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ARAŞTIRMA / RESEARCH

Evaluation of functional results of primary repair in hand extensor tendon injuries according to etiological factors, associated injuries and injury sites

El ekstansör tendon yaralanmalarında primer onarımın fonksiyonel sonuçlarının etiyolojik faktörler, eşlik eden yaralanmalar ve yaralanma yerlerine göre değerlendirilmesi

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Abstract

Purpose: The aim of this study was to evaluate the effect of surgical treatment of extensor tendon injuries in the hand with appropriate primary repair techniques on clinical and functional outcomes, taking into account the mechanism of injury, concomitant injuries and injury sites.
Materials and Methods: This is a cross-sectional study in which 103 patients who were operated between 2016-2020 in Orthopedics and Traumatology Clinic were evaluated retrospectively. Existing treatment modalities were evaluated in terms of etiological factors, anatomical regions, number of injured tendons, and injuries. Complications and functional outcomes were statistically evaluated according to anatomical regions, mechanism of injury and additional injuries.
Results: 114 extensor tendon injuries of 103 patients (mean age: 37.2 years) were evaluated. The mean follow-up period was 26.8 months. Among the etiological factors, it is seen that the most common one is sharp object injury (57.3%). According to the Miller classification performed at the 8th week and 12th month in sharp object injury, moderate and poor outcome and the presence of complications were found to be statistically significantly lower than other injury types. A statistical correlation was observed between the accompanying injury (n: 21/103) and the occurrence of complications and functional outcomes. While there is no difference between complications, depending on the body regions, and functional results at 8. week statistically significantly lower functional results were found in zone-2 injuries at 12 months.

Öz

Amaç: Bu çalışmanın amacı, eldeki ekstansör tendon yaralanmalarının uygun primer onarım teknikleri ile cerrahi tedavisinin; yaralanma mekanizmasını, eşlik eden yaralanmaları ve yaralanma bölgelerini göz önünde bulundurarak bunların klinik ve fonksiyonel sonuçlara etkisini değerlendirmektir.
Gereç ve Yöntem: Bu çalışma 2016-2020 yılları arasında Ortopedi ve Travmatoloji Kliniği'nde ameliyat edilen 103 hastanın retrospektif olarak değerlendirildiği kesitsel bir çalışmadır. Mevcut tedavi yöntemleri etiyolojik faktörler, anatomik bölgeler, yaralanan tendon sayısı ve eşlik eden yaralanmalar açısından değerlendirildi. Komplikasyonlar ve fonksiyonel sonuçlar anatomik bölgelere, yaralanma mekanizmasına ve ek yaralanmalara göre istatistiksel olarak değerlendirildi.
Bulgular: 103 hastanın (ortalama yaş: 37,2 yaş) 114 ekstansör tendon yaralanması değerlendirildi. Ortalama takip süresi 26,8 aydı. Etiyolojik faktörler arasında en sık görüleninin kesici alet yaralanması (%57,3) olduğu görülmektedir. Keskin alet yaralanmalarında 8. hafta ve 12. ayda yapılan Miller sınıflamasına göre orta ve kötü sonuç ve komplikasyon varlığı diğer yaralanma tiplerine göre istatistiksel olarak anlamlı derecede düşük bulundu. Eşlik eden yaralanma (n: 21/103) ile komplikasyon oluşumu ve fonksiyonel sonuçlar arasında istatistiksel bir ilişki gözlendi. Yaralanma bölgelerine göre komplikasyonlar ile 8. Haftadaki fonksiyonel sonuçlar arasında fark bulunmazken, zon-2 yaralanmalarında 12. ayda istatistiksel olarak anlamlı derecede daha düşük fonksiyonel sonuçlar bulundu.

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Conclusion: While successful postoperative recovery primarily depends on the type of injury and associated injuries, good and excellent functional results can be achieved with early mobilization after surgery with the appropriate repair technique in any region.
Keywords:. Extensor tendon, Tendon repair, hand injury, Extensor zones

Sonuç: Başarılı postoperatif iyileşme öncelikle yaralanma tipine ve ilişkili yaralanmalara bağlı olmakla birlikte, herhangi bir bölgede uygun onarım tekniği ile cerrahi sonrası erken mobilizasyon ile iyi ve mükemmel fonksiyonel sonuçlar elde edilebilir.
Anahtar kelimeler: Extensör tendon, Tendon onarımı, El Yaralanması, Extensör Bölgeler

