Long-term Results after Restoring Flexor Tendon Injury in Children Younger than Age 10 Years

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Abstract

Background: In regard to the rarity of pediatric tendon lacerations compared with the adult population, sparse knowledge exists. Published reports indicate that the incidence of "good" flexor tendon repair outcomes is low. This study aimed to determine the injury pattern and demographics of pediatric flexor tendon injuries over the past decade.

Methods: A retrospective chart review of all flexor tendon injuries between 2005 and 2015 was performed. Parameters reviewed included demographics, injury mechanism, repair technique, outcomes, and complications.

Results: A total of 20 patients with a median age of 4 years and 4 months experienced 45 tendon injuries. The most common cause of injury was glass (n = 10), with the most common digit injured being the index finger (n = 8). Zone II had the highest number of injuries (n = 14). The modified Kessler core and peripheral running sutures technique were used in all primary repairs (n = 18). Using author designed evaluation system, 80% of patients experienced excellent recovery. Four patients had good results. Only one patient complicated with rupture necessitating further surgery that its final evaluation was excellent.

Conclusions: The outcome of restoring flexor tendon injury of children is satisfactory, and we recommend that.

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Introduction

A flexor tendon injury is less common in children than adults (1). Due to advances in suture techniques and rehabilitation methods after surgery, the results of tendon healing in adults, in numerous studies reported good to excellent (2), while the results in children are various, from poor to excellent (3,4). It has been considered that unsatisfactory results are caused by several specific conditions for young children: a relatively long interval from injury to surgery because of delayed diagnosis; small fingers requiring great technical expertise; difficulty in maintaining the digit in the proper position post-surgery; and no expected cooperation in performing rehabilitation after repair (5).

Because of the low number of studies on the treatment of these injuries in children than adults, we cannot choose management type in children confidently as an adult. The purpose of this study is to evaluate demographic and surgical result in children < 10 years with flexor tendon injury.

Materials and Methods

In a retrospective review, we list all the patients who underwent surgery due to rupture of the flexor tendon at Shafa Orthopedic Hospital in the past 10 years (from 2005 to 2015) (394 patients in total). In this initial review, we identified 24 children under 10-year-old that only 20 cases were assessable on follow-up. Using patients file, demographic data extracted in each case as summarized in table 1. All operations were under general anesthesia via a hand surgeon assessing magnifying loupe. A palmar zigzag incision was used to explore the flexor tendon. In 2 patients with delayed presentation, two-stage grafting was carried out using the palmaris longus tendon. The tendon was sutured proximally with a Pulvertaft knot to the proximal stump of the injured tendon after resection of its distal fibrous end. The graft distal end was externally fixed to the finger nail. The pretension of the graft was clinically appreciated. The clinical aspect of the hand should be harmonious in passive flexion and extension of the wrist.

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Table 1. Demographic data and final outcome of each patient

