

<http://www.pjbs.org>

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSI*net*

Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

RESEARCH ARTICLE

OPEN ACCESS

DOI: 10.3923/pjbs.2015.32.36

Flexor Tendon Injuries and Treatment Results of 67 Patients

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ARTICLE INFO

Article History:

Received: October 18, 2014

Accepted: January 14, 2015

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ABSTRACT

Flexor tendon injury is the most commonly seen hand injury. Tendons are the structures which enable the muscles to adhere to the bones and transmit the movement starting from the muscle to the bones. They have significant role in hand movement. As treatment method, surgical repair: (1) Primary repair, (2) Secondary repair; techniques are used. With the scientific studies conducted, flexor tendon morphology, kinematics, biomechanics, biological properties and tendon improvement became quite understandable, good suturing materials were developed and consequently successful studies regarding primary repair results were published. Flexor tendon surgery has reached its current level with the accumulation of knowledge obtained from the increased clinical and experimental studies. This study addresses flexor tendon injuries and surgical treatment methods. We achieved 76.12% full functioning fingers in the results; we obtained following the physical treatment application that started on the 10th day after primary repair that we performed in 67 patients who applied with acute flexor tendon Zone 1-2 and 3 incision. Flexion restriction and contracture developed in 16 patients (23.88%) at various levels. Scar softening and revision surgery for contracture excision was performed in 8 patients (11.94%) with Zone 2 injury due to contracture. Superficial skin infection developed in 21 patients (31.34%) and was treated. Revision surgery was performed in 6 patients with Zone 1 injury due to rupture occurred during rehabilitation.

Key words: Flexor tendon, surgery, zone

INTRODUCTION

Two flexor tendons which are digitorum superficialis and profundus are available in hand. The FDS adheres to middle section of middle phalanx and FDP adheres to volar side of the distal phalanx. The FDS tendon separates in the distal metacarpal region and extends to distal at Proximal Inter Phalangeal (PIP) joint level in a way in which FDP passes through (Clavero *et al.*, 2002; Nas, 2012). Although flexor tendon injuries account for less than 1% of all hand injuries, functional results are so important that they cannot be ignored by both the patient and society (Ciloglu *et al.*, 2012). Flexor tendon might be injured with a blunt, sharp tool or by being quashed or ruptured with avulsion (Polatkan, 2007). In patients with no trauma history, spontaneous FDP tendon rupture is thought to be resulting from chronic damage in tendon

associated with patient's profession (Nas, 2012). Flexor tendon injury of the hand might be open or closed (Clavero *et al.*, 2002). Spontaneous tendon rupture pathogenesis is not clear and depends on various factors (Bois *et al.*, 2007). The most common injury mechanism in spontaneous flexor tendon rupture is the resistance by hand against the flexion movement (Nas, 2012; Simman and Fietti Jr., 2000). Flexor tendon injury is separated into 4 types; tendon retraction is at metacarpal level in type 1 and PIF is at joint level in type 2. In type 3, considerable bone fragment avulsion is observed. In addition to type 3, in type 4, FDP tendon avulsion is observed from fracture fragment (Clavero *et al.*, 2002; Nas, 2012). It is possible to prevent postoperative adhesions with suitable atraumatic surgery technique and starting to early controlled movement and positive results might be obtained (Ciloglu *et al.*, 2012). Tendon rehabilitation aims to prevent

tendon rupture and contractures, to stimulate tendon healing, promote active and passive range of motion, maintain joint range of motion in healthy joints of upper extremity, to reach pre-injury functional level (Aydemir and Yazicioglu, 2011).

