Chapter 4

Application of Free Flow-Through Anterolateral Thigh Flap for the Reconstruction of an Extremity Soft Tissue Defect Requiring Vascularization

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Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.69404

Abstract

Patients with severe injury or vasculopathy of the extremities often require resurfacing of tissue defects as well as preservation of functional blood flow to distal areas. In conventional free flap transfer, the recipient vessel is sacrificed to facilitate pedicle anastomosis. On the other hand, a flow-through flap can provide blood flow to distal tissues. In this chapter, we present cases of successful salvage and reconstruction of the extremities using free flow-through flaps and highlight their advantages and applications. Free flow-through flap use should be a good option in the following cases: (1) Gustilo-Anderson IIIC type open fracture, (2) chronic ulcer resurfacing in the less vascularized extremities, and (3) additional blood supply for an ischemic flap. This flap facilitates not only the reconstruction of soft tissue defects, but also restores the functional vascular anatomy and maintains the original blood flow by interposing the T-portion of the vessel. This technique enables both vascular and soft tissue reconstructions simultaneously with minimal donor site problems. The anterolateral thigh flap is recommended as a free flow-through-type flap due to its advantages, including the variety of flap sizes, adequate calibers of the vascular pedicle, and the lack of a need for position changing.

Keywords: reconstruction of the extremity, soft tissue defects, revascularization, free flow-through flap, anterolateral thigh flap

1. Introduction

The disadvantage of traditional methods for reconstruction of soft tissue deficits using pedicle flaps is the need for multiple stages. In addition, donor site morbidity may be another disadvantage [1]. Following recent trends to overcome these problems, microsurgical flap transfer has revolutionized the reconstruction of soft tissue defects and has become a standard

technique for the resurfacing of wounds, because it facilitates not only the safe coverage of large tissue defects, but also yields a cosmetically acceptable appearance [2–4]. Regarding hand and leg salvage and reconstruction after trauma and oncologic resection, surgeons often need to ensure both soft tissue coverage and blood flow supply to the distal extremities. Free tissue transfer can be superior to pedicle flap coverage for the resurfacing of a large tissue defect, as it reduces infection, induces bony healing, and optimizes limb salvage [5–7].

However, in conventional free flap transfer, the recipient vessel is sacrificed to facilitate pedicle anastomosis, a procedure which may reduce the distal blood flow. Especially, patients with vascular injury or chronic vasculopathy of the extremities require resurfacing of tissue defects as well as preservation of functional blood flow to distal areas. The concept of flow-through circulation in free flaps is using a one-staged technique for wound coverage and the revascularization of ischemic extremities [8].

In this chapter, several cases of successful salvage and extremity reconstruction using free flow-through flaps are presented; their advantages and applications are highlighted.

2. Surgical principle of free flow-through flap

In the flow-through flap concept, both the proximal and distal ends of the vascular pedicle of a free flap are anastamosed to provide blood flow to distal tissues (**Figure 1**). Since the concept

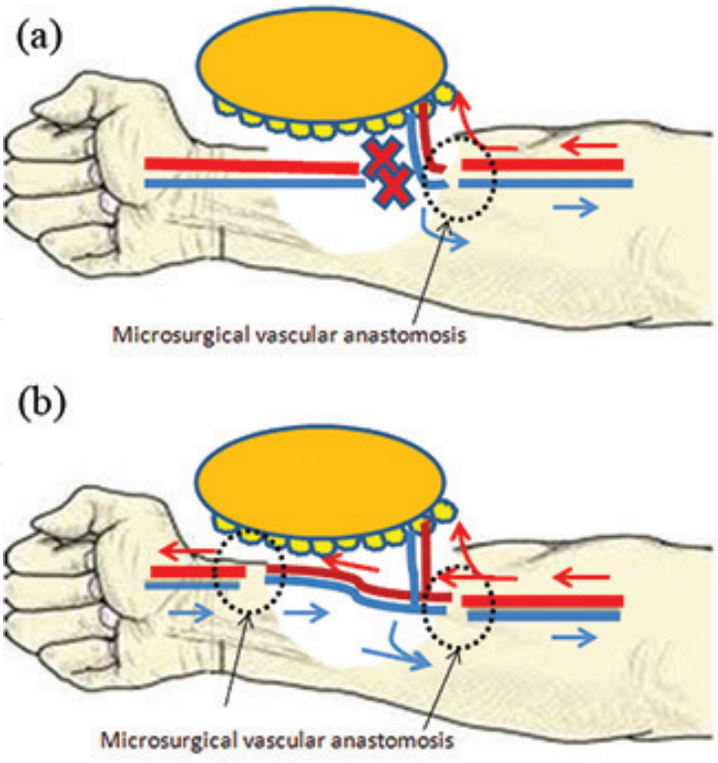

Figure 1. Schematic representation of the conventional and flow-through-type free flap. (a) Conventional free flap transfer. Major blood vessels are sacrificed; consequently, blood flow to the distal area is reduced. (b) Free flow-through flap transfer. Flow-through anastomosis preserves the recipient arterial flow, and the flaps are anatomically consistent.

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was first described by Soutar et al. [9] using a radial forearm flap, many investigators have described the application of flow-through flaps for extremity reconstruction; latissimus dorsi musculocutaneous, rectus abdominis musculocutaneous, fibula osteomyocutaneous, and anterolateral thigh (ALT) flaps have been diversely used [9–12]. The ALT flap, in particular, can provide a large skin paddle yet with minimal donor site morbidity; thus, it is ideal for extremity reconstruction [10, 13–16].

