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Long-Term Outcomes Following EHL Jones Tenosuspension With or Without Peroneus Longus to Brevis Transfer for First Metatarsal Head Ulcers in Patients With Diabetes

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Abstract

Background: Forefoot ulcers, particularly those beneath the first metatarsal head (MTH), are a common and serious complication in patients with diabetes. These ulcers typically result from elevated plantar pressures and loss of protective sensation due to peripheral neuropathy. We conducted this study to evaluate long-term outcomes following EHL Jones tenosuspension, with or without peroneus longus to brevis tendon transfer, in promoting healing of first metatarsal head ulcers in patients with diabetes.

Methods: The retrospective study of 45 patients with diabetes and a plantar first metatarsal head ulcer who underwent extensor hallucis longus (EHL) Jones tenosuspension with or without a concomitant peroneus longus to brevis tendon transfer during the study period. They were divided into 2 groups: group 1 included those who had undergone a modified EHL Jones transfer with peroneus longus to brevis tendon transfer; and group 2, who had undergone a modified EHL Jones transfer only. We studied the long-term wound healing rates from patient records and then did a prospective survey of the post-review period.

Results: In group 1, the mean time for the ulcers to heal was 5.3 weeks, and in group 2, it was 6.2 weeks. One ulcer failed to heal in group 1, and 2 in group 2. In group 1, 1 patient had a recurrence of the first metatarsal head ulcer, while 3 had transfer lesions under the lesser metatarsal heads. In group 2, 1 patient reported a recurrence at the first metatarsal head region and subsequently underwent a peroneus longus to brevis transfer.

Conclusion: We observed high recurrence-free healing rates (approaching 95% at 30 months) following EHL Jones tenosuspension with or without peroneus longus to brevis transfer in patients with diabetes and plantar first metatarsal head ulcers. Although findings are encouraging, the absence of a formal comparator group and the small number of patients treated with the single procedure limit definitive conclusions regarding comparative effectiveness.

Level of Evidence: Level IV, evidence from single descriptive study.

Keywords: diabetic foot, metatarsal head ulcer, EHL Jones, peroneus longus, peroneus brevis, tenosuspension, tendon transfer

Introduction

Diabetic foot ulcerations are the leading cause of nontraumatic lower limb amputation. Forefoot ulcers, particularly those of the first metatarsal head (MTH) ulceration, are common.[10,23] The causes for these ulcers include high plantar pressures combined with loss of protective sensation secondary to diabetic neuropathy. High plantar pressure

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beneath the first MTH are usually secondary to a peroneus longus overdrive, limited joint mobility (LJM) of the first tarsometatarsal joint, extensor hallucis longus (EHL), and flexor hallucis longus (FHL) recruitment secondary to intrinsic muscle weakness.[5,11,21] A prominent sesamoid secondary to plantar fat atrophy can also produce excessive pressure and ulceration under the first metatarsal head.

Literature on the outcomes of tendon balancing for treating plantar first MTH ulcers in the neuropathic foot is scarce. Most of the techniques described for the treatment of plantar MTH ulcers focus on excision of the metatarsal head, which results in an increase in the incidence of transfer ulcers to other areas of the forefoot.[18] Tendon balancing procedures aim to retain the anatomically intact head of the first metatarsal, thereby preserving a crucial load-bearing structure of the forefoot while reducing the focal pressure on the underlying plantar skin and allowing for healing of the ulcer and reducing the recurrence rate.[9]

The distal displacement and atrophy of fat pads beneath the metatarsal heads, flexed metatarsals, an excessively pronated foot, peroneal overdrive, and most importantly, an ankle in equinus due to contracture of the tendoachilles apparatus are all closely related to the development of metatarsal head ulcers.[1,4,6,7] A comprehensive clinical examination aids in identifying the contributing factors, which are then appropriately addressed.

