Limb salvage after failed transmetatarsal amputation despite collateral only flow to the foot

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Peripheral vascular disease is a common affliction in the diabetic patient, and its presence adds great complexity to limb salvage efforts. While many patients with critical limb ischemia may be relegated to a major amputation, especially in the setting of a failed minor amputation, worthwhile salvage efforts may be possible. We present a case of limb salvage by way of a Chopart's amputation performed after a failed amputation at the transmetatarsal level. In this patient, pedal circulation was supplied only by collateral vessels, as occlusion affected all 3 major below-knee arteries. To our knowledge, limb salvage has not been previously described in this scenario. Given the favorable outcome presented in this piece, we hope to raise awareness of the potential for salvage in this patient population, and spur continuous research into the complex entity of peripheral vascular disease. Additionally, we present our operative and perioperative pearls as a resource for the limb salvage surgeon.

Keywords: angiosomes, PVD, CLI, revascularization, diabetic

Limb salvage, the preservation of pedal structures in part or total to form a functional appendage, may be fraught with difficulties. This is particularly true regarding the comorbid diabetic host. Peripheral vascular disease, often a concomitant ailment in this particular patient population, can further complicate salvage efforts, if not render them futile. Revascularization prior to these undertakings is optimal to improve salvage success rates, though end-stage vascular disease may present a scenario where the below-knee vascular tree cannot be improved via open or endovascular methods. In this event, optimizing alternative routes of perfusion is paramount [1].

While vascular supply to the foot in patients with peripheral vascular disease is often characterized by the patency of native in-line vessels to the foot, situations may exist where the foot is supplied solely by collateral circulation. While the latter pattern of circulation may allow the intact pedal tissue to survive, the added circulatory demands of a superimposed ulceration or wound are likely to affect limb loss, as demands of tissue repair outweigh host perfusion. Three vessel occlusion to the lower extremity with recalcitrant ulceration with or without subsequent infection is a well-accepted indication for proximal amputation.

To our knowledge, limb salvage has not been described in a scenario of below-knee 3 vessel occlusion in the face of a non-healing intra-pedal amputation. In this report, we present a case of a limb-sparing Chopart's amputation in a patient with collateral-only flow to the affected foot who had failed to heal a transmetatarsal amputation (TMA) necessitated by gangrene. Additionally, we present several peri-operative and operative pearls with respect to our soft tissue management that we contend contributed to the success of this endeavor.

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Figure 1 Clinical photograph of patient upon initial presentation to the emergency department. Clinical photograph of worsening changes to the affected toe.

Case Study

We present a 74-year-old hispanic female with a past medical history of NIDDM with peripheral neuropathy, hyperlipidemia, hypertension and peripheral arterial disease who presented initially to the emergency department in February of 2017 with concern for worsening left 4th digit necrosis (Figure 1a). The patient admitted a one month history of hyperpigmentation to the respective area with an acute history of darkening to the toe. The patient was also complaining of a recent increase in claudication symptoms and malaise. On clinical exam, the patient had distal tuft necrosis to the left 4th digit extending from the proximal interphalangeal joint distally with associated peri-ulcerative edema and ischemic rubor proximally. The left posterior tibial and dorsalis pedis arteries were non-palpable. She was admitted to the hospital for vascular optimization. Duplex arterial doppler exam revealed occlusion of the right iliac, common femoral, posterior tibial and peroneal arteries, and stenosis of the left superficial femoral artery with peroneal occlusion and significant infrapopliteal disease with an ABI of 0.42. The patient ultimately underwent left superficial femoral artery angioplasty. Recanalization of the left pedal vascular tree was unsuccessful as the procedure revealed single vessel runoff to the anterior ankle via the anterior tibial artery which was then seen to be occluded at that level, leaving collateral only flow to the left foot. The patient was discharged with plans to await tissue demarcation in preparation for outpatient amputation. The patient returned to the emergency department for acute worsening gangrenous change to the affected toe (Figure 1b).

Figure 2 One week status post transmetatarsal amputation. At this point the incision is well coapted.

The patient had no acute signs of infection, however, the tissues appeared non-viable distally. Based on the recent vascular findings the discussion was had with the patient and her family that a proximal amputation may be imminent. Ultimately, the patient underwent a transmetatarsal amputation (Figure 2) despite understanding the multifactorial risk for a more proximal amputation. She was discharged postoperatively following a pathology report negative for osteomyelitis at the proximal metatarsal margins.