3. Surgical procedure of free flow-through ALT flap

The musculofasciocutaneous ALT flap is supplied by the descending branch of the lateral femoral circumflex artery. Thus, it can be harvested as a fasciocutaneous or myocutaneous flap [17]. The descending branch traverses downward in the intermuscular septum between the rectus femoris and vastus lateralis muscle [18]. The rectus femoris muscle is retraced medially to expose the vascular bundle of the descending branch, and the length and diameter are examined. It proceeds downward, while sending perforators to supply the skin and muscles around the anterolateral aspect of the thigh (**Figure 2**). Usually, the descending branch has an external diameter of more than 2 mm at the proximal end with a pedicle of more than 8 cm in length (**Figure 3**) [18, 19]. When a larger flap is required, more than two perforator arteries should be preserved between the flap and pedicle.

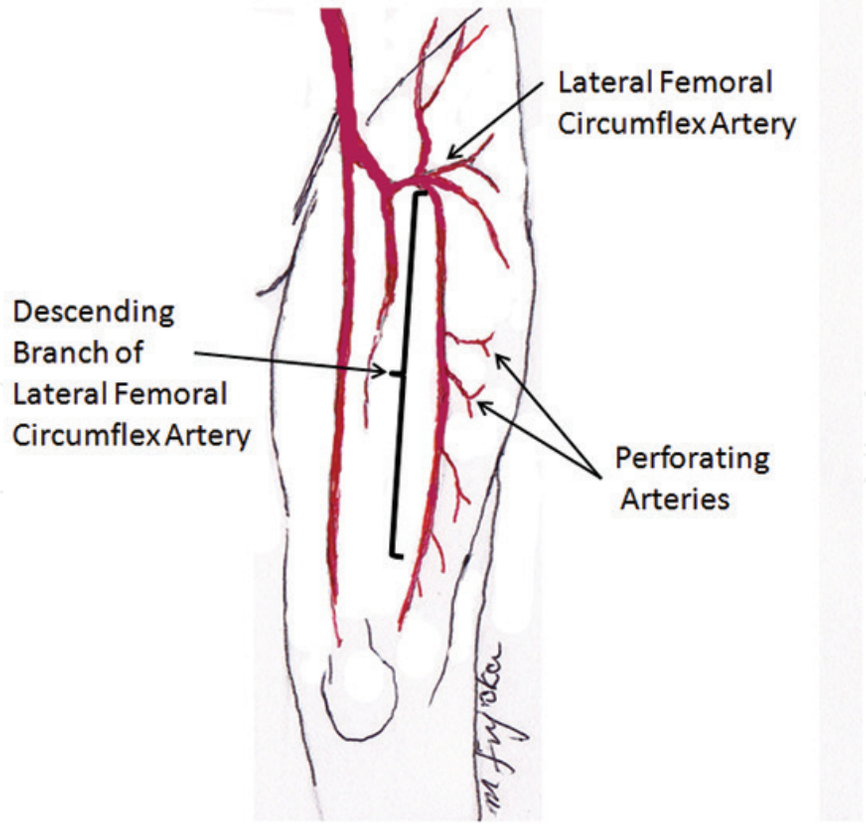

Figure 2. Vascular anatomy of the descending branch of the lateral femoral circumflex artery. The descending branch of the lateral femoral circumflex artery (marked in the illustration) is used as an interposing vessel.

