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Local Autograft and Strong Pulvertaft Fixation Technique for Reconstruction of a Rupture of the Extensor Hallucis Longus Tendon: A Case Report

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ABSTRACT

There are different treatment options for extensor hallucis longus injuries. For primary repair, the end-to-end suture is recommended. The treatment of reruptures or tendon defects is challenging, and a wide range of procedures have been used in this regard, including primary and secondary repairs with and without auto- and allografts. To overcome the disadvantages of second-site morbidity and to achieve high primary stability, we demonstrate a technique using a local tendon graft in combination with a strong Pulvertaft suture technique in a case of rerupture of the extensor hallucis longus tendon.

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Extensor hallucis longus (EHL) injuries are commonly caused by laceration of the dorsum of the foot. Diagnosis is often missed at the first medical consultation (1). There are some reports of spontaneous closed EHL ruptures caused by repeated stress during sports such as soccer, taekwon do, and kickboxing; caused by wearing special shoes such as hiking and ski boots (2–8); or as a complication after ankle (4,9) or forefoot (10–13) surgery. Although the true incidence of EHL rupture or laceration is unknown, the largest reported series of muscle and tendon disruptions of the extremities (1014 cases) detected 16 cases (1.6%) of EHL ruptures (14).

In the available literature about treatment options surgical repair is consistently recommended (1,10,15,16). Surgical treatment can be performed by end-to-end repair, reconstruction with allo- or autograft, or local tendon transfer. When there is no significant retraction and tendon ends can be reapproximated, as in an acute rupture or laceration, most surgeons perform end-to-end repair (1,10,15). In case of delayed repair or rerupture, when end-to-end suture is not possible, a tendon graft may be necessary to bridge the gap between tendon ends. Allografts, autografts, or local tendon material can be used for reconstruction of the EHL tendon. Transplantation of semitendinosus tendon autograft is a commonly used technique (2,8–10). Other options are fascia lata allograft (11), gracilis

tendon autograft (17), palmaris longus tendon autograft (15), split peroneus longus tendon autograft (18), and local tendon transplantation or transfer such as extensor digitorum V (3), extensor hallucis brevis (19), and extensor digitorum longus II (1,16,20). At the end of surgery, the big toe is fixed in slight hyperextension with either cast alone (1,2,16) or Kirschner wire (K-wire) transfixation of the interphalangeal joint (10,15). Postoperative management after reconstruction of EHL tendon with graft material consists of cast immobilization and non-weightbearing for 4 to 7 weeks (1,2,8,10,15,16).

Some case reports and reviews exist, but evidence is lacking and there is no consensus for the best treatment of EHL defects or reruptures when end-to-end repair is not possible. In hand surgery, tendon ruptures are common and extensively studied. For secondary reconstructions, especially for the extensor pollicis longus tendon, in which a tendon graft is necessary, a free transfer of the extensor digitorum communis II (EDC II) tendon is an often-used surgical technique (21). We used the advantages of this local autograft and transferred it to foot surgery in combination with a strong suture technique, namely the Pulvertaft suture, for a rerupture of the EHL tendon. We present an innovative treatment option for reruptures or chronic ruptures of the EHL tendon.

Case Report

A 32-year-old patient suffered from a laceration of the EHL when the dorsum of the foot was cut by a shattered bottle. He presented with dropping of the big toe and inability to actively extend the hallux. Tenorrhaphy was performed on the day of admission by end-to-end repair

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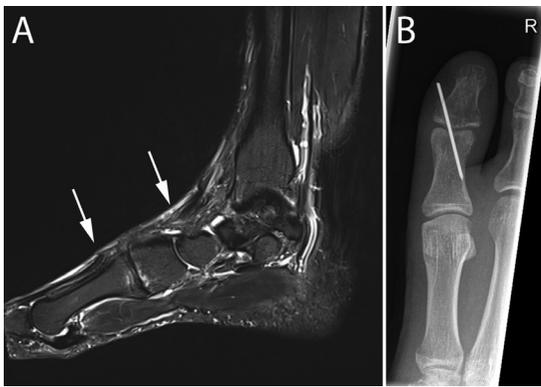


