

# TOTAL TIBIALIS ANTERIOR TENDON TRANSFERS IN HIGH RISK DIABETIC PATIENTS WITH TRANSMETATARSAL AMPUTATIONS

*Natalie T. Hua, DPM*

*Naren Patel, DPM*

*Eric J. Lew, DPM*

*Nicholas A. Giovinco, DPM*

## INTRODUCTION

Nearly 21 million Americans have diabetes mellitus, and that number is expected to double by 2030 according to the Centers for Disease Control and Prevention. Of the 21 million diabetics in this country, about 15-20% will have foot ulcers (1). These diabetic foot complications are the leading cause of amputations worldwide (2).

Transmetatarsal amputation (TMA) has been performed for over 50 years as a limb salvage procedure. It has been generally believed to be a better choice than transtibial amputation and has decreased energy expenditure compared to a transtibial amputation (2,3). The goal of TMA is to allow for a plantigrade foot to ambulate on, prevent reulceration and ease of proper shoeing and bracing. However, it comes with its own pitfalls and complications. TMA healing rates reported in the literature have high variability ranges (from

39-93.3%) depending on the study (3, 4). Pollard et al in 101 cases of TMA showed that 32% of TMA cases required further proximal amputations, and the 30-day mortality rate was 1.98%. These results reveal the need to evaluate factors that contribute to postoperative complications following a TMA. Loss of the extensor digitorum longus and extensor hallucis longus and possibly the peroneus brevis cause the anterior tibialis, posterior tibial, and gastrocnemius muscle complex to be unopposed. The sequelae of which may lead to an equino-adductovarus deformity (Figure 1). This deformity predisposes the foot to the development of a plantar-lateral lesion or ulceration on the TMA residuum (Figure 2). Postoperative complications following a TMA have been attributed to persistent uncontrolled diabetes mellitus, equinovarus deformities, and inadequate shoe gear and bracing.



Figure 1. Equinovarus deformity after proximal transmetatarsal amputation.



Figure 2. Plantar-lateral ulceration as a consequence of equinovarus deformity.

There have been few procedures described in the literature to improve equinovarus deformities after a TMA. These corrective procedures include tendon balancing through tendo-Achilles lengthening, peroneus brevis and peroneus longus tenodesis, peroneus brevis transfers, and split tibialis anterior tendon transfers (5-10). The authors describe their experience with a novel technique of utilizing a total tibialis anterior tendon transfer to improve an equino-adductovarus deformity after a TMA and assist with dorsiflexion and eversion of the foot and ankle during the swing phase of the gait cycle. This also lends to a more rectus and plantigrade alignment of the foot and ankle through midstance and propulsive phases. The authors believe this method provides a more powerful dorsiflexory and eversion force while decreasing pressure to a problematic lateral amputation residuum. This method in conjunction with a percutaneous tendo-Achilles lengthening yields favorable outcomes after a complicated TMA.

## SURGICAL TECHNIQUES

The patient is placed in the supine position, prepped and draped in the usual sterile manner. The patient undergoes general anesthesia with a local or regional anesthetic block. Hemostasis is accomplished with a pneumatic thigh tourniquet. Palpation and identification of the tibialis anterior tendon insertion is identified on the medial cuneiform. An incision is made extending from the inferior medial border of the medial cuneiform towards the anterior medial ankle gutter (Figure 3). The tendon is then reflected from its insertion. Another incision is made proximally along

the ankle joint approximately 5-7 cm above the retinaculum, first sharply, then bluntly. Utilizing Mayo scissors, the deep crural fascia is then incised, exposing the tendon sheath anterior to the tibialis tendon (Figure 4).

The tendon is then pulled through its tendon sheath through the proximal incision (Figure 5). An interlocking whip stitch is applied to the tendon stump with #2-0 fiberwire to facilitate later retrieval of the tendon. A laterally-placed incision is made overlying the lateral cuneiform or



Figure 3. Tibialis anterior tendon is identified at its insertion.



Figure 4. Tibialis anterior tendon is seen at the proximal incision at the ankle level.