The prominent first metatarsal head is frequently affected by ulceration.[10,13,16,23] Extensor hallucis longus (EHL), flexor hallucis longus (FHL), and peroneus longus are the 3 extrinsic muscles to the first ray, and they are thought to cause digital imbalance, secondary to intrinsic muscle weakness. Long flexor and extensor recruitment causes a "Z collapse" of the digit with plantar prominence at the metatarsophalangeal joints and a resultant raised plantar pressure.[5,21]

Our study aims to add to the outcomes on the use of tendon-balancing procedures to treat plantar diabetic foot ulcers under the first metatarsal head.

Research Methodology

This retrospective study included all patients who underwent a single or double tendon transfer for the management of noninfected plantar first MTH ulcers in patients with diabetes mellitus between January 2015 and June 2021. A total of 45 patients underwent an extensor hallucis longus (EHL) Jones tenosuspension with or without a concomitant peroneus longus to brevis tendon transfer during the study period. They were divided into 2 groups: group 1 included those who had undergone a modified EHL Jones transfer with peroneus longus to brevis tendon transfer, and group 2, who had undergone a modified EHL Jones transfer only. We reviewed all inpatient and outpatient patient records. We collected retrospective data from case records about the patient demographics, comorbidities, ulcer distribution, ulcer characteristics, surgery, wound healing, laboratory parameters, neuropathy, details of any previous treatments, perioperative complications, recurrence of ulcers, and incidence of secondary ulcers. After collecting preliminary data from inpatient and outpatient records, follow-up assessments were conducted through direct in-person interviews or structured telephone interviews. Of the 45 patients, 35 attended an in-person follow-up visit at our outpatient clinic, and 10 patients completed the standardized interview questionnaire via telephone due to logistical constraints. The same questionnaire format was used for in-person and telephone follow-ups to ensure consistency in data collection. During the interview, we collected data on ulcer recurrence, secondary ulcerations, footwear use, function after surgery, and patient satisfaction. We rated patient satisfaction on a scale of 1 to 10, with 1 being very unsatisfied and 10 being highly satisfied. The study's primary outcome was assessing the healing of the index first metatarsal head ulcer, which was defined as the complete epithelialization of the index ulcer. The secondary outcomes were to assess the recurrence rates, which is the reulceration at plantar first metatarsal head region after complete healing of the index ulcer and incidence of transfer ulcers, which are new ulcers occurring in other parts of the foot except because of trauma.

Inclusion criteria included all patients with diabetes and a first-metatarsal head plantar ulcer who underwent surgery in the form of modified EHL Jones tenosuspension with or without peroneus longus to brevis tendon transfer. All included patients had been on various modalities of conservative management offered by their primary care physician for the ulcer before they presented to our institute. None of the patients included in this study had signs or symptoms of a concomitant gastrocsoleus tightness, such as multiple metatarsal head ulcers or an increased forefoot-to-hindfoot pressure ratio greater than 2 in a pedobarogram analysis. Patients with lower limb ischemia (no palpable pedal pulse clinically), a scarred foot with a rigid first tarsometatarsal joint, any other associated plantar ulcer on the foot, infection or osteomyelitis (as evidenced by probe to bone test and radiologic assessment), and those with a weak EHL function (power $< 4/5$) were not offered tendon balancing surgery. Patients with an immobile first metatarsal were offered a combination of peroneus longus to brevis transfer with a plantar apex closing wedge osteotomy of the first metatarsal base. These patients were not included in this study.

Technique

Patients with a noninfected plantar first metatarsal head ulcer with a flexible metatarsal-medial-cuneiform joint were chosen for surgery. A single preoperative dose of intravenous prophylactic antibiotic (cefuroxime 1.5 g) was

administered at the time of anesthesia. The patient was usually given a regional femoral and sciatic nerve block. A thigh tourniquet was applied. In those patients who received a double tendon transfer, the peroneal transfer and Jones transfer were done sequentially. An incision was placed just behind the distal subcutaneous border of the fibula to identify the peroneus longus and brevis tendons beneath the deep fascia in the lateral compartment of the leg. The peroneus longus tendon was identified by its superficial location to the brevis tendon. It was further conformed by the plantar movement of the first ray when the peroneus longus tendon was tugged. The identified longus tendon was sharply divided behind the lateral malleolus as low as possible in the surgical wound. The distal end of the tendon was allowed to retract. The proximal end of the divided peroneus longus tendon was weaved through the peroneus brevis tendon in a Pulvertaft fashion, with the ankle in the neutral position. The deep fascia and skin incisions were repaired.

