Z-lengthening Plasty of the Extensor Hallucis Longus (EHL) Tendon Proximal to the Retinaculum Extensorum to Repair a Chronic Rupture of the Distal EHL Tendon

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Abstract: Extensor hallucis longus (EHL) tendon injuries may be diagnosed late, which can result in a nonreducible gap. When end-to-end suture is impossible, a reconstruction with a graft or a transfer may be necessary to restore hallux alignment and active dorsiflexion. We propose a new surgical technique and postoperative protocol to repair a traumatic EHL rupture with a nonreducible gap by using a Z-lengthening of the EHL tendon proximal to the superior retinaculum of the extensors, thus creating sufficient length of the proximal stump to allow end-to-end suture. Our patient recovered at 3 months with an active hallux dorsiflexion of 50 degrees at the metatarsophalangeal joint (60 degrees on the healthy side). There was no loss of active or passive plantarflexion in the metatarsophalangeal or interphalangeal joint. At 3-month follow-up, the FAAM score was 83/84 (activities of daily living) and 12/12 (sports). The AOFAS score was 90/100 and the EQ-5D was 0.8. This method to repair a distal EHL rupture appears safe and simple. It eliminates the need for an allo-/autograft, and potential donor site morbidity.

Level of Evidence: Level V.

Key Words: EHL reconstruction/repair, extensor hallucis longus tendon rupture, Z-lengthening plasty

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The extensor hallucis longus (EHL) is responsible for dorsiflexing the big toe and stretching the plantar aponeurosis. In addition, it assists foot dorsiflexion, inversion, and eversion.[1–3] The true prevalence of EHL tendon ruptures remains unknown. The only available epidemiological data comes from a 1959 study by Anzel et al,[4] which reported that 11% of lower extremity tendon ruptures involved the EHL, based on an analysis of 1014 cases. These injuries generally occur following traumatic lacerations to the dorsum of the foot. The chronic closed rupture of the EHL tendon is an exceedingly rare injury, and its prevalence remains unknown to our knowledge.[5] Delayed diagnosis of a closed rupture may be considered as a similar entity to a chronic rupture.

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Historically, surgical treatment of those injuries was debated due to the risk of painful scar tissue caused by a larger or a second incision. Some authors relied on 2 historical cases describing good extension recovery following conservative treatment of EHL rupture to consider it as a viable option.[6,7] Experts seem to agree that better function can be achieved with surgical treatment.[8,9] In the case of a chronic EHL rupture or delayed diagnosis, predicting an outcome is generally difficult due to many factors. First, active ankle motion contributes to tendon retraction, keeping the stumps apart. Second, the tendon's immobility progressively causes adhesions within its sheath.[10] Third, surgery is technically more demanding due to scar tissue. Finally, tendon rupture inevitably leads to fatty degeneration of its muscular body, resulting in a loss of function.[10]

When addressing chronic EHL tendon lacerations, the best results are achieved with direct tendon repair when tendon retraction is minimal.[11,12] When end-to-end repair is not feasible, surgery may require an additional or longer incision to retrieve the proximal stump and grafting or tendon transfer to restore tendon length and function.[5,13] In such techniques, the use of autografts or allografts poses a risk of complications, including disease transmission,[14] donor site morbidity, and potential functional deficit at the harvest site.[15] It is essential to recognize the inherent limitation of each surgical technique.[16]

Joseph and colleagues proposed an alternative approach to address excessive retraction through a split tendon lengthening. This technique allows repair without the need for a tendinous graft and its associated complications. However, it relied on an acellular dermal scaffold to reinforce the repaired tendon.[15] Despite numerous techniques previously described in the literature for the ideal reconstruction of chronic EHL ruptures,[8] there is currently no consensus. Our objective is to propose and describe an easy reconstruction technique for nonrepairable EHL lacerations without utilizing any grafts by carrying out a small second incision proximal to the superior extensor retinaculum to realize a Z-lengthening plasty of the shortened EHL.

