Foot Sparing Amputations in Diabetics

These techniques can save limbs and lives.

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The recent global Sars-CoV-2 (COVID-19) pandemic significantly disrupted the delivery of healthcare across many disciplines and the effect of the pandemic has had an especially detrimental effect on people with diabetes-related foot complications, resulting in more amputations. Major level lower extremity amputation is one of the most feared complications of diabetes. One study found that patients with diabetes and lower extremity complications were more in fear of major amputation than death.[1] In many cases, major level amputations can result in loss of function, decline in quality of life, and even death. A recent systemic review and meta-analysis revealed mortality rates of 27.3 percent within one year, and 63.2 percent within five years after a major level amputation.[2] The pandemic serves as a reminder of the grave consequences of diabetes related foot complications.

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There are, however, certain situations in which a more definitive, proximal amputation may provide better overall outcomes compared with drawn-out attempts at limb salvage. Although the five-year mortality is worse in those with more proximal, high-level amputations, it has been suggested that proximal amputation may be a surrogate marker for frailty rather than a causative factor for death. Major level amputations are performed more proximal to infection, necrosis, inflammation, and edema and may be less likely to require subsequent surgery. Some studies suggest that if patients are able to rehabilitate with a functional prosthesis, they do well, even with a more proximal amputation.[3]

Figure 1: Non-functional amputation

However, a recent study analyzing function after 206 patients underwent 256 major level lower extremity amputations found that only 46.1 percent of these amputees are ambulatory at one year.[4] The inability to ambulate can result in significant deconditioning, musculoskeletal atrophy and a decline in overall health.

Despite the fact that patients undergoing minor, foot-sparing amputations are more likely to require multiple surgeries (for repeat debridement and irrigation), as compared to those undergoing major level amputations, patients strongly prefer to save their foot. Given the grave physical and psychological costs, every effort should be made to avoid a major limb loss situation. This article will review the most commonly performed partial foot amputations and offer surgical techniques and pearls to optimize patient outcomes.

Selecting the appropriate level to amputate is critical for success, but determining the optimal level is not always obvious. In patients presenting with a rapidly progressing limb-threatening infection, emergency surgery is indicated to control infection. Any delay in treatment will result in further tissue loss and may ultimately lead to a more proximal major level limb amputation.

A properly performed surgical debridement consists of exposing all infected tissue planes, exploring tendon sheaths, and removing infected and necrotic soft tissue and bone. The extent of infection and/or necrosis will always dictate the initial extent of debridement. When properly performed, surgical debridement removes devascularized tissue and necrotic material, eliminates dead space, and reduces wound contamination.[5] Deep tissue cultures (bone

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and soft tissue) using clean, unused instrumentation are obtained for microbiology cultures.

In some instances, an appropriately performed debridement will result in a non-functional, partial foot amputation (Figure 1). Once intraoperative cultures ascertain elimination of infection, and the clinical presentation of the patient and local tissues have improved, one may shift their focus to the functional status of the foot. Therefore, during the initial surgical debridement or incision and drainage, it is important to remember that removal of all infected and/or necrotic bone and soft-tissue is the priority and debridement overrides thoughts of reconstruction and function.

After the infection is resolved, the final amputation level is made based on the vascular status of the lower extremity and its potential to heal and function. Vascular assessment is performed through physical findings, noninvasive, and if necessary, invasive studies. If warranted, referral to a vascular specialist is performed for further work-up and possible revascularization to restore blood flow to the foot. Restoring adequate blood flow is essential to allow the surgeon to perform a successful foot sparing amputation.[6]

Attention must also be given to the balance of forces in the foot and recognizing muscle and tendon imbalances. Negating the biomechanics of the foot results in a nonfunctional foot amputation and will lead to further complications. As such, more proximal partial foot amputations (i.e., TMA) are preferred over unbalanced, more distal forefoot amputations. A prudent surgeon will preserve as much of the foot as possible, but will also consider the overall function, and implement appropriate tendon balancing procedures as needed. It is important to understand that residual deformity and/or muscle/tendon imbalances will lead to subsequent deformity, ulceration and higher level re-amputation.

Figure 3A: Digital amputation

Figure 3B: Hallux amputation

Nutritional status is also important to consider for healing capability. A detailed history and physical exam will reveal those patients who are suspected to be mal- or undernourished, and if a referral to a dietician is recommended.

Figure 2: Infected toe ulcer with exposed phalanx

In certain situations (limb-threatening and septic), staged open amputations may be necessary.

