Reconstruction of diabetic foot ulcers by lateral supramalleolar flap

Huseyin S. Yercan, MD, Tackin Ozalp, MD, Guvenir Okcu, MD.

ABSTRACT

Objective: To report a series of 8 diabetic patients in whom the reconstruction of large-sized defect of the foot was performed using lateral supramalleolar flap.

Methods: Coverage of the soft tissue defect was carried out by a lateral supramalleolar flap in 8 patients who had large-sized, non-healing ulcers at the Celal Bayar University, Department of Orthopedics and Traumatology, Manisa, Turkey, between 1998-2003. The mean age was 54 years. Preoperatively Doppler flowmeter evaluation was performed, and the ischemic index was calculated in all patients.

Results: The flaps survived except for one patient who had a large defect on the heel with low ischemic index. The average healing time of the ulcer region and recovery of regular walking status was 34 days. The average healing period of the donor site was 35 days. After the average follow-up period of 40 months, neither infection nor a recurrence of the ulcer was encountered. The major problem of the donor area was skin graft breakdown and its non-aesthetic appearance due to hypertrophic granulation tissue.

Conclusion: The lateral supramalleolar flap is a reliable option for the reconstruction of large-sized diabetic ulcers involving the dorsal aspect of the foot. This can also be used in conjunction with local muscle flaps, such as abductor hallucis for covering deep and large heel defects when the sural neurocutaneous flap is contraindicated.

Saudi Med J 2007; Vol. 28 (6): 872-876

From the Department of Orthopedics and Traumatology, Medical Faculty, Celal Bayar University, Manisa, Turkey.

Received 8th October 2006. Accepted 27th December 2006.

Address correspondence and reprint request to: Dr. Tackin Ozalp, Department of Orthopedics and Traumatology, Medical Faculty, Celal Bayar University, 1786/1 sok. No:1/7 35540, Karsiyaka, Izmir, Turkey. Tel. +90 (532) 7025968. Fax. +90 (236) 2370213. E-mail: tackino@yahoo.fr

Diabetic foot ulcers are probably the most challenging wound healing problem faced in modern medicine. Diabetic foot and its complications are a leading cause of amputation. Through the mid-1980's, no special reconstruction procedure was performed in diabetic foot ulcers and the solution for wide wounds was amputation. However, in recent years, early surgical treatment and coverage of the defect with free or local flaps has become an increasingly common procedure.[1-10] The flap chosen should be easy to execute quickly with minimal discomfort to the patient, and should provide durable coverage for the defect. The lateral supramalleolar flap (LSMF) described by Masquelet et al,[1,11,12] is a distally based fasciocutaneous flap supplied by the perforating branch of the posterior peroneal artery. The arterial anatomy of LSMF is based on the anastomotic arcade of the ankle and foot. The perforating branch of the peroneal artery pierces the interosseous membrane at the distal tibiofibular angle approximately 5 cm proximal to the tip of the lateral malleolus. It anastomoses with the anterolateral malleolar branch of the anterior tibial artery. It descends anterior to the inferior tibiofibular syndesmosis and anastomoses with the lateral tarsal artery on the lateral border of the foot. The distal based island pedicled flap is based on the perforating branch of the peroneal artery, which is divided just proximal to the cutaneous artery to flap, and its pedicle can be extended by dissecting the premalleolar artery as far as the level of the sinus tarsi. The maximal length of the vascular pedicle is 7 to 8 cm, which allows this flap to be used to cover skin defects over the medial aspect of the leg, ankle, and foot (**Figure 1**).[1,11-13] The closure of the donor site is facilitated by suturing the peroneal and extensor muscles together. This step is very important especially in diabetics. When the flap is raised, the lower part of it should be taken to preserve the cutaneous branches that lie on the

fibula. The release of the septum should be performed subperiosteally on the fibula. If the fibula is not covered by peroneal and extensor muscle belly, covering of the donor site by split thickness skin graft will probably fail. The aim of this study is to present our clinical experience with LSMF for coverage of large-sized soft-tissue defects in the diabetic foot.