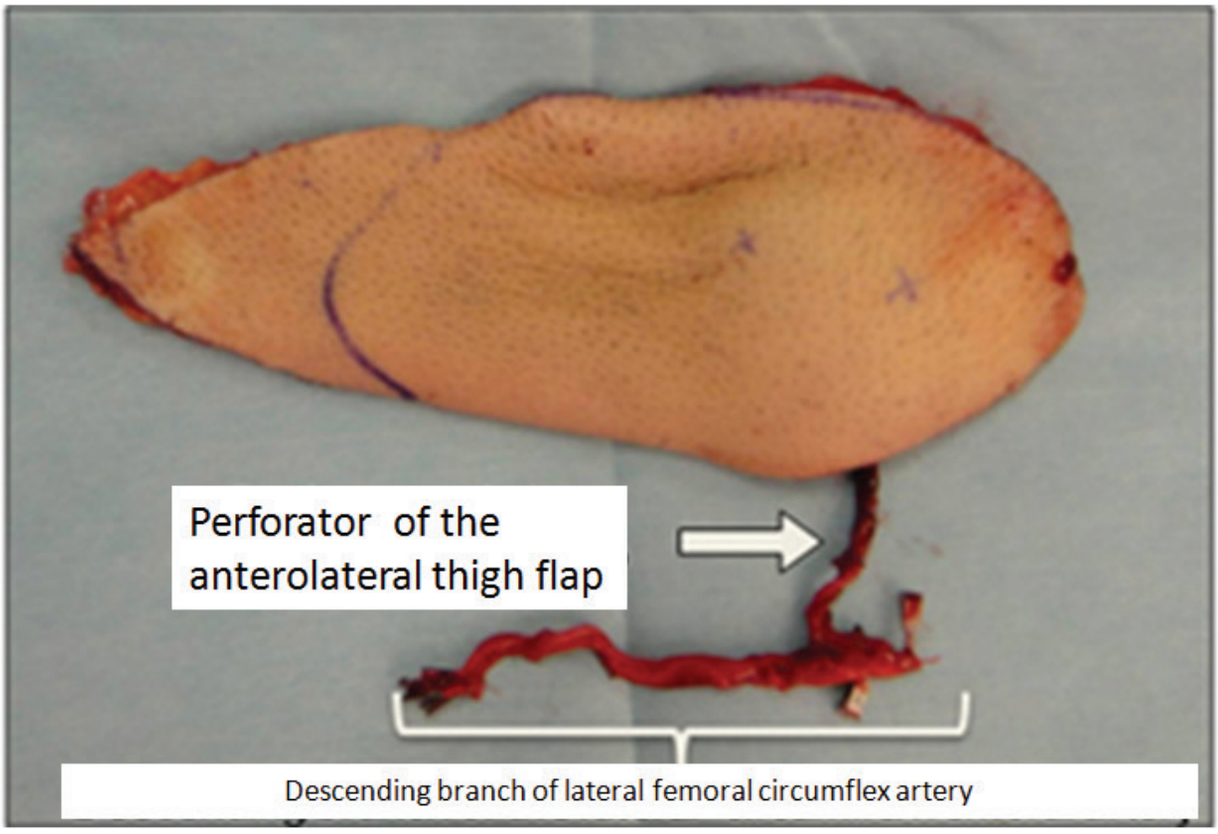

Figure 3. The harvested TFL flap and descending branch of the lateral femoral circumflex artery.

After the ALT flap has been harvested with an elliptical skin island from the thigh in the usual manner, the T-portion of the descending branch is interposed with the defect of the recipient artery (**Figure 1 (b)**). After confirming the vascular flow in the distal extremity, two veins are connected by end-to-end anastomosis. Vessel size mismatch has not been an issue because the caliber of the descending pedicle is considered to be consistently maintained throughout its course down the upper half to two-thirds of the vastus lateralis [20]. Generally, venous anastomosis does not have to be performed using the flow-through technique, except in re-plantation surgery for amputated limbs. Consequently, the interrupted recipient artery resumes normal blood flow, while the flap is vascularized via the perforator vessels of the descending branch.

4. Indication of free flow-through flap

Maintaining distal blood supply is important at all times for preventing the development of many diseases due to ischemia or peripheral circulation disorders (including frostbite, a contaminated leg ulcer, peripheral arterial disease, and skin and soft tissue problems associated with diabetes mellitus). Therefore, free flow-through flap use can be recommended in any case when combined free flap reconstruction and preservation/restoration of distal blood flow are required. In this fact indicating that the absolute indication of free flow-through flap use may be limited. However, additional indications include severe trauma involving the

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extremities and after malignant tumor resection, as these often cause blood vessel loss associated with soft tissue defects. Extremity reconstruction in vasculopathy patients also requires primary preservation of functional blood flow to distal areas. In such cases, one-stage reconstruction using a free flow-through flap may be an absolute application.

Free flow-through flap use should be a good option for soft tissue reconstruction in the following three cases:

(1) severe trauma (for example, Gustilo-Anderson IIIC type open fracture);

(2) chronic ulcer resurfacing in the less vascularized extremities; and

(3) additional blood supply for an ischemic flaps.

The author presents some cases of successful salvage and reconstruction of the extremities using free flow-through flaps.

5. Case presentation

5.1. Severe trauma (Gustilo-Anderson IIIC type open fracture)

Gustilo-Anderson IIIC type fracture requires both vascular and soft tissue repair immediately [21]. For reconstruction, flow-through flap use is beneficial, because blood flow of the distal extremity can be maintained, while the soft-tissue-insufficient wound can be resurfaced simultaneously.

Case 1. Due to a traffic accident, a 64-year-old man sustained a Gustilo-Anderson Type IIIC bone-exposing fracture to the left fibula and tibia with wide skin abrasion and involvement of the anterior tibial muscles (**Figure 4 (a, b)**). Circulation of the left foot had ceased because three main arteries in the leg (peroneal, posterior tibial, and anterior tibial arteries) had been ruptured with subsequent flow interruption (**Figure 5**). After the crushed bones had undergone external fixation, the bone-exposing wound was repaired with a free flow-through ALT flap. The T-portion of the descending branch of the ALT flap was interposed to the defect of the anterior tibial artery (**Figures 6**, **7**). Subsequently, the interrupted anterior tibia artery resumed normal blood flow. The viability of the flap was favorable without infection or necrosis (**Figure 8**). The patient could walk without canes 1 year after surgery.

5.2. Chronic ulcer resurfacing in the less vascularized extremities

Chronic ulcer resurfacing, especially reconstruction after oncologic resection, in the less vascularized extremities is a challenge, because single artery scarification can cause amputation [22]. Free flow-through flap use is beneficial as it can maintain the distal blood flow [6].

Case 2. A 65-year-old man suffered from a chronic right leg ulcer, which rapidly enlarged and developed a fungating wound over a 6-month duration (**Figure 9**). Histological analysis of

