

Minimally Invasive Percutaneous Tendon Transfer of Extensor Digitorum Longus Second Toe to Extensor Hallucis Longus for Chronic Traumatic Extensor Hallucis Longus Rupture: Technical Description

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ABSTRACT

Aim and background: The management of chronic extensor hallucis longus (EHL) tendon ruptures presents a challenge. While primary suturing is feasible in acute cases, the challenge lies in treating chronic ruptures, as the gap between torn edges widens due to tendon contracture, rendering direct end-to-end repair unviable. Despite the variety of reconstruction methodologies available, a definitive consensus on the optimal technique remains elusive. The innovative approach to minimally invasive percutaneous tendon transfer of the extensor digitorum longus (EDL) from the second toe to the EHL for chronic traumatic EHL rupture holds promise as an alternative solution.

Technique: The goal of surgical treatment was to restore normal gait by realigning the hallux and restoring its capacity to actively extend. For a minimally invasive approach, in this case, four small incisions of size 1 cm were made for the tendinous transfer of the EDL of the second toe to the EHL, making use of a Pulvertaft technique.

Conclusion: By providing a less invasive alternative to traditional reconstructive approaches, this method addresses the limitations of functional compromise associated with common graft or transfer procedures. The described approach not only overcomes the challenges posed by tendon retraction and degeneration but also decreases the risks of donor site morbidity and disease transmission.

Clinical significance: As the field continues to explore advanced surgical techniques, the minimally invasive percutaneous tendon transfer stands out as a valuable addition to the armamentarium of treatments for chronic EHL ruptures.

Keywords: Chronic tendon rupture, Extensor digitorum longus, Extensor hallucis longus, Innovative approach, Minimal invasive.

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INTRODUCTION

The management of chronic extensor hallucis longus (EHL) tendon ruptures presents a challenge due to tendon contracture or degeneration, often necessitating reconstructive surgery involving tendon grafts or transfers. Commonly utilized options include the extensor digitorum longus (EDL) tendon, semitendinosus, gracilis, or peroneus longus for autografts, and the EDL tendon to the second toe for tendon transfer. However, these procedures can be invasive, leading to functional compromise.¹⁻⁶ Injury to the EHL tendon is a relatively infrequent occurrence, often stemming from incidents such as sharp object lacerations on the dorsum of the foot.^{7,8} Notably, factors like diabetes, rheumatoid arthritis, local steroid injections, and even iatrogenic errors during ankle arthroscopy have been associated with such injuries.^{2,9} Surgical intervention becomes essential in averting apical deformities and gait disturbances.^{10,11} While primary suturing is feasible in acute cases, the challenge lies in treating chronic ruptures, as the gap between torn edges widens due to tendon contracture, rendering direct end-to-end repair unviable.¹² To address this, tendon transfer, autografting, or allografting techniques may be employed. However, these approaches carry the risk of donor site morbidity and potential disease transmission concerns.¹³

Despite the variety of reconstruction methodologies available, a definitive consensus on the optimal technique remains elusive. In this context, the innovative approach of minimally invasive

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percutaneous tendon transfer of the EDL from the second toe to the EHL for chronic traumatic EHL rupture holds promise as an alternative solution. This technical description aims to elucidate the steps and benefits of this procedure, offering a less invasive option with the potential to enhance functional outcomes while mitigating donor site complications.

CASE DESCRIPTION

We report the case of a 45-year-old male with a history of injury to his left foot with a tile cutter machine that fell over his foot, leading to a laceration on the dorsum of his foot. The patient was initially managed by a quack in the village. The patient was presented to our hospital 3 months after the injury with a chief complaint of inability to dorsiflex his left great toe and difficulty walking.

Clinical Findings

The patient was unable to voluntarily dorsiflex his great toe (Figs 1 and 2) and attempts at dorsiflexion revealed no EHL tendon that could be felt or seen. The great toe's metatarsophalangeal joint had a passive range of motion limited to 15° of dorsiflexion and 20° of plantarflexion in relation to the plane of the foot. There was a disturbance in his gait as during the third rocker, the ankle plantar flexes over a fixed forefoot about metatarsophalangeal joints, ending in toe-off since the patient is unable to lift his great toe due to the ruptured EHL. This stage of the gait was affected, causing difficulty in the initiation of the swing phase of gait. The rest of his foot examination was normal, and there was no sign of neurologic or vascular damage. Plain radiographs of this joint showed no signs of fracture or dislocation. Ultrasonography

showed discontinuity in EHL and a scar of >5 cm between the two ends.

