CHAPTER **48**

# CONCEPTS OF TRANSMETATARSAL AMPUTATIONS

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## INTRODUCTION

Transmetatarsal amputations have long been advocated as an alternative to below-the-knee amputations in the salvage of both the threatened ischemic and neuropathic limbs. First performed in 1855 for trench foot, studies dating back as early as 1949 report satisfactory results in over 67% (current literature 77%) of patients undergoing transmetatarsal amputations for the treatment of gangrene and neurotrophic ulcerations. Modernized techniques in vascular evaluation, diagnostic imaging, and patient-tailored surgical techniques have contributed to increasing success in limb salvage and functionality in this patient population. With over 18 million estimated diabetics within the US and approximately 20% of adults over the age of 55 affected by peripheral arterial disease, this procedure continues to become increasingly invaluable in the prevention of major lower extremity amputations.

Transmetatarsal amputation indications were initially centered primarily on gangrene and neurotrophic ulcerations. Current indications, however, have expanded to include forefoot infection with or without osteomyelitis, traumatic injuries, forefoot deformity, and malignancy.

In the presence of gangrene, when well-demarcated and limited to the digits or distal most forefoot, transmetatarsal amputation can be a viable option to below-the-knee amputation even with involvement of the plantar soft tissues. Both traditional and open transmetatarsal amputations have been performed with success, although often requiring skin grafts and local wound care measures with prolonged recovery periods. Regardless of the possibility of an extended recovery time, the high morbidity associated with below-the-knee amputations (reportedly 25-53% over a five-year period) is nevertheless avoided or delayed.

Approximately 15% of diabetics will develop at least 1 ulceration within their lifetime. With an annual health care cost of over 10 billion dollars within the US, the financial impact is substantial. With an ever increasing diabetic population, the incidence of foot wounds with subsequent soft tissue and potential bone infection are likely to increase. With patient compliance struggles and various, often inadequate methods of offloading, wound healing is commonly prolonged and complicated by osteomyelitis. While initial amputations may be limited to digits or isolated rays, especially in the case of osteomyelitis, these attempts at conservative limb salvage often lead to increased instability and vulnerability of the foot for recurrent ulceration. Thus, early consideration for transmetatarsal amputations in these patients is imperative.

## EVALUATION

Evaluation of all patients must include a thorough and detailed medical history, especially for known risk factors for lower extremity ulceration (i.e., diabetes, PAD/PVD, ESRD, and neuropathy). Consideration must also be given to patient goals, including preoperative and postoperative ambulatory status. A comprehensive lower extremity examination with careful attention paid to all segments is a must for the podiatric physician. Given the poorer outcomes for patients with lower extremity ischemia, careful evaluation of dorsalis pedis, posterior tibial, popliteal, and femoral arterial flow is an appropriate starting point. Evaluation of the skin texture, temperature, and color will also provide insight as to suspected vascular compromise. Special attention must also be paid to the neurologic evaluation including protective and vibratory sensations and proprioception as early recognized deficits here will identify patients that may benefit from protective shoe gear. Also, examining the skin for any callosities, macerations, or open lesions is crucial. Finally, any plantar fat pad atrophy, osseous prominences, structural or residual foot deformities should be noted. Equally important is the identification of the patient’s foot type (pes planus versus pes cavus) and any equinus deformity, as these can affect the longevity and function of the amputated foot.