At initial follow up, the surgical incision had dehisced with a large area of lateral breakdown despite compliance with non-weight-bearing recommendations. In initial salvage efforts, the patient underwent serial debridements under local blockade as she had ischemic pain to the amputation site.
Operative Technique – Chopart’s Amputation

The patient was placed supine on the operative table, and the modified Chopart’s procedure was carried out under local anesthetic with monitored anesthesia care. No tourniquet was used so as not to provoke further damage to the tenuous vasculature, and to fully assess the intra-operative bleeding and viability of the tissues. After removing gross non-viable tissue and necrosis from the prior incision site distally, we began sharply elevating the dorsal flap proximally to the level of the Chopart’s joint as a full-thickness layer to preserve vascularity. To accommodate this, the medial and lateral portions of the incisions were extended proximally to apices just at the level of the Chopart’s joint.

No attempt was made to preserve tendon structures for later transfer. Gentle retraction was used to lift the flap and expose the naviculocuneiform joint. We sharply incised through the dorsal capsule, exposing the distal navicular cartilage. Sharp dissection was then carried laterally to disarticulate the calcaneocuboid joint in similar fashion. We then sectioned the disarticulated osseous structures from the plantar flap sharply, preserving a robust plantar flap. We then transected both dorsal and plantar flaps distally at increasingly proximal intervals until bleeding margins were obtained, after which the flaps were able to be opposed. Particular attention was paid in the retention of deep plantar structures within the plantar flap. Given the robustness of our plantar flap and intact deep vascularized structures, the plantar flap was extended distally and dorsally. The dorsal flap was revised to accommodate in-setting of the plantar tissues dorsally, leaving the dorsal subcutaneous and muscular layers intact along with the neurovascular bundle. This affected a “dual deep tissue” layer dorsally, which we felt would add to the healing potential of the flaps, especially along the dorsal closure. Despite the thickness of the flap dorsally, we were able to carefully approximate the skin overlying the flap with the more proximal dorsal skin using simple sutures of prolene. The proximal extension of the plantar flap is vividly appreciated in the clinical images as evidenced by the sharp demarcation of the pink plantar tissue with the darker anterior skin (Figure 4). No deep sutures were utilized so as to prevent occlusion of any remaining deep auxiliary vessels. Given that there were no signs of infection or deep abscess, the surgery was not staged, but rather closed primarily. The osseous structures were sent for procurement of a clean margin biopsy.

Adjunctively we attempted negative pressure therapy as well as hyperbaric oxygen (HBO) treatments. The wound unfortunately persisted with predominantly fibrotic tissue and areas of deep probing to bone. While the wound remained stable and without infection, no improvements were noted in the wound’s size or characteristics (Figure 3). We discussed with the patient and family members at length the likelihood of a proximal amputation. The patient and family wished to avoid proximal amputation if at all possible. Considering her age and comorbid conditions, and likely deconditioning and increased cardiac demand with a proximal amputation, it was surmised that she would not likely obtain a prosthesis. We made no guarantees in success following a limb salvage attempt, but ultimately agreed to proceed with a Chopart’s amputation.
Post-operative course

The patient did experience an area of breakdown about the lateral incision which had appeared somewhat tenuous intra-operatively. She ultimately healed after 5 months of wound care which included debridements under local blockade in the office. Infection did not complicate the area of wound breakdown. She understood wound healing would be prolonged given her advanced peripheral vascular disease, and that she was still at risk for a proximal amputation which she continually expressed her desire to avoid. Hyperbaric oxygen therapy was used as an adjunct. She was fitted for a custom AFO shortly thereafter which she uses to ambulate with a gait assistive device both at home and in the community. The patient has denied experiencing any phantom, ischemic, or neuropathic pain at the limb. During this postoperative period she was able to reduce her hemoglobin A1C from 9.5 to 7.5% over a 2 month period with the assistance of family practitioner in adjusting her insulin regimen and by dietary modifications. Her sound limb has also remained ulceration free. She is now 7 months ulceration free, 1 year postoperatively.

