CHAPTER 17

PEDAL AMPUTATION IN THE DIABETIC FOOT A FUNCTIONAL PERSPECTIVE

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Lower extremity amputations in the diabetic patient are common. Unfortunately, what is also common is the lack of regard for the overall function of the foot after partial amputations, which often results in the need for a more proximal revisional amputation.

Long-term success with pedal amputations obviously requires proper preoperative planning. However, postoperative control of these patients, with the use of prosthetic devices and proper shoes is sometimes ignored. This results in the patient presenting shortly after surgery with new ulcerations. This scenario can be prevented with proper preoperative and postoperative planning.

The first decision to be made when planning an amputation is to determine the level of healing. Non-invasive, or invasive testing and a vascular consult are required to determine this level. Once the level has been determined, and any necessary re-vascularization performed, the function of the proposed level of amputation needs to be considered before the patient is brought to the operating room. Amputation of the 4th and 5th rays in a neuropathic foot will predispose the patient to complications if the postoperative footwear is not considered (Fig. 1). The most common complication of healed distal amputations is recurrent ulceration, necessitating amputation.

This paper will address the three most common amputations performed in the foot; digital amputations, ray amputations, and trans-metatarsal amputations (TMA). Preoperative, intraoperative and postoperative considerations need to be addressed equally. Each period in the operative process is important for the long-term control of the diabetic foot and the ultimate salvaging of the leg. This can be achieved if the amputation is performed at a level that allows healing, when good surgical technique is utilized intraoperatively, and when the appropriate postoperative footwear or prosthetic devices are prescribed.

PREOPERATIVE PLANNING

Once a decision has been made that the foot can be salvaged, it is important to inform the patient as to the type of amputation to be performed. Good communication between the patient and the surgeon is necessary so that the patient has a realistic view of the postoperative appearance and function of the foot. It is also important to convey to the patient the seriousness of the problem, and explain in detail the procedures that are needed to salvage the foot. It is important to reassure the patient that the intention is not to gradually whittle the foot away, which is frequently their greatest fear. The intention is to leave the patient with a foot

Figure 1. A neuropathic diabetic patient with a previous 4th and 5th ray amputation, secondary to infection. One year later he developed Charcot foot changes and a plantar lateral ulceration secondary to an equinus deformity that was not addressed, and the absence of appropriate shoes, orthotics, or prosthetics.

that, when controlled with the appropriate shoe and/or orthotic device, will give the best chance to avoid developing further ulceration or complications.

Digital amputations are usually better accepted by the patient. However, occasionally the patient will view this procedure as "the beginning of the end." It should be stressed to the patient before the digital amputation, that recurrence of ulcers can be prevented with digital prosthetic devices and routine foot care.

Patients usually have a harder time accepting the idea of a ray amputation or trans-metatarsal amputation (TMA). Therefore, it is important to carefully describe and use an illustration to inform the patient. Sometimes illustrating how it will look by using the opposite foot is helpful. Occasionally, patients who did not clearly understand the postoperative appearance of a ray amputations are unhappy with the overall appearance of the foot (Fig. 2). It is not uncommon to have some patients express regret that they did not have a TMA instead, because of a better postoperative appearance.

The preoperative planning also involves possible adjunctive procedures to make the amputation more functional, and prevent the future occurrence of deformities. An Achilles tendon lengthening or tenotomy is necessary in a more proximal TMA, to prevent equinus and distal ulcerations from developing. Occasionally, the long extensors to the dorsal aspect of the foot will be transferred to prevent distal stump ulcers. Lateral ray procedures that disrupt the peroneal brevis insertion may result in a varus deformity because of the resultant muscle imbalance. Appropriate tendon transfers or fusion procedures can be considered to prevent this from occurring.