General Surgical Principles

One of the first surgeries ever recorded was a below knee amputation. At the time, in 1901, a good surgeon was one who performed the procedure in the shortest time. After the advent of anesthesia, surgeons were able to prioritize surgical technique over speed. Proper technique is mandatory, and the surgeon must adhere to basic principles to reduce the risk of complications in this high risk population. Procedures are generally performed without the use of a tourniquet. This will assist in evaluating the viability of the tissue margins. However, a tourniquet may be applied in case it will be needed and inflated if bleeding becomes extensive.

If a tourniquet it used, it is recommended to deflate before closure to ensure adequate hemostasis and assess the viability of the tissue. Achieving uninfected, viable tissue margins is paramount to achieving optimal wound healing.[3] A tourniquet is contraindicated in patients with vascular compromise and those who underwent recent revascularization. Skin incisions should be made full thickness with minimal undermining. Excessive undermining and rough tissue handling will lead to further tissue loss, wound complications, and re-operation.

In certain situations (limb-threatening and septic), staged open amputations may be necessary. A staged approach allows for post-debridement soft tissue and bone culture and histopathology results to guide the timing of closure.[7] In these situations, negative pressure wound therapy (NPWT) may be used. A clinical trial found the rate of wound healing and granulation tissue formation was faster in the NPWT group compared to the controls (standard moist wound care) after partial diabetic foot amputation. The NPWT group trended toward reduced risk for a subsequent amputation compared to the control.[8] NPWT with

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instillation works well for staged procedures after an initial debridement or partial foot amputation. This technology combines the benefits of NPWT with an automated topical wound solution. Depending on the goals of therapy, a wound cleanser or an antimicrobial may be used.

Hallux and lesser digital amputations are common amputations performed on the foot.

Hallux and Lesser Digital Amputations

Hallux and lesser digital amputations are common amputations performed on the foot. Primary indications include gangrene of the toe or a chronic non-healing wound with osteomyelitis of the phalanges (Figure 2). The skin incision is placed proximal to open ulcerations, infection, and/or gangrene. A plantar flap is preserved, and the bone is resected at a level proximal to infection and where bleeding and normal marrow are noted. If possible, the base of the proximal phalanx is left intact to preserve the flexor mechanism and act as a buttress to prevent transverse migration of the adjacent toe(s) (Figures 3a and 3b).

In cases where the infection extends more proximal, the proximal phalanx is disarticulated at the metatarsophalangeal joint (MTPJ). When this occurs proximal to the first MTPJ, a first ray resection is indicated (amputation of the phalanges and at least part of the first metatarsal) (Figure 4). A racket-type incision with a plantar flap is made circumscribing the hallux and extending proximal along the medial glabrous junction proximal to infection and/or gangrene. The hallux is disarticulated and the metatarsal is cut and is angled from dorsal-distal to plantar-proximal and proximal-medial to distal-lateral to avoid resultant bone prominences.[9]

Figure 4: Hallux gangrene

Central metatarsal resections may result in a biomechanically unstable, cleft foot which is often complicated with a difficult-to heal-wound. A forefoot narrowing technique using a "mini" external fixator may be used to create a more stable forefoot and assist in wound closure (Figure 5).[10]

Figure 5: Forefoot narrowing

Figure 6: Metatarsal parabola, post-TMA

The surgical site is irrigated, and hemostasis is achieved. The wound may be closed, or if there is concern for residual infection, may be left open. This is a good indication for NPWT with or without instillation. Post-operatively, patients are placed in a post-operative shoe or removable walking boot. In some higher-risk situations, a well-padded posterior splint may be applied and patients will remain non-weight-bearing until the first post-operative visit.

Patients are followed weekly and sutures are removed when the incision is healed, often three or four weeks after surgery. It is important to evaluate the residual foot and assess risk for future complications. A prosthetic is often unnecessary after lesser toe amputation, but an accommodative orthotic that provides dispersion of pressure areas should be considered. Custom molded inserts with a Plastizote toe filler placed in extra-depth shoes with a rocker sole may assist in ambulation after a hallux or first ray resection.[11]

Today, TMAs are typically performed in patients with gangrene of the digits, chronic osteomyelitis involving the forefoot, or a non-healing forefoot ulceration after a previously resected first ray.

Re-amputation rates after minor amputations are high.[3] Murdoch, et al. reported on 90 diabetic patients who underwent a hallux or first-ray amputation, and found that 60% required a second amputation.[12] Both the surgeon and the patient must be aware of the high rates of re-amputation after minor amputation, and great efforts should be made to protect the affected and contralateral foot.

