Transmetatarsal and Midfoot Amputations

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The objective of lower extremity amputation surgery is to create a viable, functional residual limb to maximize patient mobility and independence. When part or all of the forefoot is lost to trauma, infection or gangrene, and the hindfoot is viable, every attempt should be made to preserve as much foot function as possible. The use of the transmetatarsal level is common. In the past, amputations through the Lisfranc and Chopart’s joint lines involved significant complication rates. With improvements in patient selection and surgical technique, these two amputation levels are viable options to consider when attempting salvage of the hindfoot structures.

The issue of what to do with a severely compromised foot always has been a difficult problem for physicians. Severe trauma, infection and/or vascular compromise to the foot can raise the question of amputation to obtain tissue stability. Gait and metabolic demand studies of patients with amputations show that with more proximal amputations, there is a higher metabolic requirement for ambulation. In patients with diabetes and vascular disease this translates into decreased mobility and the rise of other health issues.

Using these data it would seem reasonable to attempt to preserve as much tissue as possible when considering amputations.

The difficulty is in maintaining ambulatory function and preserving tissue. It is well accepted that compromise of the heel pad leads to a transtibial amputation or that an infected toe can be controlled with a more distal amputation. The debate is what to do with the foot that has extensive soft tissue compromise, with or without bony destruction. The decision on an amputation level must be based on tissue viability and residual limb function.

The concept of using midfoot and hindfoot amputation levels to preserve limb length and function is not new. Transmetatarsal amputations are common and function well when done in properly selected patients. Amputations at the Lisfranc and Chopart’s joint levels have proven more difficult and until recently were out of favor. Initial problems with these midfoot amputation levels were the result of difficult shoe fit and positional malalignment of the residual limb, resulting in high complication rates and poor patient satisfaction. Recent advances in surgical technique and prosthetic fit have addressed these earlier problems.

GENERAL CONSIDERATIONS

Two factors always must be considered when determining the proper amputation level for
a patient. The remaining soft tissue must be viable, and the residual limb must be functional for the patient. The issue of tissue viability is discussed regularly when assessing patients with vascular disease but is just as important when evaluating trauma or infection. The choice of an amputation level must be at a site where the remaining tissues have the ability to heal. The use of preoperative vascular studies should be routine to determine the adequacy of blood flow to the tissues. Doppler flow measurements and transcutaneous $O_2$ measurements can be used to gauge tissue perfusion and viability. Each method has its advantages and disadvantages. The important information is whether the proposed level of amputation has the vascular supply to heal. If there is any doubt about vascular compromise at an otherwise adequate amputation level, a vascular surgery consultation should be obtained to ascertain whether revascularization is an option to improve the chances of wound healing. Recent advances in surgical techniques have proven very effective in restoring vascular flow to tissue in the foot resulting in satisfactory healing of midfoot amputations.

In addition to local vascular supply, more general information such as nutritional status is also important for surgical success and should be evaluated preoperatively. Serum albumin levels greater than 3g/dL, serum protein levels greater than 6g/dL, and total lymphocyte counts greater than 1500 are important parameters to measure not only patients with diabetes but all patients whose ability to heal a wound is in doubt. Specifically for patients with diabetes it is important to gain and maintain control of their glucose level to maximize their ability to heal the surgical wound.

Adequate coverage of the residual limb with viable soft tissue is also important. The soft tissues of the foot constantly are exposed to significant stress, whether through bearing weight on the plantar surface or frictional contact with shoe wear. It is best to make full use of local tissue to cover these amputations. These tissues are designed anatomically to withstand the unique forces placed on the foot and supply sensory feedback to help protect from overuse. Ideally as much plantar tissue as is viable should be saved to provide the majority of wound closure. Effective use of dorsal tissue or rotational flaps when necessary, should help to obtain local closure. The important factor is to have as much sensate skin as possible to minimize soft tissue complications from outside pressure and shear stresses. Grafted tissue, if used, is best reserved for the non-weightbearing surfaces of the foot.

After considering tissue viability in determining an appropriate amputation level, the aspect of residual function must be considered. The normal, intact foot is a unique structure providing a stable platform for single leg weightbearing and an extended lever arm from the ankle to the ball of the foot to reduce energy demands in normal walking. To disturb this functional unit can have a significant impact on balance and energy use.

When considering the various options in midfoot amputation, the musculotendinous structures must be assessed. The intact foot has only one muscle attachment to the hindfoot. It is the Achilles tendon insertion onto the calcaneus and this produces plantar flexion and some inversion of the foot. This is the strongest muscle group controlling the foot. The amount of force this muscle unit can generate must be sufficient to stabilize the body weight over the ball of the foot. Amputations involving the foot shorten this lever arm and result in increasing the weightbearing pressure seen at the distal end of the residual foot. The midfoot, from Chopart’s joint to Lisfranc joint, also has only one exclusive tendon insertion. The tibialis posterior inserts on the medial aspect of the navicular tubercle and extends to the plantar surface of all midfoot bones and the bases of the second and third metatarsals. This muscle provides inversion and plantar flexion power to the foot. It is only at the level of the
metatarsal bases, Lisfranc joint, that various muscle attachments begin to affect the foot position. The muscles that are involved are the peroneus brevis and tertius, which attach at the base of the fifth metatarsal, the tibialis anterior to the medial base of the first metatarsal, and the peroneus longus to the plantar lateral base of the first metatarsal.