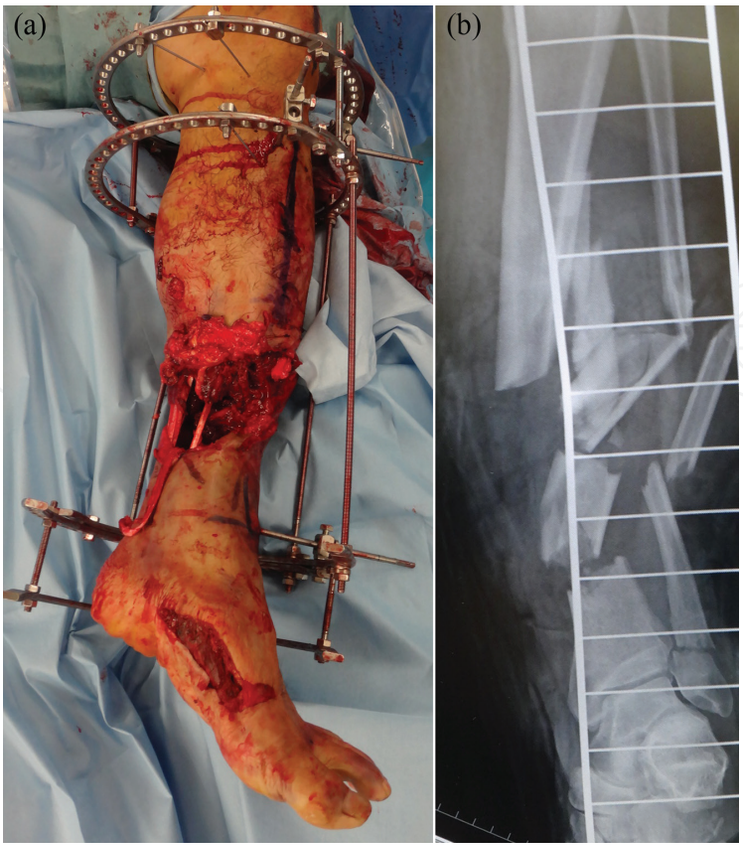

Figure 4. *Case 1*. The photographs show a Gustilo-Anderson IIIC type bone-exposing fracture to the left fibula and tibia with severe abrasion of the skin and anterior tibial muscles.

Figure 5. Contrast-enhanced CT reveals that circulation of the left foot had ceased because peroneal, posterior tibial, and involvement of anterior tibial arteries had been interrupted.

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Figure 6. A harvested flow-through ALT flap.

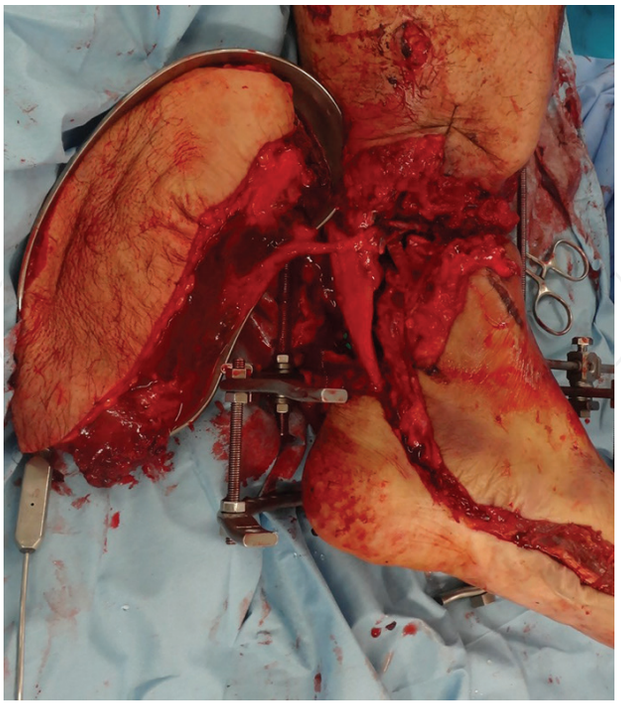

Figure 7. The intra-operative photograph shows the T-portion of the descending branch of the ALT flap interposed within the defect of the posterior tibia artery.

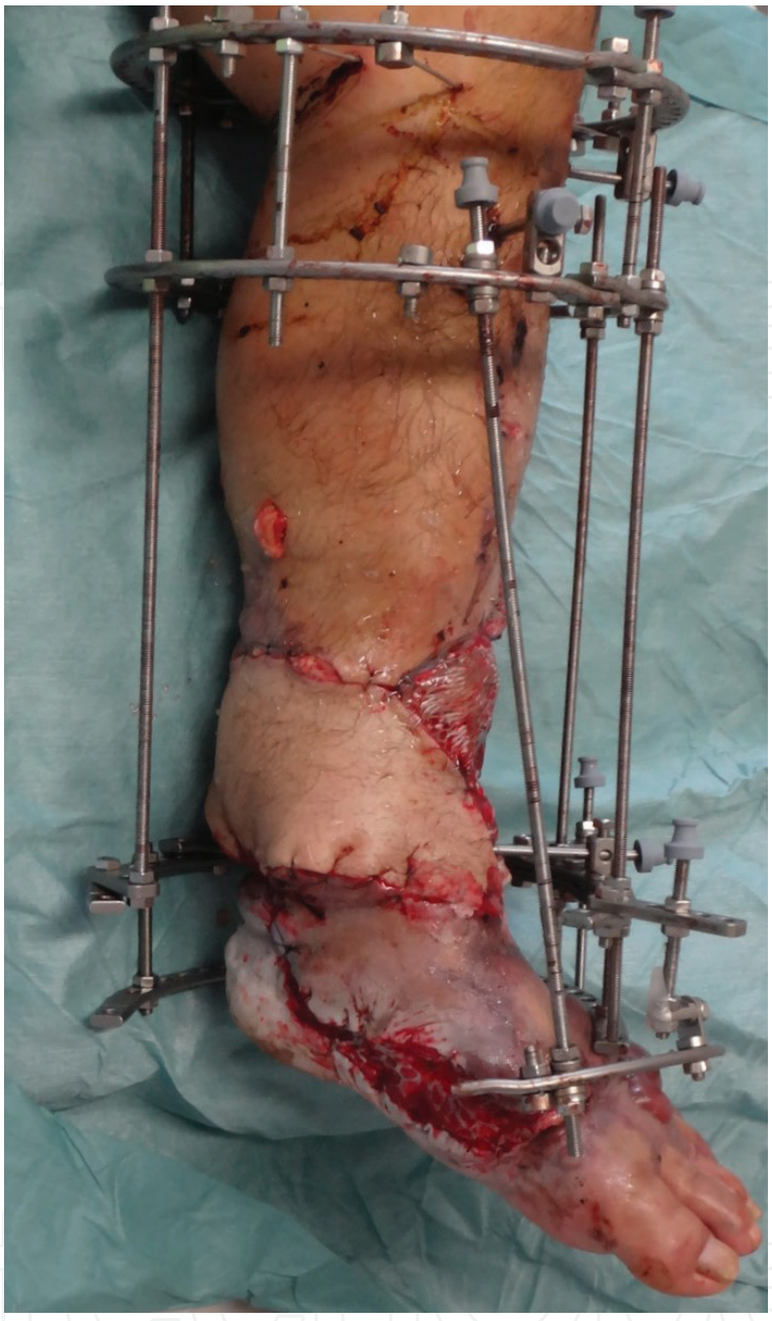

Figure 8. The postoperative photograph shows the resurfacing of all of bone-exposing wound and assumption of circulation to the foot.