INTRODUCTION

Extensor tendon injuries in the hand are more common than flexor tendon injuries due to their superficial anatomical localization[1,2]. This anatomical feature also predisposes the extensor mechanism to more complex tendon injuries such as abrasion, crush, and avulsion. To facilitate the classification and treatment of extensor tendon injuries, the back of the hand, wrist, and forearm are divided into 9 anatomical regions[3,4]. The extensor tendons have a thinner and flatter profile and are very close to the bony structures. Due to this condition, the adhesion or shortening of the tendons can seriously reduce the range of motion and function of the joints. Extensor tendon injuries can result in loss of function in one or more fingers, loss of function in the wrist, and contractures in the joints. Surgical repair is frequently preferred in hand surgery and tendon injuries due to satisfactory functional results and rapid recovery potential[5]. The most ideal treatment is the one that provides the best functional outcome. İf local conditions allow, the direct repair is the most appropriate treatment option[6-8]. The injury site, the mechanism of injury, and the presence of combined injuries affect functional outcomes[3,9].

Compared to flexor tendons, repairs of extensor tendons are particularly challenging for surgeons due to their smaller size and lack of collagen bundle connection, which reduces the grip strength available for the suture material[10]. The ideal suture technique should allow easy tendon gliding, cause minimal adhesion and shortening, and be simple to apply while being strong enough to allow early movement. When the literature is examined, different suture techniques are recommended according to the zones, running suture, modified Kessler suture and additional epitendinous suture added to it, and horizontal running matres suture that interlock with each other is alternative suture techniques used in different zones[11-13]. In recent systematic reviews, there is strong evidence that early mobilization after hand and wrist extensor tendon repair provides a better range of motion compared to immobilization protocols[14,15]. To evaluate the degree of healing of the extensor tendons after surgery, Miller's scale, which was reported with 4 different categories as excellent, good, moderate, and poor, is frequently used[16]. In this study, early mobilization was applied to all patients, and functional evaluation was performed using the scale mentioned above.

The aim of this study is to evaluate the functional results of surgical treatment of hand extensor tendon injuries using appropriate repair techniques that will allow early mobilization. We believe that this study will contribute to the literature by evaluating the mechanism of injury and accompanying injuries.

MATERIALS AND METHODS

Study design and participants

In this cross-sectional study, a retrospective analysis of 135 patients with informed consent who were operated by the same surgeon for acute extensor tendon injury in Adana Private Medline Hospital between 2016/2020 was performed. All data were retrospectively scanned from hospital records. The study was approved by the Private Medline Hospital Ethics Committee, dated 12.02.2021 and number 08. Patients with open wounds and cuts on the back of the hand or forearm, and injured one or more tendons were included in the study. Exclusion criteria were patients with late repair (operated after 48 hours), repaired with a tendon graft, tendon transfer, soft tissue defect with flap or patients who underwent graft repair. In the 135 patient files analyzed, 7 patients who underwent late surgery, 4 patients who underwent graft repair, 2 patients who underwent tendon transfer, 8 patients with soft tissue defects, and 11 patients who did not attend regular follow-ups were excluded from the study.

Surgical technique and physical therapy

The decision of the suturation technique was made according to the thickness of the tendon. The simple running suture technique was used in Zone 2 tendon repairs. Running interlocking horizontal matres

suture was used in zones 3 and 4, modified Kessler suture technique was used between zones 5 and 6 and epitendinous suture was used on it. The double right angle suture technique was used in Zone VII. After the repair, a plaster cast was applied to all patients, with the fingers in full extension, the metacarpophalangeal joint at 0 degrees, and the wrist at 30 degrees. After the 2nd week, the plaster was wrapped with an elastic bandage and passive flexion of the fingers as tolerated was started for 5 minutes every 2 hours during the day. After the 3rd week, active flexion of the fingers up to 40 degrees was started. At the end of the 4th week, the plaster cast was removed during the day, and rehabilitation to increase the range of active flexion was started for 2 weeks. The splint was continued to be used at night for 6 weeks.

Functional evaluation and follow-up

We performed goniometry and recorded it for all joints of the affected digit at all follow-up visits. Outcomes were graded by the criteria of Miller: excellent is 0° extension lag, 0° flexion loss; good is 10° extension lag, 20° flexion loss; fair is 11° to 45° extension lag, 21° to 45° flexion loss; and poor is 45° extension lag, 45° flexion loss. Complications that developed were recorded[16]. The functional results of the patients at the 8th week and 1st year were evaluated and recorded by same surgeon.

Statistical analysis

Descriptive statistics were used to define continuous variables (mean, standard deviation, minimum, median, maximum). Evaluation of additional injury, injury types and injury areas by Miller Classification were tested with Chi-Square (or Fisher Exact test, Yates Continuity Correction where appropriate). The statistical significance level was determined as 0.05. Analyzes were performed using MedCalc® Statistical Software version 19.7.2.