These motor groups and their attachments are important for positioning of the residual limb. Balancing unopposed muscle forces is necessary to achieve a functional midfoot or hindfoot amputation.

Finally, prosthetic wear must be considered when deciding whether to amputate. The advantage of midfoot amputation is that limb length is maintained. Ankle and subtalar motions are left intact to help dissipate the normal torque generated through leg rotation during weightbearing. This allows a patient to weightbear on the residual limb without any prosthetic device, which can improve mobility greatly. Transmetatarsal amputations still have enough forefoot left that an orthosis acting as a filler for the missing forefoot is all that is necessary to wear normal shoes. In the past, shoe fitting for patients who had amputation at the Lisfranc joint and Chopart’s joint proved difficult because of the lack of distal foot to hold a shoe. The use of an ankle foot orthosis with a forefoot filler to fit the shoe routinely is used with satisfactory results.

Rarely, with all these factors considered, is the definitive amputation level determined at the initial surgery. In the presence of trauma or infection, the initial surgeries involve removal of necrotic and dysvascular material until the remaining tissues stabilize. It is best to secure the viable muscle flaps loosely over the wound between debridements to prevent wound edge contracture. Multiple debridements should be done at 24-hour intervals. The same is true in dysvascular cases. There must be a clear demarcation between viable and nonviable tissue before a determination of amputation level can be made. The availability of local viable tissue determines the proper midfoot amputation level. Within these guidelines, the longer the residual limb the better.

**TRANSMETATARSAL AMPUTATIONS**

A transmetatarsal amputation is an amputation performed at the level of the proximal metatarsal shafts. This level should be considered if the instigating disease has disrupted the normal weightbearing pattern in the forefoot. The skin incision is variable, depending on the availability of local tissue. It is best to leave as much viable plantar skin as possible during the initial debridement. Ulcerative or necrotic areas in the distal plantar flap should be removed by a wedge shaped incision. The wedge is based distally and the apex should reach beyond the compromised tissue proximally. The excised tissue should be the full thickness of the flap. The dorsal incision is normally made 1 cm distal to the proposed bony amputation site. This incision should be made more distally if tissue is needed to make up for plantar tissue loss. Bony resection is made in a manner that ensures the stability of the tarsometatarsal joints and present a smooth distal stump for even weightbearing. Exposure of the metatarsals is achieved by subperiosteal dissection of the dorsal flap to the desired level of amputation.

The second metatarsal base and the Lisfranc ligament from the medial cuneiform to the medial aspect of the second metatarsal base are key to this joint line’s stability. The best level to cut the second metatarsal is approximately 3 cm from its base, just distal to the proximal metaphyseal diaphyseal junction. The cut should be made with an oscillating saw to prevent splintering of the bone and result in the proximal surface that slopes from dorsal distal to plantar proximal. The first metatarsal should be cut at the same level as the second with the same distal slope. The medial ⅓ of the first metatarsal should be rounded proximally. The third
through fifth metatarsals should be cut in a manner similar to the second but approximately 2 mm shorter than its medial neighbor, creating a gentle cascade to the lateral border of the foot. The lateral 1/3 of the fifth metatarsal should be rounded proximally also. It is imperative that no sharp bony distal or plantar surfaces be left.

The length of the plantar flap determines wound closure. It is brought up square to the cut bony ends to cover as much of the plantar and distal stump as possible. The remainder of the tissue is trimmed to make a loose, secure closure. Routinely the skin is closed and the flap secured with interrupted vertical mattress sutures of 3-0 nylon.

Muscle balancing is important at even this level of amputation. Gait studies on patients with diabetes and transmetatarsal amputations show an increase in distal weightbearing pressure when compared with the opposite, normal side. Although at this level only muscle units involving toe function were sacrificed, the loss of the lever arm of the forefoot significantly increases the relative strength of the Achilles motor unit over the normal antagonists. To help protect against this overload, a percutaneous heel cord lengthening should be done once the wound is closed. Adequate lengthening of the Achilles tendon will allow the residual limb to reach full ankle dorsiflexion with the knee extended.