a biopsy specimen indicated squamous cell carcinoma. The peripheral side of his lower leg was perfused only by the posterior tibial artery, because both the anterior tibial and peroneal arteries had been interrupted due to a trauma suffered 40 years previously (**Figure 10**).

After the complete removal of the tumor (**Figure 11**), the bone-exposing wound was resurfaced with a free flow-through ALT flap with a 22.0 × 8.0-cm elliptical skin island (**Figure 12**). The T-portion of the descending branch of the lateral circumflex femoral vessel was interposed

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Figure 9. *Case 2*. The photograph shows a chronic right leg ulcer, which developed a fungating wound.

Figure 10. Contrast-enhanced CT revealed that the lower leg was solely being perfused by the posterior tibial artery.

within the divided posterior tibial artery. Two veins were connected to the accompanying posterior tibial veins by end-to-end anastomosis (**Figure 13**). The viability of the skin flaps was favorable without infection or necrosis (**Figure 14**). Contrast-enhanced computed tomography of the reconstructed leg 1 month after surgery demonstrated successful revascularization at the vascular anastomotic sites, which maintained effective circulation of the right foot (**Figure 15**). Six months later, the patient showed a favorable outcome of the lower leg without recurrence (**Figure 16**).

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Figure 11. Intraoperative picture after the complete tumor removal showing the large bone-exposing wound.

Figure 12. A harvested flow-through ALT flap.

Case 3. A 57-year-old male had developed a diabetic ulcer on the medial malleolus, which had enlarged over a 1-year period. He had non-controlled diabetes mellitus for more than 7 years. There was evidence of peripheral circulatory disturbance. The chronic ulcer reached the fibula and osteomyelitis occurred (**Figure 17**). He underwent debridement that included infected bone. To maintain peripheral circulation, the defect after resection was resurfaced

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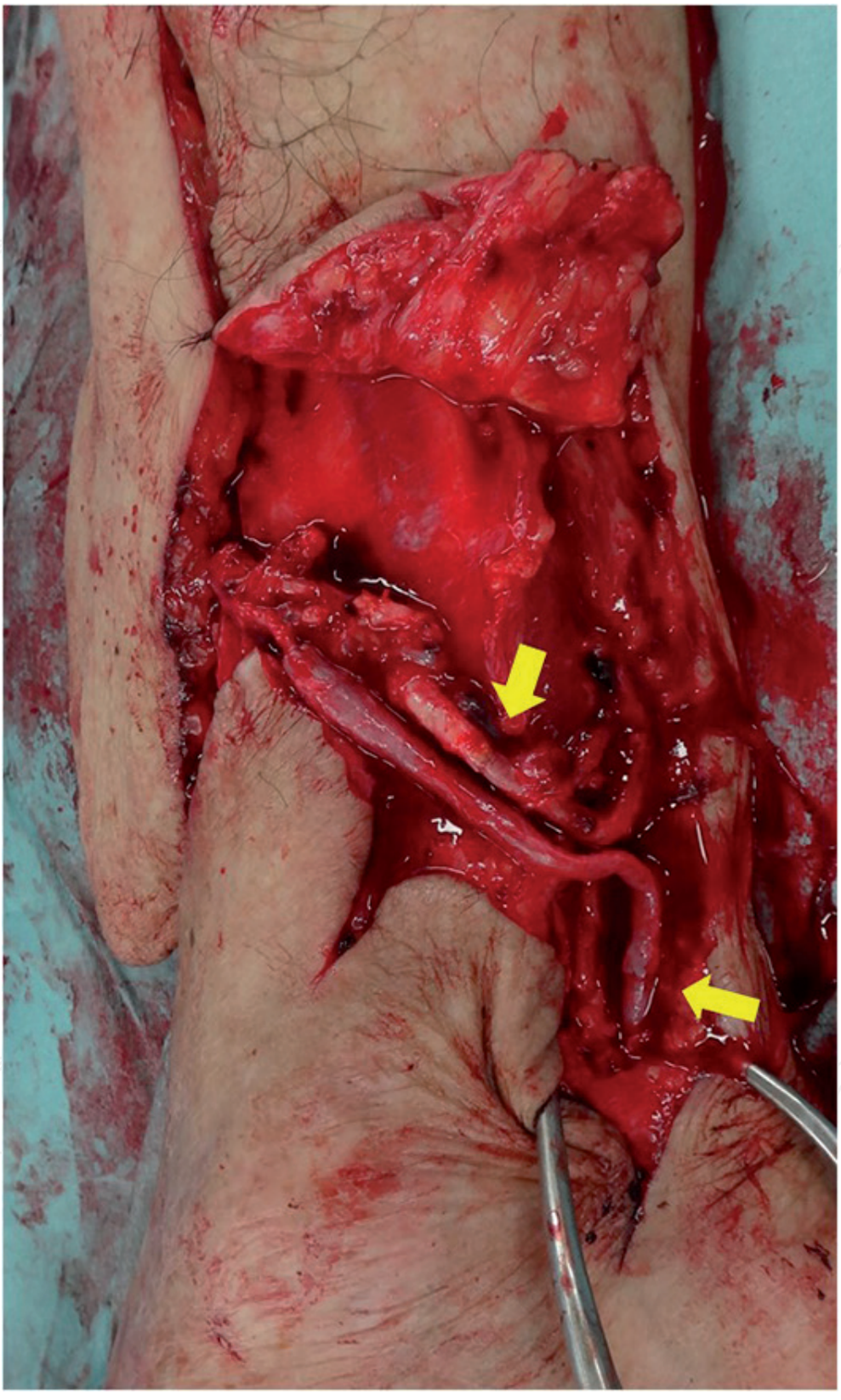