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Transmetatarsal Amputation

Transmetatarsal metatarsal amputation (TMA) was first described in 1855 by Bernard and Heute for the treatment of trench foot and in 1946, McKittrick described the procedure for the diabetic foot. Today, TMAs are typically performed in patients with gangrene of the digits, chronic osteomyelitis involving the forefoot, or a non-healing forefoot ulceration after a previously resected first ray.[13]

A skin incision is placed proximal to the relevant pathology. A fish-mouth incision is made preserving a plantar soft tissue flap. All incisions are made full thickness with minimal undermining to preserve the metatarsal arteries in the flaps. The metatarsals are resected proximal to the skin incision, ideally leaving as much metatarsal length as possible to preserve function. However, if not possible, it is critical to at least maintain the metatarsal bases to avoid an equinovarus deformity.

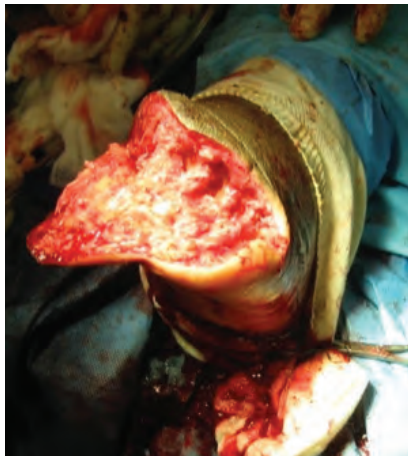

Figure 7: TMA plantar flap

Figure 8: TMA closure

Figure 9: Post TMA equinovarus with ulcer

The metatarsal bones are cut to maintain the parabola and are angled dorsal-distal to plantar-proximal and, in addition, the first and fifth metatarsals are beveled medially and laterally to reduce bony prominences (Figure 6).

The plantar flap is debulked, exposed tendons are excised, and muscular attachments to the flap are preserved (Figure 7). The flap is rotated dorsally and remodeled as needed to allow for primary closure with minimal tension (Figure 8). A closed suction drain may be used if there is concern for hematoma. Ideally, the final suture line will lie on the dorsal aspect of the stump after closure.

An Achilles tendon lengthening procedure (open or percutaneous) or a gastrocnemius recession is often performed at the time of surgery to address a pre-existing or impending ankle equinus deformity and reduce pressure at the distal stump. It is important to identify any other residual deformity and evaluate for muscle-tendon imbalances. The loss of some of the extensor tendons leads to muscle imbalance, and an equinovarus deformity is a commonly reported complication (Figure 9). Additional tendon transfers or other soft tissue procedures may be necessary to address the altered biomechanics. Split tibialis anterior tendon transfer or a peroneous brevis tendon transfer are examples of commonly performed procedures to rebalance the forefoot after TMA.[14]

Figure 10: Post TMA orthotic with filler

A bulky dressing, followed by a well-padded posterior splint, are applied and the residual stump is protected. Patients remain non-weight-bearing until the flap is healed and sutures are removed (usually 3-4 weeks after surgery).

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Patients are then transitioned to a removable walking boot and long-term management will depend on their activity and ambulatory status and if there is any residual foot or ankle deformity. A therapeutic shoe with a custom molded accommodative orthotic with a prosthesis (Plastizote filler) is often prescribed to provide stability and balance (Figure 10). A shoe with a rigid rocker bottom sole may be helpful to assist with ambulation. The surgeon should conduct a falls risk assessment; in patients requiring more control and stability, an ankle foot orthosis (AFO) may be used with an ambulatory assistive device.

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Lisfranc and Chopart's Amputation

The initial level of debridement is dictated by the extent of infection and/or necrosis and when the relevant pathology extends proximally and a TMA is not possible, disarticulation at the tarsometatarsal joint (Lisfranc amputation) or through the midtarsal joint (Chopart's amputation) may be necessary.

These more proximal amputations will result in more pronounced muscle tendon imbalances which will lead to deformity if disregarded. Therefore, soft tissue balancing procedures and tendon transfers are essential and necessary for long-term function and stump viability.

Chopart's amputation leaves only the talus and calcaneus and, as a result, significant rebalancing of the foot is required.

An Achilles tendon lengthening or gastrocnemius recession is performed. If a Chopart's amputation is performed, an Achilles tenotomy or tenectomy is also performed. The peroneal tendons (if uninfected) are preserved and the peroneous longus is anastomosed to the peroneous brevis tendon. If disarticulating at the tarsometatarsal joint, the peroneal tendons can be transferred to the cuboid. Medially, the insertions of the posterior tibialis and tibialis anterior tendons are mostly preserved, but if sacrificed, can be reattached more proximally.