In evaluating patients for transmetatarsal amputations, plain film radiographs are a valuable tool in evaluating the presence of soft tissue gas, establishing the appropriate amputation level, as well as to rule out an overt osteolysis. Radiographs also provide evidence as to the status of the tibialis anterior and peroneus brevis tendons, especially in patients with previous osseous resections. If present, any radiographic changes concerning osteomyelitis should be further investigated using a nuclear imaging study or magnetic resonance imaging to provide a more definitive guide as to the level of osseous involvement. This can often be difficult to obtain in a patient population that often demonstrate some degree of renal compromise. Important consideration should also be given to the vascularly-impaired patient. Although noninvasive, vascular studies have proved often questionable predictors of distal foot healing potentials, the identification of macrocirculatory occlusive disease may lead to potential bypass for revascularization of the affected limb. In 2005, Stone et al found that patients with an ankle systolic >100 mm Hg and biphasic Doppler signals for pedal arteries had a 79% positive predictive value for healing following transmetatarsal amputation. This value dropped to 55% with an ankle systolic <100 mm Hg and monophasic signals. In the same study, Stone noted a 91% healing rate following transmetatarsal amputations when toe pressures were greater than 50mm Hg. This decreased dramatically to 50% healing in those patient with toe pressures <50%. These findings were supported by Anthony et al, who stated that while toe pressures are found to be superior to ABIs for predicting healing following transmetatarsal amputations, there was no correlation with avoiding more proximal amputation or revisions.

## INCISIONAL APPROACH

Early incisional approaches in transmetatarsal amputations provided the current model standard that we use a slight variation of today. The standard transmetatarsal approach involves a fish-mouth type incision with a longer plantar flap to allow for wound closure. Although the incisional approach has been generally standardized, more recent attention to biomechanical concerns and plastic surgical closure techniques have lead to improved success with primary wound closure. In current literature, amputations can be closed primarily or delayed, if concern for infection persists. Delayed primary closure with and without the use of split-thickness skin grafts or artificial graft material is common. Initially described as resections at the level of the metatarsal necks, current metatarsal resection levels vary greatly, depending on the degree of osseous involvement and the viability of the surrounding soft tissues available for wound closure. Another wide variation exists in the plane of osseous resection (perpendicular to the weightbearing surface versus a range of 15 to 45 degrees angulated dorsal distal to plantar proximal). Also discussed in the literature is the concept of beveling the lateral aspect of the fifth metatarsal and the medial aspect of the first metatarsal to avoid potential prominences, that could become problematic with shoe gear. Little research exists comparing the results of osseous resection techniques with reulceration following transmetatarsal amputation, as there are multiple factors that commonly lead to failure.

## OUTCOMES

Outcomes of transmetatarsal amputations are unpredictable even in the hands of the most skilled and experienced surgeons. Multiple factors, including patient and surgeon variables, lead to complications and increased morbidity. Key matters for the surgeon to address are identification of pre-existing foot deformities and equinus, which can often be overcome by tendon transfers and Achilles lengthening procedures and recognition of osseous regrowth or inadequate resections, which should be promptly addressed to avoid complication.

Regardless of diligent preoperative planning, issues of patient non-compliance and comorbidities can sometimes overwhelm the healing process. Stone et al found that 50% of dialysis patients undergoing transmetatarsal amputation progressed to major lower extremity amputations versus 20% of those without renal failure. In another study, Anthony et al found a greater propensity toward BKA and AKA amputations following TMAs in patients with non-insulin dependent diabetes. This was theorized as due to the less tightly controlled glycemic levels in this group as compared with those on insulin. Finally, a study performed by Mwipatayi et al demonstrated a significantly higher failure rate following TMAs in diabetics with extensive tibial-peroneal occlusive arterial disease versus diabetics with femoral-popliteal disease and good crural runoff. These findings were further supported by Anthony et al, adding that prior ipsilateral vascular procedures led to a 14-fold greater risk of failure to remain ambulatory following transmetarsal amputation, leading to increased morbidity.

## CASE DISCUSSIONS

### Case 1

The first case involves a 52-year-old diabetic male with a 1 year history of a chronic ulceration and osteomyelitis of the second metatarsal (Figures 1A-1D). After failed conservative care including intravenous antibiotics, the patient underwent a proximal transmetatarsal amputation and percutaneous triple hemisection tendoachilles lengthening. This patient had undergone total contact casting prior to surgery to aid in ulceration healing and obviate the need for extensive skin flaps for wound closure.