Figure 13. Intraoperative picture showing the T-portion of the descending branch interposed within the divided posterior tibial artery. The arrows indicate the microsurgical anastomosis points.

Figure 14. A postoperative photograph showing the resurfacing of all of the bone-exposing wound, and immediate resumption of foot circulation.

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Figure 15. Contrast-enhanced CT demonstrated sufficient circulation of both the transferred flap and right foot.

Figure 16. A 6-month postoperative view. The viability of both the leg and flap was favorable, without tumor recurrence.

with a free flow-through ATL fasciocutaneous flap (**Figure 18**). The T-portion of the descending branch was interposed within the posterior tibial vessel. The viability of the skin flaps was favorable without infection or necrosis (**Figure 19**). This flap was thin enough to enable him to wear shoes (**Figure 20**).

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Figure 17. *Case 3*. This photograph shows a diabetic ulcer on the medial malleolus associated with osteomyelitis.

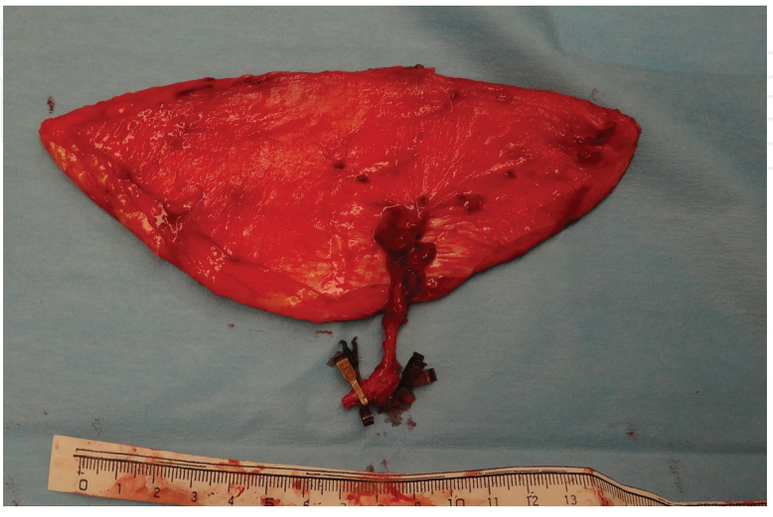

Figure 18. A harvested flow-through ALT fasciocutaneous flap.

Figure 19. A 6-month post-operative view. The viability of both the leg and flap was favorable, there was no ulcer recurrence.

5.3. Additional blood supply for ischemic flap

As a flow-through flap can supply circulation for distal areas, it may be utilized to improve blood flow to other distally-based ischemic flaps, which show poor circulation [7, 23].

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Figure 20. A 6-month post-operative view. The ALT fasciocutaneous flap was thin enough to enable the patient to wear shoes.

*Case 4***.** A 53-year-old man underwent resection of a malignant melanoma presenting at the distolateral plantar weight-bearing region of the right foot (**Figure 21**). The defect after resection of the melanoma was repaired with a reversed island median plantar flap (**Figure 22**). However, the flap became ischemia as the reversed blood flow was insufficient to maintain adequate circulation. Thus, the instep donor defect was covered with a free anterolateral thigh

Figure 21. *Case 4.* This photograph shows a malignant melanoma on the distolateral plantar weight-bearing region of the right foot.

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Figure 22. Intraoperative photograph of the wound after complete resection of the tumor.