RESULTS

90 male (87.4%) and 13 female (12.6%) patients hospitalized in Adana Private Medline Hospital Orthopedics and Traumatology Clinic were included in this study. The mean follow-up time was 26.8+14.7 and the median follow-up time was 18(12-65) months. The male/female ratio was found to be 7/1. The mean age was 37.2+15.6 and the median age was 35 (4-81). The incidence of left-hand extensor tendon injuries was statistically significantly higher than right-hand extensor tendon injuries at the p = 0.001 significance level (Table 1). While 82 of the patients had no additional injuries, 21 had additional injuries (Figure 1). The injury was most common in zone 2 and zone 3, while injury was found in zone 5 at least (Figure 2). Injury with a sharp object (57.3%) was statistically the most common type of injury (p<0.001) (Figure 3)

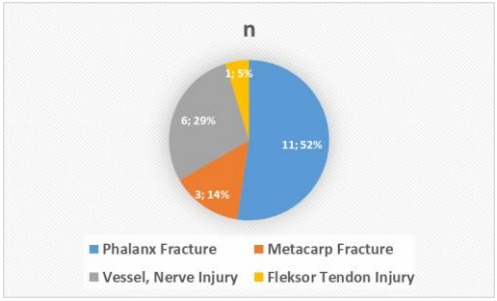

Figure 1. Concomitant injuries distribution chart.

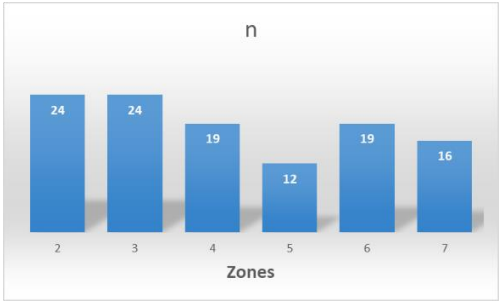

Figure 2. Distribution of tendon incisions by zones.

Re-rupture occurred in 1 patient in each of the injuries in zones 3 and 4. These patients were reoperated. Superficial infection developed in a total of 4 patients, one in each of the injuries occurring in zones 2,4,5,6. These infections were controlled with oral antibiotic therapy. Miller Classification according to the type of injury showed a statistically significant difference at the 8th week (p<0.001). According to Miller classification, statistically significantly better functional results were observed in sharp object injuries compared to crush injuries and saw injuries (Table 2).

Table 1. Demographic data

Variable		
Age	Mean±SD	37.2+15.6
Gender n (%)	Med(min-max)	35(4-81)
	Male	90 (87.4)
Side of the Injury n (%)	Female	13 (12.6)
	Right	42 (40.8)
Additional Injury Situation n (%)	Left	61 (59.2)
	No	82 (79.6)
Follow Up Time/ Month	Yes	21 (20.4)
	Mean±SD	26.8+14.7
Complication n (%)	Med(min-max)	18(12-65)
	No	97 (94)
Repeated Surgery n (%)	Yes	6 (6)
	No	101 (98)
Miller Classify/ 8 weeks n (%)	Yes	2 (2)
	Bad	15 (14.6)
	Moderate	14 (44.7)
	Good	28(27.2)
	Perfect	46(44.7)
	Negative (Bad+Moderate)	29 (28.2)
	Positive (Perfect+Good)	74 (71.8)
Miller Classify/12 months n (%)	Bad	2 (1.9)
	Moderate	9 (8.8)
	Good	30 (29.2)
	Perfect	62 (60.2)
	Negative (Bad+Moderate)	11 (10.7)
	Positive (Perfect+Good)	92 (89.3)

SD: Standart Deviation.

. The 12th month distributions of the Miller Classification show a statistically significant difference according to the type of injury (p=0.002). According to Miller classification, statistically significantly better functional results were observed in sharp object injuries compared to crush injuries and saw injuries (Table 3).

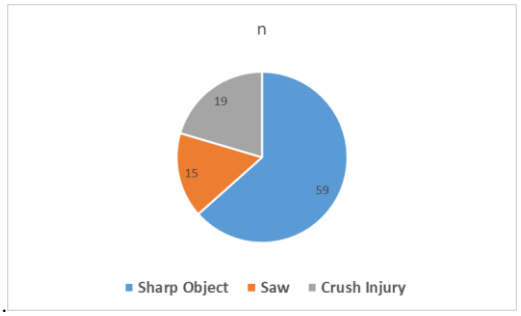

Figure 3. Injury mechanism distribution graph.

