# Embolization of a Free Flap Nutrient Artery to Reduce Late Postoperative Edema

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In lower leg reconstruction, free flap surgery has become a routine procedure in microsurgical centers. Flap edema in the early postoperative period is a well-known phenomenon, and multiple factors including decreased lymphatic drainage,[1,2] increased arterial blood flow,[3,4] and histologic changes of the transferred tissue[5] are believed to be important. To treat this cosmetic and functional disability, compressive garments can be applied or surgical debulking can be performed.

The exact reason why free flaps become edematous immediately postoperatively has not been well studied in human flaps. Salmi et al.[6,7] and Lorenzetti et al.[3,4] concluded that blood flow increases in the recipient arteries and the pedicle,[6,8,9] which can explain at least part of the edema formation. Other authors investigated the lymphatic function[2] and alterations in muscle histology[5] to evaluate their role in this phenomenon.

The goal of this study was to document, by arteriographic examination, the vascular network of the reconstructed area in three patients with long-standing flap edema. Moreover, we performed selective embolization of the nutrient artery of these flaps to alter the hemodynamics and thus reduce the edema.

## Patients and Methods

Three patients were studied with arteriographic examination and selective embolization. All had had a free flap transfer to the lower leg, and flap reconstruction was performed for chronic osteomyelitis, osteosynthesis coverage, and plantar radiodermatitis. The microvascular flaps used included one serratus anterior, one latissimus dorsi, and one fasciocutaneous temporal flap. The arterial microvascular anastomoses were performed in an end-to-side fashion on the posterior tibial artery, and all veins were sutured end-to-end on a concomitant vein of the posterior tibial artery. All procedures were uneventful, and there were no postoperative complications. Early postoperative edema of the flaps was not different from that of other free flaps performed for lower limb reconstruction in our department; however, flap thickness and volume did not decline to the same extent after 9 months despite compressive garments. Soft-tissue excess could be excluded because of the topographic data noted during the inset procedure indicating adequate filling of the defect. All three patients complained after 12 to 24 months (mean, 16 months) postoperatively of this cosmetically impairing flap edema. Only one patient had already had two debulking procedures (fasciocutaneous temporal flap, 13 and 16 months postoperatively), unfortunately without a satisfying result.

Digital angiography of the lower limb was performed on all patients to document the vascular pattern of the flap and its surroundings. Subsequently, distal branches of the nutrient artery were embolized with particles of polyvinyl alcohol, measuring 100 to 500 $\mu$m in diameter. Postembolization angiography was performed in every case to document the effectiveness of the embolization in terms of flow

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distribution. The free flap contour changes and the complications were evaluated during follow-up.

## Case Reports

### *Case 1*

A 38-year-old woman presented with chronic osteitis after an open fracture of the left talar bone. Adequate débridement was performed and the defect was covered with a free muscle flap (serratus anterior muscle) anastomosed end-to-side on the posterior tibial artery. The postoperative course was uneventful, with complete wound healing after 2 weeks. However, 12 months after the operation, the patient still complained about the functionally and cosmetically impairing flap swelling, which could not be diminished by pressure garments. The patient was referred to the medical imaging department for selective embolization of the nutrient artery. Digital subtraction angiography of the left lower limb showed multiple vessels in the subcutaneous soft tissue of the heel. Most vessels, especially in the region of the free flap, were nourished by a branch from the posterior tibial artery, corresponding to the free flap nutrient artery. Tissues surrounding the free flap were mainly nourished by a few branches of the fibular artery. The posterior tibial artery and nutrient pedicle were selectively catheterized with a microcatheter. Distal branches of the nutrient artery were embolized with 100- to 300-$\mu$m-diameter particles of polyvinyl alcohol. However, no occlusion of branches could be detected, and larger diameter particles (300 to 500 $\mu$m) were infused. Postembolization distraction angiography showed good occlusion of the embolized branches, without pedicle occlusion. Clinical follow-up showed a significant decrease of edema, without any ischemic complication.