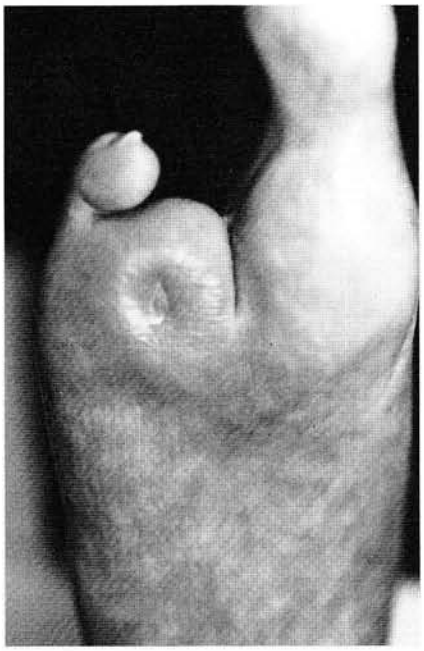

Figure 2. A patient after a central ray and multiple digital amputations. The patient had recurring ulcerations under the 4th metatarsal head. He was unhappy with the overall appearance of the foot, and had continuing problems.

INTRAOPERATIVE TECHNIQUE

The intraoperative technique is important in the healing of all amputation sites. Care should be taken to handle the wound edges gently with forceps to prevent local necrosis. It is best to avoid excessive undermining, unless it is necessary to create a flap to cover the wound. Debridement of fibrotic and nonfunctional tissue (capsule, tendon) is also necessary. The skin edges should bleed within three minutes of cutting, which indicates a 90% healing potential. If bleeding occurs much longer than three minutes, the potential for healing reportedly declines.

POSTOPERATIVE TREATMENT

Digital Amputations

A digital amputation refers to either a distal Symes procedure or an amputation at the base of the digit. Postoperative follow-up is minimal with a distal Symes, and there is generally no significant loss of function other than possible loss of purchase with weight bearing.

A true digital amputation, which is performed at the base of the digit, does have an effect on overall function. Adjacent digits will either adduct or abduct, and change the dynamics of the metatarsophalangeal joint. This eventually creates instability at the lesser metatarsophalangeal joints, resulting in increased pressure under the metatarsal heads. If not controlled, this scenario can lead to a porokeratotic lesion, and the development of an ulceration. The use of a simple inter-digital spacer helps prevent this from occurring. It is important to use a spacer after amputation of the second toe, because of the effect on the first metatarsophalangeal joint if the hallux

abducts (Figs. 3A, 3B). A spacer constructed of a soft plastizote is best used for the neuropathic diabetic patient. This spacer can be incorporated into the orthotic, or be used as a separate spacer (Figs. 4A, 4B). A functional or accommodative orthotic device (depending on the severity of the foot deformity) may also be needed to control the plantar foot pressure. An attempt should be made to salvage as much of the toe as possible. A small stump can serve as an adequate spacer itself. This also allows the spacer to be seated on the stump more securely.

Digits adjacent to the amputated digit will usually contract and hammer at the proximal interphalangeal joint due to increase firing of the long flexors to make-up for the loss of the amputated digit (Fig. 5). An extra-depth shoe, or orthopedic shoe should be used following amputation of the digit to prevent digital ulcerations from occurring. The digits adjacent to the amputation also change in their frontal orientation, and invert or evert as the digit is pushed into the space left by the amputated digit. This can cause deviation of the nail.

Ray Amputations

A ray amputation is defined as an amputation of the toe and partial or total resection of the corresponding metatarsal. The weight-bearing portion of the metatarsal is lost, creating the potential for the development of ulcerations under the adjacent metatarsal heads. The amount of pressure underneath each individual metatarsal head will increase, and hammering of the adjacent digits will occur. Instability of the metatarsophalangeal joint will eventually create acquired plantar-flexion of the metatarsal, creating plantar pressure.

The obvious goal of any postoperative regimen is to decrease the load under the remaining metatarsal heads. This can be accomplished in a number of ways. An accommodative orthotic with a plastizote material helps support the foot and absorb shock. Metatarsal pads can be utilized to distribute pressure more proximally. Extra-depth shoes, or soft-leather shoes with a large toe box are also effective. Patellar tendon braces can also be prescribed to transfer this increase in forefoot pressure to the leg (Fig. 6).