Miller Classification is seen at a high rate of "negative" at week 8 compared to those with additional injuries (Yates Continuity Correction p<0.001) (Table 4).

Compared to those without additional injuries, Miller Classification has a higher rate of "negative" in the 12th month evaluation (Fisher Exact test p<0.001) (Table 5).

Miller Classification 8th week distributions according to Injury Sites do not show a statistically significant difference (p=0.43) (Table 6).

Miller Classification according to Injury Regions 12 months distributions show a statistically significant difference (Chi-Square p=0.037). According to the Post-Hoc evaluation, only the distribution in Zone-2 differs from other zones (Table 7).

Table 2. Evaluation of injury types according to Miller classification in 8 weeks

Miller Score	Sharp Object	Crush Injury	Saw	p
Negative (Bad+Moderate)	5 (8.5)[a]	7 (46.7)[b]	17 (58.6)[b]	<0.001
Positive (Perfect+Good)	54 (91.5)[a]	8 (53.3)[b]	12 (41.4)[b]	
Total	59 (100)	15 (100)	29(100)	

Table 3. Evaluation of injury types according to Miller classification 12th month

Miller Score	Sharp Object	Crush Injury	Saw	p
Negative (Bad+Moderate)	1 (1.7)[a]	4 (26.7)[b]	6 (20.7)[b]	<0.002
Positive (Perfect+Good)	58 (98.3)[a]	11(73.3)[b]	23 (79.3)[b]	
Total	59 (100)	15 (100)	29 (100)	

Table 4. Evaluation of additional injury according to Miller classification 8th week

Miller Score	Positive (Good+Perfect)	Negative (Bad+Moderate)	p
Additional Injury "No"	69 (84.1)	13 (15.9)	<0.001
Additional Injury "Yes"	5 (23.8)	16 (76.2)	

Table 5. Evaluation of additional injury by Miller classification 12 months

Miller Score	Positive (Good+Perfect)	Negative (Bad+Moderate)	p
Additional Injury "No"	79 (96.3)	3 (3.7)	<0.001
Additional Injury "Yes"	13 (61.9)	8 (38.1)	

Table 6. Evaluation of injury area (zones) Miller classification by 8 weeks

Zones	Positive (Good+Perfect)	Negative (Bad+Moderate)	p
2	13 (54.2)	11 (45.8)	0.43
3	17 (70.8)	7 (29.2)	
4	11 (57.9)	8 (42.1)	
5	9 (75)	3 (25)	
6	14 (73.7)	5 (26.3)	
7	13 (81.2)	3 (18.8)	

Table 7. Evaluation of injury region according to Miller classification 12th month

Zones	Positive (Good+Perfect)	Negative (Bad+Moderate)	p
2	17 (70.8)[b]	7 (29.2)[a]	0.037
3	21 (87.5)[a]	3 (12.5)[a]	
4	17 (89.5)[a]	2 (10.5)[a]	
5	12 (100)[a]	0(0)[a]	
6	18(94.7)[a]	1 (5.3)[a]	
7	16 (100)[a]	0 (0)[a]	

The distribution of the presence of complications according to the Injury Regions does not show a statistically significant difference (Chi-Square p=0.867).

DISCUSSION

In this study, we evaluated the patients who underwent primary repair with the appropriate surgical suture technique, functionally and clinically, according to the etiology of injury, the site of injury, and the presence of concomitant injury. When the literature is reviewed, it is seen that direct repair is the first-choice treatment method in extensor tendon injuries, regardless of the etiological factor and injury site[7,17]. Karabeg et al. evaluated 76 male and 11 female patients with a mean age of 37.17 years in their study and reported that left hand injuries were more prevalent, similar to our findings[18]. Salihagic S. et al., in their study, reported that 57.3% of injuries occurred with sharp objects and 24.7% with saws in the analysis of the etiology of injury[17]. In the same study, 2 tendon re-ruptures and 8 infection complications were observed in the follow-up of 279 patients. In our study, re-rupture was found in 2 patients and superficial infection was found in 4 patients. Altobelli et al. reported the results of 9 extensor tendon repairs in 8 patients, and they stated that unicortical phalanx or metacarpal fractures were accompanied in 3 patients, and traumatic arthrotomy was found in 5 patients[13]. On the other hand, in a 5-year cross-sectional retrospective study in which Karabeg et al. examined extensor tendon repairs in 87 patients; They reported that they found bone fractures in 41 patients, accompanying vascular and nerve injuries in 4 patients, and accompanying extensor tendon and vascular injuries in 2 patients[18]. In our study, we found phalangeal fractures in 11 patients, accompanying vessel and nerve injuries in 6 patients, metacarpal fractures in 3 patients, and accompanying flexor tendon injuries in one patient. In addition, we investigated whether there is a relationship between the etiology of injury and functional outcomes in our study. In our 8th week evaluation, 91.5% of the patients had good and excellent results, 8.5% had moderate and bad results in sharp instrument injuries, while 53.3% of the patients had good and excellent results, and 46.7% had moderate and bad results in crush injuries. In saw injuries, good and excellent results were obtained in 41.4% of the patients, and moderate and poor results were obtained in 58.6%.