### *Case 2*

A 50-year-old woman was admitted with a left bimalleolar ankle fracture and cutaneous tissue loss as a result of a traffic accident. The orthopedic surgeons performed an osteosynthesis that had to be covered by free tissue transfer because of skin loss. We performed a free muscle flap (latissimus dorsi muscle) anastomosed end-to-side to the posterior tibial artery to cover the defect. There were no postoperative complications, with complete wound healing after 17 days. She presented 12 months later, complaining of increasing volume and thickness of the muscle flap despite use of a compressive garment and physiotherapy. At clinical examination, hyperemia was noted, but palpation was painless. Angiography of the posterior tibial artery showed an early intense vascular network around the flap (blush phenomenon). Embolization with 150- to 350-$\mu$m polyvinyl alcohol particles of the distal branches was performed, and follow-up was without ischemic events. After 3 months, flap thickness and volume had declined almost to immediate postoperative values.

### *Case 3*

A 46-year-old woman was admitted for treatment of chronic plantar radiodermatitis. At the age of 16 years, she had received radiation therapy as treatment for warts on her left heel. We performed a full-thickness excision, leaving a 4 $\times$ 5-cm defect at the lateral side of the heel and ankle. A free fasciocutaneous temporal flap, anastomosed end-to-side to the posterior tibial artery, was used to cover the defect. All wounds healed well, and weight-bearing pressure was authorized after 6 weeks. The presence of hair on the surface of the flap did not result in a functional defect, but after 6 months, the patient insisted on reduction of flap thickness. Debulking was performed on two occasions between 6 and 20 months after resection, with an unsatisfactory result. Two years after the reconstruction, ulceration caused by friction was noted at the periphery (Fig. 1). The flap was still bulky, but no signs of inflammation or infection could be detected. Digital pressure did not reduce swelling. Selective angiography of the posterior tibial artery showed an intense arterial network at the recipient site (Fig. 2). Embolization with 150- to 350-$\mu$m particles of polyvinyl alcohol was performed by selective catheterization of the pedicle with an F3 microcatheter through a homolateral antegrade puncture of the popliteal artery. Control distraction angiography, performed after the selective embolization of the distal branches of the feeding artery, showed a highly reduced vascular network (Fig. 3). No skin or fat necrosis was noted. Two months after embolization, the ulceration had healed and flap thickness had declined to its intraoperative value (Fig. 4). Moreover, the amount of hair on the flap diminished impressively, and at 36 months postembolization, the result remained stable.

## Discussion

Postoperative edema in free microvascular flaps is a commonly encountered problem. It may cause not only cosmetic but also functional disabilities when situated in regions such as the weight-bearing area of the foot or malleolar area. In previous works, increased muscle thickness and volume have been studied by computed tomographic scan, magnetic resonance imaging, and ultrasonography.[7,8] This can be explained partially by a transient increase of blood flow into the flap linked to a decreased vascular resistance. These findings are documented in muscle flaps[6,7] and in skin flaps.[10] However, bulky flaps are often seen on the lower extremities, probably because of persistent, vigorous blood flow in the pedicle.[8]

Fig. 1. Focus on ulceration located on the border of the edematous flap.

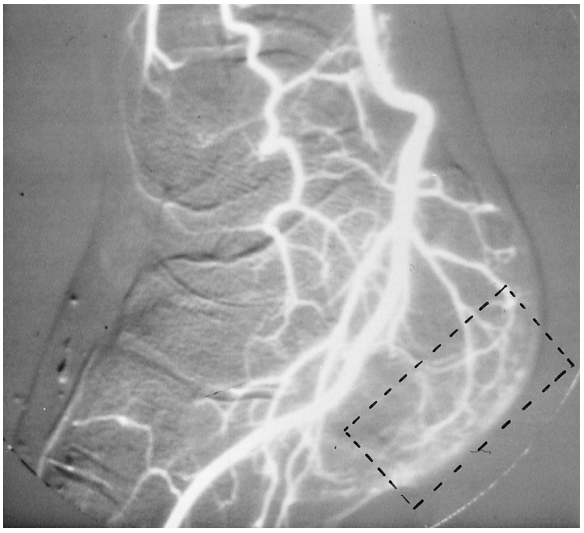

FIG. 2. Selective angiogram of the left posterior tibial artery shows an intense vascular network at the heel.