**LISFRANC AMPUTATION**

This level of amputation should be considered when there is inadequate soft tissue coverage for a transmetatarsal amputation or instability of the Lisfranc joint is evident. Soft tissue flaps are formed in the same manner as discussed earlier, with emphasis on preserving plantar tissue. Bony excision is not just a simple dislocation of the tarsometatarsal joints. The goal is to maintain as smooth an endbearing surface as possible and minimize disruption of muscle insertion. The biggest problem with postoperative malposition other than the calcaneus is the inversion caused by the unopposed pull of the tibialis posterior if the peroneus brevis is lost. Therefore, excision should occur through the joints of the first, third, fourth, and fifth tarsometatarsal joints. The base of the second should be left in place because its keystone position provides stability to the medial cuneiform through the vast network of plantar ligaments. The fifth metatarsal base has the attachment for the peroneus brevis, peroneus tertius and plantar fascia. Great care should be taken to shell out the fifth metatarsal base subperiosteally to maintain the integrity of the soft tissue attachments of these tendons. With exposure of the joint surfaces it is best if these surfaces are debrided to expose healthy, bleeding cancellous bone. This serves two purposes. It removes the avascular cartilage from the wound. Exposure of the raw bone ends allows for the possibility of improved vascularization of the overlying flap during healing. Before closure, it is important to secure adequately the preserved periosteal insertion of the peroneus brevis and tertius to the lateral aspect of the exposed cuboid and to the surrounding tissue to preserve some eversion control to the foot. The foot should be in a slightly everted, dorsiflexed position when securing the tendons. If located as they approach the base of the first metatarsal, the peroneus longus and tibialis anterior tendons should be secured to surrounding soft tissue.

Wound closure is accomplished as described previously using as much of the plantar tissue as possible to cover the exposed plantar and distal surfaces. With the loss of more than 1/2 of the length of the foot, mobility of the ankle joint becomes a greater priority than gastrosoleus motor strength. Complete transection of the Achilles tendon should be done routinely after closure of the wound. The plantar flexion power of the tibialis posterior is adequate for this length of residual foot, considering that all the normal dorsiflexors have been disrupted.
CHOPART’S JOINT LEVEL AMPUTATION

Amputation at the Chopart's joint level is considered only when the longer of the two options are not available and there is no obvious compromise to the plantar heel pad or articular surfaces of the ankle and subtalar joints. The preparation of the soft tissue flaps remains the same. Priority is given to maximizing the size of the plantar flap with inadequacies made up with increased length of the dorsal flap. The normal dorsal skin incision is made from the navicular tubercle to the midline of the cuboid. The dissection is carried directly down to these two bones before subperiosteal dissection to expose the talonavicular and calcaneocuboid joints. The tibialis anterior and extensor tendons should be identified and preserved during this dissection.

Excision involves disrupting the talonavicular and calcaneocuboid joints. Both of these surfaces present bony prominences that should be removed before closure. When removing the articular cartilage it is best to flatten the head of the talus to present a broader end surface in line with the distal end of the calcaneus and remove the anterior tuberosity from the calcaneus. The stump should have no obvious bony projections into the flap.

At this level of amputation only the Achilles tendon is left at its original attachment. There is no foot lever arm to counterbalance the pull of the gastrosoleus complex on the hindfoot. Functionally it is desirable to have a free moving ankle on which the leg can rotate. An open transection of the Achilles tendon should be performed with removal of at least 1.5 cm to minimize the risk of reattachment and late equinus deformity. Any remaining distal attachment of the tibialis posterior should be released to allow retraction of the tendon proximally. Failure to do so can result in late equinus or varus deformity. If there are any viable extensor tendons remaining, they should be secured to the talar neck. Creating a tendon sling about the talar neck with the tibialis anterior medially and the extensor tendons laterally is ideal. Otherwise the tendon ends can be secured by suture or drill holes to the talus. It is important to have the talus in a slightly dorsiflexed position to obtain adequate tension in the tendons.

The wound is closed using the same techniques described previously.

POSTOPERATIVE CARE

If a tourniquet is used during the case, it is important to release the tourniquet and inspect the tissues before closure. All remaining dysvascular tissue should be removed and hemostasis achieved. Once satisfactory wound closure is obtained and muscle balancing complete, the residual limb should be dressed and placed in a short leg plaster cast. Careful molding of the cast is needed to ensure that the talus is in a slightly dorsiflexed position in relation to the tibia and the calcaneal tuberosity is parallel to the long axis of the tibia. Depending on the underlying cause for the amputation, the wound should be checked and the cast changed at weekly intervals until the wound is healed. Sutures are removed only when the wound is healed. Weightbearing is not permitted until the soft tissues have healed and stabilized. Because these are designed to be independent weightbearing limbs, orthotic manufacture and placement is a decision that the individual patient helps make. No devices are required for ambulation, but may be necessary to allow shoe wear. Commonly, patients with an amputation at the transmetatarsal and Lisfranc joint levels require little more than a shoe filler with an ankle lace up shoe. Patients with a Chopart's joint level amputation usually need a custom fitted ankle foot orthosis with a filler to hold a shoe adequately.

Aside from the occasional traumatic amputation, many of these patients are compromised hosts who must be monitored closely for any problems on the residual limb to prevent additional loss. Skin breakdown because
of sensory loss or vascular dysfunction may be salvaged if the underlying cause is addressed early. Even with meticulous muscle balancing at the time of closure, late deformity can occur and should be addressed with appropriate soft tissue release to maintain a plantigrade foot. Success with these amputations now is reported at 80% to 90%.3,6,8,11,14,15

References