With the patient in a supine position, attention was directed to the posterior aspect of the leg where a transverse linear stab incision was performed along the medial margin of the tendoachilles 2-centimeters proximal to its insertion. Next a transverse tenotomy was performed through the medial one-half of the tendoachilles. Attention was then directed to the lateral aspect of the tendoachilles, where a transverse linear stab incision was performed 4-centimeters proximal to the insertion. Next the lateral one half of the tendoachilles was sharply transected. Attention was then directed to the medial aspect of the tendoachilles 6-centimeters proximal to the insertion where a third transverse linear stab incision was made. The medial one half of the tendoachilles was sharply transected. The foot was then dorsiflexed, allowing for slide lengthening of the tendon.

Our surgical approach for the transmetatarsal amputation began with careful surgical incision planning which involved a transverse linear incision performed at the midfoot just distal to the tarso-metatarsal joints (Figure 1E). The medial and lateral ends of the transverse incision were extended in a linear longitudinal fashion in line with the long axis of the first and fifth metatarsals respectively. The incisions were subsequently extended distally in a curvilinear fashion along the distal plantar forefoot. The incisions were deepened to the level of bone.

Attention was directed to the flexor and extensor tendons, which were transected as far proximally as possible. Using a periosteal elevator, the capsular and periosteal tissues were carefully dissected free from their underlying osseous attachments. Utilizing a sagittal bone saw, a dorsal to plantar through-and-through osteotomy was created along the metatarsal bases with care taken to maintain the metatarsal parabola. Each osteotomy was performed at approximately 15 degree angulation in the sagittal plane from dorsal-distal to plantar-proximal with care taken to avoid a plantar shelf (Figure 1F). The osteotomies of the first and fifth metatarsals were beveled approximately 10 degrees in the transverse plane. At this time, all remaining soft tissue structures were dissected free and the forefoot was disarticulated at the level of the osteotomies (Figure 1G).

The tibialis anterior tendon was then sutured to the dorsal aspect of the first metatarsal base. The peroneus longus tendon was identified and was sutured to the plantar capsular structures at the first metatarsal-cuneiform joint. The wound was then flushed with copious amounts of normal sterile saline in a pulse lavage fashion. Any remaining pathologic soft tissues were subsequently resected. The plantar flap was then rotated dorsally to join the dorsal flap and was reapproximated using 2-0 and 3-0 nylon suture (Rigure 1H). A TLS drain was inserted and a bulky sterile dressing with a posterior splint was applied.

The patient healed without complication, and was fitted with custom high topped boots with custom molded inserts (Figure 1I). The patient initially complained of some instability, but now ambulates without a walking aid and is an avid golfer. The patient is 2 years post-surgery and has had no reulceration (Figures 1J-IL).


Figure 1A. Preoperative lateral radiograph.


Figure 1B. Preoperative AP radiograph.


Figure 1C. Preoperative medial oblique radiograph.


Figure 1D. Preoperative photograph showing subsecond metatarsal ulceration.


Figure 1E. Incision planning for transmetatasal amputation.


Figure 1F. Osteotomies were performed in an angulated fashion with care taken to maintain the metatarsal parabola.


Figure 1G. Disarticulated forefoot.


Figure 1H. Primary closure with the use of closed suction drain.


Figure 1I. Healed transmetatarsal amputation with custom molded plastizote insert.


Figure 1J. Lateral radiograph at 1 year postoperative.


Figure 1K. AP radiograph at 1 year postoperative.


Figure 1L. Medial oblique radiograph at 1 year postoperative.

## Case 2

The next case involves a 65-year-old male with diabetes and PVD with an acutely infected right foot followed a non-healing laceration for the past two months (Figure 2A). The patient was treated with intravenous antibiotics, however, residual infection was noted on MRI in the fourth and fifth metatarsals. Once the soft tissue infection resolved, a TMA was performed (Figure 2B). No tendoachilles lengthening was performed as no preoperative equinus deformity was idenitified. The patient healed well and was given a pressure relief shoe as temporary shoe gear as he had multiple contralateral ulcerations with limited mobility. The patient is currently 10 months postoperative and has no recurrent breakdown of the transmetatarsal amputation (Figure 2C).