Deep Finger Flexor (DFF) tendons, Superficial Finger Flexor (SFF) tendons, tendon cuff, annular (A) and cross pulleys are available within the flexor system (Bayram and Herdem, 2003). Basic flexors of hand wrist are Flexor Carpi Radialis (FCR) and Flexor Carpi Ulnaris (FCU) muscles. Long hand flexors and palmaris longus provide help. Main flexors of fingers are Flexor Digitorum Superficialis (FDS) and Flexor Digitorum Profundus (FDP) muscles (Elhan, 1997) primary flexors of metacarpophalangeal joints are intrinsic muscles of the hand. The FDPs pull three hand joints to flexion since they adhere to the distal phalanx floors. Since they adhere to middle phalanx floors, FDSs do not have impact on DIP joints. This anatomical difference can be used in the evaluation of functions between FDP and FDS (Ay *et al.*, 2012). International Federation of Societies for Surgery of the hand separated flexor tendons into five anatomical classes (Aydemir and Yazicioglu, 2011; Stewart, 1992; Kleinert *et al.*, 1981). Zone 5 is in the forearm. It extends from 1/3 distal of the forearm to the proximal of flexor retinaculum (Polatkan, 2007; Stewart, 1992; Van Strien, 1990). All incised structures should be repaired individually. Post reparative functional results are quite good (Bayram and Herdem, 2003; Tsuge, 1989; Strickland, 1993). Zone 4 is located in the region of carpal tunnel below the transverse carpal bond. It extends from transverse carpal canal distal to proximal (Polatkan, 2007). Functional results are better compared to Zone 2. Good rehabilitation programme is required (Bayram and Herdem, 2003). Zone 3 is the region which extends to A1 pulley in the distal of carpal tunnel between distal palmar flexion (Aydemir and Yazicioglu, 2011; Polatkan, 2007). The injuries in this region heal easier due to sufficient bleeding and absence of fibroosseous tunnel (Ay *et al.*, 2012). Zone 2 is located at middle level of distal palmar flexion and middle phalanx (Ay *et al.*, 2012). The name of the region called as "No man's land" by Bunnell has been changed as "Skilled man's land" (Bayram and Herdem, 2003; Ay *et al.*, 2012). Neurovascular structures frequently accompany injuries. Additional incisions are required for the repair (Bayram and Herdem, 2003). Zone 1 extends from adhesion place of FDS to proximal phalanx to adhesion place of FDP to distal phalanx and synovial sheath ends in this region (Ay *et al.*, 2012). Zone 1 injury is the avulsion from the adhesion point of deep flexor tendon in distal phalanx and leads to flexion loss in finger tip (Leddy and Packer, 1977). Surgery is the prioritized method. Tendon should be explored and fixed to the distal phalanx (Vigouroux *et al.*, 2006). Tendon graft is required in delayed cases (Ay *et al.*, 2012).

It is possible from radiological examinations, while in MR examination normal ligaments and ten examine tendon integrity with Ultra Sound (US) and Magnetic Resonance (MR) imaging (Nas, 2012) does indicate low signal changes in all sequences, increased signal change is observed during damaging in these structures (Clavero *et al.*, 2002). In US,

tendon rupture is monitored as tendon continuity loss (Nas, 2012). MR examination facilitates pre-operative surgical planning and approach (Agarwal, 2004). US can be used pre-operatively in evaluating tendon rupture and determine proximal section of the rupture (Lee *et al.*, 2000).

Strict rules are followed in the surgery of flexor tendon injury (Boyer *et al.*, 2002). As the suturing material, non-absorbable stranded sutures should be used. It is important to repair tendon sheath (Elliot, 2002). This repair minimizes mechanic malfunctioning of the repaired tendon and contributes to healing by nourishing synovial liquid tendon within the sheath (Beredjikian, 2003). Post-tendon operation rehabilitation is as important as the technique applied in the surgery in achieving success (Bayri *et al.*, 1993; Kaplan, 2008; Ay *et al.*, 2012). If contraindication is not available in flexor tendon injuries, urgent surgical treatment is the prioritized method today. Another accepted application is repairing both tendons instead of repairing only DFF in incision of DFF and SFF together (Bayram and Herdem, 2003). In cases when tendon injuries are not or cannot be treated early, the problem is solved with attempts like delayed primary repair, secondary repair, free tendon graft or two step tendon repair. In the presence of serious scar in the fingers, more complex reconstructive procedures are required (Green and Niebauer, 1974; Komanduri *et al.*, 1996; Duran and Hauser, 1975). Magnifier tool (loop) should be used during surgical application. Atraumatic surgery should be performed by avoiding hard tools, appropriate suturing materials and suturing techniques that do not upset the tendon nourishment should be preferred (Silfverskiold and May, 1994).

Following the flexor tendon repair, various hand surgeons recommend the repair of tendon sheath. Sheath repair has advantages and disadvantages. The advantages include prevention of extrinsic adhesiveness, increasing synovial nourishment, contributing to the reconstruction of tendon. Disadvantages include difficulty in sheath repair and that repair sheath prevents tendon slide (Saldana *et al.*, 1987). Flexor Pollicis Longus (FPL) tendon repair and follow up is not different from finger flexors. Generally, it is easier to carry tendon proximal to incision line. The pulleys should be protected. Tendon repair is performed in line with the basic principles. If the incision is 60% below the tendon thickness, no repair is required. In incisions above 60%, repair indication like full incision is available. Malfunctions and late ruptures associated with partial incisions that are not repaired might occur (Bayram and Herdem, 2003; Chow and Yu, 1984; Grewal *et al.*, 1999). The aim of this study was the address flexor tendon injuries and surgical treatment methods.