Discussion

The ability to perform basic activities of daily living, ambulation, functional independence, or even simply to transfer or adjust position in bed after loss of the contralateral limb are among the goals sought to be attained by the amputee. Interestingly, ambulatory status may specifically confer a benefit to mortality after lower extremity amputation [2]. This rehabilitation demand is often unmet in the transtibial or transfemoral amputee. This is attributable to hurdles such as a delay in obtaining a prosthesis, slower postoperative convalescence, greater rehabilitation demands compared to a minor amputation, and an inability to use the prosthesis secondary to cognitive or physical limitations. Though the reamputation rate after minor amputations has been shown to be greater than after a major amputation such as a below-knee amputation (BKA) [3,4], they ultimately offer a greater chance of ambulation if successful [5], offering a much quicker rehabilitation process. Nearly one third of patients will not ambulate after a major amputation [6]. Furthermore, bipedal ambulation after a transtibial amputation for vascular disease is uncommon [6]. In addition to these biomechanical advantages of limb salvage, other advantages are compounded in the dysvascular patient. Pinzur [7], in his pioneering work, illustrated the near linear relationship between increasing metabolic demand and ascending amputation level. In amputees afflicted with peripheral vascular disease, metabolic reserve is greatly diminished, so much so that ambulating with

Figure 5 Healed Chopart’s amputation.
an above knee amputation in this cohort demands maximum aerobic capacity. In other words, self-selected and maximum walking speeds are nearly identical. In this regard, a Chopart’s amputation may provide the select patient with a greater level of independence and improved overall outcomes as compared with a proximal amputation. With regards to quality of life, Wukich [8] has shown that amongst diabetic patients with foot ulcerations, major amputation is feared more than death, and the loss of a limb has been compared to the death of a spouse in terms of psychological impact [4].

Figure 6 Radiograph of healed modified Chopart’s amputation. With this technique, equal segments of bone remain anterior and posterior to the ankle.

It should be remembered that successful completion of the operation is only the beginning of the recovery process, especially in the amputee. Depression is especially common after major amputation [4].

In this instance, we chose to employ the Boffelli modified Chopart’s amputation [9]. He and his colleagues have described the numerous biomechanical derangements that ensue after the traditional method of a Chopart’s amputation; complete loss of the calcaneal inclination angle, maximal talar plantarflexion within the ankle mortise, and an overload of the lateral column. With preservation of the navicular as their modification describes, weight transfer is encouraged through the medial column by way of extended reach of the talar head, as there is now an equal amount of osseous structure both anterior and posterior to the ankle joint (Figure 5). One drawback this modification does not address is the violation of the extensor tendons, where concern for an equinus contracture remains. As long as the soft tissues are amenable, our practice is to simply elevate and preserve the dorsal tendons with their respective flap and allow adherence to plantar flap distally, as well as the surrounding tissues after closure. As evidenced by the supplementary video (Video), this has not only prevented equinus contracture in our patient, but has afforded her maintenance of active dorsiflexion. Additionally, maintenance of the extensors has combated the potential inversion deformity from retention of the posterior tibial tendon insertion, as her muscle inventory is equal and symmetric across the ankle.

We feel this modification contributes to improved function and decreased susceptibility to wounds postoperatively.

Regarding the function in this particular patient, her family has reported that she is independently ambulatory in the home with a gait assistive device, and ambulates short distances in the community. Her prosthesis is a socket type partial foot ankle-foot orthosis. While a simple diabetic shoe with plastazote insert and toe filler may suffice for managing a foot after a transmetatarsal or Lisfranc amputation, a more extensive device is needed after a more proximal pedal amputation. These types of devices serve to protect the residuum of the foot from high pressures, restore lost foot length, and temper external moments caused by loading of the prosthetic foot [10]. The prosthesis manufactured for our patient incorporates an extensive carbon fiber shell that encompasses the leg and remnant foot, a so-called “above ankle” intervention (Figure 6). The shell provides a laminated foot socket which is bonded to the prosthetic forefoot consisting of complaint foam to redistribute the pressure of ambulation away from the

Figure 7 Custom socket-type AFO which has allowed for bipedal ambulation. The device can be inserted into a shoe as well.
residuum of the foot. The carbon fiber extends from the socket beneath the foam filler to form a foot plate the entire length of the prosthetic. Given the relatively small amount of surface area of the remnant foot over which to distribute the loading forces of gait, this stiff shell-type design allows loading forces to instead be distributed over a wide area, and prevent pistoning of the amputation site that would occur in a normal shoe [10,11]. Given the alteration in center of pressure excursion in persons with partial foot amputation [10], a stiff above ankle device is needed to allow the center of pressure to extend beyond the residual foot and be borne by the prosthetic, rather than the vulnerable amputation stump. The advantage of the Chopart’s amputation over a more proximal amputation in regards to postoperative ambulation are that the residual foot offers direct end-bearing with a full limb and a stable heel pad, permitting short distance brace free ambulation. [9,11] However, with the failure rate after Chopart’s amputation being reported at 60% over a 5 year period [12], clearly, an experienced prosthetist is invaluable in preserving the salvaged extremity. Most illustrative of this fact is the systematic review by Schade of 74 Chopart’s amputations where high-profile prosthetic devices were seen to maintain function of these residual limbs at a mean follow-up of 21.1 months [13].

