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ORIGINAL ARTICLE

Medicine Science International Medical Journal

Medicine Science 2024;13(3):644-8

Analysis of traumatic flexor tendon injuries: A single-center experience

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Received 11 June 2024; Accepted 16 July 2024
Available online 23 August 2024 with doi: 10.5455/medscience.2024.06.057

Abstract

Flexor tendon injuries cause serious work and health losses. Studies on flexor tendon injuries have generally focused on treatment modalities. The study's goal is to retrospectively screen the cases admitted to a single center and reveal in detail the causes of injury and the patients' sociodemographic characteristics. The study included 120 patients who applied to our center between January 2015 and December 2017 with a flexor tendon injury and underwent surgery on the same day. We investigated the patients' age, gender, and hand dominance as demographic characteristics. We classified the injury characteristics as the mechanism of the injury, the nature of the injury, the identity and number of affected fingers, the injured area and side, the number of involved tendons, the accompanying fractures, the nerve injury, and the vascular injury. As surgical details, we evaluated the type of anesthesia and the duration of the surgery. We identified 171 flexor tendons and 120 patients, of which 85% (n=102) were male and 15% (n=18) were female. Home accidents caused 26.6% of the injuries (32/120). Most patients had a single finger injury (88/120, 73.3%). Injuries were most common in Zone 2 (61/171, 35.6%). Patients with vascular and nerve injuries, along with flexor tendon injuries, were in the majority (48%). Our study provides detailed sociodemographic information about flexor tendon injuries. Because this study sheds light on injury mechanisms, it will serve as a guide for preventing such injuries.

Keywords: Flexor tendon injury, aetiology, trauma, mechanism, hand

Introduction

Flexor tendon injuries occur in 4.83 of every 100,000 people. Despite their low prevalence, flexor tendon injuries can cause severe cost and labor loss [1]. In 980–1037, Avicenna made the first tendon repairs in history. Today, these restorative interventions, together with the accumulation of knowledge and experience, yield successful results [2,3]. Previous studies on flexor tendon repair have not thoroughly examined the demographic characteristics of patients, the type of injury, and the surgical procedures [4].

Examining patients' demographics and injury types can contribute in several ways. The socioeconomic effects of flexor tendon injuries on patients, employees, insurance companies, and health institutions are quite evident [5,6]. A detailed evaluation of these demographic characteristics and injury types will make it easier to prevent such injuries and develop various measures. Ultimately, there will be an increase in people's quality of life and a decrease in health expenditures. This clinical study aimed to retrospectively examine in detail the patients admitted to our clinic with flexor tendon injuries.

Material and Methods

The ethics committee approved this study under the number 2323. Between January 2015 and December 2017, our clinic's emergency department at Batman State Hospital admitted a total of 120 patients with flexor tendon injuries, who underwent same-day surgery. All consents were obtained. We obtained approval from the Institutional Review Board prior to the study. We conducted this study adhering to the ethical standards outlined in the 1964 Declaration of Helsinki and its subsequent amendments.

CITATION
Ceran F, Kapi E, Dokur M. Analysis of traumatic flexor tendon injuries: A single-center experience . Med Science. 2024;13(3):644-8.

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DOI: 10.5455/medscience.2024.06.057

We evaluated the information from the electronic registry system and clinical notes from patient files. We admitted all patients under emergency conditions and operated on the same day for zone I to V tendon repair of flexor digitorum profundus (FDP), flexor digitorum superficialis (FDS), or flexor pollicis longus (FPL), with or without accompanying fracture, nerve, or vascular injury. All included patients met at least one total flexor tendon injury criterion. The study excluded patients with missing data or information. We excluded patients who underwent total amputation and underwent replantation, as well as those who did not undergo tendon reconstruction, tendon transfer, tendon grafting, or primary flexor tendon repair. We noted the patients' age, gender, and hand dominance as demographic characteristics. The parameters examined under injury characteristics included the mechanism of injury, the nature of the injury, the identity and number of fingers involved, the injured area and side, the number of affected tendons, any accompanying fractures, and any nerve or vascular injuries. Different injury mechanisms evaluated in this study included glass lacerations, knife/blade lacerations, other metal injuries, crush injuries, saw injuries, traffic accidents, and other types of material or object lacerations. Different "nature of injury" types included occupational accidents, home accidents, accidents at other locations, assault, and road traffic accidents. The surgical details section assessed the type of anesthesia and the length of the procedure.

