p=.235). In EAM group in age >30 years one (20%) had excellent outcome and 4 (80%) had good outcome as compared to Immobilization group where 8 (10%) had good outcome. (Chi-square 1.733, p=0.188). In EAM and Immobilization group for zone VII, 3 (100%) had excellent outcome.

Outcome was compared among two groups with stratification of gender. In EAM group in Males 3 (13%) had excellent outcome and 20 (87%) had good outcome as compared to Immobilization group where 20 (95.2%) had good outcome and 1 (4.8%) had fair outcome. (Chi-square 3.917 p=.141). In EAM and IM group among females 6 (100%) had excellent outcome.

Outcome with zone stratification was also compared. In EAM group in zone V one (14.3%) had excellent outcome and 6 (85.7%) had good outcome as compared to Immobilization group where 8 (100%) had good outcome. (Chi-square 1.244 p=.268). In EAM group, in zone VI 2 (13.3%) had excellent outcome and 13 (86.7%) had good outcome as compared to Immobilization group where 13 (92.9%) had good outcome and 1 (7.1%) had fair outcome. (Chi-square 2.969 p=.227). In EAM and Immobilization group in zone VII 6 (100%) had excellent outcome

Table-1: Group statistics

	Group	n	Mean	Std. Deviation	Std. Error Mean	t test. *p* value
Pain Score (NRS-11) at 12 weeks	Early Active Mobilization	25	.0800	.40000	.08000	t = -.586
	Immobilization	25	.1600	.55377	.11075	*p* = .561
Total Active Motion (TAM) 12 weeks	Early Active Mobilization	25	255.4000	9.99166	1.99833	t= 6.725
	Immobilization	25	231.8000	14.42509	2.88502	*p*= .000

Table-2: Early active motion crosstab for outcome

			Group		Total
			Early Active Mobilization (EAM)	Immobilization (IM)	
Outcome	Excellent	Count	3	0	3
		% within Group	12.0%	.0%	6.0%
	Good	Count	22	24	46
		% within Group	88.0%	96.0%	92.0%
	Fair	Count	0	1	1
		% within Group	.0%	4.0%	2.0%
Total		Count	25	25	50
		% within Group	100.0%	100.0%	100.0%

(A) Splint at 1st week follow up (b) Splint at 2nd week follow up (c) Splint at 4th week follow up (d) Splint at 6th week follow up

Figure-1: Postoperative splint

DISCUSSION

For the last 20 years flexor tendon repairs have been in point for concern for surgeon and rehabilitation workers. Rehabilitation of extensor tendon has always been over estimated in comparison with flexors and therefore, they have always been neglected.[5,6] Outcome of lacerated extensor tendon is varied. Hauge proposed better outcome of extensor tendons after repair, but his research did not commented if there was any loss in flexor function.[5] Kelly and Zander emphasized on careful repair of extensor tendons for optimum results.[7,8]

In past 20 years, early mobilization has been widely used with beneficiary outcomes. This early mobilization was with use of splints which where dynamic and various gliding programs. This has shown promising results.[9-13] Normal motion and gliding movements can be achieved with balanced tensile strengths in the repaired tendons. A 5 milli-meter excursion of the extensor tendons is achieved in long and index finger if there is flexion of 30 degrees in metacarpophalangeal joints and a 40 degrees flexion in small and ring finger. Duran and Houser showed that for extensor system these degrees are enough for flexion in case of dynamic splint is applied.[14] For extensor excursion no direct method has been devised, as animal experimental models have shown no significant results, therefore, this indirect method is in practice.

Most of the dynamic splints prevent digits from full flexion and provide limited flexion in proximal part of wrist in proper position. In a study by Browne and Ribik.[9] it was said that rehabilitation, when hand is put in large angle of flexion with dynamic splint, has excellent outcomes. In another study by Minammikawa, *et al.* excellent results were shown with no stress on the repaired tendon if the wrist is put in 21-degree extended position and a full composite flexion is practiced. Over extension at wrist joint may result in buckling of extensor tendon in a proximal area resulting in decreased functioning of gliding motion.[15] We still have limited knowledge on shortening of tendon following the repair procedure, its effects on position of joints and the protocols in rehabilitation of such cases. But over time we have learned that a wrist in extended position and an almost complete movement in fingers has better outcomes than other protocols. This protocol decreases the chances of complications and loss of flexion in digits. It has been discussed earlier that a loss in flexion movement in digits is more challenging problem than an extensor lag or adhesions at the repair site. There is far less incidence of these complications in dynamic splitting in comparison with use of static splint.[9,10,16,17]