Attention was then shifted to the dorsum of the forefoot. A long dorsal incision was made from the distal interphalangeal joint of the great toe to the proximal third of the first metatarsal. The EHL tendon was identified, freed, and divided near its distal insertion into the distal phalanx of the great toe. The divided EHL tendon was then passed through a transverse tunnel drilled into the distal third of the first metatarsal. It was sutured to itself, tensioning it to maintain the first metatarsal in maximal dorsiflexion. The interphalangeal joint of the great toe was stabilized in neutral with a cannulated headless compression screw (Figure 1). Incisions were closed over a drain after tourniquet release and hemostasis. The ankle was maintained in slight dorsiflexion with a plaster-of-Paris slab. After suture removal in about 2 weeks, the foot was protected in a total contact cast for 4 weeks, after which the patient was asked to gently weight-bear on the operated foot with a gradual return to normal activities.

Results

A total of 45 feet were operated on in 41 patients (Table 1). Four patients had bilateral foot problems, which were operated sequentially. All the patients were consecutive cases operated by a single surgeon. In group 1, 41 feet underwent modified EHL Jones transfer with peroneus longus to brevis tendon transfer. The mean age of the patients was 38.1 years. The sex distribution revealed 32 males and 9 females. They had a mean duration of diabetes of 5.3 years. Their mean HbA1c at presentation was 8.2. On looking into comorbidities, systemic hypertension was present in 21, coronary artery disease in 14, hypothyroidism in 2, and renal failure in 3 patients. Thirty patients had callosities and 11 had ulcers in the first metatarsal head plantar region at presentation. The mean duration of the ulcer or the callosity was 7.3 months. In group 2, 4 feet underwent modified EHL Jones transfer only. The mean age of the patients was 40.2 years. Sex distribution revealed 3 males and 1 female. The mean duration of diabetes was 5.1 years. On presentation, the mean HbA1c was 7.3. Two patients had systemic hypertension, and 1 had coronary artery disease. Two feet had callosities and 2 had ulcers. The mean duration of the lesion was 12.5 months. All the 45 feet that had been examined had peripheral sensory neuropathy, with loss of protective sensation indicated by the inability to perceive a 10-g monofilament. None of the patients had an invasive infection of the ulcer, and all of them had at least 1 palpable pedal pulse. All these patients had been treated with dressings, and 32 feet had had a trial of footwear prescribed by the primary care physician before presenting to our institute.

Immediate Postoperative Results

In group 1, the mean time for the ulcers to heal was 5.3 weeks, and in group 2, it was 6.2 weeks. One ulcer failed to heal in group 1, and 2 in group 2. None of the patients in both groups had any wound-related complications. The surgical wounds healed primarily, and all the patients were advised preventive offloading with therapeutic footwear per the protocol followed at our institute. For the ulcer that failed to heal in group 1, a follow-up first metatarsal basal plantar apex closing wedge osteotomy was done to dorsiflex the head, and for the 2 group 2 cases, a subsequent peroneus longus to brevis transfer was done. The ulcers healed with these secondary procedures.

Long-term Follow-up

In group 1, the mean follow-up period was 30.7 months and in group 2, it was 26.5 months. All patients were followed up for their long-term results by reviewing outpatient records (Figures 2 and 3). Once preliminary data collection were completed, a follow-up interview was conducted, and the patients were asked to complete a questionnaire. Thirty-five patients attended our follow-up clinic in person and completed the questionnaire. Ten patients could not attend the follow-up clinic because of logistical reasons and were contacted telephonically, and the interview questionnaire was completed.

