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Case report

Case series of traumatic neglected Extensor Hallucis Longus lacerations: choice of surgical treatment based on injury type

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Abstract. *Background and aim:* Extensor Hallucis Longus (EHL) tendon rupture is a rare injury of the foot, representing only 1% of overall tendon rupture. Early diagnosis and surgical repair are recommended but there is still no consensus regarding the ideal treatment**.** The purpose of this study was to evaluate a case series of patients with neglected extensor hallucis longus (EHL) tendon rupture. *Methods:* We report a case series of 3 patients affected by traumatic neglected EHL lacerations treated with reconstructive surgery using tissue scaffolds, between November 2019 and May 2020. Demographics data, mechanism of injury, zone of injury, tendon gap, time to surgery, type of surgical repair, preoperative and postoperative functional score were collected with a minimum follow-up of 8 months. *Results:* The zone of injury (according to Al-Qattan classification) involved was in 1 case zone 2, in 1 case zone 4 and in the last case zone 5. The mean value of intraoperative tendon gap was of 3,4 cm. The elapsed time from injury to surgery was an average of 3,3 months. One tendon transfer surgery and two primary repairs with Krakow fashion were performed, all augmented with tissue scaffolds. The mean preoperative and postoperative American Orthopedic Foot and Ankle Society (AOFAS) scores were, respectively, 43 and 97. *Conclusions*: Our results highlight good functional result and satisfaction with active extension of the hallux restored in all patients. According to our experience, we recommend choosing reconstruction technique basing on the topographic zone of lesion and intraoperative tendon gap. (www.actabiomedica.it)

Key words: orthopedic surgery, extensor hallucis longus, tendon repair, tissue scaffolds

Background and aim

Extensor Hallucis Longus (EHL) tendon rupture is a rare injury of the foot and represents only 1% of overall tendon rupture and approximately 1,6% of all the extensor tendons lesions of the foot (1-4). Only a few reports are available in literature and there is no consensus regarding the ideal treatment and how much time is acceptable between the point of injury and surgery (1-7).

The EHL tendon is vulnerable to laceration due to its subcutaneous location especially with traumatic events (8-10); but it is also associated with chronic disease, tendon overuse, steroid injections, and shoe gear pressure (11).

EHL lacerations can be partial or complete and can cause an acute hallux dysfunction with drop hallux which determines abnormality of gait, due to an inability to clear the toe from the ground, and can result in a progressive contracture deformity with steppage. Unfortunately, the clinical presentation is not always so clear and obvious to the orthopaedic surgeon. Neglected lacerations are among the most complicated tendon injuries to treat because of their

association with greater tissue necrosis. This condition requires extensive debridement with disruption of the tenosynovium integrity and increased risk of adhesions formation (2). In order to obtain an optimal result and to avoid future disability, early diagnosis and surgical repair is recommended.

This paper reports our experience in the treatment of neglected EHL complete lesions with reconstructive surgery using a dermal substitute consisting of a native (non-cross-linked) collagen matrix supplemented by elastin hydrolysate (Matriderm®, MedSkin Solution Dr. Suwelack AG, Billerbeck, Germany), treated by a single surgeon.

Methods

We retrospectively reviewed the cases of 3 patients, affected by traumatic neglected EHL rupture, treated with reconstructive surgery using tissue scaffolds, between November 2019 and May 2020. We collected information about: demographics data, mechanism of injury, zone of injury, time to surgery, surgical repair or reconstruction technique, intraoperative tendon gap, preoperative and postoperative function with a minimum follow-up of 8 months. We defined the injury site using the topographic classification proposed by Al-Qattan (Table 1) (11).

Case 1

Patient 1 is a 25-year-old female with no significant medical history presented with a progressive chronic loss of dorsiflexion of left hallux following a domestic accident. The patient had suffered a dropped knife trauma on her foot approximately 3 months before our evaluation. At the time of the trauma, she was treated in another emergency department where she underwent radiographic study and consequent inspection and suturing of the wound. The wound was not grossly contaminated. She had a negative surgical history, took no prescription medications, and denied any allergies. Her tetanus status was updated. Our physical examination highlighted a well-healed cicatrix secondary to the laceration, localized to the dorsum of the foot at the level of zone 4, according to Al-Qattan topographic classification, and progressive functional limitation to the dorsiflexion of the hallux.