INDICATIONS

Chronic EHL rupture with an impossible end-to-end repair due to retraction.

CONTRAINDICATION

Fatty degeneration of the muscular body.
Poor local skin and soft tissues condition.
Vascular insufficiency.

FIGURE 1. A transverse scar and loss of active big toe dorsiflexion were observed on the left foot.

CASE PRESENTATION

A 40-year-old female experienced a complete laceration of the EHL tendon when a cake dish fell on the dorsum of her foot. Four weeks later, she faced another trauma involving a metal bar, resulting in a small wound, motion pain, and inability to actively dorsiflex the hallux. This impairment significantly affected her ability to walk barefoot. The patient had a history of daily tobacco use, consuming half a pack of cigarettes per day for the previous 20 years. During physical examination, a 1-cm transverse scar was observed on the dorsal aspect of her foot and the patient was unable to perform active dorsiflexion of the big toe (Fig. 1). The proximal stump was palpable and had retracted 3 cm proximally to the rupture site. The neurovascular status of the foot was intact.

PREOPERATIVE PLANNING

Although an MRI was not initially required for diagnosing the EHL dysfunction, its importance was evident for precisely defining the gap length (Fig. 2). The MRI illustrated the distal EHL stump at the metatarsophalangeal joint (MTP) level (Fig. 2A) and the proximal stump at the tarsometatarsal joint (TMT) level (Fig. 2B). The quantified gap measured 36 millimeters (Fig. 2C).

SURGICAL PROCEDURE

Patient's informed consent for the operation was obtained. Surgery was performed under general anesthesia with the patient in the supine position. Antibiotic prophylaxis with 3rd-generation Cephalosporin was administered, and a tourniquet was inflated at the thigh at 280 mm Hg for 1 hour.

To access the distal stump, we carried out a direct longitudinal approach between the 1st and 2nd metatarsals, lateral to the EHL. Debridement of the distal tendon stump was performed, and it was armed with a PDS 3.0 using a locking loop suture technique. As the proximal tendon stump was retracted to the tarsometatarsal joint, we exposed and prepared it through the same approach and in the same way as we did for the distal stump. Fibrous scarring around the tendon was released to facilitate lengthwise mobilization. Despite these efforts, the gap, measured with the ankle in neutral position, remained at 3 cm (Fig. 3).

Given the impossibility of achieving a tension-free primary end-to-end suture of the 2 stumps, we opted for a more proximal EHL Z-lengthening plasty to enable distal suturing without excessive tension. Through a dorsal supraretinacular incision at the ankle, the EHL was identified. A Z-lengthening plasty of the EHL tendon proximal to the retinaculum was performed through the full thickness of the tendon, using a classic Z-pattern. This technique allows controlled elongation while preserving at least 50% of the tendon's width along each limb of the Z.

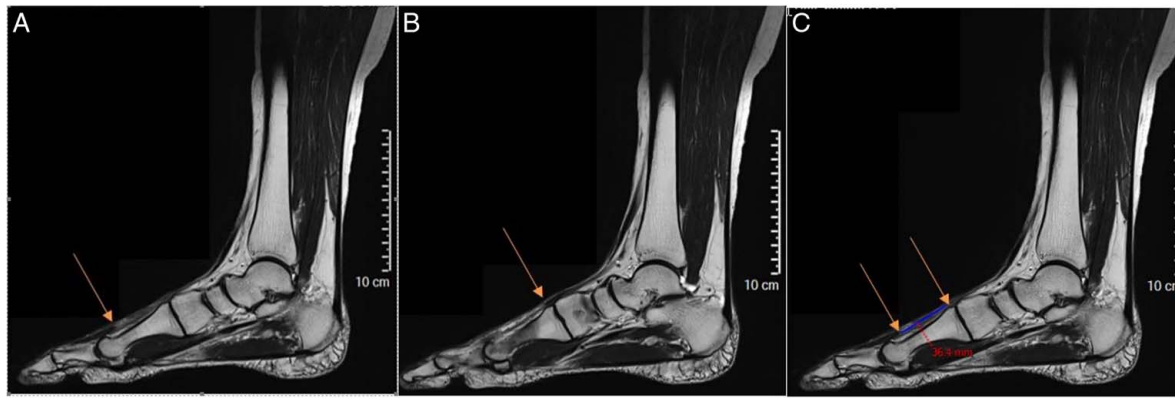

FIGURE 2. (A) Distal stump of the EHL was at the MTP joint, (B) proximal stump at the level of the TMT, and (C) gap between both stumps at 36 mm.

