Tendon Transfers for Chronic Ulcerations in Diabetics

This can be an effective treatment.

BY TOMMY HO, DPM AND JOHN M. GIURINI, DPM

Introduction

Peripheral neuropathy has been identified as a major underlying cause of diabetic foot disease as the majority of ulcerations are neuropathic in nature. Hyperglycemic-induced metabolic abnormalities have been identified as the primary cause of diabetic neuropathy.[1]

Chronic elevations of glucose (i.e. poor control) result in conversion of glucose to advanced glycation end products (AGES).[2,3] Accumulation of these sugar products damages nerves, not only resulting in loss of sensation but also loss of innervation to motor nerves.

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With loss of innervation and muscle function, tendon imbalances can occur resulting in anatomic foot deformities.[4] Over time, this loss of tendon function results in loss of tendon elasticity and eventual creation of abnormal bony prominences and pressure points which are the precursor to ulcerations.[2,4,5,6] This pathway to ulceration is well cited in the literature regarding the effect of contractures of the Achilles tendon or gastroc-soleus complex.[2,3,5,7]

Treatment of foot ulcers with either a tendoAchilles lengthening (TAL) or gastrocnemius recession has good support in the literature, both for healing ulcers and preventing recurrence.[8] According to Laborde, et al., 90% of ulcers healed after tendon lengthening compared to good wound care (31%) or total contact cast (80%).[9-11] While there is sufficient evidence in the literature to advocate for Achilles tendon lengthening as an adjunct to most bone and joint procedures in limb salvage surgery, there are few reports to make the same recommendation of tendon transfers for chronic non-healing ulcerations, either as an adjunct or in isolation.

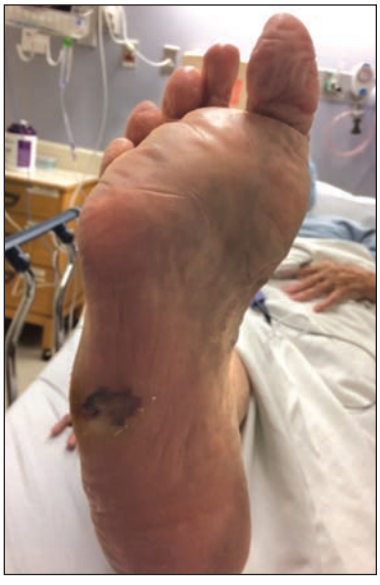

Figure 1: Pre-operative reducible varus position resulted in lateral ulceration at base of 5th metatarsal. Attempts at conservative management failed.

Principles of Tendon Transfers

The goals of tendon transfers are to improve motor power where weakness and imbalance exist, eliminate deforming forces, and to provide better stability. Tendon transfers involve redistribution of power and not the creation of power as they are transferred from lesser to more important functions such that overall function and balance is improved.

When it is decided to perform a tendon transfer, there are certain basic principles that should be used as a guide:

1) Tendons should pass unimpeded through a healthy bed of tissue. Therefore, local tissues need to be thoroughly evaluated and deemed absent from inflammation, edema, and scar.

2) Tendon transfers cannot overcome a fixed deformity. Therefore, joints must show a sensible range of passive motion. If there is a structural or contracture deformity, this must be corrected prior to or concurrent with tendon transplantation.

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3) Selecting the suitable tendon or tendons is crucial to ensure there is sufficient power in the remaining muscles to provide adequate function. Before harvesting a tendon, the strength grade of the tendon should be 4+ or greater as there is a loss of one strength grade following transplantation. While choosing muscles that function within the same phase of gait is ideal, it is neither essential nor absolute. According to Close, transfers of tendons in the same phase of gait will rapidly regain their activity in 7-8 weeks.[12]

4) Surgeons should choose a tendon that can be re-routed in a straight line between the muscle's origin and the tendon's new insertion. One should avoid introducing more than one change of direction. The more this line of pull is altered, the greater the demand on the muscle for adaptability and greater the potential loss of function.

5) Lastly, providing adequate muscle-tendon tension with fixation is one of the most critical aspects of the procedure. Post-operative tendon tension should resemble pre-operative resting tension. However, it is best to err on the tendon being too tight rather than too loose. Too little tension will cause the muscle to shorten, leaving a loss of power.

It is important to remember these principles when evaluating a patient for a tendon transfer procedure. Although abidance to these principles does not promise success, disregarding them invites failure.

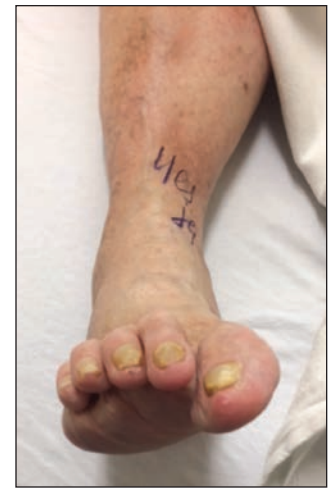

Figure 2: Pre-operative resting position shows varus position of the forefoot.