Her foot and ankle radiographs were negative for fractures. Sonography scans and magnetic resonance imaging scans were obtained and revealed complete transection of the EHL tendon.

The non–weightbearing resting position of the hallux was slightly inferior to the transverse plane alignment of the lesser digits.

Proximal retraction of the EHL was clinically noted to the level of the dorsal midfoot as a palpable mass, as confirmed on MRI scans (Fig. 1).

In the operating theater, an Extensor Digitorum Longus-to-EHL transfer was performed using tissue scaffolds (Matriderm®) (Figs. 2, 3, 4).

Table 1. Al-Qattan topographic classification divide the injury site in six zones using anatomical landmarks (11)

Zone	Description
1	At the insertion site on the distal phalanx
2	Site between zones 1 and 3
3	Over the metatarsophalangeal joint
4	Dorsum of foot between zones 3 and 5
5	Injury to the tendon under the extensor retinaculum
6	Lower leg proximal to the extensor retinaculum

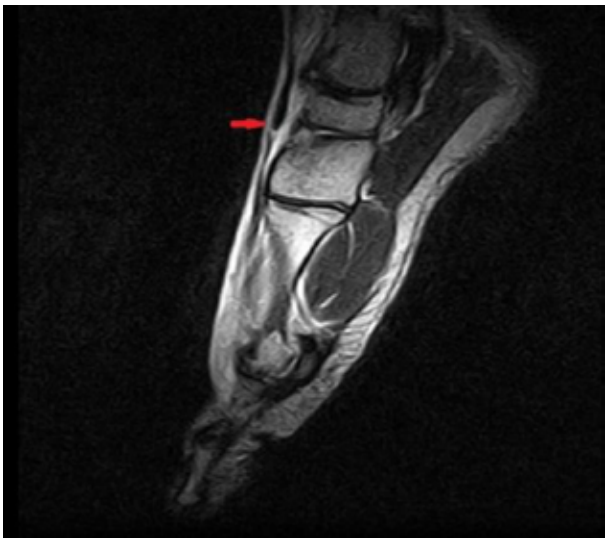

Figure 1. Preoperative magnetic resonance imaging (MRI). Sagittal T1-weighted MRI revealed the complete rupture of the extensor hallucis longus tendon (red arrow).

Figure 2. EHL lesion site between the metatarsophalangeal joint and the extensor retinaculum (zone 4 according Al-Qattan Classification) in patient 1.

Figure 3. Intraoperative image of EDL-to-EHL transfer.

Case 2

Patient 2 is a 43-year-old male with a complete laceration of the EHL tendon, following a work accident, with a progressive steppage and a chronic dysfunction of hallux.

He had sustained an injury to the dorsum of the foot and ankle, at the level of Al-Qattan zone 5 caused by the breaking of a mirror (11).

The patient was seen in another emergency department where he underwent radiographic study and suturing of the wound. The wound was not grossly contaminated. He had a negative surgical history, took no prescription medications, and denied any allergies. At the clinical evaluation the patient presented progressive and chronic steppage. His foot and ankle

Figure 4. Intraoperative image of placement of tissue scaffold (Matriderm®). The scaffold has been placed directly over the suture site, wrapping the tendon.

radiographs were negative for fractures. Sonography scans and magnetic resonance imaging scans were obtained, which revealed a complete transection of the EHL. The patient was treated with primary repair with Krakow fashion using tissue scaffolds (Matriderm®).

Case 3

Patient 3 is a 24-year-old female with a chronic and neglected EHL tendon complete lesion. Her clinical history was an injury caused by a dropped knife on the dorsum of the hallux, at the level of zone 2, according to Al-Qattan classification. The patient was evaluated by an emergency department of another hospital were X-rays and sonography scan were obtained with negative results for injuries. After a month from injury, the patient had persistent loss of hallux dorsiflexion and decided to obtain another sonography study that revealed a complete EHL tendon lesion. At the clinical evaluation the patient had a scar on the dorsum of the hallux, presented progressive and chronic steppage, proximal phalanx pain and swelling. We obtained an MRI scan that confirmed the diagnosis of complete EHL tendon lesion (Fig. 5). She had a negative surgical history, took no prescription medications, and denied any allergies. The surgical procedure performed was a primary repair with Krakow fashion using tissue scaffolds (Matriderm®).