While many surgeons generally advocate for transtibial amputation if a transmetatarsal amputation cannot be performed or has failed [6], we find this recommendation to be unfounded. In a review of 77 TMAs, 41 failed to heal. Of these failures, 32 were treated with 22 Chopart’s and 10 Lisfranc amputations, ultimately allowing salvage in 25 [14]. The authors do not further delineate the results between the Lisfranc and Chopart’s amputations, but we can clearly conclude that at least 15 of the salvaged limbs were salvaged with a Chopart’s amputation. Distal level amputees achieve proportionally higher functional dependence and social reintegration [15]. In the diabetic host, Stone and colleagues elucidated better function and a demonstrable survival advantage for patients undergoing proximal foot amputations than those undergoing BKA [14]. This has been illustrated in the patients’ case. Yet, preservation of function is not the only consideration concerning level of amputation. Often soft tissue healing potential, of which vascular supply is integral, is a barrier in maintaining the proximal foot. As the amount of perfusion decreases, the potential for salvage is concurrently reduced. Angiography is the diagnostic modality of choice in assessment of lower extremity perfusion. Yet, while angiography can define the specific perfusion pattern of the affected limb and provide a route of intervention, the predictability in healing potential after intervention is uncertain [16]. In our patient, the vascular service offered that she would not likely heal any amputation distal to the transtibial level, based on computed tomography angiography. Despite recommendations from vascular surgeons and interventionists, the foot and ankle surgeon is ultimately tasked with judiciously deciding a reasonable level of amputation that is not only functional and in line with the patient’s wishes, but that also has adequate perfusion.

Our case is a vivid illustration that a simple cutoff of vessel patency, angiosomal supply, or arterial brachial index does not exist when predicting amputation healing. In the endeavor of limb salvage in the vascularly compromised limb, the question is simply whether there is, or is not, enough perfusion to support tissue healing. Histologically, no overt differences between lower extremity arteriosclerosis between diabetic and non-diabetic individuals has been elucidated. Conversely, a more distal predilection of these obstructive changes has been observed in those with diabetes [17]. In this way, blockage of the metatarsal and digital arteries, coupled with blockade of the named vessels, may create an end-artery situation [18]. In this scenario, the amount of tissue dependent on a single artery may comprise nearly the entire foot. When this artery is compromised, the dependent tissue dies, as there is no replacement for its function. This scenario occurred in the patient’s sentinel event leading to a digital amputation. Thereafter, the tenuous perfusion that had allowed her limb to simply exist, was not apt to heal the insult of an amputation at the transmetatarsal level. Rather than relegating her to a below-knee amputation, a limb-sparing Chopart’s amputation was performed after careful consideration and discussion with the patient. At this level, it appears her collateral network had in fact developed sufficiently to provide adequate perfusion for soft tissue preservation.

We offer that in the face of end-stage vascular disease, that is, a situation where the pedal circulation cannot be surgically improved, a failed minor amputation does not necessarily mandate limb loss, even with no direct in-line flow to the foot. While a potentially more expedient cure in that of a proximal amputation is always discussed with the patient, a limb without emergent infection in this scenario can
be, with appropriate clinical acumen, considered for salvage. Adherence to the tenants of limb salvage is paramount to allow the surgeon to decide if this is a reasonable goal. Assuming the resultant extremity would provide appropriate form and function, this may not only better align with the patient’s desires, but could provide a more metabolically sound solution, while concurrently allowing improved independence and mental health. These benefits must be tempered cautiously with the potential for failure, which could have the inverse effect on these desired goals. A prolonged course of attempted limb salvage with multiple levels of amputation failure and extended wound care could metabolically decondition the patient, exacerbate depression, and potentially affect a delay in return to function that could potentially be obtained with a prosthetic.

Keeping in mind limb salvage is more than merely preserving tissue, nearly any pedal structure can be expendable in the pursuit of a functional limb. Likewise, a named pedal artery is not an absolute exception. Of course, a certain amount of perfusion is necessary to allow salvage, but in some cases, in-line angiosomal flow is not mandatory.

In conclusion, in patients with poor or even collateral only flow to the foot, limb salvage may be possible. In those patients who are adequately informed about the potential for failure and major amputation, limb salvage may be entertained. This decision must be carefully made, weighing all available relevant patient characteristics, and crucially, with due consideration to the patient’s goals, desires, and tolerance for risk of failure.

References