At the time of the interview, 4 patients in group 1 reported ulcers on the operated foot. One patient had a recurrence of the first metatarsal head ulcer, whereas 3 had transfer lesions under the lesser metatarsal heads. The patient with the recurrent first metatarsal head ulcer underwent a closing wedge dorsiflexion osteotomy of the first ray, after which the ulcer healed. In the 3 patients with lesser metatarsal head transfer ulcers, a distal metatarsal floating osteotomy was done, following which the ulcers healed. In group 2, 1

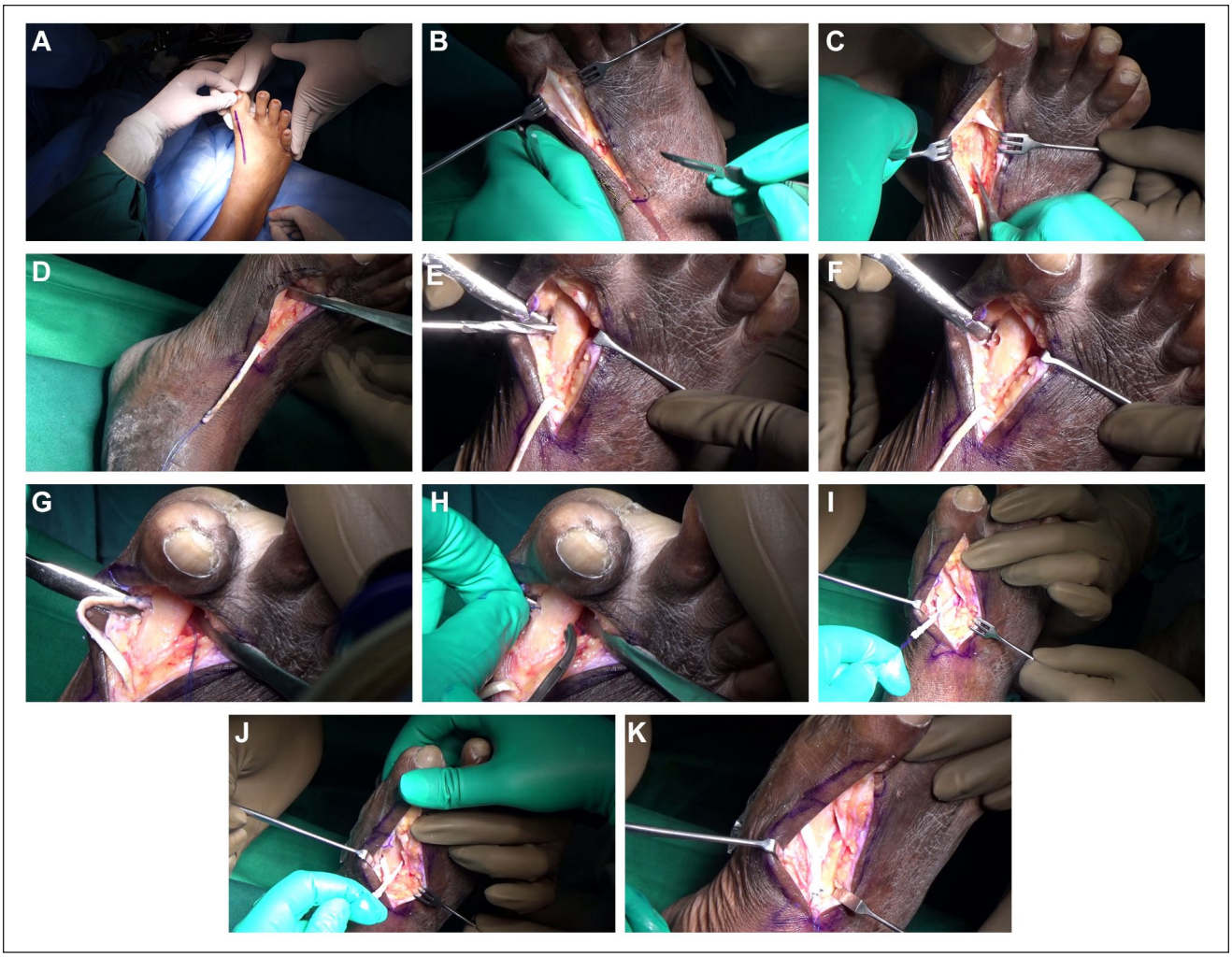

Figure 1. (A) Incision for modified EHL Jones tendon transfer over the dorsum of foot along the first ray has been made. (B) The incisions are deepened, and the EHL tendon is now visualized. (C) The EHL tendon is retracted and the dissection is carried over the distal aspect of first metatarsal, and the periosteum is incised. (D) The EHL tendon is divided at its insertion and a whipstitch using No. 3-0 Prolene suture is done to avoid crushing of EHL tendons while passing through the transosseous tunnel. (E) A drill is made from the medial aspect in the distal aspect of the first metatarsal. (F) Interoperative photograph showing the drill hole made in the first metatarsal. (G, H) Using the whipstitch, the EHL tendon is passed from the medial to the lateral direction through the transosseous tunnel. The whipstitch is passed through the transosseous tunnel and can be held with artery forceps for passing the EHL tendon through the transosseous tunnel without crushing the tendon. (I) The EHL tendon is passed through the transosseous tunnel and is ready to be transferred onto itself with the foot held in a dorsiflexed position. (J) The tensioning of the EHL tendon transfer is shown. (K) The Pulvertaft weave of EHL tendon over itself. EHL, extensor hallucis longus.