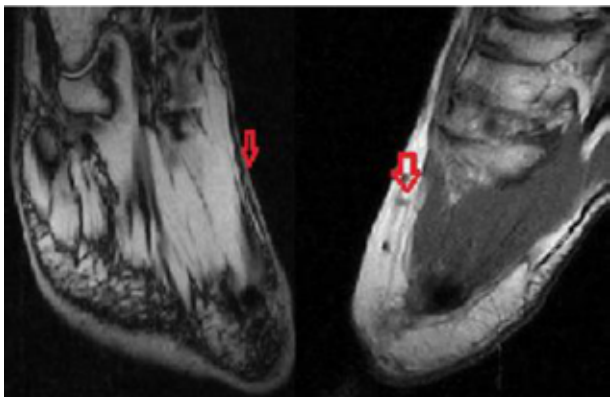

Figure 5. Preoperative magnetic resonance imaging (MRI). Sagittal T1-weighted MRI revealed the loosening of the extensor hallucis longus tendon in patient 3 (red arrow).

The neurovascular status of the foot was intact in all our patients.

The post-operative treatment was the same for every patient, characterized by a short-leg cast with toe extension placed in the operating room and applied for 3 weeks. Patients had a non-weight bearing walking for 3 weeks and subsequently a progressive load was allowed. Physiotherapy was started after cast removal, including progressive passive and active range of motion of the hallux.

The return to sport activities was possible progressively after 3 months postoperative.

Results

We retrospectively analyzed 3 cases. The average age at the time of injury was 30,67 years old. The gender distribution was 2 females and 1 male. The injured side distribution was 2 right side and 1 left side. All our patients had a traumatic mechanism involving a sharp or a heavy object (knife or mirror) that caused a wound in the dorsum of the foot.

Postoperatively we performed a clinical follow-up until 4 months and a telephonic follow-up, because of Covid-19 sanitary emergency, of at least 8 months. We submit to our patients 2 functional scores: Lipscomb and Kelly grading system for EHL tendon repairs and American Orthopedic Foot and Ankle Society (AOFAS) Hallux Metatarsophalangeal Interphalangeal score, as illustrated in (Table 2).

Case 1

Case 1 is a 25-year-old female. She had her left foot involved in a dropped knife accident that interested zone 4, according to Al Qattan topographic classification. The intraoperative tendon gap was of 4,2 cm and we decided to perform a transfer of Extensor Digitorum Longus tendon pro Extensor Hallucis Longus addicted with MatriDerm®. Time elapsed from the accident to surgery was of 3 months.

Patient 1 had a preoperative AOFAS score of 40. At 8 moths follow-up her functional scores were: AOFAS 95 and a fair result according to Lipscomb and Kelly grading system for EHL tendon repairs (Fig. 6).

Table 2. Case analysis with functional score results

Case	**1**	**2**	**3**
Age (Years)	25	43	24
Gender	F	M	F
Mechanism	Dropped knife	Broken mirror	Dropped knife
Injury Zone	4	5	2
Time to Surgery	3 Months	2 Months	5 Months
Surgical Procedure	Transfer EDL pro EHL + Tissue scaffold (Matriderm®)	Krakow + Tissue scaffold (Matriderm®)	Krakow + Tissue scaffold (Matriderm®)
Intraoperative tendon gap	4,2 cm	3,5 cm	2,5 cm
Preoperative AOFAS score	40	46	43
Postoperative AOFAS score	95	97	100
Lipscomb e Kelly	Fair	Good	Good

Figure 6. Surgical scar in patient 1.

Case 2

Case 2 is a 43-year-old male. He was involved in a work accident with a broken mirror that lacerated his EHL tendon of the right foot at zone 5, according to Al-Qattan topographic classification. Intraoperatively, the tendon gap measured was of 3,5 cm but tissues were quite elastic and mobilizable and so we achieved to perform a primary repair with Krakow fashion with the addition of MatriDerm®. Time elapsed from the accident to surgery was 2 months.