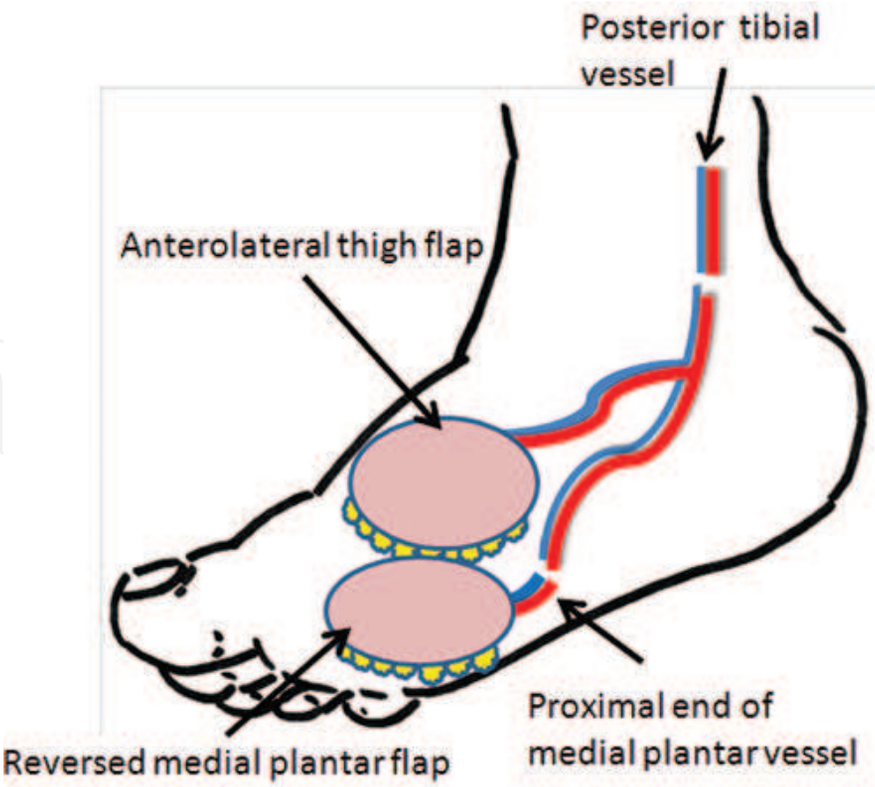

Figure 23. Schematic representation of the instep donor defect coverage with a free flow-through ALT flap.

flap, while the T-portion of the descending branch of the lateral circumflex femoral vessel was interposed within the transected medial plantar vessel providing additional blood supply to the ischemic flap (**Figures 23** and **24**). Consequently, ischemia of the reversed median plantar flap improved, because the interrupted medial plantar vessel resumed normal blood flow (**Figure 25**). The patient could walk without tumor recurrence 1 year after surgery (**Figure 26**).

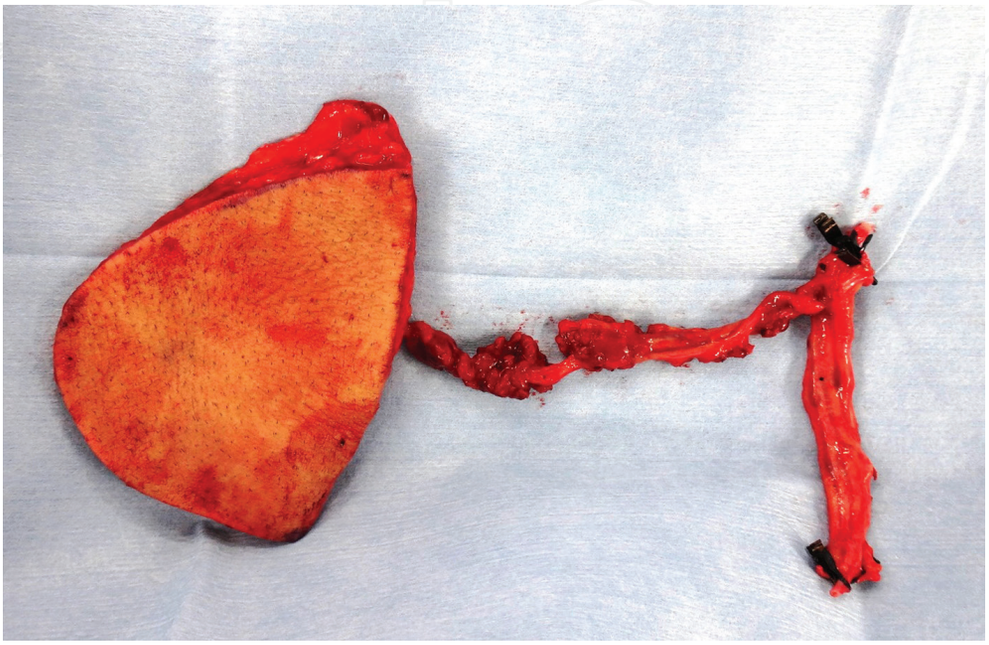

Figure 24. A harvested flow-through ALT flap.

Figure 25. The T-portion of the descending branch was interposed within the transected medial plantar vessel. Subsequently, ischemia of the reversed median plantar flap improved.

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Figure 26. A 12-month postoperative view. The viability of both the leg and flap was favorable; there was no tumor recurrence.

6. Discussion

Reconstruction of soft tissue defects in areas of the extremities with no or impaired circulation is one of the most difficult challenges. Surgeons must reconstruct the defect as well as maintain the peripheral circulation, or patients will lose their limbs. A flow-through flap may be utilized in an effort to reconstruct the vasculature as well as provide soft tissue coverage [24].

The author believes that this flap is useful not only for establishing arterial blood supply to the peripheral tissue, but also for preserving venous return, especially in legs with venous stasis. This is particularly so, because it does not sacrifice the valuable deep venous return system. Furthermore, several investigators have reported that flow-through arterial anastomosis leads to a higher patency rate than conventional end-to-end and end-to-side arterial anastomosis, and even promoted more favorable blood flow through the anastomotic site [25, 26].

7. Conclusion

The principal advantage of the flow-through flap is that it allows a single-stage composite reconstruction of both soft tissue and vascular defects, making it particularly useful in the reconstruction of ischemic extremities and defects resulting from oncologic ablations.