patient reported a recurrence at the first metatarsal head region and subsequently underwent a peroneus longus to brevis transfer, after which the ulcer healed without further recurrence. The mean time for the ulcer to recur postsurgery in group 1 was 1.5 years and 2.3 years in group 2. These differences were not tested for statistical significance because of the small size of group 2. One patient in group 1 had reported an amputation of the first ray following a history of trauma and infection.

All patients were prescribed therapeutic footwear, and they did not have any difficulty wearing it. Only 35 patients continued using the therapeutic footwear during the interview, and 20 reported using it indoors. Eight of them had reported vague pain in the great toe for a mean period of 7 months postsurgery, which required medications and footwear modification.

The satisfaction scores in group 1 were 8.1 ± 1.1 (mean $\pm$ SD), and in group 2 were 3.25 ± 2 (mean $\pm$ SD). Overall, 34 patients reported satisfaction with surgery. Patients evaluated in person and those evaluated by telephone interview had comparable outcomes; ulcer healing, recurrence, and satisfaction scores did not differ between

Table 1. Population Characteristics.

Category	Group 1 (EHL Jones and PL to PB Transfer) (n = 41)	Group 2 (EHL Jones Transfer Alone) (n = 4)
Age, y, mean (range)	38.1 (11-61)	40.2 (30-52)
Sex: male/female, n	32/9	3/1
Duration of diabetes, mo, mean (range)	63 (1-144)	61 (3-132)
HbA_{1c}, mean (range)	8.2 (6.5-11)	7.3 (6-10.2)
Callosity/ulcer, n	30/11	2/2
Duration of ulcer/callosity, mo, mean	7.3	12.5
Time to healing of the ulcers, wk, mean (range)	5.3 (3.5-12)	6.2 (4-14)
Follow-up, mo, mean	30.7	26.5
Failure to heal, n	1	2
Ulcer recurrence postsurgery		
First metatarsal head	1	1
Other sites	3	
Time for ulcer to recur postsurgery, y, mean	1.5	2.3
Amputation postsurgery	1	

Abbreviations: EHL, extensor hallucis longus; PB, peroneus brevis; PL, peroneus longus.

Figure 2. (A) Preoperative photograph of a patient showing the first metatarsal head ulcer. (B) Postoperative photograph showing healed first metatarsal head plantar ulcer post modified EHL Jones tendon transfer and peroneus longus to brevis transfer. (C) Scar on the dorsum of foot over the EHL tendon transfer site. EHL, extensor hallucis longus.