Figure 5. Tibialis anterior tendon is pulled through its tendon sheath through the proximal incision.

cuboid, first sharply, then bluntly, exposing subcutaneous tissue to the periosteal level. Utilizing a Freer under mini fluoroscopy guidance, the lateral cuneiform or cuboid is identified. A suture anchor is then placed into the structure first by placing a pilot hole, followed by insertion of the anchor (Figure 6). It is important to test the integrity of anchor placement and ensure adequate seating before proceeding to suturing the transferred tendon. The tendon is then passed through the tendon sheath using a tendon passer, taking extra care to make sure it is deep to the extensor retinaculum (Figure 7). Using the #2-0 fiberwire suture of the anchor, the tendon is then secured and hand-tied with the tendon under physiologic tension and the foot and ankle in rectus alignment (Figure 8).

A tenodesis to the extensor digitorum longus may also be performed to reinforce the transfer. An alternative to using a suture anchor is utilization of an absorbable interference screw for tendon fixation and to aid in intra-operative tensioning. This is also placed under physiologic tension with the foot in 90° of dorsiflexion. Adequate range of motion should be noted intra-operatively. The wounds are then flushed with copious amounts of sterile normal saline. The deep fascia is closed with running interlocking #3-0 vicryl, followed by closure of the subcutaneous layer with #4-0 vicryl in an inverted interrupted fashion. The skin is closed with #3-0 nylon in horizontal mattress or simple interrupted suture fashion.

Often a concomitant equinus contracture is found along with the adductovarus deformity. This can be addressed with a gastro-soleal muscle group lengthening. A gastrocnemius recession may be performed. However, the authors prefer a percutaneous tendo-Achilles lengthening.

This adjunctive procedure is performed prior to the tendon transfer in order to aid in reduction of the deformity and for positioning and tensioning of the tendon prior to fixation. This is performed through 3 small stab incisions with either an #11 or #15 blade. The incisions are placed vertically and midline to the Achilles tendon. The blade is turned 90° and approximately one-third of the tendon is cut. Care is taken to avoid perforation of the skin while sectioning the tendon. The first incision is made 3 cm proximal to the Achilles insertion and laterally, followed by a medially



Figure 6A. Suture anchor is placed in the lateral cuneiform.



Figure 6B.



Figure 6C.



Figure 7. The tibialis anterior tendon is passed through the tendon sheath using a tendon passer, taking extra care to make sure it is deep to the extensor retinaculum.



Figure 8A. Using the #2-0 fiberwire suture of the anchor, the transferred tibialis anterior tendon is secured and hand-tied with the tendon under physiologic tension and the foot and ankle in rectus alignment.



Figure 8B. The transferred tibialis anterior tendon is secured.

placed stab incision about 2 cm proximal to the first one and a laterally placed stab incision 2 cm proximal to the second one. After these incisions are made, the foot is taken through a controlled, low-velocity dorsiflexory moment to elongate the Achilles tendon. At this step, it is important to avoid over lengthening the tendon to prevent calcaneal gait. These small incisions are closed with #3-0 nylon in a simple interrupted fashion. The foot is dressed with xeroform, a dry sterile dressing, followed by a well-padded posterior splint with the foot and ankle in rectus alignment.

## CASE REPORTS

### Case 1.

A 65-year-old male presented with a past medical history of diabetes mellitus Type 2, with peripheral neuropathy, hypertension, and hepatitis A. He presented emergently with gas gangrene of the right foot. The patient reported that he had a longstanding infection, which was treated unsuccessfully at another care facility abroad. Radiographs taken on initial presentation revealed osteomyelitis of the right second toe middle and distal phalanges and right third toe distal and middle phalanges. Extensive soft tissue gas was visualized in the plantar and dorsal soft tissue of the forefoot, extending to the midfoot in the plantar soft tissues. There was high suspicion of a deep tissue abscess (Figure 9). Due to the severity of the infection, he underwent a TMA amputation (Figure 10).

Three weeks later, he underwent revisional TMA and additional resection and debridement. Delayed primary closure was performed with stabilization of the plantar flap with several Kirshner wires (Figure 11). The amputation site



Figure 9A. Radiographs of initial presentation with osteomyelitis of the second toe middle and distal phalanges and right third toe distal and middle phalanges. Extensive soft tissue gas in the plantar dorsal soft tissues of the right forefoot, extending to the midfoot in the plantar soft tissues, in keeping with abscess.



Figure 9B.



Figure 9C.



Figure 10A. Initial view after transmetatarsal amputation.



Figure 10B.



Figure 11A. View after revisional transmetatarsal amputation with use of SALSA Spike Kirschner wires.