Fig. 1. Preoperative magnetic resonance imaging (MRI) and postoperative radiograph. (A) MRI confirmed the rupture with gap formation. The arrows mark the tendon stumps. (B) Temporary interphalangeal joint fixation of the big toe by Kirschner wire.

using a Kessler suture (3-0 PDS; Ethicon; Johnson & Johnson) and a peripheral simple locking suture (5-0 PDS; Johnson & Johnson). The postoperative treatment protocol encompassed a cast in neutral position for 6 weeks, limited weightbearing, and nicotine withdrawal. Wound healing was undisturbed, and the cast was removed after 6 weeks. Despite the instruction not to engage in vigorous sports, the patient suffered a sports injury and presented 8 weeks after initial repair again with a dropping big toe. Magnetic resonance imaging confirmed a rupture of the suture and the healing EHL tendon, with a gap of 25 mm between the tendon ends (Fig. 1A). Because of dropping of the big toe, the patient had difficulty walking barefoot and putting on shoes. Therefore, he desired the revision with reconstruction of the tendon and complied with restrictive postoperative treatment.

Surgical repair began via the same approach as in the first operation, whereby the incision at the medial dorsum of the foot was extended in both directions. The proximal end of the tendon was retracted under the retinaculum extensorum inferius, and the distal end was frayed. A z-shaped incision of the retinaculum was conducted, and the proximal EHL tendon was detected. After mobilization of both stumps, a tendon dehiscence of 25 mm was exhibited. The tendon sheath was luckily adequate, and the old suture material was removed from the tendon stumps. The EDC tendon of the second toe was harvested between the retinaculum extensorum inferius and proximal to the metatarsophalangeal II joint. This tendon graft was used to bridge the defect. Fixation of the graft was done by weaved Pulvertaft suture technique (22). The tendon graft was threaded through the recipient tendon 5 times at each site. The weaves were fixed by separate stitches (3-0 PDS; Ethicon; Johnson & Johnson) (Fig. 2). To support healing of the tendon and compliance of the patient, the interphalangeal joint was fixed in a slight hyperextension with a 1.6-mm K-wire for 6 weeks (Fig. 1B). For better tension of the second toe, a tenodesis of the distal stump of the tendon of the extensor digitorum III was performed. At the end of the operation, the retinaculum extensorum inferius was reconstructed (Fig. 2D), and the tendon sheath of the EHL was closed as far as possible. After layered wound closure and application of a sterile bandage, a short leg cast was applied in neutral position with plantar support of the big toe.

Additional immobilization by cast and limited weightbearing completed the treatment protocol. K-wire removal was performed after 6 weeks, and physiotherapy was started. There were no further complications such as infection, delayed wound healing, or rerupture. In the recent follow-up examination, 13 months after reconstruction, the patient showed a good clinical result. There was no painful scar formation, and the EHL tendon was palpable and visible with normal tension. A slight dropping of the second toe was visible but did not affect walking or standing (Fig. 3). The patient had no major complaints except for



Fig. 2. Intraoperative situs. (A) Exploration of reruptured extensor hallucis longus (EHL) tendon. Arrows indicate lacerated tendon ends and significant gap formation. (B) Extensor communis longus tendon graft. (C) Tenoplasty of the EHL tendon. The graft was fixed by the weaved Pulvertaft technique. (D) Arrow shows the sutured retinaculum extensorum inferius.

mild pain under the metatarsophalangeal joint while standing or walking for a long time, especially barefoot (Fig. 4), and could perform all activities at work or at home in conventional shoes. Active extension of the big toe was possible and strong. There was a slight reduction of the range of motion compared with the other side. In the metatarsophalangeal joint, an extension of 50° and a flexion of 15° was possible (other site extension/flexion 80°/0°/20°). The interphalangeal joint showed an extension of 0° and a flexion of 55° (other site extension/flexion 0°/0°/60°) (Table). Measured with the hallux metatarsophalangeal-interphalangeal scale (American Orthopaedic Foot and Ankle Society; 23,24), the great toe showed good function, with 85 points (out of 100). Foot and Ankle Ability Measure for daily living and sports (25) showed no difficulties except for walking on even ground without shoes and walking on tiptoe because of pain under the metatarsophalangeal joint, as well as moderate difficulty participating in sports for the desired duration (Fig. 4). At the 1-year follow-up, the patient described the current level of function as nearly normal.