METHODOLOGY

All patients underwent detailed physical examination and graphs were taken when patients applied. Since all injuries were open, wound exploration was performed with a simple sterile tool and tendon pathologies were observed. One gram cefazolin sodium and 160 mg gentamicin prophylaxis were administered to all patients. At the time of emergency

application, the injury on which local anaesthesia was applied and irrigated with baticon and pressured serum physiologic. In addition to various local anaesthesia, digital block and axillar block methods applied under operation room conditions, sedation was performed. All the wounds were explored in the right way and incisions were expanded in some patients. The whole trauma field was washed with baticon and irrigated with serum physiologic. Tendon was found without damaging the ends and primary repair was performed with six-stranded suturing method in a way which did not give harm to tendon circulation. Tendon synovial sheath was repaired in all cases. Tendon stability, vein nerves in traumatic area were controlled, damaged pulleys were repaired. Bone avulsion was detected in 13 injuries in Zone 1 and repair was achieved with the sutures passed through the bone. Prolen suture with non-absorbable atraumatic needle was employed in tendon and skin repair in all patients. Upon completing the skin repair of all patients, 125 mg rifampicin injection was made in tendon repair region. Plaster splint that keeps the metacarpophalangeal joints at 60-degree flexion was fixed in all patients. Postoperative antibiotics prophylaxis continued and patients were followed from the clinic. All patients were taken to controlled rehabilitation program on the 14th postoperative day.

RESULTS

Sixty seven patients with flexor tendon incision applied to our clinic due to emergency trauma on various dates were included in the study. All of the incisions are in acute Zone 1-3 regions. The age interval of our patients was 18-46 (the mean age is 31.7). Thirty eight of the incisions were in Zone 1, 17 are in Zone 2 and 12 are in Zone 3. In 21 patients flexor digitorum superficialis and in 46 patients flexor digitorum profundus injuries were detected. Thirty five of the injuries were dirty injuries associated with occupational accidents. Patients did not have fracture, vein and vessel injury along with incision. No systemic disease was found in the interviews conducted with the patients. Twenty six patients out of 67 (38.80%) are chronic smokers.

We achieved 76.12% full functioning fingers in the results we obtained following the physical treatment application that started on the 10th day after primary repair that we performed in 67 patients who applied with acute flexor tendon Zone 1-2 and 3 incision. Flexion restriction and contracture developed in 16 patients (23.88%) at various levels. Scar softening and revision surgery for contracture excision was performed in 8 patients (11.94%) with Zone 2 injury due to contracture. Superficial skin infection developed in 21 patients (31.34%) and was treated. Revision surgery was performed in 6 patients with Zone 1 injury due to rupture occurred during rehabilitation. All the patients were enabled to use their hands actively within 2.5 months in average.

DISCUSSION

Two flexor tendons known as flexor digitorum superficialis and profundus are available in the hand. The FDS

adheres to middle section of the middle phalanx; FDP adheres to volar side of the distal phalanx. FDS tendon separates in the distal metacarpal region and extends to the distal in a way in which FDP passed through at joint level (Clavero *et al.*, 2002; Nas, 2012). It is difficult for the tendons to heal following the injury without surgical application. Since tendons are made up of living cells and connective tissue, healing starts with the cells coming from inside and outside when tendon ends are brought together. Postoperative splinting necessary for tendon healing and rehabilitation protocols applied for gliding again is of great importance in tendon injuries (Polatkan, 2007).

When patients with 76.12% full finger flexion obtained from 67 patients in our study is concerned, that 50 patients have Zone 1 and Zone 3 tendon injuries contributed to the result positively due to healing potential. Starting physical treatment at an early period is important. In the event that physical treatment is not started timely, it is difficult to regain the movements later (<http://www.elcerrahi.com/hasta-bilgilendirme/60-fleksor-tendon-yaralanmalari.html>, access date: 03.07.2014). All the patients included in this study were enabled to use their hands actively within 2.5 months in average. For sportsmen returning to spor in short time is very important. In another our study, the sportsmen with hand phalangeal fracture, we returned the patients in 3-6 weeks to spor and we mentioned the importance of returning to spor in short time. The time need for full hand fuction in this study is 2.5 months and this time is long compared to the patient with phalangeal fractures in our another study (Catikkas *et al.*, 2014). In another our study, we treated 38 sportsmen having scaphoidal fractures and we obtained union in all patients with our treatment. The success rate of union was 100% in our study. We thought this high success rate was because of all our patients were sportsmen (Yaman *et al.*, 2014). In this study, we don't have sportmen in our patients so we think this effects the results of having full functioning finger negatively.