Figure 3. (A) Preoperative photograph showing ulcer over the plantar aspect of the first metatarsal head region. (B) Postoperative photograph showing the healed first metatarsal head plantar ulcer post EHL Jones tendon transfer and peroneus longus to brevis transfer. EHL, extensor hallucis longus.

the 2 groups; however, because of the small number of patients evaluated by telephone, no formal statistical analysis was conducted.

Discussion

The first metatarsal head plays a critical role in forefoot load distribution, bearing nearly 50% of the total forefoot load during gait. Accordingly, preservation of the first metatarsal head is a key principle in the treatment of plantar forefoot ulcers in patients with diabetes. In this case series, we observed promising long-term healing outcomes following EHL Jones tenosuspension, most often combined with peroneus longus to brevis transfer. Although most patients in our cohort received the combined procedure, a small subset underwent EHL Jones tenosuspension alone during the early phase of our surgical practice. Given the limited size of this comparator group (n=4), no formal statistical analysis was conducted. Thus, although differences in recurrence and healing time were observed descriptively, the data should not be interpreted as evidence of comparative efficacy between procedures.

The first metatarsal head is crucial for load distribution and bears nearly 50% of the forefoot load.[14] Therefore, the treatment for a first metatarsal head ulcer focuses on preserving it. An EHL Jones tenosuspension involves re-siting the insertion of the EHL from the distal phalanx to the first metatarsal neck. A fusion of the interphalangeal joint of the great toe was added as a later modification of the original operation described in 1916.[15]

Authors in their early surgical practice performed EHL transfer alone for the first metatarsal head ulcers in patients with diabetes mellitus. We had a higher recurrence in this group where the deforming force of the peroneus longus was not corrected in a few initial cases accounting to 50%. Hence, the isolated modified Jones procedure was seldom done by the authors after the initial 4 cases, considering the high incidence of ulcers failing to heal. The combination of a modified Jones procedure, with the addition of a peroneus longus to brevis transfer later, significantly decreased the

pressure in the area and the allowed the ulcers to heal.[12] A cadaver study demonstrated that excessive EHL activity increased the pressure beneath the first metatarsal head due to the deformity of a clawed hallux.[21] The transfer of the EHL alone is insufficient to overcome the active peroneus longus. The findings of our study also concur with the statement.

Currently, a total-contact cast is advocated as the most effective method for healing an index plantar trophic ulcer by lowering local pressure.[3] However, studies that followed up with patients after removal of the total contact cast post healing of the index ulcer revealed recurrence rates ranging from 59% in the first 7 months to 81% at 2 years.[19,22] The need for frequent hospital visits to change casts can be expensive and have high complication rates.[2,20,22] External offloading techniques only have a transient effect on healing while being actively applied and have a high risk of reulceration when discontinued. Furthermore, the usage of the total-contact cast, though often touted as a gold standard, is less than 2% even in developed countries.[24]

In a study by Dayer and Assal,[9] tendon-balancing techniques that aim to reduce plantar pressure was able to promote rapid healing. After surgery, the average recovery time was 4.4 weeks, whereas the average preoperative period of conservative treatment without recovery lasted 16.2 months. Only 1 of the 26 patients who were a part of Dayer and Assal's analysis had a plantar ulcer that did not heal after surgery. During a mean postoperative follow-up of 39.6 months, the ulceration under the first metatarsal head did not return.

Dayer and Assal[9] advocate staged offloading of the first metatarsal head initially by modified Jones transfer, the transfer of FHL, and if equinus contracture is present, the addition of a Strayer-type gastrocsoleus recession. In cases where there is reulceration or persistent ulceration, a peroneus longus to brevis transfer is a second procedure. In group 2 of our study, where isolated modified EHL Jones transfer was done, ulcers that failed to heal were seen in 2 patients, which amounted to 50%, and there was a postsurgery ulcer recurrence in 1 patient. The ulcers failed to heal or had a recurrence in 3 of 4 patients.