Discussion

EHL tendon injuries are commonly caused by laceration injuries of the dorsum of the foot by sharp items such as broken glass, knives, or



Fig. 3. Clinical results 1 year after reconstruction.

Foot and Ankle Ability Measure (FAAM) – Activities of Daily Living Subscale

	No difficulty	Slight difficulty	Moderate difficulty	Extreme difficulty	Unable to do	N/A
Standing	x					
Walking on even ground	x					
Walking on even ground without shoes				x		
Walking up hills	x					
Walking down hills	x					
Going up stairs	x					
Going down stairs	x					
Walking on uneven ground	x					
Stepping up and down curbs	x					
Squatting	x					
Coming up on your toes				x without shoes		
Walking initially	x					
Walking 5 minutes or less	x					
Walking approximately 10 minutes	x					
Walking 15 minutes or greater	x					
Home responsibilities	x					
Activities of daily living	x					
Personal care	x					
Light to moderate work (standing, walking)	x					
Heavy work (push/pulling, climbing, carrying)	x					
Recreational activities	x					

Foot and Ankle Ability Measure (FAAM) – Sports Subscale

	No difficulty	Slight difficulty	Moderate difficulty	Extreme difficulty	Unable to do	N/A
Running	x					
Jumping	x					
Landing	x					
Starting and stopping quickly	x					
Cutting/lateral movements	x					
Ability to perform activity with your normal technique	x					
Ability to participate in your sport as long as you like			x			

Fig. 4. American Orthopaedic Foot and Ankle Society hallux metatarsophalangeal-interphalangeal scale (26).

Table
Range of motion

Joint	Right			Left		
	Extension	Neutral	Flexion	Extension	Neutral	Flexion
MTP joint	50	0	15	80	0	20
IP joint	0	0	50	0	0	60

Range of motion of the metatarsophalangeal (MTP) and interphalangeal (IP) joint of both big toes.

metal objects. In a case series of 20 patients with acute EHL laceration, 13 of the EHL lacerations were missed at the time of examination in the emergency room (1). Delayed diagnosis can lead to retraction of the tendon ends so that end-to-end suture is not possible and reconstruction is needed. Another reason for retracted tendon ends can be reruptures, as in the present case, or closed ruptures with delayed diagnosis.

Reruptures after primary end-to-end repair are rarely reported. In 2008, Smith and Coughlin (17) published a case of rerupture because of an early fall after primary surgery, and Wong et al (1) showed in their 2014 retrospective review a case of a rerupture 4 weeks after primary repair without mentioning a cause. In the literature, the end-to-end repair with postoperative immobilization in a cast with or without additional K-wire transfixation of the interphalangeal joint is constantly recommended in acute ruptures and lacerations, when tendon ends can be reapproximated (1,10,15,16). Because only a few cases of reruptures are published, this treatment protocol seems to be an adequate option for acute EHL ruptures or lacerations. Nevertheless, the literature regarding the end-to-end suture of EHL ruptures or lacerations does not tell us very much about the suture technique.

An often-used technique is the Krakow suture. In the largest case series of 23 patients with EHL laceration, Wong et al (1) mostly used Krakow suture for primary repair. In only 1 case was Kessler-Tajima suture performed; a nonresorbable suture material (2-0 Ethibond; Ethicon; Johnson & Johnson) was used. There were no reruptures (1). A cadaver study of 10 EHL tendons and 10 tibialis anterior tendons compared modified Krakow and Kessler-Tajima sutures and found that there was a significant difference in gap formation and maximum load failure, and that the Krakow suture is stronger (26). Al-Qattan et al (15) published a case series of 17 patients with EHL laceration. He performed a mattress suture with nonresorbable suture material (3-0 polypropylene), arguing that there is no stress on the suture site until strength is regained because of immobilization after surgery. The postoperative protocol included K-wire transfixation with slight hyperextension of the big toe and cast immobilization for 6 weeks; no reruptures were seen (15).