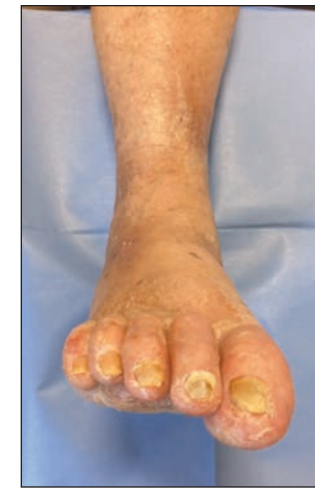

Figure 3: Post-operatively foot is in anatomic resting position.

Case Reports:

Case Report #1:

A 76-year-old female with type 2 diabetes, peripheral neuropathy and a history of foot ulcerations presented for surgical correction of a right foot deformity. Examination of her right foot showed a Wagner grade 1 ulceration on the plantar lateral aspect over the styloid process of the fifth metatarsal (Figure 1). Her biomechanical and musculoskeletal examination showed an inversion deformity of the foot that was completely reducible with passive range of motion (Figure 2). She had 5+/5 strength of the inverters, dorsiflexors and plantarflexors, but 0/4 strength of her peroneus brevis muscle. As a result, her right foot remained inverted on stance and throughout gait. Conservative treatment consisted of off-loading with a total contact cast (TCC), orthotic devices, and double upright brace. She failed all conservative measures.

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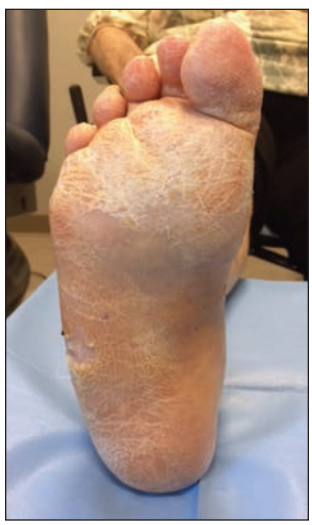

Figure 4: Varus deformity has been corrected and ulcer resolved following transfer of anterior tibial tendon to the lateral cuneiform.

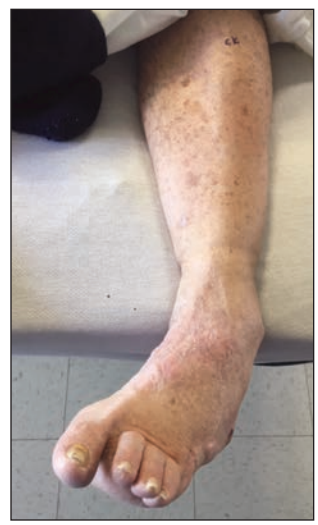

Figure 5: Severe equinovarus deformity of foot resulting in a plantar lateral ulceration.

Therefore, surgical correction of the inversion deformity was selected. Due to the fact she had a non-functioning peroneus brevis muscle, fully functioning tibialis anterior tendon, and a deformity that was fully reducible with passive motion, it was decided to perform a transfer of her tibialis anterior tendon laterally to the lateral cuneiform with a bio-absorbable interference screw. Adjunctive procedures performed included a TAL, tibialis posterior tendon lengthening, and exostectomy of the 5th metatarsal.

Post-operatively the patient was maintained non-weight-bearing in a below-the-knee fiberglass cast for 6 weeks, followed by increasing degrees of weight-bearing in a controlled ankle motion (CAM) boot. She returned to her diabetic shoes with orthotic devices at 12 weeks. She maintained the corrected position of her foot and fully healed ulceration (Figures 3 and 4).

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Case Report #2:

A 77-year-old male with type 2 diabetes, hypertension, and a previous right partial 5th ray amputation developed a chronic non-healing ulcer on the plantar lateral aspect of the 5th met base. The patient was treated with conservative therapy for up to 7 months with failure to heal the ulceration. On physical examination, the patient had a cavus foot type and a reducible varus deformity of the heel due to loss of the peroneal brevis tendon (Figure 5). He also had contracture of the Achilles tendon with a full thickness ulceration at the base of the 5th metatarsal. Due to the dynamic muscle imbalance of the tibialis posterior tendon over the peroneus brevis tendon, the surgical procedure chosen was a transfer of the tibialis posterior tendon through the interosseous ligament into the cuboid with bone anchor and TAL (Figures 6 and 7).