To enhance the healing process logical choice is to start active movement. It has two obvious benefits; one is promotion of gliding movements in tendon and second is increase in strength of repair.[18–20] For the rehabilitation of repairs in zone III and zone IV, arc of motion protocol has shown beneficiary results.[21] In a study Evan, without increase in complication rate, was able to improve lag in extension from 8 degree to 3 degrees and the PIP motion was shown to improve from 72 degrees to 88 degrees as compared with cases using static splint. In cases with repair in proximal area, minimal active muscle tendon tension shown better results.[10] Keech, *et al*. observed that if the wrist is kept in little extended position, it will decrease the extension force up to one third in the proximal phalanges.[22] Repair is protected and a gliding movement is enhanced in cases with such extension at wrist along with use of other active tension protocols.

We recruited total 50 patients and divided them equally in two groups. Group–A was rehabilitated with early active mobilization and Group–B with immobilization. Surgeries were performed by different surgeons in the department who have special expertise in hand trauma. Complete follow up was done by same doctors who were conducting this study. We repaired the extensor tendons with 4 strand modified Kessler repair. We found that outcome of 12% cases in Group–A as excellent and no patient fell in category of fair results. While, in comparison, there was no case with excellent results in Group–B. 4% cases showed fair results that were treated with immobilization. The pain score at the end of treatment, i.e., at 12 weeks were same in both the groups but generally the score remained higher in group of EAM. There was significant difference in adhesion formation that was more in patients that followed the protocol of immobilization. The overall suture dehiscence was insignificant and was only 8% in each group. This showed that EAM does not have any adverse effect on suture dehiscence.

Varying mechanisms of injury resulted clean cut or crushed tendon injuries. In both of these cases the ends of tendons were debrided and primary suturing of tendons were done. Furthermore, different number of tendons involved has bearing on surgical procedure. The rehabilitation protocols remained same in all cases regardless of nature of injury or number of tendons involved. We found no significant difference of results on these bases.

In year 2012 a prospective study from 2004–2008 was published which was conducted by Valentin Neuhaus. Repair of extensor tendons of all the subjects was performed by same surgeon. Patients with injury to extensors in zone IV to zone V for fingers and zones TI to zone TIII for thumb were included in this study. A 4–strand core methodology was used for repair with help of epitendinous suturing. From 0 to 7th day, every patient was allocated with a static splint for night and a dynamic split for day time. With use of these dynamic splint passive extension and active flexion was allowed. After a period of three weeks the dynamic splint was totally removed and patients were put on active movements of finger but a static splint was used for another 3 weeks at night time. Out of 19 patients, 17 were included in the study. Twelve patients had injury to extensor tendons of fingers in zone IV and zone V and five patients had an extensor tendon laceration in thumb. The average time taken before the patients were operated after the injury was 11 days. Follow up of these patients was from 43 to 215 days. By the end of 6th week 16 patients had optimum results. No patient had rupture of tendon and not a single tenolysis was performed. Outcome of the study was, good functional outcome can be achieved with dynamic splinting in cases of injuries to extensor tendons of zone IV and zone V for finger and zone TI to zone TIII for thumb. Our study has same results but we had different treating zones.[23]

Patil and Koul compared the result of immobilization and early actively mobilization in a prospective study. Injuries of zone V to zone VII were selected. A lesser degree of stiffness was seen in patients with early mobilization in comparison with immobilization. By the end of 4 weeks follow up a significant total active motion (TAM) was observed. In the immobilization group total of 142±16 patients achieved TAM, whereas, in early active mobilization group total of 200±26 patients showed TAM. But by the end of 6 months, a decrease in difference was seen. No adhesion formation was reported in whole study.[4] In the study by Chow, *et al.* 17.1 percent patients experienced formation of adhesions in the group with use of static splinting. But no adhesion was observed in the group with dynamic splinting.[17]

One of the limitations in our study was lack of assessment of timing of return to work. As there was diversity of cases and their occupation, this variable was excluded from the study. This variable is also dependent on handedness and occupation of patients which can complicate the results.

CONCLUSION

Extensor tendon injuries are relatively more common than flexor tendon injuries due to their superficial location. Rehabilitation protocols after extensor tendon repair are less debated in the literature. Early, immobilization after tendon repair has been practiced for long but now the trend is changing towards

dynamic splintage and early active mobilization. In comparison of these two protocols we have found that early active mobilization is better than immobilization as it will reduce the pain and the outcome is superior in terms of range of motion.

AUTHORS' CONTRIBUTION

MJR: Conduction of actual study, Write up, study design. MA, HK, IS, AR, KK, MN: Conduction of actual study. MNT: Conduction of actual study, proof reading. SR: write up and proof reading

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