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The results of treatment for isolated zone 3 extensor tendon injuries

Üçüncü bölge ekstansör tendon izole yaralanmalarında tedavi sonuçları

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Amaç: Üçüncü bölgede izole ekstansör tendon kesisi olan hastalarda uygulanan cerrahi onarım ve fizik tedavinin geç dönem sonuçları geriye dönük olarak incelendi.

Çalışma planı: Üçüncü bölgede izole basit santral slip ekstansör tendon yaralanması nedeniyle cerrahi onarım uygulanan 16 hasta (13 erkek, 3 kadın; ort. yaş 28; dağılım 11-57) çalışmaya alındı. Yaralanan parmaklar 2. parmak (n=7), 3. parmak (n=3), 4. parmak (n=2) ve 5. parmak (n=4) idi. On dört hastada tendon onarımı primer yapıldı. İki hastada girişim sırasıyla bir hafta ve iki aylık gecikmeyle yapıldı. Dört hastada modifiye Kessler ve epitendinöz dikiş, 12 hastada kilitli devamlı dikiş kullanıldı. Tendon onarımı sonrasında üç hastada iki hafta süreyle ekstansiyonda K-teli ile tespit uygulanırken, 13 hastaya kısa ark hareket programı uygulandı. Hastalar son kontrolde proksimal interfalengeal (PİF) eklem hareket açıklığı ve ekstansiyon kaybı açısından değerlendirildi. Sonuçlar, Strickland formülü kullanılarak değerlendirildi. Ortalama izlem süresi 58 ay (dağılım 8-120 ay) idi.

Sonuçlar: Proksimal interfalengeal eklem hareket açıklığı 15 hastada (%93.8) tam bulundu. Ortalama PİF eklem hareket açıklığı 89 derece idi. Bir hastada (%6.3) PİF eklem hareket açıklığında 10º fleksiyon kaybı görüldü. K-teli ile tespit uygulanan üç hastada hareket açıklığında kayıp gözlenmedi. Strickland ortalaması %94.8 (dağılım %74-100) bulundu. On beş hastada (%93.8) çok iyi, bir hastada (%6.3) iyi sonuç elde edildi. Hastaların tamamı sorunsuz olarak işlerine döndü. Hiçbir olguda geç dönemde düğme iliği deformitesi, yumuşak doku komplikasyonu gözlenmedi.

Çıkarımlar: İzole üçüncü bölge ekstansör tendon yaralanmalarında, uygun dikiş tekniği ve kısa ark hareket programı ile iyi sonuçlar elde edilebilir.

Anahtar sözcükler: Parmak yaralanması/cerrahi/rehabilitasyon; parmak eklemi; atel; tendon yaralanması/cerrahi/rehabilitasyon.

Objectives: We evaluated late-term results of surgical repair and physical rehabilitation of isolated zone 3 extensor tendon injuries.

Methods: Sixteen patients (13 males, 3 females; mean age 28 years; range 11 to 57 years) underwent surgical repair for isolated simple central slip injuries of zone 3 extensor tendon. Injuries involved the second, third, fourth, and fifth fingers in seven, three, two, and four patients, respectively. Primary tendon repair was performed in 14 patients. Two patients were treated after one week and two months following primary injury, respectively. Tendons were repaired by modified Kessler and epitendinous sutures in four patients, and by locking running suture in 12 patients. Following surgical repair, three patients underwent K-wire fixation in extension for two weeks, while 13 patients received the short arc motion protocol. The patients were assessed with respect to proximal interphalangeal (PIP) joint motion and extension loss. Functional results were assessed using the Strickland formula. The mean follow-up was 58 months (range 8 to 120 months).

Results: Full range of motion of the PIP joint was achieved in 15 patients (93.8%). The mean PIP joint motion was 98 degrees. One patient (6.3%) had an extension loss of 10 degrees in the range of motion of the PIP joint. There were no losses in the range of motion in three patients treated with K-wire fixation. The mean of the Strickland formula was 94.8% (range 74% to 100%), showing an excellent result in 15 patients (98.3%) and a good result in one patient (6.3%). All the patients returned to their pre-injury work status. None had buttonhole deformity or soft tissue complication.