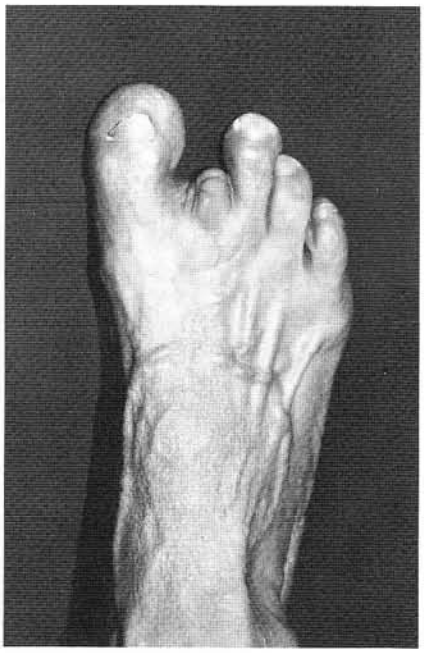

Figure 3A. This patient is 2 years postoperative after a second digit amputation.

Figure 3B. A spacer has been used to maintain proper hallux position.

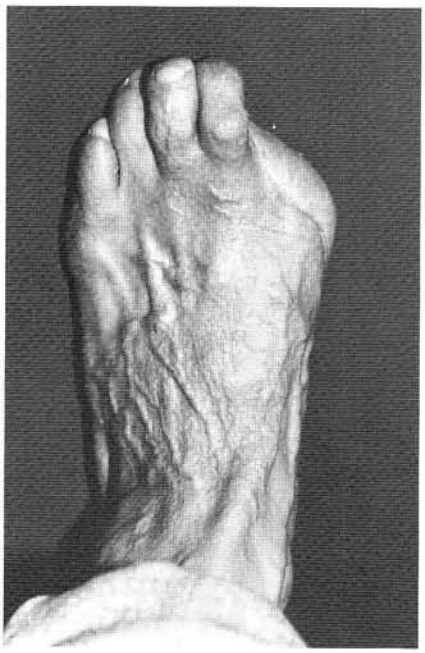

Figure 4A. The patient is 1 year postoperative after a hallux amputation.

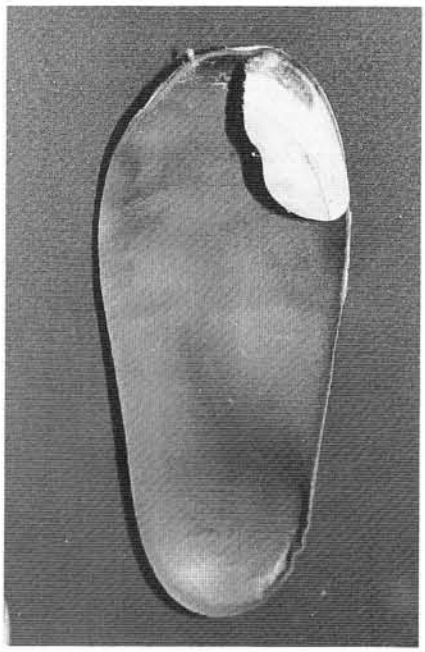

Figure 4B. A soft orthotic with a plastizote spacer was constructed.