Statistical Analysis

We analyzed the data using the Statistical Package for the Social Sciences, PC version 19.0 (SPSS, Chicago, IL, USA). We used the one-sample z-test to determine if the observed sample ratio for each component significantly differed from the hypothetical population ratio. All tests were two-tailed, and $p<0.05$ was considered statistical significance. We present the descriptive data as medians and percentages.

Results

Patient Demographics

The study included a total of 171 flexor tendon injuries in 120 patients admitted to our clinic under emergency conditions between January 2015 and December 2017. Of the patients, 85% (n=102) were male, and 15% (n=18) were female. The mean age of the patients was 23.2 years (range: 3–82, 23.208±13.211). While patients were mostly right-handed (n=113/120; 94.1%), only a small number of patients were left-handed (n=7/120; 5.9%).

Injury Characteristics

While the injuries were caused by home accidents in 26.6% of the patients had injuries caused by home accidents (n=32/120), the rate of occupational accidents was remarkably high (n=58/120; 48.3%) ($p<0.05$). Glass and similar materials primarily caused injuries to patients (n=43/120; 35.8%). On the other hand, injuries with knives (n=29/120; 24.1%) and other metal objects (n=22/120; 18.3%) also had significant rates (Table 1).

Table 1. Patients' mechanism of injury and nature of injury numbers and frequencies (n=120)

	n	Frequency (%)
Mechanism of injury		
Glass-related lacerations	43	35.8
Knife/blade lacerations	29	24.1
Other metal injuries	22	18.3
Crush injury	7	5.8
Other types of material or object lacerations	11	9.1
Saw injury	6	5
Nature of Injury		
Work accidents	58	48.3
Home accidents	32	26.6
Accidents at other locations	21	17.5
Assault	7	5.8
Road traffic accidents	2	1.6

Most of the patients had a single finger injury (n=88/120; 73.3%) ($p<0.05$). A striking finding was that most patients had injuries in their non-dominant hands (n=110/120; 91.6%). Although not statistically significant, the index finger was the most affected (n=41/120; 34.1%) (Figure 1A, B).

We evaluated the injury zones using the Verdan classification [7]. Injuries occurred mostly in zone 2 (n=61/171; 35.6%), followed by zone 1 (n=45/120; 26.3%), and zone 5 (n=43/120; 35.8%) (Figure 1C).

All patients had total flexor tendon cuts, and most of them had accompanying vascular and nerve injuries (48%). Of the patients, 25.8% had only a flexor tendon injury. Only nerve injuries accompanied flexor tendon injuries in 14.4% of the patients. These data suggest that nerve injuries often accompany flexor tendon injuries (Figure 1D).

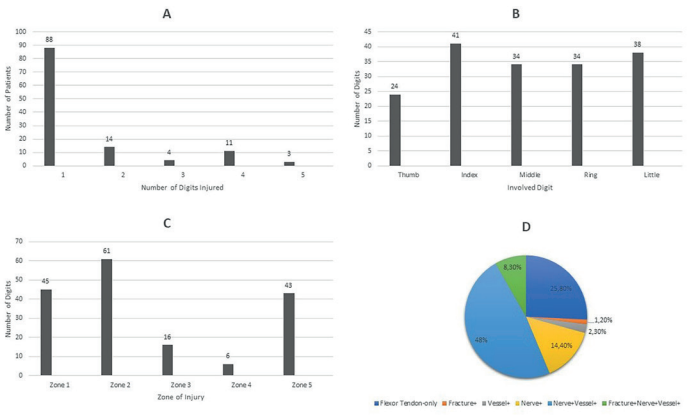

Figure 1. Patients' cilinical characteristics, **A.** Number of digits injured for each patient in the study population (n =120); **B.** Distribution of flexor tendon injuries according to involved digit (n=171); **C.** Distribution of flexor tendon injuries according to injury zone (n=171); **D.** Percentage of digits with flexor tendon injuries and with the distribution of concomitant injuries

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Surgical Details

We evaluated all patients in urgent situations and performed emergency surgery. Surgery times were between 1 and 2 hours for most cases (n=42/120; 35%) (Figure 2A). 73.90% of the patients were operated on under local anesthesia ($p<0.05$). Pediatric cases and multi-finger injuries (15.8%) favored general anesthesia (Figure 2B).