Case	Age at surgery	Sex	Side	Finger	Zone	Cause of laceration	Lacerated tendon	Management of FDS tendon	Concomitant neurovascular injury or fracture	Time elapsed since injury	Follow-up	Arbitrary occupational therapy	Evaluation*
1	4 years	M	R	2	3	Glass	FDP, FDS	Resect	Nerve	7 days	49 months	No	Excellent
2	2 years, 8 months	M	R	5	3	Glass	FDP	-	Nerve	1 day	61 months	No	Excellent
3	4 years	M	L	4	2	Meat grinder	FDP, FDS	Resect	Nerve, artery, bone	1 day	54 months	Yes	Excellent
4	1 year	M	L	4	2	Glass	FDP	-	Nerve	1 day	59 months	No	Good
5	2 years	M	R	3	1	Glass	FDP	-	Normal	1 day	73 months	No	Excellent
6	5 years, 6 months	M	R	2	2	Glass	FDP, FDS	Repair	Nerve	3 days	48 months	Yes	Excellent
7**	6 years	F	R	2	2	Glass	FDP, FDS	-	Normal	6 months	41 months	Yes	Excellent
8**	4 years, 7 months	M	R	1	2	Glass	FPL	-	Normal	1 month	36 months	No	Excellent
9	4 years, 3 months	M	R	5	2	Knife	FDP, FDS	Repair	Nerve	1 day	53 months	Yes	Excellent
10	7 months	M	R	3,4	2	Knife	FDP, FDS	Resect	Normal	8 days	28 months	No	Excellent
11	4 years, 11 months	F	L	1,2	3	Glass	FDP, FDS, FPL	Repair	Nerve	1 month, 15 days	20 months	No	Excellent
12	7 years	F	R	2	2	Mixer	FDP, FDS	Resect	Nerve, artery, bone	1 day	18 months	No	Excellent
13	6 years, 5 months	M	R	3,4	3	Glass	FDP, FDS	Repair	Nerve	3 days	18 months	No	Excellent
14	3 years	M	R	4	2	Razor	FDP, FDS	Resect	Normal	3 days	18 months	No	Good
15	8 years, 7 months	F	R	2,3	2	Glass	FDP, FDS	Resect	Nerve, artery	6 days	3 months	Yes	Good
16	4 years, 4 months	M	R	3,4,5	1	Mixer	FDP	-	Normal	6 days	3 months	No	Excellent
17	2 years, 8 months	M	R	1,2	2	Meat grinder	FDP, FDS, FPL	Resect	Nerve, artery, bone	3 days	7 months	No	Good
18	1 year, 8 months	M	L	4	2	Razor	FDP, FDS	Resect	Normal	8 days	10 months	Yes	Excellent
19	9 years, 6 months	M	L	5	2	Knife	FDP, FDS	Repair	Nerve	3 days	12 months	Yes	Excellent
20	2 years, 8 months	M	L	2	2	Knife	FDP, FDS	Repair	Normal	10 days	34 months	Yes	Excellent

*Base on evaluation system summarized in table 2, **Underwent two-staged tendon reconstruction. FDS: Flexor digitrum superficialis; FDP: Flexor digitrum prefundus; FPL: Flexor policies longus; M: Male; F: Female; R: Right; L: Left

Table 2. The author evaluation grading in final follow-up

Excellent	Full range of motion of operated finger that is not distinguishable from intact fingers
Good	There is a little flexion or extension contracture that is not obvious or disruptive in daily living function
Poor	There is obvious flexion or extension contracture that parents are looking for to improve their child's conditions

In 18 patients, the injured tendon was restored with primary repair, that pulley A1 and A2 preserved complete or partial over the procedure. In flexor digitrum superficialis (FDS) and flexor digitrum prefundus (FDP) tendon simultaneously injured cases, the surgeon's attempt was on restoration of both, but this goal was not achievable, that suture site was bulky and obstacle for normal gliding. In these cases FDP tendon repaired and residual of FDS tendon resected. In all, the FDP tendon was sutured with a two-strand or four-strand core suture according to the modified Kessler method using 3-0, 4-0 or 5-0 nylon. The peripheral suture of the tendon was performed by a running suture or interrupted suture with 5-0 or 6-0 nylon. If digital neurovascular injury was suspected, the digital nerve was identified. When the nerve was severed, it was sutured using 8-0 or 9-0 nylon. The digital artery was not repaired because there was no case with bilateral digital artery damage. Concomitant phalanx bone fracture (3 cases) stabilized with fine pins. After the skin was closed, a bulky dressing was applied to the hand and fingers. The upper arm to fingertip was immobilized by an above elbow splint. The immobilized position was the elbow in 90°, the wrist in slight extension, the metacarpophalangeal and the proximal interphalangeal (PIP) joints in 90° flexion, and the distal interphalangeal joint in 60° flexion. The period of immobilization ranged from 3 to 4 weeks. After removal of the splint, the patient was allowed to move the hand freely. The parents did not advise to occupational therapy by the surgeon for their child at all, however, eight of children received that based on the arbitrary decision of their parents. It is noteworthy that only 6 patients residing in Tehran and the others were referred from far or near cities. So for final follow-up, we requested all parents to refer for examination, which only 4 cases who residing in Tehran came and it was inevitable that other's patients' data achieved on the phone call. For evaluation report, the results are divided into three categories: excellent, good, and poor that table 2 described it. All statistical comparisons were performed using SPSS software (SPSS, Inc., Chicago, IL, USA).