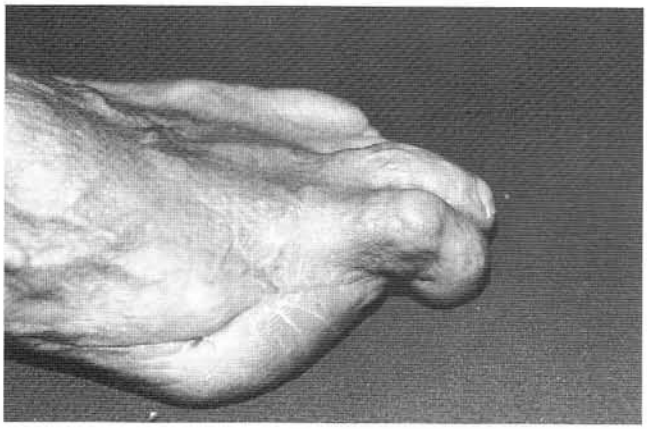

Figure 5. Increased load on the 2nd metatarsophalangeal joint plantarly, caused by contraction of the 2nd digit.

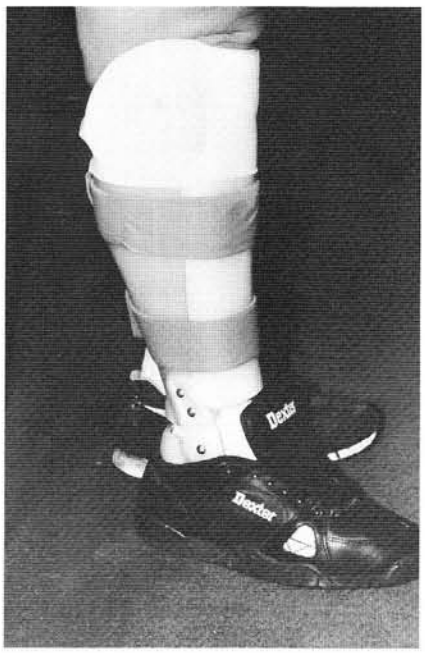

Figure 6. A patellar tendon brace is helpful in reducing forefoot pressure and transferring it to the leg.

Neuropathic patients require close monitoring because an orthotic or brace can cause irritation or pressure in new areas.

A shoe with a light, shock-absorbing sole is also indicated. The sole should be stiff only from the heel to the metatarsal heads, and should not have any restriction at the metatarsophalangeal joint. A restriction at the metatarsophalangeal level in a patient with a propulsive gait will cause shearing pressures to develop under the metatarsals. The inner-sole should be removable and an orthotic device should fit easily in the shoe. A spacer should be added into the area of the shoe where the ray amputation has occurred.

The author will frequently add a rocker-bottom sole to many of these patients. The rocker should be placed slightly proximal to the metatarsal phalangeal joints (Fig. 7). This allows the heel to lift efficiently, while placing less stress on the metatarsal region.

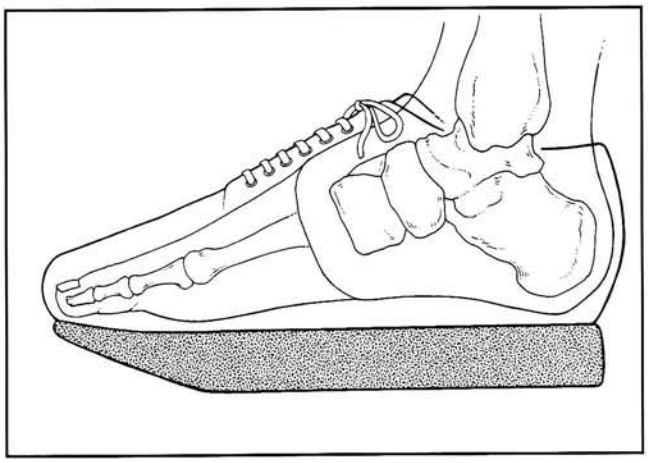

Figure 7. The appropriate placement of the rocker in a patient with a ray amputation.

Trans-Metatarsal Amputations

Trans-metatarsal amputations (TMA) can be a necessary alternative in diabetic limb salvage. The TMA has been found to be more reliable than multiple ray amputations in the long-term, with respect to recurrence of ulcerations. The procedure should create even distribution of distal weight bearing. The metatarsal resections should be made in an angled fashion, removing slightly more bone plantarly than dorsally. This will prevent sharp edges that potentially could ulcerate. The maintenance of a relatively normal metatarsal parabola will also prevent ulcerations.

