Partial Foot Amputations in the Combat Wounded

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Throughout the current conflicts in Afghanistan and Iraq, there have been more than 1100 combat-related major limb amputations, with approximately 80% involving the lower extremity. There is, however, a paucity of data regarding the number of amputations below the level of the ankle. Although not as common, partial foot amputations, in the appropriate setting, offer a way to improve function and decrease energy consumption when compared to proximal amputations. Sound surgical tenets are prerequisite for successful outcomes when performing a distal amputation. Maintaining a robust soft tissue envelope allowing for tension-free wound closure is paramount in determining the feasibility of a partial foot amputation. Careful consideration of tendon balancing is also of utmost importance in avoiding common complications of contracture and deformity. Partial foot amputations present a viable surgical option for successful outcomes and maximization of patient function in the combat injured when certain criteria are met. (Journal of Surgical Orthopaedic Advances 20(1):19–22, 2011)

Key words: amputation, foot trauma, partial foot, war trauma

Traumatic combat-related amputations are devastating injuries and comprise 2.3% of all battle injuries and 7.4% of major limb injuries (1). During the current conflicts in Afghanistan and Iraq, there have been more than 1100 combat injuries resulting in limb loss, of which greater than 80% have involved the lower extremity (2). Although major limb amputation is one of the most visible injuries sustained by our servicemen and women, little information is available regarding amputations of the foot distal to the ankle. Although relatively uncommon, accounting for approximately 5% of all amputations, partial foot amputations can be a successful option in treating the combat injured.

Metabolic studies of amputee patients previously demonstrated that more proximal amputations require higher energy for ambulation. With transtibial amputations, improved prosthetic function and decreased energy consumption are seen when the residual limb is an appropriate length (3, 4). In regard to partial foot amputations, these data may suggest that preserving as much of the foot as possible would translate into improved function and decreased energy expenditure compared to more proximal amputations. Experience with traumatic partial foot amputations from the Vietnam War demonstrated that successful retention of the foot can be achieved when pliable terminal soft tissue coverage of the foot is obtained (5). More recently, Tintle et al. (4) have suggested that managing severe foot and ankle trauma with transtibial amputation may allow for better prosthetic fit and component options compared to a more distal foot or ankle amputation.

Certain cases of severe foot and ankle trauma are more amenable to salvage at the level distal to the ankle. With combat-related partial foot amputations, the level of definitive amputation is often determined by the location of the most durable soft tissue envelope that allows for tension-free closure with sensate, full-thickness flaps robust enough to withstand areas of high pressure and shear. Partial foot amputations may be considered when faced with multiple extremity involvement, burn-injured patients, or those with lower functional expectations. The final decision on amputation level must be based on tissue viability, patient autonomy, and anticipated residual limb function. This article reviews the pertinent literature as well as describes the authors' experiences with partial foot amputations in this patient population, which, in concert with basic tenets of amputation surgery, present a viable option in caring for the combat injured with severe foot and ankle trauma.

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General Considerations

Combat injuries are usually the result of blast and fragmentation, referred to as outside-in, high-energy mechanisms (6). After appropriate debridement, adequate soft tissue flaps that allow for more traditional amputations are often unavailable. Frequently, the remaining viable soft tissue results in unconventional soft tissue flaps that require the use of creativity with wound closure (Fig. 1).

In the combat-injured patient with severe foot trauma, the injury does not occur in isolation but rather is often associated with proximal fractures, contralateral amputations, traumatic brain injuries, and burns. It is critical to consider the concomitant injuries when deciding to proceed with salvage of the residual foot.

Two factors always must be considered when determining the most appropriate amputation level for a patient. The required remaining soft tissue must be viable and the anticipated residual foot must be functional. The most common indication for partial foot amputation is an individual's unwillingness to have an amputation at a more proximal level. Another key consideration in the decision-making process is the psychological status of the patient with regards to perception of his or her appearance as well as expectations regarding function and rehabilitation.

Other relative indications for performing partial foot amputations include the consideration for preservation of length of the forefoot, intact neurologic function with maintained plantar sensation, and musculotendinous balance of the residual foot. Intact neurologic function has implications for tendon balancing as well as sensation for prevention of skin breakdown with prosthesis use. These factors, in combination with the other associated injuries, are critical in the decision-making process. Decision making is finalized after conferring with a multidisciplinary team, including the surgeon, physiatrist, prosthetist, physical therapist, and patient. The surgeon must respect patient wishes to proceed with a partial foot amputation when a safe procedure with adequate soft tissue coverage and functional residual foot can be achieved.

FIGURE 1 A typical example of traumatic foot injury resulting from blast injury.

Surgical Considerations

Lange and Nasca have reported successful longitudinal foot amputations but poorer results than those with tranverse level amputations, especially when skin grafting is required for coverage (5). When performing partial foot amputations, the authors have adapted the following surgical tenets from previous descriptions (5, 7, 8).

1. All viable plantar skin with normal or protective sensation should be preserved.
2. Intact longitudinal rays should generally be maintained with soft tissue attachments.
3. Ankle dorsiflexors and everters should be preserved or transferred, when necessary, to provide balanced motion at the ankle joint.
4. The residual foot should be covered with plantar skin, when possible.
5. Because of their inability to withstand sheer forces, split-thickness skin grafting and free muscle flaps are generally not advised as a way to provide soft tissue coverage and preserve foot length distally, especially when involving weightbearing areas of the foot.
6. Achilles tendon lengthening or release should be performed to allow for the residual limb to reach full ankle dorsiflexion with the knee extended.
7. Traditional levels of partial amputations of the foot may be disregarded provided that bone resection is made in a manner that ensures joint stability and presents a smooth distal residual foot for even weightbearing and tension-free soft tissue coverage.