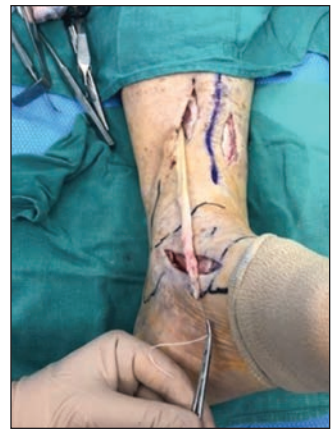

Figure 6: Posterior tibial tendon being harvested through two small incisions and prepared for transfer laterally.

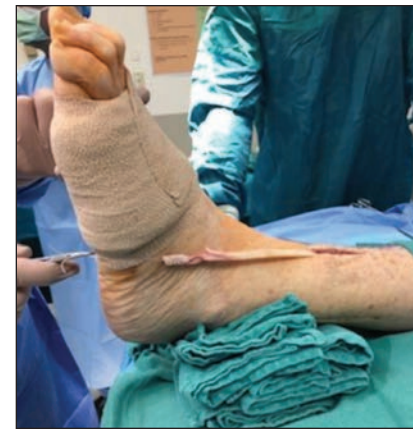

Figure 7: Tendon will be routed subcutaneously and transferred laterally into the cuboid.

A transfer of the tibialis anterior tendon was considered. However due to the severity of the Achilles contracture, it was preferred to avoid any loss of dorsiflexory strength. Standard post-operative protocol as stated above was followed (Figures 8 and 9). Several weeks later, corrected foot position was maintained and the wound has significantly reduced in size.

Literature Review

In Laborde's retrospective study of neuropathic ulcers, patients with sub-5th metatarsal ulcers were treated with gastroc-soleus recession (Strayer procedure) and intramuscular lengthening of the tibialis posterior tendon.[11] The incision was made medial and proximal to the ankle at the musculotendinous junction to allow elongation on full pronation of the foot. Full weight-bearing was allowed immediately in a walking boot for 6 weeks. Lateral column ulcerations all went on to heal in this study. However, this study lacked a control group and included a heterogeneity of ulcer locations.

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A larger study with only lateral column ulcerations with tibialis posterior tendon lengthening as well as transfers would make for a stronger study. This study, however, provides evidence that tendon balancing and transfer procedures deserve greater consideration in the surgical treatment of neuropathic diabetic foot ulcers.

Kim, et al. proposed a novel surgical procedure where the tibialis anterior tendon and tendo-Achilles are lengthened for the treatment of equinovarus deformities.[13] Kim emphasizes, among other things, the importance of assessing the integrity of the tibialis anterior tendon and whether the deformity is reducible. In Kim's procedure, the tibialis anterior tendon is lengthened in a sagittal Z fashion utilizing a 4-5cm skin incision while not lengthening the tibialis posterior tendon as opposed to Laborde's technique.[11]

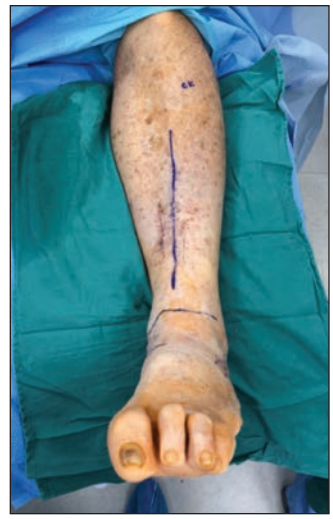

Figure 8: Tendon transfer complete and varus deformity has been corrected.

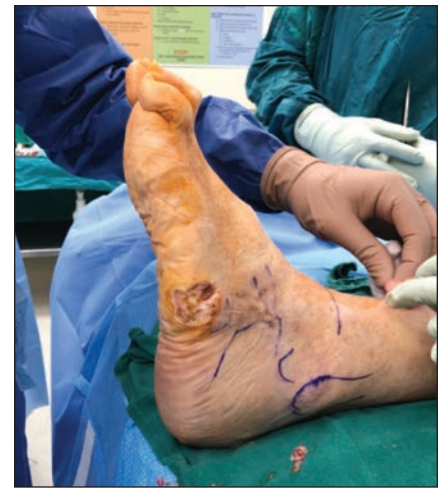

Figure 9: Tendon transfer is complete. Note that ulcer is now located directly laterally showing degree of deformity correction attained.

Kim believes that lengthening of the tibialis anterior is adequate without compromising the dorsiflexion component, which may be desired in patients with a severe equinus deformity and without diminishing the inversion strength of the tib-

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ialis posterior tendon. Also, the dissection for the tibialis anterior tendon transfer (TATT) is less extensive, decreasing possible complications compared to the tibialis posterior tendon transfer (TPTT).[14] Kim theorizes that an isolated deformity can be addressed with an isolated procedure such as the TATT.

Transmetatarsal Amputations

Transmetatarsal amputations (TMA) are routinely performed in the setting of diabetic foot complications, namely infections or chronic ulceration from peripheral neuropathy. The ultimate goal of a TMA is to manufacture a stable plantigrade, shoeable/braceable foot that allows for ambulation while limiting the risks of new or recurrent wounds. However, they are not without risk of complications. An equinovarus deformity commonly occurs. This leads to excess pressure on the plantar lateral stump, causing an ulceration.