Trans-metatarsal amputations can be performed successfully at any level of the metatarsal. However, performing the amputation at the most distal level possible provides a better lever arm. It also allows the surgeon to avoid disruption of the insertions of the peroneal muscles, the tibialis posterior, and tibialis anterior. The more proximal the TMA, the more potential for this disruption. This will result in the eventual varus orientation of the stump. Appropriate tendon transfers and tendon lengthening can be performed to lessen this effect.

The author routinely performs a tendo-Achilles lengthening or tenotomy in conjunction with a TMA. This decreases the distal pressure, by weakening the triceps surae. If the foot is already in a varus attitude, the author considers relocating the tibialis anterior more laterally, or performing a tibialis posterior tendon transfer to the dorsal aspect of the foot. These transfers require extensive soft tissue dissection, therefore an adequate blood supply and eradication of any previous infection are necessary for successful healing.

Once the TMA has been completed, it is necessary for the appropriate prosthetic device and shoe to be worn to prevent the development of ulcerations. If ulcerations do develop, they generally occur at the distal aspect of the stump along the area of the incision, or on the plantar distal aspect of the stump underlying an osseus prominence. This is caused by the shearing pressures at the stump prosthetic interface.

The object of the prosthetic device is to enable the patient to wear shoes and support the foot. This device can be as simple as a filler placed in the toe box, or a custom-made prosthetic device that the foot fits into. A number of different varieties are available and can be constructed by a prosthetist or certified pedo-orthotist (Figs. 8A, 8B). The interface between the stump and the prosthetic should be of a soft, but resilient material. The author has found a soft plastizote material to be the most effective. It is important for the stump prosthetic fit to be snug, and allow the least amount of motion at the stump prosthetic interface (Figs. 9A-9C).

It can also be beneficial to have a rocker placed on the shoe of a person with a TMA to reduce the shear pressure at the interface. The rocker should be placed underneath the distal portion of the amputation (Fig. 10). If the rocker is placed too far distally it may create more pressure than desired at the interface.

Figure 8A. A Chicago boot is a laced prosthetic for a patient with a trans-metatarsal amputation. The boot is placed into a shoe.

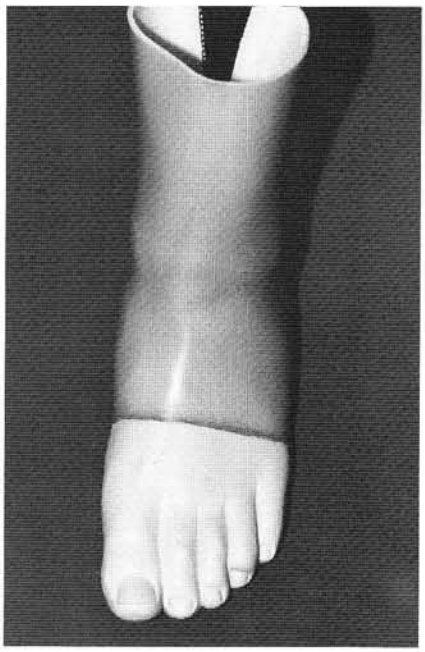

Figure 8B. An elastic prosthetic built for a patient with a trans-metatarsal amputation.

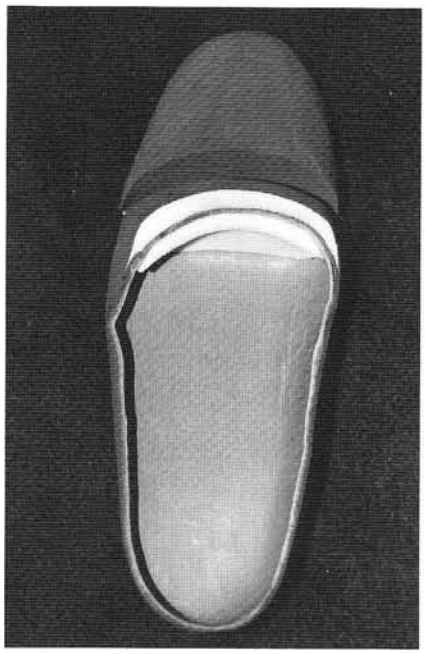

Figure 9A. Soft plastizote orthoses with a distal filler, which allows motion at the metatarsophalangeal joints. This decreases the shearing forces at the interface.