Figure 11B.

healed uneventfully. Postoperatively, the patient developed an equino-adductovarus contracture. Upon ambulation and advancement of weightbearing activity, he developed a chronic ulceration at the plantar distal lateral aspect of the amputation residuum. Four months later, he presented with an acutely infected foot (Figure 12). Radiographs revealed interval bone resorption about the base of the metatarsals, with focal involvement at the fifth and second metatarsal bases for which osteomyelitis was considered (Figure 12).

A magnetic resonance image was performed and confirmed subjacent osteomyelitis of the fifth metatarsal stump with nonenhancing areas of necrotic bone in the fifth metatarsal stump. The patient underwent debridement of the prominent metatarsal stumps and application of negative pressure wound therapy (NPWT) to assist with wound bed granulation (Figure 13). Five weeks later, the patient underwent a total tibialis anterior tendon transfer and percutaneous tendo-Achilles lengthening



Figure 11C.



Figure 12B.



Figure 12A. Possible osteomyelitis fifth and second metatarsal bases.



Figure 12C.

with the techniques described above. The patient received appropriate culture-driven antibiotic therapy throughout the course of treatment.

Postoperatively, the patient was placed in a well-padded posterior splint for one week. His activity was non-weightbearing (NWB) in a short leg cast for an additional four weeks. Once the incisions are healed about a month after the tibialis tendon transfer, the patient's foot is in

more rectus position on active dorsiflexion (Figure 14). The patient was fitted with a custom insert with toe-filler, solid ankle-foot-orthotic, and depth inlay shoe with rocker-bottom outsole modifications. These bracing and protective modalities enabled the patient to maintain a relatively high activity level, meaningful employment, and remission of ulcer recurrence.



Figure 13A. View after debridement of prominent metatarsal stumps and application of negative pressure wound therapy to assist with wound granulation.



Figure 13B.



Figure 13C.



Figure 14. Postoperative image showing the foot is in more rectus position on active dorsiflexion.

**Case 2.**

A case is presented of a 40-year-old male with diabetes mellitus and peripheral neuropathy. He was admitted for management of an acutely infected left foot ulceration with underlying osteomyelitis. The patient presented with an associated adductovarus and equinus foot deformity following a previously performed transmetatarsal amputation. Adequate debridement and resection of the osteomyelitis, which involved the fifth metatarsal residuum

was performed. The resultant soft tissue deficit was addressed with NPWT. He also received appropriate culture-driven antibiotic therapy. Once the infection was suppressed and eradicated, the deformity was corrected with muscle tendon balancing procedures, including a percutaneous Tendo-Achilles lengthening and total tibialis anterior tendon transfer (Figure 15).

The procedure was performed as detailed above. Postoperative wound care consisted of NPWT inciting





Figure 15A. 40-year-old male who has had a transmetatarsal amputation presented with an equinovarus foot deformity and resultant ulceration to the lateral residuum.



Figure 15B. The foot and ankle are in rectus alignment 8 weeks after percutaneous Achilles tendon lengthening and total anterior tibialis tendon transfer.



Figure 16. A plantar-lateral ulceration that had undergone negative pressure wound therapy following operative resection of osteomyelitis involving the fifth metatarsal.

granulation tissue to fill the wound bed (Figure 16). A split-thickness skin graft procedure was then performed to obtain complete closure of the wound (Figure 17). This was performed two weeks after the muscle-tendon balancing procedures.

Postoperatively, the patient was kept NWB in a well-padded posterior splint for four weeks. He was advanced to weightbearing as tolerated in a walking fracture boot for an additional two weeks. To maintain remission of any ulcer recurrence, the patient was fitted with a prescriptive custom diabetic foot insert with a toe filler, depth in-lay shoe with an out-sole rocker bottom modification.



Figure 17. Appearance 1 week after application of split-thickness skin graft, which went on to fully incorporate.

## DISCUSSION

The cases presented highlight the utility of a total tibialis anterior tendon transfer in conjunction with tendo-Achilles lengthening to address equinovarus foot deformity in high risk diabetic patients who underwent TMAs. Total tibialis anterior tendon transfer can be used for aggressive correction of equinovarus deformity. The authors have been performing these procedures in patients that undergo TMA and have equinovarus deformity and have seen good results without any ulcer recurrences. Surgical principles and technique are presented. Long term goals of this treatment include improvement of foot and ankle alignment for functional bracing, and preventing ulcer recurrence.

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