In the case we describe in this report, primary tendon repair was performed using a Kessler suture with a slow resorbable material (3-0 PDS; Ethicon; Johnson & Johnson). It remains unclear whether a different suture technique such as the Krakow suture or the use of nonabsorbable high-strength suture material would have prevented the rerupture. On the other hand, it is known that the Krakow suture compromises the blood administration of the tendon tissue, which can lead to delayed or failed healing. Wong et al (1) used strong nonresorbable suture material, which holds the ends together even when not fully healed. In the present case, however, the patient suffered from a rerupture as a result of early sports activity ~6 to 7 weeks postoperatively, despite the recommendation of our postoperative treatment protocol. Magnetic resonance imaging showed a wide retraction of the tendon ends (Fig. 2), so a tendon graft was necessary for revision.

Choosing a strategy to reconstruct a defect of the EHL tendon is challenging because of the rarity of the injury and lack of evidence in the literature. Semitendinosus tendon is often used for reconstruction, with good clinical results (10). Other surgeons have used gracilis tendon (17)

or even fascia lata as an allograft (11). Using an allograft is not recommended because of the possibility of foreign body reaction and the risk of disease transmission. With respect to donor site morbidity and the possible need to use semitendinosus tendon or gracilis tendon for other procedures, we prefer local tendon transplantation or transfer options. Different local tendon transplantations have been reported in single cases. Plantaris longus (15) or extensor digitorum V as free tendon grafts (3) or, in a recently published case report, a split peroneus longus free tendon autograft (18) have been used.

We believe that the use of the EDC tendon of the second toe is preferable because of the proximity to the injury site, so there is no need for another incision, thereby minimizing donor site morbidity such as nerve injuries (plantaris longus). The dropping of the second toe can be prevented by a tenodesis of the distal stump of the EDC II to the EDC III, as we performed in the revision.

In their retrospective review, Wong et al (1) presented EHL repair in 23 patients treated from 2005 to 2012. Besides end-to-end repair, when possible, they performed tendon transfer or transplantation of the EDC tendon of the second toe when graft material was needed. In 3 cases, they performed a deep transfer of the EDC II tendon, with good clinical results all in all. Nevertheless, 1 case showed a drop in the interphalangeal joint of the hallux (1). We estimate that a free transfer of the tendon is preferable, because it enables the patient to move the big toe independently and strongly. Wong et al also demonstrated a case of free tendon transplantation of the second toe (1). To our knowledge, it is the only reported case of EHL laceration using extensor digitorum II free tendon transplantation (1). Although hallux stiffness was detected at follow-up examination, the clinical result showed good function, with a Foot and Ankle Ability Measure (25) score and American Orthopaedic Foot and Ankle Society score (25,26) of 100%. The results of our case also showed good clinical function. The active extension of the hallux was restored, and the patient had no limitation in daily activities. There was no adhesion or painful scar formation.

For the first time, we describe a Pulvertaft suture technique to integrate the graft in the tendon ends. This suture technique has strong primary stability without compromising the vitality of the tendon like a Krakow suture, so we believe that it is preferable. Because the rerupture occurred as a result of poor compliance, our postoperative treatment protocol after the revision in this case was cautious. Using this strong Pulvertaft suture technique in patients with good compliance, an early mobilization (after 3 to 4 weeks) would be possible to prevent adhesion and stiffness of the interphalangeal joint.

In conclusion, the free transfer of the EDC tendon of the second toe restores the ability of strong active extension of the hallux, overcoming the disadvantages of second-site surgery. In combination with the strong Pulvertaft suture, it is a suitable option with considerable advantages over other techniques for reconstruction of the EHL tendon, when end-to-end repair is not possible.

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