In the evaluation made at the 12th month, good and excellent results were obtained in 98.3% of the patients, moderate and bad results were obtained in 1.7% of the patients in sharp instrument injuries, while good and excellent results were obtained in 73.3% of the patients, 26.7% moderate to poor results were obtained in crush injuries. In saw injuries, good and excellent results were obtained in 79.3% of the patients, and moderate and poor results were obtained in 20.7% of the patients. These results show that functional outcomes in sharp object injuries are statistically significantly better than crush injuries and saw injuries.

In the study of Karabeg et al., the distribution of extensor tendon injuries according to zones is as follows; 6 patients in zone 1, 4 patients in zone 2, 8 patients in zone 3, 11 patients in zone 4, 8 patients in zone 5, 46 patients in zone 6, 4 patients in zone 7. They reported that zone 6 injury was the most common type of injury[18]. Mehdinasab SA et al. In their study, they reported that the most common injury occurred in zone 5 (36%) and zone 3 (34.7%), the least injury occurred in zone 1 and zone 4[19]. Karl HD. et al. reported the results of 203 extensor tendon repairs in their study. They stated that extensor tendon injury was most common in region 1 (n:90 44%), followed by region 6 (n:46 23%) and least frequently in regions 2 and 4 (n:10 5%)[9]. In our study, the distribution of injuries according to zones; There were 24 patients in zone 2 and 3, 19 patients in zone 4 and 6, 12 patients in zone 3, and 16 patients in zone 7. Injuries were most common in zone 2 and zone 3.

When the literature is examined, it is seen that various in vitro studies have investigated the applicability of various suture techniques and early rehabilitation protocols[20,21]. A review study stated that early mobilization (active or passive) procedures provided faster recovery of motion than static immobilization, and early mobilization regimens were suggested[14]. In our study, we applied early mobilization to all the patients we treated and observed that functional outcomes improved over time with rehabilitation.

Mehdinasab et al. on the other hand, in their study, they reported that excellent and good results were seen at a higher rate in the 3rd and 5th regions than in the 1st, 2nd, and 4th regions[19]. Carl et al. found excellent results in all zone 2 repairs, excellent and good results in zones 1, 4, and 5, and reported that they found moderate to bad results significantly in zones 3 and 6. They determined that the outcome of primary extensor tendon repair was significantly

worse in zones 3 and 6 when compared to zones 1, 2, 3, and 5. They said that the reason for this was due to the more frequent complex injuries in the 3rd and 6th zones. As a result, they reported that functional recovery was associated with the zone of injury and complex injury[9]. No statistically significant difference was observed between functional results at week 8 according to zones in our study. However, at our 12th month evaluation, it was observed that there were more moderate and bad results in zone 2, which was statistically significant. In addition, good and excellent results were obtained in 84.1% of the patients, and moderate and poor results were obtained in 15.9% of the patients at the 8th week evaluation in patients without accompanying injuries. In patients with concomitant injuries, 23.8% of the patients had good and excellent results, and 76.2% had moderate and poor results at week 8. At 12 months, good and excellent results were obtained in 96.3% of patients without concomitant injury, and moderate and poor results were obtained in 3.7% of patients. Of the patients with concomitant injuries, 61.9% had excellent and good results, while 38.1% had moderate to poor results. These results are compatible with the literature and show that the complexity of the injury with accompanying injuries has a direct negative effect on functional results.

There are some limitations in our study. These: The retrospective nature of the study, power analysis was not performed while planning the study, the lack of an equal number of patients in all zones, and the inhomogeneity of patient distribution in injury types.

In conclusion, to achieve successful functional results in extensor tendon injuries, primary repair with appropriate suture techniques should be applied in all suitable cases and patients should be followed up with dynamic rehabilitation procedures. The factors that we cannot determine on success are the mechanism of injury and accompanying injuries. This situation has a direct effect on functional results. There is a need for prospective studies examining the type of injury, accompanying injury, and functional outcomes of repair techniques for each of the relevant zones.

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