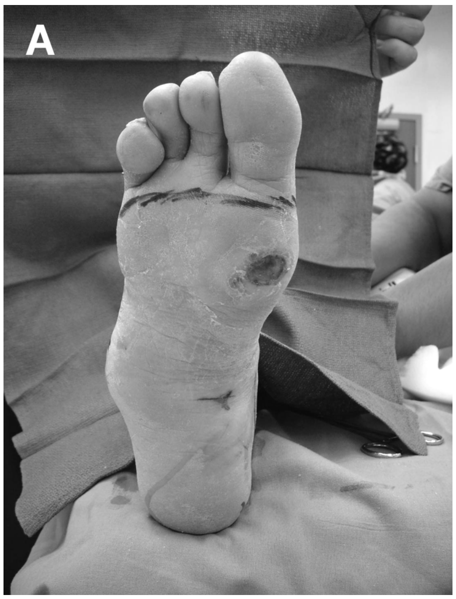


Figure 2A. Preoperative incisional planning.

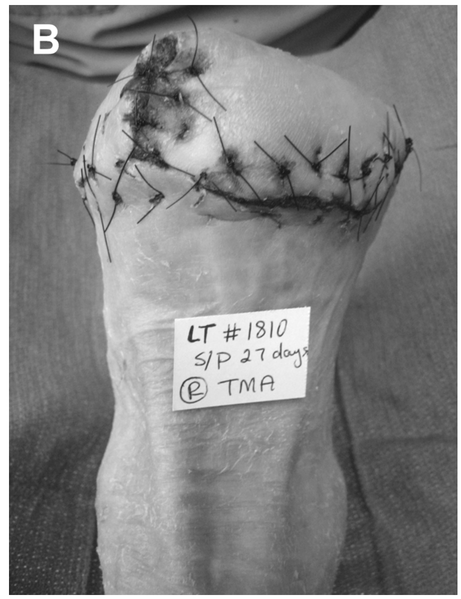


Figure 2B. Incision modification allowing for excision of submet 1 ulceration with primary closure.


Figure 2C. AP view of healed transmetatarsal amputation.

**Case 3**

The final case is a 54-year-old diabetic male with multiple previous digital and partial ray resections, now with a non-healing ulceration subsecond metatarsal head (Figure 3A). The patient underwent a TMA with percutaneous triple hemisection tendoachilles lengthening 5 months ago, with ulcer excision and "creative" primary wound closure (Figure 3B). Healing was prolonged by 6 weeks due to superficial incision dehiscence and poor patient compliance (Figure 3C). The patient healed with local wound care and has returned to full activities with custom shoe gear and reports minimal functional limitations and no reulcerations.

In summary, the transmetatarsal amputation remains a valuable tool for the treatment of the threatened diabetic, ischemic, and traumatized foot. In the evaluation and treatment of TMAs, one must consider the effect of equinus, muscle tendon balance, and foot type. Early intervention and careful preoperative planning can lead to successful limb preservation with increased survivability and functionality for these patients.


Figure 3A. Preoperative photograph with incision planning.


Figure 3B. Intraoperative photograph demonstrating plantar flap.

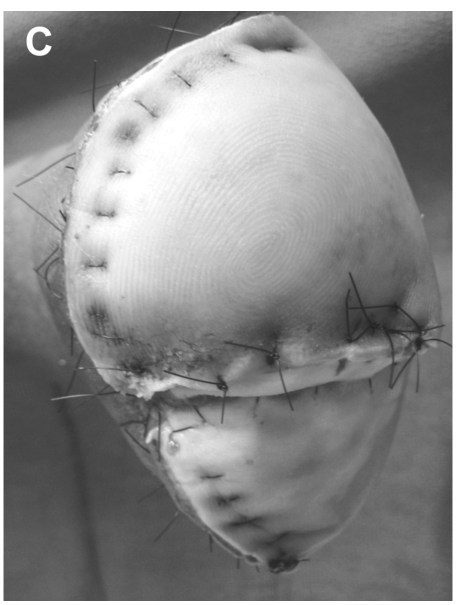


Figure 3C. One-week postoperative view. Note peri-incisional maceration and dehiscence.

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