FIGURE 3. An irreducible 3 cm gap between the 2 stumps.

Once transposed, the overlapping segments provide sufficient surface for a solid side-to-side apposition. In this case, the lengthening achieved ~3 cm, enabling a tension-free direct repair at the site of the distal rupture (Fig. 4).

At the level of the Z-plasty, a running suture secured the tenotomy (Fig. 5). At the level of the rupture, end-to-end repair was possible with a modified Kessler technique using a locking loop suture technique (Fig. 6). During the tension-free connection of the distal stumps, we ensured that the ankle was in a neutral position. Subsequently, we closed the tendon sheath and both skin incisions.

POSTOPERATIVE MANAGEMENT AND MOBILIZATION THERAPY

Phase 1: Weeks 1 and 2

During the initial 24 hours, a short leg plaster splint was used, ensuring that the ankle and hallux were maintained in a neutral position. On day 1, this splint was replaced with a resin walking boot (Combicast, 3M, Saint-Paul, MN) for the subsequent 2 weeks and immediate full weight-bearing was allowed. There were no complications in wound healing, and stitches were removed after 2 weeks.

Phase 2: Passive and Active ROM, Weeks 3 to 6

Postoperative mobilization began at 2 weeks, using a dynamic splint with an elastic dorsiflexion spring for the hallux (Fig. 7), custom-made by our occupational therapy department. It allows tendon mobilization without tension by gently pulling the toe upwards. This splint was securely attached to a standard hard-sole postoperative walking shoe (DARCO Medsurg shoe, DARCO International, Huntington, VA). The patient actively moved her big toe daily, and further support for recovery included active and passive range of motion (ROM) training conducted by a physiotherapist twice a week. The splint was removed 6 weeks after surgery, and the patient was able to return to regular footwear.

FUNCTIONAL OUTCOME EVALUATION

The outcome and quality of life were assessed using standard evaluation scores, including AOFAS (functional assessment), FAAM (daily living), and EQ-5D (quality of life), at both the 6-week and 3-month postoperative intervals.

RESULTS

At 6 weeks postoperatively, the patient demonstrated successful restoration of active and passive hallux dorsiflexion. The active range of motion for metatarsophalangeal joint dorsiflexion was 42 degrees on the operative foot compared with 60 degrees on the contralateral foot (Fig. 8). No loss of active or passive plantarflexion was observed in the hallux interphalangeal joint, and no dysfunctions or secondary deformities were noted in the second toe. The patient was able to resume wearing regular footwear.

At 3 months postoperatively, the patient showed further improvements in clinical outcomes. The active range of motion for metatarsophalangeal joint dorsiflexion increased to 50 degrees on the operative foot, while the contralateral foot remained at 60 degrees.

Table 1 presents a summary of the AOFAS, FAAM, and EQ-5D scores at 6 weeks and 3 months postoperatively.

There were no wound complications or re-ruptures, and the patient expressed full satisfaction with the procedure at final follow-up.

DISCUSSION

The extensor hallucis longus (EHL) tendon is essential for big toe and foot movement, with chronic ruptures being rare and challenging to treat. Experts seem to agree on the necessity of surgical management for optimal outcomes in such cases. Our technique, consisting of a supraretinacular Z-lengthening plasty together with an end-to-end anastomosis at the rupture site, offers a graft-free solution for retracted EHL ruptures, avoiding donor site morbidity and allograft complications. It restored function in a patient, with no complications or re-ruptures reported.