Chopart's amputation leaves only the talus and calcaneus and, as a result, significant rebalancing of the foot is required. If viable, the tibialis anterior tendon is attached to the neck of the talus and the peroneal tendons are secured to the lateral wall of the calcaneus. If there is a concomitant hindfoot or ankle deformity present, a subtalar fusion or a tibiotalocalcaneal fusion may be performed.

Similar to what was described for TMA, the plantar flap is debulked and remodeled as necessary and closed with minimal tension. A closed suction drain may be used if there is concern for hematoma, and is encouraged in patients receiving anticoagulants.

A bulky dressing, followed by a well-padded posterior splint, iare applied and the residual stump is protected. Patients remain non-weight-bearing until the flap is healed and sutures are removed (usually 3-4 weeks after surgery). Patients are then transitioned to a removable walking boot and should remain in an off-loading device until their definitive orthotic and/or brace is available. The choice of the prosthetic device depends upon the level of amputation and the patient's ability to bear weight and ambulate. Patients with a Lisfranc amputation

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are treated similarly to that described for the TMA.

Following a Chopart's amputation, the choice of prosthetic device depends upon the patient's ability to bear weight and ambulate, and there are many options available to optimize functional mobility. Patients are often successfully managed with a custom AFO with an accommodative console with a filler (Figure 11). This brace provides stability to allow for ambulation and prevent falls for most patients. A certified orthotist/prosthetist can assist and advise on appropriate bracing in this difficult patient population.

If more control is required, patients may be fitted for a Charcot Restraint Orthotic Walker (CROW) or a clam-shell orthosis with a solid ankle.[11] A Patella Bearing Orthosis (PTB) may be helpful in taking weight off the heel if weight bearing is painful.

Partial Calcanectomy

A partial calcanectomy is an alternative to below-knee amputation for patients with calcaneal osteomyelitis and overlying tissue loss. Once healed, most patients maintain ambulation and by preserving a functional limb, can improve their quality of life.

The patient is placed in the prone or lateral decubitus position. A split heel incision is performed with full thickness medial and lateral flaps. This approach preserves the neurovascular structures and can be made to incorporate a wound. Care is taken to protect the medial and lateral skin flaps and a no-touch technique is employed throughout the duration of the procedure. The posterior body of the calcaneus is exposed. The neurovascular bundle is protected medially, the peroneal tendons are reflected laterally, and posteriorly, and the insertion of the Achilles tendon is identified and fully detached.

Figure 11: Choparts AFO with filler

Figure 12: Skin Re-approximated after partial calcanectomy

The bone cut is made transversely from immediately posterior to the posterior facet of the subtalar joint, to distal toward the calcaneocubiod joint. Elmarsafi, et al. described a more aggressive bone resection to ensure definitive eradication of osteomyelitis and allow for a better chance of complete soft tissue closure.[7]

In a retrospective review by Oliver, et al., patients who required a more aggressive calcaneal resection (13% remaining calcaneus) had similar lower extremity function scale scores when compared to those with 74% of remaining calcaneus.[15]

The wound is closed in layers without tension and a closed suction drain is used if there is concern a hematoma will form (Figure 12). The surgical site is dressed with a bulky dressing and a well-padded posterior splint with the ankle placed in slight plantarflexion. Patients are generally kept non-weight-bearing for a period of six weeks and then fitted for accommodative footwear. Depending on activity level and function, patients may be placed in an extra-depth shoe with an accommodative insert and a heel filler or an AFO to provide more support and stability to assist with ambulation.

Conclusion

The recent global COVID-19 pandemic significantly disrupted the delivery of healthcare which has had an especially harmful effect on people with diabetes-related foot complications. Any delay in treatment will have deleterious effects in this high risk population. In the presence of infection and/or osteomyelitis, surgery is a critical component of care. After eradication of infection, one must evaluate the vascular status to determine the optimal level of healing and also consider the biomechanical function of the residual foot.

Regardless of amputation level, patients must be properly educated, counseled, and prepared for the entire spectrum in the journey after a diabetes-related lower extremity complication.

The goal is functional limb salvage and to perform the most distal, functional, well-balanced foot-sparing amputation. However, at times, a limb-sparing amputation may not be possible and, in these situations, a proximal amputation can provide better outcomes compared to multiple, futile attempts at limb salvage. Regardless of amputation level, patients must be properly educated, counseled, and prepared for the entire spectrum in the journey after a diabetes-related lower extremity complication.[16] **PM**

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