Figure 2. Surgical details of the population, **A.** Distribution of the patients with flexor tendon repairs according to duration of procedures (in hours, n=120); **B.** Type of anaesthesia used for surgery (n=120); GA: general anaesthesia, LA: local anaesthesia, RA: regional anaesthesia

We performed the operations under a tourniquet. For all patients, we used both core and epitendinous suture techniques. We repaired flexor tendon injuries using the multistrand core suture technique, which used a 4.0-round prolene suture, and the epitendinous technique, which used a 5.0-round prolene suture. We used the 4-stranded cruciate technique for the core sutures. We applied the pull-out technique with the same sutures for zone 1 FDP tendon injuries.

Physical Therapy Protocol

We applied extension block splints to maintain the wrist in 30 degrees of flexion, the metacarpophalangeal joints in 45–70 degrees of flexion, and the interphalangeal joints in almost full extension or slight flexion (15 degrees of flexion). Two weeks later, we removed the stitches. On the fourth postoperative day, we incorporated all patients into the Saint John physical therapy regimen.

Surgical Outcomes and Complications

We did not observe early postoperative complications such as infection, hematoma, skin flap necrosis, and synovitis (Figure 3). In the postoperative period, 15 patients (12.5%) developed digital stiffness. Tendon rupture occurred in 3 patients after the 4th postoperative week (2.5%). These patients underwent staged flexor tendon reconstruction. In the postoperative period, we observed flexor tendon adhesion in 12 patients (10%), who underwent tenolysis surgery after completing the physical therapy protocol. We detected no long-term adhesion in these patients. Twelve patients (10%) experienced contracture in the proximal interphalangeal joint during the postoperative period. These patients were initially splinted. However, when the contractures failed to improve, we performed open capsulotomy and tenolysis. In all patients who developed complications, the primary injury was a zone 2 flexor tendon injury (Table 2). The mean proximal interphalangeal joint active range of motion (ROM) angle was 110.8 degrees (range: 95–115), and the distal interphalangeal joint value was 69.4 degrees (range: 60–80).

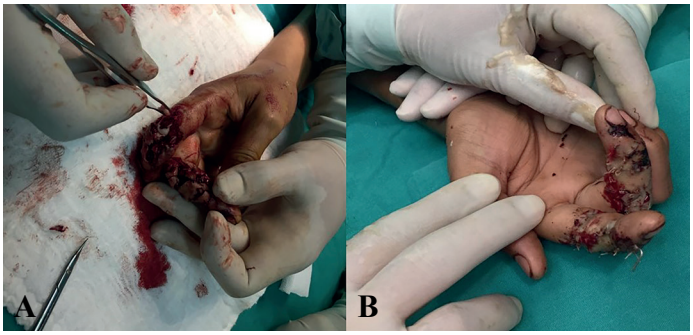

Figure 3. Pre-operative (**A**) and post-operative (**B**) views of the patient who developed flexor tendon injury, vascular and nerve injury and fracture in two fingers as a result of saw injury

Table 2. Patients' postoperative complications number and rates

Complications	n	Frequency (%)	Zone
Digital stiffness	15	12.5	2
Rupture	3	2.5	2
Adhesion	12	10	2
Contracture	12	10	2
Pulley disruption	None	0	None
Swan neck deformity	None	0	None

Discussion

In the literature, there are few studies on sole flexor tendon injuries. Two studies evaluate pediatric cases: one evaluates 28 patients and 68 tendon injuries, while the other evaluates 47 patients and 100 tendon injuries [8,9]. Regarding adult studies, one included 106 patients and 158 tendon injuries, while the other included 214 patients and 308 finger injuries [4,10]. In this latter study, Chang et al. evaluated the demographic characteristics of patients in detail and conducted the most comprehensive study in the field. In our study, we aimed to assess flexor tendon injury cases in our country and reveal their demographic and epidemiological characteristics.

According to our study, men experience hand traumas and flexor tendon injuries more frequently than women, which is in line with previous reports in the current literature [11,12]. This may be due to the fact that men in our country work more in jobs where the risk of hand trauma is high. We found the mean age of our patients to be 23.2 years, which is lower than previous studies' findings. This may be due to a lack of education on work and home accidents.

Most of the injuries were due to work accidents. Objects containing glass, knives, and other metal materials usually cause injuries. According injuries typically occur in manual workers and domestic workers, consistent with current literature [13,14]. Another critical point here is that such injuries cause profound loss of labor and working time. Patients rest for a long time after a trauma. The long rehabilitation period should also be considered.