Methods. Forty-five patients with diabetic foot ulcers were referred to the Department of Orthopedics and Traumatology, Celal Bayar University, Manisa, Turkey, between 1998-2003. Among them, coverage of a soft tissue defect was carried out by LSMF in 8 patients who had large-sized, non-healing ulcers. The mean age was 54 years (32-72 years). Three patients had defects of soft-tissue on the dorsal aspect of the forefoot, one patient had a defect on the anterior aspect of the ankle, and 4 patients had soft-tissue defects of the heel region. These diabetic wounds were non-healing large-sized ulcers, ranging from 4 x 7 to 6 x 12 cm. According to the Depth-Ischemia Classification, 2 lesions on the dorsal aspect of the forefoot were grade 3-C, one lesion on the dorsal aspect of the forefoot was grade 2-A, the lesions on the heel were grade 2-A and grade 3-B, and the lesion on the anterior aspect of the ankle was grade 3-A.[14,15] The characteristics of the patient population are summarized in **Table 1**. All the patients received conservative wound treatment in other hospitals, and 2 patients with dorsal forefoot ulcers also had necrosis of the second, third, fourth, and fifth toes. These toes were infected with material from the original wound bed. Wide debridement and irrigation were performed in all cases initially. Toe amputation was added in 2 patients with forefoot ulcers. Preoperatively, the major vascular status of each patient was assessed by palpation of the dorsalis pedis and posterior tibial pulses. Doppler flowmeter evaluation was performed, and the ischemic index (the rate of ankle to brachial pressure) was calculated in all patients. The ischemic index was higher than 0.6 in 6 patients and between 0.4-0.6 in 2 patients. When the vascular supply was in question, angiography was carried out (in one patient). Aerobic and anaerobic cultures were obtained before initiation of antibiotic treatment. A broad-spectrum antibiotic was begun, covering gram-positive and gram-negative organisms until sensitivities returned and appropriate antibiotic choices were made. The LSMF was raised in an island form as described by Masquelet (**Figure 2**). The length of the pedicle was extended by dissecting to the level of the sinus tarsi except in one patient who had a defect on the anterior aspect of the ankle. The donor area was covered with a split-thickness skin graft, which was harvested from the anterolateral aspect of the thigh. At the time of surgery, all patients were insulin-dependent diabetic patients. One patient who had a large defect on the heel was treated with an abductor hallucis muscle flap in addition to LSMF. The heel defect was very deep, down to the bone in this patient, and it was not possible to reconstruct it only with LSM. For the flaps used to cover forefoot ulcers, the limb was protected with below the knee splint for a period of 20 days. In the remaining 2 patients, the foot and flap were covered by appropriate soft tissue dressing.

Results. The follow-up period of the 8 patients ranged from 12-70 months with an average of 40 months. The flaps survived, except for one patient who had a large defect on the heel. Patients were followed

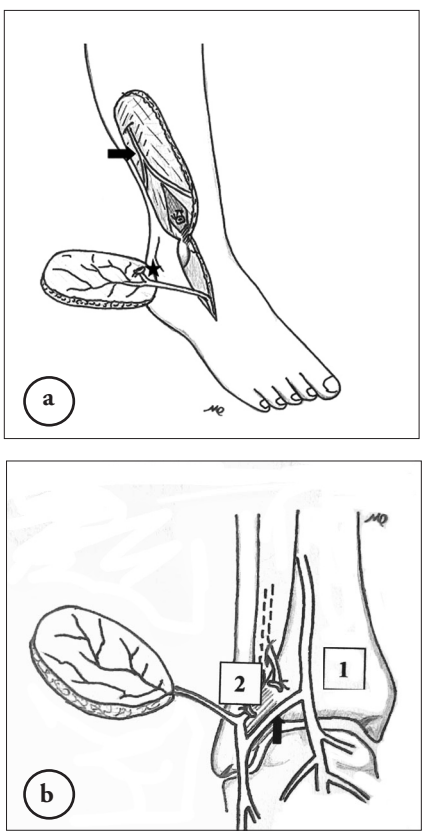

Figure 1 - Sketch **a)** The elevation of the flap includes aponeurosis. (→) superficial peroneal nerve; *ligature of the perforating branch of peroneal artery). **b)** The division of the anterolateral malleolar branch of anterior tibial artery allows pivot point to be shifted to sinus tarsi. (1) Anterior tibial artery. (2) the septocutaneous perforator from the peroneal artery and (↑) anterolateral malleolar branch of anterior tibial artery.

Table 1 - Patients' data.