His preoperative AOFAS score was of 46. At 8 moths follow-up his functional scores were: AOFAS 97 and a good result according to Lipscomb and Kelly grading system for EHL tendon repairs

Case 3

Case 3 is a 24-year-old female. She had a dropped knife accident involving her right foot and interesting zone 2, according to Al Qattan topographic classification. The intraoperative tendon gap was of 2,5 cm and we performed a primary repair with Krakow fashion with the addition of MatriDerm®. Time elapsed from the accident to surgery was of 5 months.

Her preoperative AOFAS score was of 43. At 8 moths follow-up her functional scores were: AOFAS 100 and a good result according to Lipscomb and Kelly grading system for EHL tendon repairs (Fig. 7).

No re-ruptures or other complications were reported in our group of patients.

Discussion and Conclusion

EHL tendon lacerations represent a rare injury of the foot that leads to a severe grade dysfunction of hallux extension. Early diagnosis and surgical repair of the tendon is recommended; however, it is not always possible due to difficulties in diagnosis (11). Only a few cases of EHL lacerations and treatment have been reported in literature**.** Starting from Griffiths that, in 1965, reported a case of EHL laceration that was treated conservatively (12). Most recent studies support the necessity of primary repair, when possible, or surgical reconstruction in case of excessive tension while performing tendon opposition (11,13-15). Several techniques of surgical reconstruction have been

Figure 7. Postoperative macroscopic findings in patient 3 showing no retraction e complete healing of surgical scar.

reported in literature, including: tendon transfer of the Extensor Digitorum Longus (1,2), autografts from the extensor hallucis brevis (16), autografts from semitendinous tendons (5) and fascia lata allografts (14).

In our cases report we chose to perform a tendon transfer EDL pro EHL in an injury zone 4 with a tendon gap of 4,2 cm. Instead, we performed a primary suture with Krakow fashion in the other 2 cases that had a minor tendon gap (< 3,5 cm), regardless of the area of injury, because it was possible to obtain a termino-terminal suture without tension. We observe that when an intraoperative termino-terminal suture is possible there's no need to perform a tendon transfer, obtaining good clinical results even in neglected EHL complete rupture.

In all cases we have treated, in order to avoid hyperextension of the hallux, we performed the tendon suture simply by keeping the ankle at 90°.

In order to reduce friction and adhesions formation we also used MatriDerm (MedSkin Solution Dr. Suwelack AG, Billerbeck, Germany) that is a unique collagen-elastin-template of bovine derivation, able to promote the regeneration of dermis and consequently decreases scar tissue formation (17). The addiction of a tissue scaffold (Matriderm®) reduces adhesions and the risk of secondary complications in both tendon transfer procedure and in termino-terminal suture (18-20).

Our post-operative rehabilitation program is in line with other publications. Literature suggests a period of 3 to 6 weeks of immobilization in a short cast followed by passive mobilization and cautious active mobilization (2,9,15). Besides, Al-Qattan uses a transarticular Kirschner-wire pinning fixation to maintain hallux iperextension (11).

Few complications have been reported in literature: painful scar (38%), paresthesias in the foot (15%), hallux stiffness (10%), persistent hallux droop (5%), wound complications (5%) (15,21). No re-ruptures or other complications were reported in our group of patients.

Despite the elapsed time from injury to surgery, we had good functional outcomes with satisfaction of all our patients due to the active extension of the hallux regained. We hypothesize that intraoperative evaluation of the tendon gap and the possibility of bringing the two ends of the tendon into contact without excessive tension gives the possibility to perform end-to-end sutures in inveterate lesions.

The limitations of this study are the small number of cases, the heterogeneity of the sample under examination, the short follow-up and the difficulty in the follow-up due to Covid-19.

In conclusion, our results highlight good functionality and satisfaction of all patients. We underline that his kind of surgery should be performed by specialized surgeon. According to our experience, we recommend choosing the reconstruction technique basing on the topographic zone of lesion and intraoperative tendon gap, considering that the greater the time elapsed from the traumatic event, the greater the technical difficulty of suture could be.

Conflict of Interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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