Hence, the following 41 patients had a change of surgical protocol with the addition of a peroneus longus to peroneus brevis transfer along with the modified EHL Jones transfer. Healing times appeared shorter in the combined procedure group, but no statistical comparison was performed because of the small sample size. The whole literature on the peroneus longus to brevis transfer for first metatarsal head ulcers is diminutive except for studies by Laborde[8,17] where peroneus longus tendon lengthening has been done, showing good results in the healing of first metatarsal head ulcers. Dayer and Assal[9] have shown satisfactory results in healing first metatarsal head ulcers with their staged treatment protocol that is based on peroneus longus tendon transfer in cases of first metatarsal head ulcers. A study published by Breusch et al[5] in 2000 cautioned that the elevation of the first metatarsal by a combined Jones procedure along with a peroneus transfer would alter the mechanics of the first metatarsophalangeal joint, with a resulting hallux limitus. However, in our subset of the population clinically, we have not seen any evidence of overcorrection during our follow-up except for 3 patients who had transfer ulcers to the minor metatarsal heads.

The study inherently has limitations because of its retrospective design, including the potential for selection bias and limited control over confounding factors. Additionally, the very small size of group 2 (n = 4), treated with EHL Jones tenosuspension alone, precludes any meaningful statistical comparison between the 2 procedure groups. As a result, observed differences in healing time and recurrence should be interpreted as descriptive rather than comparative. Furthermore, the study was conducted at a single center by a single surgical team, which may limit its generalizability.

Conclusion

In our experience, patients with diabetes and plantar first metatarsal head ulcers had high healing rates and low recurrence following EHL Jones tenosuspension, most commonly when combined with peroneus longus to brevis transfer. Although descriptive differences were observed between the combined and single-procedure groups, the small number of patients in the latter limits the ability to draw firm conclusions about comparative effectiveness. These findings are encouraging and suggest that combined tendon transfer may be a promising approach in this population, but further prospective studies with larger sample sizes are needed to confirm its efficacy, durability, and generalizability.

Ethical Approval

Ethical approval for this study was waived by Ganga Hospital Ethical committee as it was a retrospective study and the research involves "not more than minimal risk," and only telephonic review or in-person questionnaire with no intervention on the prospective study part.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. Disclosure forms for all authors are available online.