FIGURE 4. Visualization of the EHL tendon through a supraretinacular incision, followed by a 3 cm Z-plasty to address the distal defect.

Lacerations at the midfoot level, are prone to tendon retraction and less manageable with simple repair compared with distal lacerations.[1] Various surgical procedures, such as interpositional fascia lata allograft,[13] EDL tenodesis,[16] or free tendon autograft reconstruction using semitendinosus[5,17] or EDL,[8,16] have been described to reconstruct the EHL tendon with satisfactory outcomes.[8,13,15] When a longer graft length is required, the use of palmaris longus,[9] plantaris, and peroneus tertius[18] tendons has also been reported. Allograft reconstruction offers advantages such as the absence of donor site morbidity and reduced surgical time. However, limited availability, higher cost, susceptibility to rejection, and potential infection risk restrict their use to selected cases.[11]

Joseph and colleagues described a technique involving the splitting of the distal segment of the EHL tendon lengthened from the interphalangeal joint of the hallux to a point 1.5 cm distal to the most proximal end of that segment. The tendon was split along the midline using an L-shaped incision and rotated proximally 180 degrees to bridge a 6-cm tendon gap caused by proximal retraction of the lacerated tendon. The repair was reinforced by a dermal

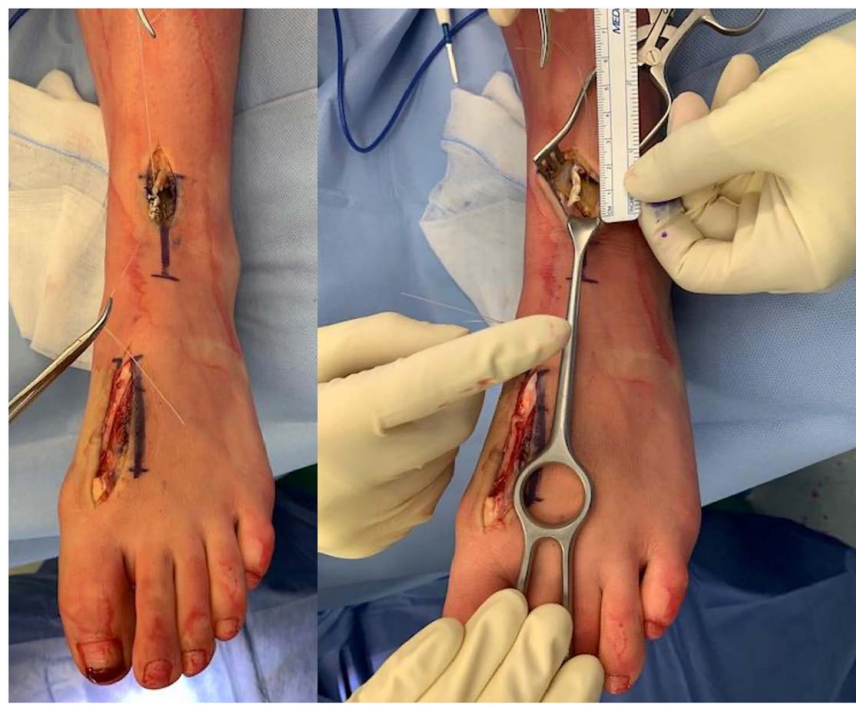

FIGURE 5. Both edges of the plasty were sutured using a PDS 2.0 absorbable running suture increasing tendon length by ~3 cm.

FIGURE 6. Each tendon stump was loaded using a locking loop suture technique with PDS 2.0, followed by a running suture for additional stability.

scaffold, which, in contrast to autograft techniques, avoids donor site morbidity associated with harvesting.[15] However, this technique required an extended distal approach, potentially leading to more scarring and stiffness of the hallux.