Primary repair of ruptured tendons in this study was performed with six-stranded suturing method in a way which did not give harm to tendon circulation. In another study about suturing techniques of tendons, the new modified Tsuge sutures described in the study have evident higher tensile and breaking forces compared to other four-strand core suture techniques, suggesting, in turn, that this new technique is a good alternative for flexor tendon repairs in clinical applications (Chen *et al.*, 2014). We didn't use different suturing techniques in this study, so we can not compare the results of suturing techniques.

In a different study, they showed that ibuprofen with an anti-inflammatory dose was effective in improving the range of motion of the involved fingers joints after flexor tendon injury (Rouhani *et al.*, 2013). We didn't give any anti-inflammatory drug to our patients, it may be helpful for improving the range of motion.

In a study about effect of phototherapy with light-emitting diodes (890 nm) on tendon repair: An experimental model in sheep. They showed that phototherapy with 890 nm light-emitting diodes decreases the inflammatory process (De Mattos *et al.*, 2014). In my study, phototherapy may be used also.

In a study about the use of hyaluronic acid after tendon surgery and in tendinopathies. They observed that after flexor tendon surgery, a greater total active motion and fingers function, with an earlier return to work and daily activities, were observed (Abate *et al.*, 2014). It may be helpful but we didn't use hyaluronic acid molecule in our study.

About Platelet-Rich Plasma (PRP) usage for tendon healing, we don't have any experience and in the literature they say PRP do not significantly improve ultimate tensile strength. PRP-treated tendons exhibited trends towards reduced healing, including a significant reduction in cell counts as well as a smaller increase in collagen deposition over time as compared to controls. Further study is needed to determine the precise effect of PRP on intrasynovial flexor tendon repairs (Kollitz *et al.*, 2014).

Revision surgery was required in 8 patients out of 17 patients with Zone 2 injuries due to scar tissue adhesion and it contributed to the result negatively. The rupture occurred in the repair in 6 patients with Zone 1 regions during rehabilitation necessitated revision surgery and contributed to the result negatively. The deficiency in the rehabilitation due to pain secondary to the skin infection contributed to the result negatively in 21 patients. Twenty six of the patients (38.80%) were chronic smokers and it contributed to the results negatively due to low healing potential. Thirty five of the injuries (52.23%) are dirty and we believe that it contributes negatively to the result. We benefitted from the positive impacts of early rehabilitation (<http://www.elcerrahi.com/hasta-bilgilendirme/60-fleksor-tendon-yaralanmalari.html>, access date: 03.07.2014).

Although overwhelming majority of the cases are dirty injuries, no deep infection development demonstrates the importance of the protocol we applied for such injuries. That study includes only acute traumatic patients and does not include spontaneous and chronic cases is the drawback of our study. Studies including a series of cases by various surgeons are needed. We believe that the results of the patients with systemic disease and connective tissue problem are important. Non-inclusion of sharp injuries and partial tendon injuries is the limitation of our study.

CONCLUSION

The muscles helping the fingers be flexed inward are called as flexor muscles. They are connected to finger bones with the structures called as tendon that look like the cord originating from the available muscles in the forearm. Following the deep incisions that occur in the forearm, wrist, hand and fingers flexor tendon injuries might develop. Anatomically, flexor tendons progress very closely with vein nerve structures on hand. Therefore, in the injuries occurring in the palm, nerve and vein structure injuries are common along with flexor tendon injuries. Tendon ends might not be found easily in the incision region. When flexor tendon incision occurs, the patient cannot flex his/her fingers. If the tendon is not completely incised, patient might flex his/her hand. This case is generally painful. If tendon ends cannot be

brought against each other surgically, improvement cannot be achieved. If tendon incision repair is delayed, tendon is shortened depending on the muscle contraction to which tendon is attached and it may not be possible to bring tendons against each other. Protecting the tunnels which are called as pulleys, through which tendons in the hands pass is of utmost importance in order for the tendons to perform their functions following the recovery. In our study, we underlined the importance of early physical treatment in treating flexor tendon injury. We achieved 76.12% full functioning fingers. Flexion restriction and contracture developed in 16 patients (23.88%) at various levels. It is worth pointing out that no deep infection developed with the scar treatment that we applied successfully in the flexor tendon injury treatment which has an important place in traumatic emergency patients although overwhelming majority of the patients have dirty injuries. All the patients were enabled to use their hands actively within 2.5 months in average.

ACKNOWLEDGMENTS

The first author acknowledges Aylin Zekiöğlu and Ali Serdar Yücel for giving support in the translation and summarization of the sources used in the research in addition to literature support.

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