Surgical Technique and Immobilization

The goal of surgical treatment was to restore normal gait by realigning the hallux and restoring its capacity to actively extend. Options to manage this case were end-to-end repair¹⁰ (could not be done due to wide gap between two cut ends), reconstruction with tendon graft^{1,14} (palmaris longus/plantar), which leads to donor site morbidity and requires incision in areas other than zone of injury, wide exploration of wound and tendon transfer^{1,15,16} leading to big surgical scar and eventually scarring and stiffness. So, it was decided to use a minimally invasive approach for this case (Figs 3 to 8). To execute this procedure, two small longitudinal skin incisions, each about 1 cm in length, were made at the base and head of the second metatarsal. After dissecting through the skin and subcutaneous tissue, the EDL tendon of the second toe was located and confirmed. Subsequently, a minor transverse incision was made at the proximal interphalangeal joint of the second toe, allowing for identification and detachment of the EDL insertion. The freed tendon was then retrieved through the proximal incision. To expose the distal cut end of the EHL tendon, a small longitudinal



Fig. 1: Preoperative deformity showing inability to dorsiflex great toe



Fig. 3: Identification of EHL tendon distal end



Fig. 2: Preoperative deformity showing inability to dorsiflex great toe



Fig. 4: Identification of proximal and distal end of extensor digitorum

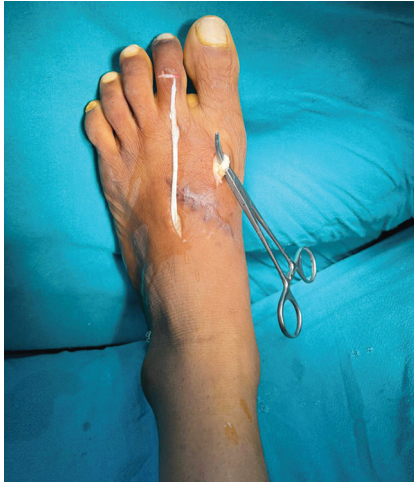


Fig. 5: Release of EDL distal attachment



Fig. 7: After final closure



Fig. 6: Transfer of EDL to EHL using Pulvertaft technique



Fig. 8: Postoperative no toe drop

incision was performed over the shaft of the first metatarsal distal to the scarred area. After pinpointing the distal end of the EHL tendon, a subcutaneous tunnel was fashioned to facilitate the passage of the retrieved second-toe EDL tendon. With the great toe held in maximum dorsiflexion, the two tendons were securely fastened together using the Pulvertaft technique. Postsurgery, the patient's lower limb was immobilized using a below-knee slab and a dynamic splint to ensure proper healing and recovery.

DISCUSSION

The management of chronic EHL tendon ruptures has evolved over the years, reflecting a change in techniques and a variety of techniques followed by various authors (Table 1). The management of chronic EHL tendon ruptures has witnessed a notable evolution, marked by a transition from traditional open surgical techniques to more minimally invasive and innovative approaches. This progression has been driven by a deeper understanding of the complexities of these injuries and a continuous quest for improved functional outcomes and patient experiences.

In the early stages, the management of chronic EHL tendon ruptures posed significant challenges. Grassi et al. introduced autogenous graft repair using a semitendinosus tendon, illustrating

the need for inventive solutions to address complex multifocal ruptures. However, this approach highlighted the limitations of traditional methods in achieving optimal results. Lui et al. ushered in a new era by introducing endoscopic-assisted repair for neglected EHL tendon injuries. This marked a shift toward minimally invasive techniques, focusing on reduced soft tissue trauma, improved cosmetic outcomes, and the preservation of extensor retinacula. This approach not only addressed the technical challenges of repairing chronic ruptures but also aimed to enhance patient recovery.

As the understanding of tendon healing and reconstruction deepened, Matsuda et al. explored the concept of wide-awake surgery with a selective nerve block for repairing chronic EHL tendon ruptures. By reducing the need for general anesthesia, this technique further aligned with the trend toward less invasive procedures and emphasized patient comfort and early mobilization. Bastias et al. presented a dynamic double-loop transfer technique using the EDL tendon of the second toe for EHL reconstruction. This innovative method aimed to overcome issues such as tendon diameter mismatch and reduced resistance, which were common concerns with previous approaches. The emphasis on innovation and adaptability reflected a growing awareness of the limitations of existing techniques.