In most of the cases in our study, the injuries were in the non-dominant hands. This is primarily due to the dominant hand

DOI: 10.5455/medscience.2024.06.057

holding sharp objects, as well as the greater risk of exposure to sharp material in the non-dominant hand. Reflexively touching sharp objects leads to dominant hand injuries. In these cases, the index and little fingers are the most frequently exposed to injury. Since these two fingers are located on both peripheries of the hand, they are more prone to injury [4].

Most of our cases had a single flexor tendon injury, and zone 1 and 2 injuries were more common. We expected these results because of the superficial location of the flexor tendons. This superficiality causes the tendons to become more frequently involved, especially in zone 1 and 2 injuries. Similarly, these zones limit the availability of protective tissues. Cultural differences may account for the contradiction between these results and the studies by Chang et al. [10] and Rosberg et al. [15].

Nerve and vascular injuries often accompany flexor tendon injuries, ultimately due to anatomical proximity. When planning flexor tendon repair for patients, it's important to prepare for the possibility of microsurgery.

Higgins et al. emphasized the advantages of using local anesthesia and stated that performing a mobility examination during the operation could prevent early rupture [16]. In most of our patients, we used local anesthesia, and we considered general anesthesia or nerve block options in pediatric cases and multi-finger injuries. We were more comfortable with local anesthesia and tourniquet management. Our operation times were mostly between 1 and 2 hours, shorter than those in the literature [17]. The primary core suture technique we used was the multistrand core suture technique. Previous studies suggested that using multiple-core suture techniques would increase tensile strength [18-21]. Similarly, we used the epitendinous suture technique on all of our patients.

Complications such as rupture, adhesion, contracture, pulley disruption, swan neck deformity, and synovitis may occur after flexor tendon repair operations [22]. Studies have shown that the tendon rupture rate is between 5% and 11.7%. Experience in the field of hand surgery, use of multistrand core sutures, and early physical therapy regimen applications are the most important factors in preventing complications in flexor tendon surgery [23]. Immobility in the postoperative period often causes adhesions, with a occurrence rate of 12–47%. Tenolysis operations often correct these adhesions [24]. 17% of tendon repairs result in contractures; we use splinting to prevent contractures and perform an open or closed capsulotomy for resistant cases that do not improve [25]. The complication rates in the cases we operated on were lower than those mentioned in the literature. According to the literature, complications occurred exclusively in patients with zone 2 injuries. Our experience in hand surgery and the early implementation of our physical therapy protocol are responsible for the low complication rates. During the early postoperative period, we included all of our patients in the Saint John physical therapy protocol.

Current techniques in flexor tendon repair have led to an evolution in rehabilitation practices and a transition from passive methods to early, controlled, more active methods. The standard of care now primarily focuses on early-controlled mobilization protocols, with the abandonment of passive rehabilitation protocols and the existence of numerous variations and modifications. The Saint John Protocol describes a regimen of actual active finger flexion initiated 3–5 days after flexor tendon repair. Waiting 3 to 5 days before moving minimizes the risk of tearing. The protocol then proceeds with passive flexion of all fingers before transitioning to active flexion. Active interphalangeal joint (IPJ) extension while in the metacarpophalangeal joint (MCPJ) flexion block prevents IP joint flexion contracture. From the 4th day to the 2nd week, patients achieve true active flexion from one-third to one-half fist. Patients participate in an active synergistic exercise program for 2 to 4 weeks, aiming to achieve a 45-degree half-to-full active fist position. The goal is to achieve the full fist position within 6 weeks. Usually, patients can start light activity at six weeks [26].

Conclusion

In this study, we found that glass cuts are more common on the right hand, resulting in a single index finger injury, and that zone 2 is primarily associated with vascular and nerve injuries. Furthermore, our thorough evaluation reveals that local anesthesia can effectively repair the majority of flexor tendon injuries. Besides, we believe that our results will shed light on the perspective of flexor tendon injuries and help develop protocols for the prevention of such injuries. We demonstrate that early physical therapy modalities are very important to reduce complication rates in flexor tendon repair.

Study Limitations

Since this study is retrospective and single-center clinical, it encountered several challenges, including data loss and incorrect data deposit.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical Approval
All procedures involving the use of human subjects in this study adhered to the ethical standards set by the institutional research committee, the 1964 Declaration of Helsinki and its subsequent revisions, or similar ethical principles. All participants gave informed consent. We prepared the article structure in accordance with the STREGA reporting guidelines. Ethical Approval Date and Number: 15.12.2022/2323 (Adana City Training and Research Hospital Ethical Committee).

Patient Informed Consent
Consent of patient documents obtained from 120 patients for this study are included in the patient file.

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