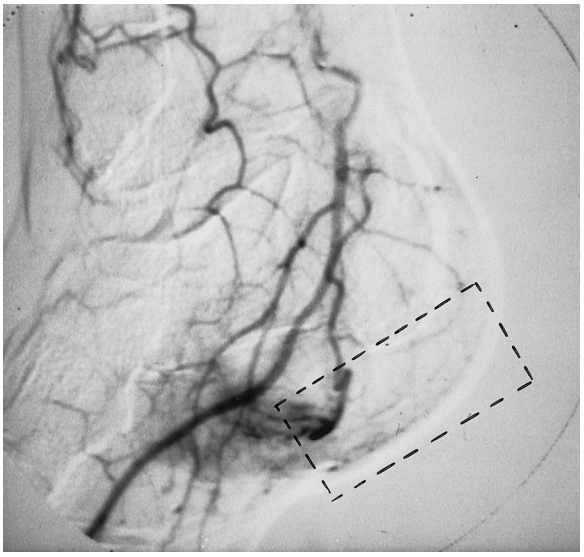

FIG. 3. Control angiogram obtained after selective embolization of the distal branches of the nutrient artery documenting a reduced vascular network.

Muscle flaps have been studied more commonly, but despite classic observations that denervated muscle will atrophy, the extent of shrinkage of the transferred nonreinnervated muscle flaps remains a subject of debate.[5,11]

The transferred tissue usually attains its initial thickness in 6 to 9 months postoperatively,[7] but occasionally it remains edematous for a longer period. It has been stated that decreased lymphatic drainage could be one of the important factors contributing to free flap edema.[7] Slavin et al.[2] documented in their study the return of lymphatic function somewhere between days 8 and 13. Other radioisotope studies have shown the normalization of lymphatic flow in the immediate postoperative period.[12]

As mentioned above, increased blood flow can partially explain the edema formation. The main reason for this increased blood flow could be a decline in vascular resistance at the arteriolar level.[3] Because of denervation and subsequently perivascular sympathectomy, arteriolar vasoconstriction will be relieved and muscular tone will be lost, facilitating vasodilatation. Modulation of the vascular resistance of the free flap will therefore cause changes in the blood flow. Thus, by increasing the vascular resistance in the flap, the increased postoperative blood flow will decrease, leading to less edema formation. Therefore, by selective embolization, using polyvinyl alcohol particles with a diameter of 150 to 350 $\mu$m or other particulate agents, our goal is to obliterate the arterioles with an equivalent diameter. This will result in a decreased capillary perfusion, causing an increase of the vascular resistance. These local hemodynamic modifications could be observed during the postembolization digital subtraction angiography. Indeed, using equal intravascular pressures, a diminished flow could be observed in the nutrient artery of the flap after embolization. Embolization was stopped once stagnation of contrast medium in the embolized vessels could be detected by distraction angiography control.

Although embolization is well known and documented in oncology to create tissue necrosis, it can also be very useful in other medical applications. In our free flap application, the risk of cutaneous necrosis is reduced be-

FIG. 4. Major regression of edema and total healing of the ulceration.

cause of embolization with adequately sized particles. Consequently, liquid embolization agents, such as ethanol, should be avoided. After embolization, the venous network will adapt to the reduced inflow without difficulties. Eventually, flap thickness and volume will decline as a result of diminished intravascular volume and moderate secondary atrophy. However, it remains uncertain how much "shrinkage" will be achieved, and spontaneous reinnervation of muscle flaps also alters muscle histology, resulting in less muscle atrophy.[5]

Surgical debulking of a free flap has been the classic procedure for reducing flap volume and thickness. However, this technique may endanger flap vascularization, and the main indication seems to be volume reduction of a flap with initial tissue excess. If fat tissue is excessive, liposuction may be an alternative for avoiding vascular complications.[13,14] Although further investigations are needed, embolization could be a feasible alternative for reducing prolonged edema of a flap with an initial adequate volume.

## Conclusions

Embolization techniques are well known and have been documented in numerous applications such as locoregional chemotherapy, induction of tumor necrosis, and exclusion of the vascular bed. Because the increased blood flow in flaps after free transfer can partially explain edema formation, modulation of this flow will also alter the flap edema. Increasing vascular resistance, resulting in decreased blood flow, can easily be obtained by selective arterial transcatheter embolization. This technique can offer an additional option in postoperative management of free flaps to reduce their bulky appearance.

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