Conclusion: A proper suture technique combined with the short arc motion protocol provides good results in the treatment of isolated zone 3 extensor tendon injuries.

Key words: Finger injuries/surgery/rehabilitation; finger joint; splints; tendon injuries/surgery/rehabilitation.

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Zones 1-6 of the hand are the most common areas of extensor tendon injuries.[1] Zones 3 and 6 are the primary zones where most treatment problems occur. Attempting sutures for this kind of injury in the emergency room increases the problem. The fact that partial or whole tendon lacerations are not recognized and the skin is closed, in the long term, causes buttonhole deformity and extension loss of PIP joint motion range.[2,3]

The extensor tendon in zone 3 has a complex structure where intrinsic and extrinsic mechanisms are joined (Figure 1).[2,4,5] An adhesion forming on the PIP joint of the extensor side results in the limitation of finger flexion or extension loss. This situation reduces the functional capacity of the hand.

It has been observed that the publications on zone three extensor tendon injuries are mostly focused on post-operational rehabilitation programs and that there are few studies on surgical techniques and forms of injury.[5-15] Moreover, another remarkable fact is that the patients observed in the studies present different forms of injury and that data concerning suture techniques is limited.

In this study, the long term results of surgical repair and physical therapy on patients with isolated zone three extensor tendon lacerations have been analyzed retrospectively.

Patients and method

Between the years 2000-2007, 53 patients have been treated for open extensor tendon injuries. 16 of these patients (13 males, 3 females; mean age 28 years; range 11-57 years) who had isolated simple central slip tendon injuries and answered our call were included in the study.

Closed injuries, multiple crush finger injuries, injuries that spread to the flexor side, multiple tendon lacerations on adjacent fingers, soft tissue loss, extra-articular phalangeal fractures, volar plate injuries, and injuries including tendon loss and partial tendon lacerations have not been taken into consideration.

The mechanisms of injury were glass laceration (6 patients), hewn stone (1 patient), saw laceration (3 patients), knife laceration (2 patients), planer injury (1 patient), guillotine (1 patient) and metal plate laceration (2 patients).

Seven of the injuries were on the left side. Injury involved second, third, fourth and fifth fingers in seven, three, two and four patients respectively. One patient had joint cartilage defect (<%10).

Primary tendon repair was performed on 14 patients. Two patients were treated after one week and two months following primary injury, respectively. It was observed in these patients that only the skin had been sutured.

Surgical repair

All patients were assessed in the emergency room, and then underwent surgical procedure in operating room conditions. All procedures were conducted by hand surgeons with at least four years of experience. In case of opened joint capsule, following joint irrigation and incision, cartilage structure was examined. Following the repair of the joint capsule, the central band was repaired using locking running sutures. In the joint dorsal where the tendon becomes thicker, core sutures were used. It is easy for the tendon to be hand-

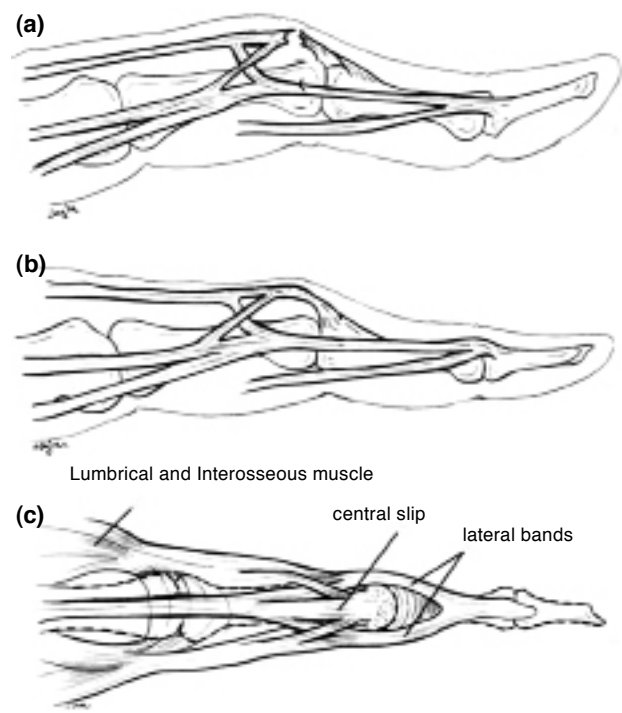

Figure 1. (a) Injured central tendon in zone 3. Since the central band is lacerated, tension on lateral band increases and causes hyperextension in distal interphalangeal joint. If surgical repair is nor performed, lateral bands will gradually shift to proximal interphalangeal joint volar; buttonhole deformity develops. **(b)** Lateral view of extensor tendon anatomy of a normal finger. **(c)** Tendon anatomy in front-rear view.