Results

A total of 20 patients were reviewed; 27 severed fingers with 45 lacerated tendons. The mean patient age at surgery was 4 years and 4 months (range 7 months to 9 years and 6 months). 16 patients (80%) were male. The median time between injury and repair was 16 days (range 1 day to 6 months), this time interval in most of the patient (n = 14, 70%) was 7 days or less and only in 3 patients, elapsed time was 1 month or more. Injuries involving the right hand occurred in 14 patients (70%). All the patients were one hand involved. The most common cause of injury was glass (10 patients) followed by knife (4 patients). The median number of tendons involved per patient was 2.25 (range 1-4). Only five patients had multiple fingers involvement. The most common digit injured was the index finger (8 fingers, 29.6%), followed by the ring finger. Zone II had the greatest number of injuries (n = 17, 62.7%), followed by Zone III (n = 6). Combined FDS and FDP tendon injury were most common type pattern injury (18 fingers, 66.7%) that only 6 FDS tendons repaired and the others resected. More than half of involved finger had concomitant neurovascular injury or fracture (59.3%), that in all of them, digital nerve injury was constantly present. On follow-up, only one patient (case number 1) complicated with rerupture which required further repair that performed with more secure core and peripheral sutures (nylon 3-0 instead 4-0 for core). Only two patients were not amenable for a primary end to end suture repair (because of long delayed time from injury and shortening of tendons due to great proximal migration) that restored with two-staged tendon graft reconstruction. On follow-up, both of them had complete satisfaction and excellent results. The average time passed after surgery to final evaluation was 32.25 months (range from 3 to 73 months). No infections were encountered. No patients needed a tenolysis. The functional status at last follow-up for each patient is summarized in table 1. 80% of patient demonstrated excellent results, and the others were in good category. No patient had a poor outcome. There was the identical question of all parents: "whether any trends to improve present conditions of their child have by anyway?" The answers were similar: "Our kid need nothing more, it's fine."

Discussion

Pediatric flexor tendon injuries are rare. In our study, the ratio of this injury in children to adult was 0.06, 24 patients over 10 years; this is comparable with similar ones performed by Sikora et al. (6). The majority of injuries in the study population involved the dominant hand and index finger. Often this included a child falling while holding a glass in the dominant hand, the second most common cause was knife. Multiple studies have also shown glass and knife injuries to be the most common cause of tendon

injuries in children (5-8). The Zone II injury was the most common pattern; this differed to recent similar study that Zone III was on top (6). On review of the adult literature, the most commonly used core repair technique is the modified Kessler (9). It has been shown that repair strength is proportional to the number of strands across a repair site and inversely proportional to the size of the suture (9). Of course, one must take into account work of resistance and glide through the pulley mechanisms when determining the limit number of strands and suture size. In addition, an epitendinous repair can clean the repair edges and increase the repair strength by 50% (9). Our results are in contrast to these tenets because the majority of our patients experienced excellent results after flexor tendon repair using a modified Kessler method that this performed by 4-strand only in four patients. Other authors showed no significant difference between two- and four-strand repairs (10); this was consistent with another group that found a slight increase in rupture rate with two-strand repairs (1). These results were not statistically significant, which may be due to insufficient power. Our findings suggest that a simple, strong core tendon repair yields excellent results in the pediatric population. Our study's favorable outcomes (based on author designed evaluation system) were higher than previous pediatric studies (1,7). Similarly, Elhassan et al. (11) studied 41 digit injuries in 35 patients involving Zones I and II. Unlike studies of adult flexor tendon repair, this group found that excellent or good results occurred in all patients independent of timing of repair (immediate vs. delayed), age, suture technique and post-operative range of motion protocol. Interestingly, these data would suggest that there are limited predictive variables that would result in a poorer result following pediatric flexor tendon repair. We would concur with other authors in the statement that pediatric flexor tendon repairs in Zones I, II and/or III are less dependent on controllable or predictable factors than in adults. The retrospective nature of the present study must be taken into account when examining the data and comparing it with the literature. In addition, total active motion scores were not always recorded in charts; therefore, most data were acquired by follow-up telephone call. This was unavoidable because patients often were living in cities far from our center in Tehran. Therefore, we designed evaluation system based on data gathering on telephone call. Finally, we suggest to restore flexor tendons in children even the little ones, but in hands of expertise hand surgeon; nevertheless, a detailed and well-powered longitudinal study is required to detect clinical variables and protocols that optimize the therapeutic ratio in children with flexor tendon injuries.

Conflict of Interests

Authors have no conflict of interests.

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