Pitfalls and Complications

In the combat-injured patient, the rehabilitation and functional potential of partial foot amputation is generally high (9). Concerns regarding vasculopathy, premorbid protective sensation, and recurrent ulceration are generally not present in the typical young combat-wounded patient. With appropriate patient selection, operative technique, and follow-up attentive to initial healing, rehabilitation and prosthesis fitting can be very gratifying (10). Patients with marginal vascular status, compromised soft tissue envelopes, or loss of plantar sensation due

to documented transection of the tibial nerve (11) are poor candidates for these procedures. Likewise, musculotendinous imbalance leading to secondary deformity often occurs, leading to compromised gait, pain, and potential ulceration. Patients in whom these sequelae cannot be reasonably prevented with adjunctive procedures are, in most cases, better served by more proximal amputation.

Acute infections following partial foot amputations ostensibly result from proximal transmission of the distal infection or traumatic contamination for which the amputation was initially performed or occur as a result of a typical surgical site infection. Other than infection resulting from poor initial soft tissue coverage, distal residual foot infections should be treated as any other infection — with early operative debridement and cultures followed by systemic antibiotic administration. Negative pressure wound therapy and/or polymethylmethacrylate antibiotic beads are useful adjuncts to local wound care and may aid in both infection eradication and amputation level preservation in these instances. Refractory infections, those resulting from poor initial distal soft tissue coverage and those compromising the musculotendinous balance of the residual foot, may be indications for more proximal revision amputation.

Apart from early infection with or without compromised initial soft tissue coverage, pitfalls for partial foot amputations and complications thereof are largely either manageable or preventable via appropriate patient selection and operative technique. These complications include secondary deformity due to musculotendinous imbalance, transfer metatarsalgia, and symptomatic neuromata. Since virtually all transected nerves form neuromas, the latter can be prevented by diligent isolation and proximal transection and/or burying of major nerves (9) and treated by revision neurectomy and deep coverage of symptomatic nerves in most instances, with attention to not deinnervating pressure-sensitive plantar and distal skin regions. Transfer metatarsalgia is best avoided and treated by appropriate myotendinous balancing and shoe inserts or partial foot prostheses. Most partial foot amputations, except for central ray resections, require specialized shoe inserts or prosthetics for optimal function, and careful follow-up and orthotic fitting has been shown to decrease complications and improve function (5, 10).

Contractures and deformity due to tendon imbalance or deficiency are therefore foremost among both the classic and common complications following partial foot amputation. These generally result in an equinus or equinovarus deformity due to peroneal and tibialis anterior compromise and overpull of the triceps surae and/or tibialis posterior (12–14). However, in extended medial and lateral ray amputations, failure to retain or reconstruct the tendinous insertions of the base of the first or fifth metatarsals may result in predominating pronation/valgus or supination/varus deformities, respectively (15). Most tendon balancing emphasis, however, is appropriately placed on retaining or reconstructing the peroneal and anterior tibialis tendon insertions under physiologic tension (12–15). Initial Achilles tendon lengthening should be considered for all transmetatarsal or more proximal amputations, and Achilles tendon lengthening or release should be performed for intertarsal amputations. Other strategies for preventing or controlling equinus contractures include provisional spanning external fixation until soft tissue healing has occurred and neuromuscular control has been regained, pantalar fusion (generally for intertarsal amputations), and late Achilles tendon release (16). In the authors' experience, splinting alone is generally inadequate and ineffective at preventing equinus contractures in patients with midfoot and hindfoot amputations.

FIGURE 2 Healed partial foot amputation, 6 months after salvage of foot.

FIGURE 3 Example of partial foot orthosis for transmetarsal level foot amputation.

Gait and biomechanical studies have demonstrated major disturbances following amputation proximal to the metatarsal heads, with minimal useful gait power generation from the triceps surae in transmetatarsal and more proximal amputees (17, 18). Heroic measures to salvage partial foot amputations, including free tissue transfer, have been described (19, 20); however, given the generally good function anticipated with well performed Syme's amputation or transtibial amputations in a young, active population, the authors do not advise routine utilization of such measures in the absence of devastating concurrent proximal injuries which may preclude a satisfactory outcome of more proximal, knee-salvaging amputation.

Case Example

A 20-year-old, active duty male sustained traumatic partial foot amputation due to blast injury while deployed for Operation Iraqi Freedom. After discussion of the risks and benefits of transtibial or partial foot amputation, the soldier requested partial foot amputation. Six months after injury, the soldier had healed soft tissue and was fitted with a partial foot orthosis (Figs. 2 and 3). After completion of the Medical Evaluation Board, he was found fit for duty. Two years after initial traumatic foot amputation he was re-deployed to Operation Enduring Freedom. On June 21, 2010, he was killed by a suicide bomber in Lar Sholtan Village, Afghanistan.

Conclusion

The goal of partial foot amputations is to create a viable, functional residual foot to maximize patient mobility and independence. It is imperative for the surgeon to pay diligent attention to preserving requisite robust, sensate soft tissue coverage with tendon balance and nerve management. Complications can be avoided and patient function subsequently maximized following partial foot amputations in the combat injured. However, patient counseling and an amputation level tailored to the patient's overall clinical picture are critical. If the injury or required resection pattern is not such that these criteria can be met and goals achieved with confidence, more proximal amputation is advocated.

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