Figure 2. Glass laceration of extensor tendon in zone 3. The patient underwent tendon repair using locking running sutures. Following treatment with short arc motion protocol, full range of motion was achieved in proximal interphalangeal joint.

led with core sutures in lacerations in this area. Lateral band were sutured if they were eligible for end-to-end repair (5/0-6/0 PDS-Polydioxanon). When the lateral band was defected, only the central band was sutured (Figure 2).

Modified Kessler and epitendineous sutures were used on four patients. On two patients, side to side modified Kessler sutures were used (so that the thin tendon would not contract as a result of single modified Kessler suture). PDS 4/0-5/0 (core) and Ethilon 6/0 (epitendineous) sutures were preferred. Locking running sutures were used on twelve patients.

Following tendon repair, three patients underwent K-wire fixation in the extension for two weeks in order to protect the repair zone. K-wire fixation was preferred for factors such as the fact that tendon ends were not very healthy, the flexor tonus was apparent in worker patients and tight repair.

Rehabilitation program

Hastaya hangi program uygulanacağına, ameliyat sonThe program that the patient would undergo was decided according to whether there were any post-op skin problems and whether any bone fragments were included.

(i) On the three patients that underwent K-wire fixation in the extension after surgical procedure, short arm plaster cast splint was used for two weeks. After that, the K-wire was removed and static finger splint was used. In the third week, active help finger exercises were started. In these patients, the use of static finger splint was continued until week five in order to prevent tendon rupture.

(ii) Short arc motion protocol (SAM): The 13 patients who did not undergo K-wire fixation received SAM. This protocol consists of a static immobilization splint and two exercise splints. On the first splint, the patient exercises pip joint extension. This splint allows flexion of 30 degrees of PIP joint extension and 20-25 degrees of distal interphalangeal (DIP) joint extension. With the second splint, flexion exercises are applied to DIP joint while the PIP joint is kept at 0 degrees. The exercises were repeated 15 times every hour. During the times excluding exercise, the finger was immobilized by static splint. Coban® dressing was used as edema prevention.

Unless extension loss occurred, patient continued with the SAM protocol until the sixth week while the degree of flexion was gradually increased after the second week. At the end of this period, active movement was allowed.

Assessment

Patients were called in again to follow up on PIP and DIP joint mobility range and extension loss. Re-

sults were assessed by using the following Strickland formula:[16] [(PIP joint mobility arc + DIP joint mobility arc) x 100] / 175.

The results were identified as 75-100% very good, 50-74% good, 25-49% average, 0-24% poor. Mean patient follow-up time was 58 months (range 8-120 months).

Results

Full range of motion of the proximal interphalangeal joint was achieved in 15 patients (93.8%). Mean proximal interphalangeal joint motion was 89 degrees. A flexion loss of 10° in PIP joint motion range was observed in one patient (6.3%). This patient had glass laceration and had undergone physical therapy according to SAM protocol. Therefore, among the 13 patients to have undergone SAM protocol, only one had 10° of flexion loss.

There were no losses in the range of motion in the three patients treated with K-wire fixation following the surgical procedure. The mean of the Strickland formula was 94.8% (range 74-100%). An excellent result was achieved in 15 patients and a good result in one (6.3%).

All patients reported non-problematic return to work. None of the cases presented buttonhole deformity, soft tissue complications or tenolysis indication in the long term.

Discussion

The factors that affect the results of zone 3 extensor tendon repair can be listed as anatomical difficulties of the zone, suture technique and the applied physical therapy protocol.