Our reconstruction of the EHL using a Z-lengthening plasty of the EHL tendon proximal to the superior extensor retinaculum involves 2 limited incisions and avoids the use of dermal scaffold, as opposed to the technique described by Joseph and colleagues. This may reduce fibrous scarring and

FIGURE 7. Dynamic splint equipped with a dorsiflexion recall spring specifically designed for the hallux, allowing mobilization of the extensor tendon without applying undue stress.

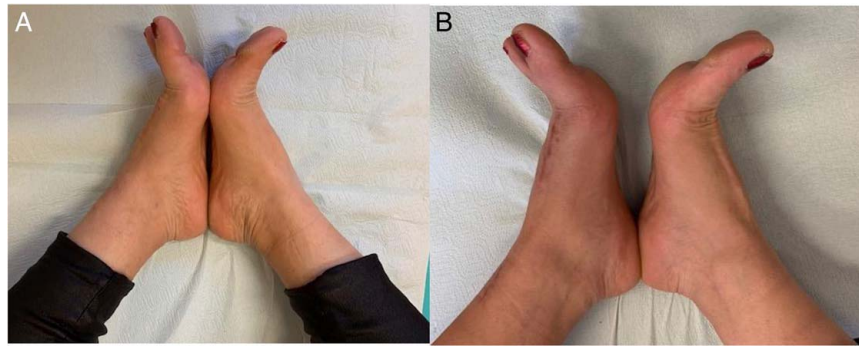

FIGURE 8. At 6 weeks, active MTP joint dorsiflexion was 42 degrees on the operative foot and 60 degrees on the contralateral foot (A), improving to 50 degrees on the operative foot and remaining 60 degrees on the contralateral foot at 3 months (B).

improve tendon gliding. However, our gap was 3 cm shorter. Compared with reconstructions using autografts, allografts, or synthetic materials, which could result in a bulky repair site, our technique provides a more anatomic restoration with minimal tendon thickening at the repair zone. Compared with graft-based reconstructions, our method provides a more anatomic repair with minimal thickening at the repair site.

Although not performed in this case, a whole-leg MRI is now part of our recommended work-up for chronic EHL ruptures, as fatty degeneration may occur as early as 6 weeks after injury. This imaging was not obtained at the time due to under-recognition of its relevance.[19]

This technique may not be suitable in cases with advanced fatty degeneration of the EHL muscle or poor tendon quality. Tension adjustment can be challenging and must be performed carefully with the ankle held in a neutral position to avoid over-lengthening or insufficient tension. Moreover, this procedure was applied to a single patient, and further cases are needed to assess its reproducibility and long-term outcomes. Postoperative mobilization relied on a custom-made dynamic splint provided by our occupational therapy department, which may not be readily available in all centers.

Research trends indicate that early mobilization therapy is crucial for tendon healing and function.[20] Early mobilization promotes tendon healing with less adhesion formation, which is more prevalent with prolonged immobilization. In contrast to current literature, which suggests a 3-week immobilization period in a non-weight-bearing cast followed by passive mobilization therapy and advancement to active mobilization against resistance,[8,12] we allowed immediate full weight-bearing in a cast and started mobilizing the hallux after 2 weeks in a passive and active manner, as described above.

TABLE 1. Results at 6-week and 3-month follow-up

Follow-up	ROM	AOFAS (/100)	FAAM activities of daily living subscale (/84)	FAAM sports subscale (/12)	EQ-5D
6 weeks	42-0-40	77	75	N/A	0.73
3 months	50-0-40	90	83	12	0.8

CONCLUSION

The utilization of a Z-lengthening plasty of the EHL tendon proximal to the superior extensor retinaculum serves as an alternative technique for the anatomic restoration of tendon length and function in cases where the length of the gap does not allow end-to-end suture. This approach seems to be safe, and cost-effective when addressing EHL ruptures where primary repair is unattainable. It obviates the requirement for allograft reconstruction and mitigates the secondary morbidities and dysfunction potentially associated with tendon transfer procedures. Early mobilization therapy is a crucial component in the rehabilitation process of the repaired tendon.

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