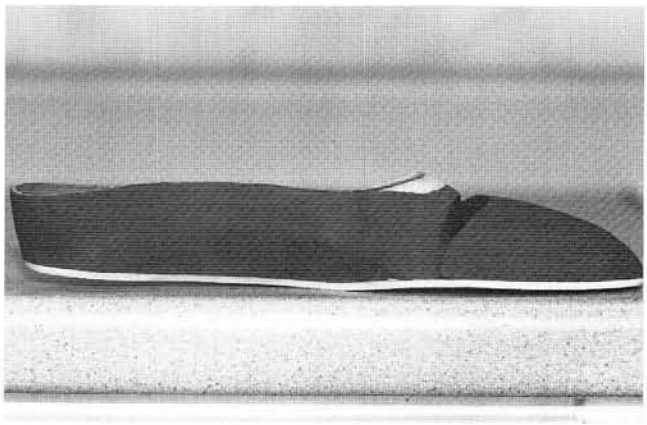

Figure 9B. Lateral view of the orthotic device.

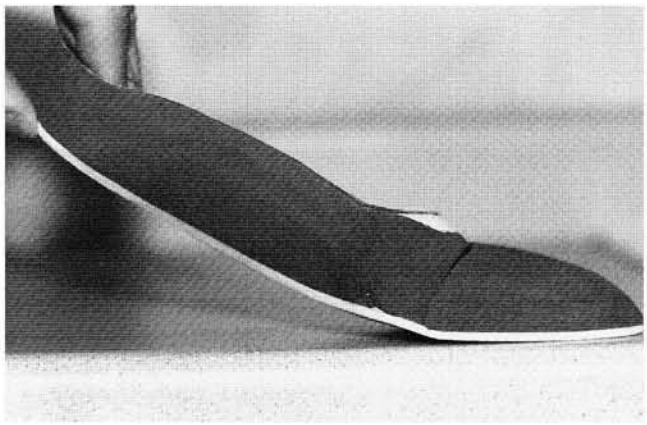

Figure 9C. Lateral view of the orthotic device showing motion which can occur at the ball of the foot at heel-off.

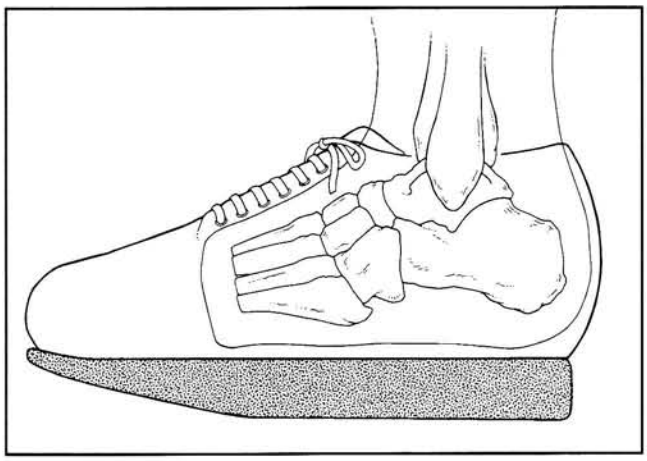

Figure 10. The appropriate placement of a rocker in a patient with a trans-metatarsal amputation.

CONCLUSION

Pedal amputations require a thorough thought process to be successful in the long term. This success can only be achieved by a good decision-making process that takes into consideration preoperative, intraoperative and especially post-operative planning.

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