Table 1: Various authors and their techniques used

<i>Author and year</i>	<i>Journal</i>	<i>Number of cases</i>	<i>Technique used</i>	<i>Results</i>	<i>Additional details</i>
Park et al., ¹ 2003	Case Reports Foot Ankle Int	1	Autogenous graft repair with semitendinosus tendon	Autograft repair using semitendinosus tendon autograft	Reconstruction using semitendinosus tendon autograft
Smith and Coughlin, ¹⁵ 2008	Case Reports Orthopedics	1	Gracilis tendon autograft with joint arthrodesis	Improved function, autograft repair, hallux joint arthrodesis	Reconstruction using gracilis tendon autograft
Lui et al., ¹⁴ 2016	Sports Med Arthroscopic Review	–	Endoscopic-assisted repair	Minimally invasive, good cosmetic results, early mobilization possible	Endoscopic-assisted repair with Krackow locking suture
Bastías et al., ¹⁶ 2019	Foot Ankle Surgery	3	EDL-to-EHL double-loop transfer	Active/passive hallux extension, good AOFAS Score	Dynamic double loop transfer of EDL for EHL reconstruction
Yeo et al., ¹⁷ 2020	Case Reports Medicine	1	Direct reconstruction with interposed scar tissue	Almost asymptomatic, near full range of motion in dorsiflexion, good functional activities	Scar tissue used for reconstruction
Kim et al., ¹² 2021	Int J Environ Res Public Health	–	Reconstruction with interposed scar tissue	An effective technique for neglected rupture, it eliminates donor site morbidity, short operative time	Scar tissue reconstruction is considered effective
Grassi et al., ¹⁰ 2021	Acta Biomed	3	Reconstruction based on injury type	Good functional results, active extension restored, satisfactory outcomes	Surgical treatment based on injury type
Matsuda et al., ¹⁸ 2018	Case Reports J Foot Ankle Surgery	1	Turndown reconstruction with selective nerve block	Improved hallux extension, good functional and subjective scores	Turndown reconstruction using wide-awake surgery
Kurashige, ¹¹ 2019	Case Reports SAGE Open Med Case Rep	1	Double-bundle autograft of extensor hallucis capsularis	Good clinical results, comparable to autografting or allografting, small incision	Reconstruction using double-bundle autograft
Won et al., ¹⁹ 2023	Case Reports Medicina	1	Surgical tenorrhaphy and adhesiolysis	Almost full function of hallux, improved quality of life, good clinical outcomes	Surgical treatment for rupture caused by arthritic adhesion

In a novel twist, Yeo et al. explored the use of interposed scar tissue for reconstructing neglected EHL tendon ruptures. This approach challenged traditional grafting methods and tapped into the potential of scar tissue to facilitate successful tendon healing. Doing so underscored the importance of considering the body's natural healing processes in treatment strategies.

Kim et al. extended this theme by focusing on neglected EHL tendon ruptures caused by arthritic adhesion. Their study shed light on the intricate interplay between underlying conditions and tendon injuries, highlighting the need for personalized interventions that address both aspects.

In recent years, Grassi et al. revisited the topic with a case series examining the treatment of neglected EHL lacerations. This study underscored the significance of tailoring treatment strategies to the location and extent of the injury, emphasizing the importance of patient-specific care. Kurashige introduced the concept of double-bundle autograft transplantation of the extensor hallucis capsularis tendon for chronic EHL tendon rupture. This technique added a new dimension to graft selection, accommodating

the variable dimensions of the graft and further expanding the treatment options. In a final illustration of the evolving landscape, Won et al. reported on a neglected EHL tendon rupture caused by arthritic adhesion. This study provided insights into the potential contribution of underlying conditions to tendon injuries.

In 2023, Fallah et al.²⁰ published a case report of EDL to EHL tendon transfer for delayed EHL tendon rupture following anterior ankle arthroscopy.

CONCLUSION

In conclusion, the innovative technique of minimally invasive percutaneous tendon transfer of the EDL from the second toe to the EHL offers a promising solution for the challenging management of chronic EHL tendon ruptures. By providing a less invasive alternative to traditional reconstructive approaches, this method addresses the limitations of functional compromise associated with common graft or transfer procedures. The described approach not only overcomes the challenges posed by

tendon retraction and degeneration but also decreases the risks of donor site morbidity and disease transmission. As the field continues to explore advanced surgical techniques, minimally invasive percutaneous tendon transfer stands out as a valuable addition to the armamentarium of treatments for chronic EHL ruptures.

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