Anatomical difficulties

Extensor tendons exhibit changes excursion and tendon structure according to the zones. In the third zone, the tendon has a thin structure. The bands formed by the connection of intrinsic and extrinsic tendons are closely adjacent. Excursion of the extensor tendon is less than that of the flexor tendon and especially in zone 5 distal, both the excursion and thickness is lessened.

In zone 3, a 3.75 mm of excursion occurs with a 30 degree PIP motion. The excursion which is at 40 mm in the forearm, is reduced to up to 1 mm in the distal. In zone 3, a 2mm reduction in the tendon's free motion causes 50% of motion loss in PIP joint.[17]

Table 1. Studies on zone 3 extensor tendon injuries.

Study	Tendon repaired	Sutures	Physical therapy protocol	Extension loss	Results
Thomes et al.[12]	29 fingers	Horizontal mattress	Finger dynamic splint	3 patients	%86 excellent, %14 good**
Pratt et al.[6]	31 fingers	?	Static splint(3 weeks), Capener finger splint (3 weeks)	5 patients	TRM 237º, %70 excellent, %30 good
Saldana et al.[11]	19 fingers	Running '8'	Finger dynamic splint (dorsal)	6 patients	%63 excellent, %27 good
Hung et al.[23]	14 fingers	?	Wrist dynamic splint	?	TRM 188°
Crosby et al.[10]	7 fingers	Mattress, '8'	Wrist dynamic splint + tendon mobilization program	2	TRM 264*
O'Dwyer et al.[9]	99 patients	?	Immobilization (10-14 days) then, Capener Finger splint	10	%88 excellent-good results
Evans[7]	24 fingers	?	immobilization/ SAM	6	63% of normal TAM 188° 75% of normal TAM 240°**
Carl et al.[1]	203 fingers	Double loop	Immobilization (6 weeks)	?	%43 good results
This study	16 fingers	Locking running/ modified Kessler	SAM / immobilization	–	%93.8 excellent, %6.3 good results***

*TRM: Total range of motion. A normal joint has about 260°.

**Strickland-Glogovak formula[28]: [(PIP flexion + DIP flexion – extensor loss) /175] x100 = PIP+DIP flexion expressed as normal percentage.

***Strickland formula: [(PIP flexion + DIP flexion) _ 100] / 175.

Figure 3. (a, b) For a laceration on the second finger in zone 3, **(c, d)** Short arc motion protocol. **(e)** Working with first exercise splint, **(f)** Blocking PIP while exercising DIP active flexion with the second splint. **(g)** Static resting splint.

Tendon Sutures

In extensors, unlike flexor tendon repair, there is no thickness in zone 3 which would allow core sutures. Only in the joint dorsal, where the tendon thickens, it is possible to use core sutures. Therefore, data showing gap and tear formation is little.[18-21]

Mostly, mattress, running and 'U' sutures are used.[4] Rockwell et al. have noted that for normal tendon balance, the length at the repair site should be maintained. In vitro testing of four band modified Bunnell, modified Krachow and MGH sutures has shown that the most resistant sutures were MGH.[22] However, this study was done for zone 6.[22] In recent years, there have been studies showing the outstanding resistance of modified Becker technique.[20]

The repair performed should not cause thickening or shortening of the tendon. Otherwise, the tendon will lose its gliding capability. In this zone, in addition to tendon injury, joint capsule, cartilage injury, fracture and PIP dislocation are frequently seen. In these cases, expectation of motion loss is higher than isolated tendon laceration.[7,9,14] In cases of isolated tendon laceration, mean PIP range of motion was observed to be 89 degrees; in 15 patients (93.8%), full range of motion was achieved. This data supports the fact that with the appropriate suture technique, satisfactory results can be obtained.

Thus, it is important in zone 3, that the tendon structure is carefully examined and the most appropriate suture technique, sutures (in terms of thickness and durability) are chosen to prevent shortening. We used 4/0 and 5/0 absorbable monofilament sutures. However, new research is needed in this area.

Post-op rehabilitation programs

It is observed that there is no consensus on treatment protocols regarding extensor tendons.[1,6,7,9-14,23-26] This is also true for other extensor tendon zones.[8,27] Some authors support immobilization and others early passive or active exercise (Table 1).