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References

1. Albert S, Rinoie C. Effect of custom orthotics on plantar pressure distribution in the pronated diabetic foot. *J Foot Ankle Surg*. 1994;33:598-604.
2. Armstrong DG, Lavery LA. Evidence-based options for offloading diabetic wounds. *Clin Podiatr Med Surg*. 1998;15:95-104.
3. Armstrong DG, Nguyen HC, Lavery LA, van Schie CH, Boulton AJ, Harkless LB. Off-loading the diabetic foot wound: a randomized clinical trial. *Diabetes Care*. 2001;24(6):1019-1022.
4. Birke JA, Franks BD, Foto JG. First ray joint limitation, pressure, and ulceration of the first metatarsal head in diabetes mellitus. *Foot Ankle Int*. 1995;16(5):277-284.
5. Breusch SJ, Wenz W, Döderlein L. Function after correction of a clawed great toe by a modified Robert Jones transfer. *J Bone Joint Surg Br*. 2000;82-B(2):250-254. doi:10.1302/0301-620x.82b2.0820250
6. Bus SA, Maas M, Cavanagh PR, Michels RP, Levi M. Plantar fat-pad displacement in neuropathic diabetic patients with toe deformity: a magnetic resonance imaging study. *Diabetes Care*. 2004;27:2376-2381.
7. Caselli A, Pham H, Giurini JM, Armstrong DG, Veves A. The forefoot-to-rearfoot plantar pressure ratio is increased in severe diabetic neuropathy and can predict foot ulceration. *Diabetes Care*. 2002;25:1066-1071.
8. Chlebinskas D, Flatt E. Tendoscopic peroneus longus to brevis tendon transfer technique for flexible cavovarus deformity with medial forefoot overload and chronic diabetic foot ulceration. *Arthrosc Tech*. 2025;14(5):103372. doi:10.1016/j.eats.2024.103372
9. Dayer R, Assal M. Chronic diabetic ulcers under the first metatarsal head treated by staged tendon balancing: a prospective cohort study. *J Bone Joint Surg Br*. 2009;91(4):487-493. doi:10.1302/0301-620X.91B4.21598.
10. Delbridge L, Ctercteko G, Fowler C, Reeve TS, Quesne LPL. The aetiology of diabetic neuropathic ulceration of the foot. *Br J Surg*. 1985;72(1):1-6. doi:10.1002/bjs.1800720102
11. DiDomenico LA, AbdelFattah SR, Hassan MK. Emerging concepts with tendon transfers. *Podiatry Today*. 2018;31(2):26-32.
12. Elias FN, Yuen TJ, Olson SL, Sangeorzan BJ, Ledoux WR. Correction of clawed hallux deformity: comparison of the Jones procedure and FHL transfer in a cadaver model. *Foot Ankle Int*. 2007;28(3):369-376.
13. Faris I. Foot lesions in diabetic patients: pathogenesis and management. *Med J Aust*. 1977;1(17):628-633.
14. Greisberg J. Foot and ankle anatomy and biomechanics. In: DiGiovanni C, Greisberg J, eds. *Core Knowledge in Orthopedics: Foot and Ankle*. Elsevier; 2007:6,7,12,15.
15. Jones R. The soldier's foot and the treatment of common deformities of the foot. *Br Med J*. 1916;1:749-753.
16. Katsilambros N, Tentolouris N, Tsapogas P, Dounis E. *Atlas of the Diabetic Foot*. John Wiley & Sons Ltd; 2003.
17. Laborde JM. Neuropathic plantar forefoot ulcers treated with tendon lengthenings. *Foot Ankle Int*. 2008;29(4):378-384.
18. Molines-Barroso RJ, Lazaro-Martinez JL, Aragon-Sanchez J, Garcia-Morales E, Beneit-Montesinos JV, Alvaro-Afonso FJ. Analysis of transfer lesions in patients who underwent surgery for diabetic foot ulcers located on the plantar aspect of the metatarsal heads. *Diabet Med*. 2013;30(8):973-976. doi:10.1111/dme.12202
19. Mueller MJ, Sinacore DR, Hastings MK, Strube MJ, Johnson JE. Effect of Achilles tendon lengthening on neuropathic plantar ulcers: a randomized clinical trial. *J Bone Joint Surg Am*. 2003;85-A:1436-1445.
20. Nabuurs-Franssen MH, Sleegers R, Huijberts MS, et al. Total contact casting of the diabetic foot in daily practice: a prospective follow-up study. *Diabetes Care*. 2005;28(2):243-247.
21. Olson SL, Ledoux WR, Ching RP, Sangeorzan BJ. Muscular imbalances resulting in a clawed hallux. *Foot Ankle Int*. 2003;24(6):477-485. doi:10.1177/107110070302400605
22. Pua BB, Muhs BE, Maldonado T, Ben-Arie E, Sheehan P, Gagne PJ. Total-contact casting as an adjunct to promote healing of pressure ulcers in amputees. *Vasc Endovascular Surg*. 2006;40(2):135-140.
23. Robertson DD, Mueller MJ, Smith KE, Commean PK, Pilgram T, Johnson JE. Structural changes in the forefoot of individuals with diabetes and a prior plantar ulcer. *J Bone Joint Surg Am*. 2002;84(8):1395-1404. doi:10.2106/00004623-200208000-00016
24. Wu SC, Jensen JL, Weber AK, Robinson DE, Armstrong DG. Use of pressure offloading devices in diabetic foot ulcers do we practice what we preach? *Diabetes Care*. 2008;31(11):2118-2119. doi:10.2337/dc08-0771