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References

[1] Clymer MA, Burkey BB. Other flaps for head and neck use: Temporoparietal fascial free flap, lateral arm free flap, omental free flap. Facial Plastic Surgery. 1996;**12**(1):81-89. DOI:10.1055/s-2008-1064498

[2] Shindo ML, Sullivan MJ. Soft-tissue microvascular free flaps. Otolaryngologic Clinics of North America. 1994;**27**(1):1731-1794

[3] Coleman JJ 3rd. Reconstruction of the pharynx and cervical esophagus. Seminars in Surgical Oncology. 1995;**11**(3):208-220

[4] Baker SR. Microvascular free flaps in soft-tissue augmentation of the head and neck. Archives of Otolaryngology--Head & Neck Surgery. 1986;**112**(7):733-737

[5] Saint-Cyr M, Langstein HN. Reconstruction of the hand and upper extremity after tumor resection. Journal of Surgical Oncology. 2006;**94**:490-503. DOI:10.1002/jso.20486

[6] Fujioka M, Hayashida K, Murakami C. Emergent free flow-through anterolateral thigh flaps for Gustilo-Anderson III fracture of the upper extremity. Journal of Emergencies, Trauma and Shock. 2014;**7**(1):53-55. DOI: 10.4103/0974-2700.125642

[7] Fujioka M, Hayashida K, Senju C. Reconstruction of lateral forefoot using reversed medial plantar flap with free anterolateral thigh flap. Journal of Foot and Ankle Surgery. 2014;**53**:324-327. DOI: 10.1053/j.jfas.2013.12.012

[8] Costa H, Cunha C, Conde A, Barsdley A, McGrouther DA. The flow-through free flap in replantation surgery: A new concept. European Journal of Plastic Surgery. 1997;**20**(4)181-185. DOI: 10.1007/BF01152186

[9] Soutar DS, Scheker LR, Tanner NS, McGregor IA. The radial forearm flap: A versatile method for intra-oral reconstruction. British Journal of Plastic Surgery. 1983;**36**(1):1-8

[10] Koshima I, Fujitsu M, Ushio S, Sugiyama N, Yamashita S. Flow-through anterior thigh flaps with a short pedicle for reconstruction of lower leg and foot defects. Plastic and Reconstructive Surgery. 2005;**115**(1):155-162. DOI:10.1055/s-2008-1040770

[11] Miyamoto S, Kayano S, Umezawa H, Fujiki M, Sakuraba M. Flow-through fibula flap using soleus branch as distal runoff:. A case report. Microsurgery. 2013;**33**(1):606-602. DOI:10.1002/micr.22043

[12] Garvey PB, Clemens MW, Rhines LD, Sacks JM. Vertical rectus abdominis musculocutaneous flow-through flap to a free fibula flap for total sacrectomy reconstruction. Microsurgery. 2013;**33**(1):32-38. DOI: 10.1002/micr.21990

[13] Rowsell AR, Davies DM, Eisenberg N, Taylor GI. The anatomy of the subscapular-thoracodorsal arterial system: study of 100 cadaver dissections. British Journal of Plastic Surgery. 1984;**37**:574-576

[14] Xu DC, Zhong SZ, Kong JM, Wang GY, Liu MZ, Luo LS, Gao JH. Applied anatomy of the anterolateral femoral flap. Plastic and Reconstructive Surgery. 1988;**82**:305-310

[15] Ceulemans P, Hofer SO. Flow-through anterolateral thigh flap for a free osteocutaneous fibula flap in secondary composite mandible reconstruction. British Journal of Plastic Surgery. 2004;**57**(4):358-361. DOI:10.1016/j.bjps.2004.02.013

[16] Ao M, Nagase Y, Mae O, Namba Y. Reconstruction of posttraumatic defects of the foot by flow-through anterolateral or anteromedial thigh flaps with preservation of posterior tibial vessels. Annals of Plastic Surgery. 1997;**38**:598-603

[17] Wong CH, Wei FC. Anterolateral thigh flap. Head and Neck. 2010;**32**(4):529-540. DOI: 10.1002/hed.21204. DOI:10.1002/hed.21204

[18] Wei FC, Jain V, Celik N, Chen HC, Chuang DC, Lin CH. Have we found an ideal soft-tissue flap? An experience with 672 anterolateral thigh flaps. Plastic and Reconstructive Surgery. 2002;**109**:2219-2226

[19] Gokhan M, Ulusal AE, Atik A, Sargin S, Ulusal B, Sukru Sahin M. Descending branch of the lateral circumflex femoral artery as a recipient vessel for vascularized fibular grafts: Clinical case series. Microsurgery. 2014;**34**(8):633-637. DOI: 10.1002/micr.22299

[20] Haffey TM, Lamarre ED, Fritz MA. Auto flow-through technique for anterolateral Thigh Flaps. JAMA Facial Plastic Surgery. 2014;**16**(2):147-150. DOI:10.1001/jamafacial.2013.2263

[21] Fujioka M, Hayashida K, Murakami C. Artificial dermis is not effective for resurfacing bone-exposing wounds of Gustilo-Anderson III fracture. Journal of Plastic, Reconstructive & Aesthetic Surgery. 2013;**66**(4):e119-121. DOI: 10.1016/j.bjps.2012.12.005

[22] Kells AF, Broyles JM, Simoa AF, Lewis VO, Sacks JM. Anterolateral thigh flow-through flap in hand salvage. Eplasty. 2013;**13**:e19

[23] Oberlin C, Accioli de Vasconcellos Z, Touam C. Medial plantar flap based distally on the lateral plantar artery to cover a forefoot skin defect. Plastic and Reconstructive Surgery. 2000;**106**:874-877

[24] Hidalgo DA. Aesthetic improvements in free-flap mandible reconstruction. Plastic and Reconstructive Surgery. 1991;**88**:574-585

[25] Kim JT, Kim CY, Kim YH. T-anastomosis in microsurgical free flap reconstruction: An overview of clinical applications. Journal of Plastic, Reconstructive & Aesthetic Surgery. 2008;**61**:1157-1163. DOI:10.1016/j.bjps.2008.03.048

[26] Miyamoto S, Okazaki M, Ohura N, Shiraishi T, Takushima A, Harii K. Comparative study of different combinations of microvascular anastomoses in a rat model: end-to-end, end-to-side, and flow-through anastomosis. Plastic and Reconstructive Surgery. 2008;**122**:449-455. DOI:10.1097/PRS.0b013e31817d62c5