Figure 4. Static and exercise splints used in the short arc motion program for extensor tendon injuries of zone 3 of the fourth finger.

Physical therapy protocols are, (i) immobilization (4-6 weeks), (ii) early limited active exercise (SAM) and (iii) early controlled passive exercise (extensor dynamic splint).

Evans[7], who is a supporter of short arc motion protocol, has compared patients who have undergone immobilization and SAM and has reported extension loss (+5°) and a reduction of PIP range of motion (-16°) in the immobilization group (Table1). He has explained this difference with the adhesion that developed in zone 4 extensor tendon during immobilization, and conveyed that the stiffness developing in the joint and ligaments had contributed to this outcome. According to the author, the splint should only cover the finger and exercise should be initiated early.[7]

Carl et al.[1] have noted that the heterogeneity of treatment methods constitutes a problem in comparing the studies. Therefore, in their study, they have used positive determinant factors (undergoing surgery in the first 8 hours, age <30, mild soft tissue damage) and negative determinant factors (contamination of the injury, age >50, tendon atrophy, multiple tendon injury). Since complex injuries were more frequent in zones 3 and 6, they have found the results to be less satisfactory in these zones. However, in this study, physical therapy protocol was initiated at the end of a six-week immobilization. It may be due to this fact that the results were found to be less satisfactory.[1] Today, a transition from static to dynamic is observed in physical therapy protocols.[7,9-13,23]

Pratt et al.[6] have achieved excellent results in 70% of their cases, observed extension loss in only 5 patients and have reported total active motion as 237 degrees. O'Dwyer and Quinton[9] have reported excellent-good results of 88% by using Capener splint.

Crosby and Wehbé,[10] in their study which included all zones, have attributed the excellent results in all their patients to the dynamic splint that covered the wrist and the tendon mobilization program they used. Saldana et al.[11] have achieved 90% excellent-good results by using dynamic splint for only the finger. In our study, excellent results were achieved in 15 (93.8%) patients and good in 1 (6%).

Limiting finger splints (SAM) which maintain early active motion in the proximal interphalangeal joint have become more widely accepted in recent years. In this way, motion in wrist and other fingers is not limited (Figure 3,4).

Tendon injuries in zone 3 may not always be identified. In some patients, due to the fact that the injury is treated as a simple laceration and the skin is simply sutured, the tendon injury may be diagnosed later (Figure 1). In our two such cases, the scar on the central tendon was excised and secondary tendon repair was performed. Grundberg[3] has noted that excision of scar tissue of up to 0.3mm is possible in this zone. If the central tendon is not eligible for sutures, proximal side may be attached by opening a transverse tunnel to the middle phalanx basis. Since this kind of repairs require more care than those where there are tendon ends on both sides, K-wire fixation may be performed in the extension for 2-3 weeks. There are also authors who use K-wire fixation routinely in injuries of zones1-4.[5]

No extension loss was seen in our cases. This situation is rarely documented (Table1). O'Dwyer and

Quinton[9] have reported that extension loss reduces from eight weeks to six months. The elongation and adhesion in the tendon leads to extension loss. The extension loss here is that the finger cannot perform active extension but may be brought to extension passively. This condition is tried to be overcome by keeping finger in extension by means of a the low-profile splint.[26]

The fact that it does not provide comperative information on physical therapy protocols or isolated and complex zone 3 extensor tendon lacerations may be seen as a drawback for our study. In this area, there is a need for prospective observation of complex injuries. However, we believe that our study will be instructive in how clean isolated central band lacerations result unless they are complicated. The remarkable point in literature is the minority of surgical studies specific to zone 3 extensor tendon. The information on this topic constitutes of case series and cases control (stage3-4) studies, and most are focused on physical therapy protocols. As a matter of fact, the surgical suture type has not been specified in some publications. Our study presents a retrospective section on suture technique, physical therapy protocol and functional results in isolated lacerations.

Proximal interphalangeal joint level injuries are those that require all components (bone, tendon, soft tissue) to be separately considered with great care. In our study, early motion protocols have achieved good results in isolated zone 3 extensor tendon lacerations and no extension loss has been observed.

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