Lengthening the Achilles tendon has been shown to aid in reducing the lateral plantar pressures associated with TMAs. Barry, et al. performed 33 TAL procedures in 31 patients who had TMAs.[15] Results demonstrated a 91% healing rate and no recurrent ulcerations at 27 months. However, LaFontaine, et al. found a high rate of recurrence and new ulcers after performing TAL in patients with TMAs. They concluded that the surgeon may need to address additional intrinsic/extrinsic factors.[16]

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Split Tibialis Anterior Transfer (STATT)

Researchers have also looked at other tendon balancing procedures. A split tibialis anterior transfer (STATT) is effective in addressing forefoot varus deformities after midfoot amputations according to Schweinberger MH, et al. A peroneus brevis to peroneus longus transfer creates plantarflexion of the first ray resulting in eversion of the forefoot, thus correcting the varus deformity of the TMA.[17] Another technique discussed by Roukis, is transferring the flexor hallux longus (FHL) to the 1st metatarsal and the extensor digitorum longus (EDL) to the 4th metatarsal.[18] The FHL transfer corrects the varus deformity through plantarflexion of the 1st ray, while the EDL concomitantly everts the lateral column. This procedure along with a TAL can effectively balance the foot.

Drop Foot

A drop foot is an abnormal neuromuscular disorder affecting a patient's capacity to dorsiflex at the ankle, which could lead to ulcerations. Biomechanically, this disrupts normal gait by preventing the patient from having enough clearance during toe off to enter the swing phase, which can cause mechanical falls. Often patients compensate by a circumvented gait or high steppage gait. Drop foot can occur from a variety of etiologies such as direct injury to the common peroneal nerve, polio, intraneural tumor, or Charcot-Marie-Tooth (CMT). Tendon transfer for drop foot should be considered as a surgical treatment of such deformity. The tibialis posterior tendon transfer has long been considered the treatment of choice for drop foot as first described by Watkins, et al.[19] The proposed transfer is done through the interosseous membrane and anchored to the lateral cuneiform.

A combination of tibialis posterior, tibialis anterior, peroneus brevis, and peroneal longus tendon transfers known as the Bridle procedure is another option.

Split Tibialis Posterior Tendon Transfer

The most common modification to this procedure is the split tibialis posterior tendon transfer. The tendon is bisected longitudinally at the myo-tendinous junction, and the lateral half is anastomosed to the peroneus brevis proximal to its insertion.[14] This procedure balances the rear foot and restores dorsiflexory motion without diminishing tibialis posterior tendon function. A combination of tibialis posterior, tibialis anterior, peroneus brevis, and peroneal longus tendon transfers known as the Bridle procedure is another option. The tibialis posterior tendon is anchored into the intermediate cuneiform while the peroneus longus is anastomosed to the peroneus brevis proximally. Both the peroneus brevis and the peroneus longus are subsequently sutured to the tibialis anterior tendon, proximally to balance inversion, eversion, dorsiflexion and plantarflexion.[20-22]

For lower extremity pathologies that result in a reducible varus deformity associated with isolated muscle weakness most notably the peroneus brevis, the tibialis anterior tendon can be transferred into the lateral cuneiform to relieve excess pressure to the lateral column.[14] If adequate reduction is not achieved after transfer, the tibialis posterior tendon can be lengthened to reduce a remaining de-

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forming force.[9-11] An alternative procedure for addressing isolated muscle weakness is the split tibialis anterior tendon transfer.

This procedure corrects the inversion deformity without sacrificing dorsiflexion.[14] Lastly, an anastomosis of the peroneus longus to the peroneus brevis at the level of the lateral ankle or near the insertion of the fifth metatarsal base is another option. This procedure allows the peroneus longus to provide functional assistance to the peroneus brevis by lifting the lateral column while maintaining its own plantarflexory mechanism on the 1st ray.[14,23]

The overall goal of any surgery for recalcitrant ulcers is to off-load the area of excess pressure and allow the ulcer to heal. Tendon transfers are powerful techniques and appear to be effective treatments for diabetic foot ulcerations.

Conclusions

The overall goal of any surgery for recalcitrant ulcers is to off-load the area of excess pressure and allow the ulcer to heal. Tendon transfers are powerful techniques and appear to be effective treatments for diabetic foot ulcerations. They have a relatively low complication rate and do not preclude performing osseous procedures in the future should they fail. Therefore, they should not be overlooked for the treatment of recalcitrant ulcerations. However, no surgical procedure is without risk. In order to maximize results, a thorough evaluation of the patient and adherence to the principles of tendon transfers need to be followed. **PM**

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