Patient number	Age(years)/ gender	Defect location	Additional pathologies	Classification of the ulcers (depth-ischemia)	Ankle/ brachial index	Diagnostic evaluation	Dimension of flap (cm)	Compli-cations	Additional procedures	Results	Recovery of regular walking status (day)	Follow-up period (month)
1	44 / F	Dorsal aspect of the forefoot	2, 3 and 5 toes gangrene	Grade 3-C	0.62	Doppler	5 × 6	None	Toes amputation	Successful	25	70
2	72 / M	Dorsal aspect of the forefoot	4th toe gangrene	Grade 3-C	0.58	Doppler	5 × 7	None	Toe amputation	Successful	24	56
3	70 / M	Lateral aspect of the heel	None	Grade 2-A	0.64	Doppler	4 × 7	Donor-site skin graft breakdown	None	Successful	28	54
4	57 / M	Heel	None	Grade 3-B	0.46	Doppler and angiography	6 × 10	Complete necrosis of flap	Removal of the necrotic tissue and skin graft	Successful	90	48
5	32 / M	Dorsal aspect of the forefoot	None	Grade 2-A	0.68	Doppler	7 × 8	None	None	Successful	22	40
6	54 / M	Heel	None	Grade 2-A	0.70	Doppler	5 × 8	None	None	Successful	32	18
7	52 / M	Anterior aspect of the ankle	None	Grade 3-A	0.6	Doppler	6 × 12	Partial necrosis	Skin graft	Successful	28	22
8	51 / F	Insertion of Achilles tendon	None	Grade 2-A	0.6	Doppler	4 × 7	None	None	Successful	24	12

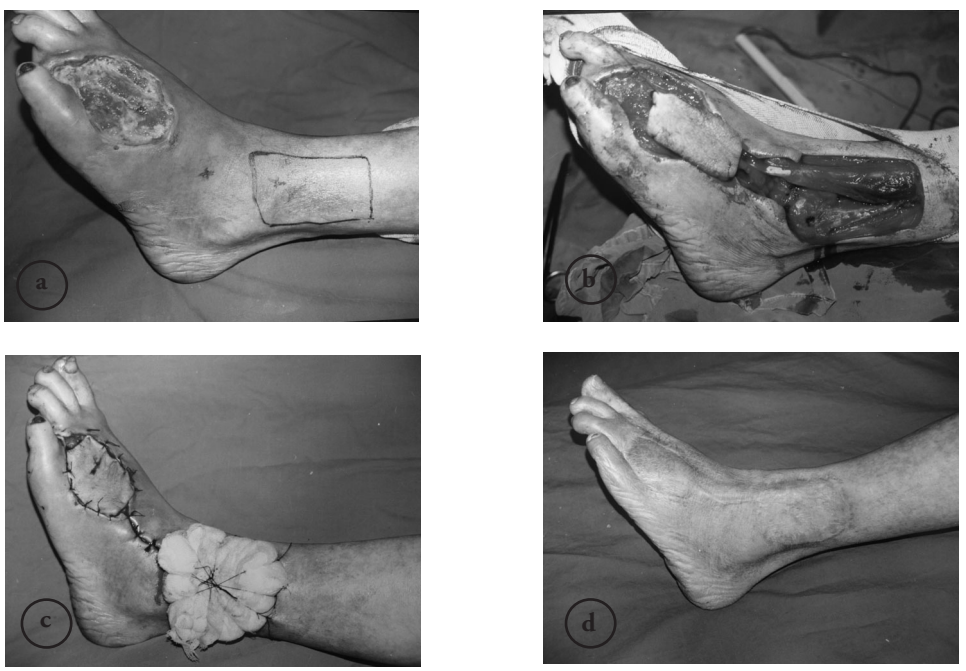

Figure 1 - Photograph **a)** 5 x 7 dorsal forefoot ulcer. Design of the distally based flap. **b)** Elevation of the flap and dissection of the pedicle to the level of sinus tarsi. **c)** The flap in place. Covering the donor site with split-thickness skin graft. **d)** Final result 4 years later.

weekly, from the time of operation up to complete healing. The average healing time of the ulcer region and recovery of regular walking status was 34 days (22-90 days). Neither infection nor a recurrence of the ulcer was encountered during the follow-up. The average healing period of the donor site was 35 days (20-50 days). The major problem of the donor area was skin graft breakdown and its non-aesthetic appearance due to hypertrophic granulation tissue. The patients began progressive weight bearing after healing of the defect area. No special footwear was required in any case, and a full range of motion of the ankle was maintained in all cases. The patients with heel ulcers were able to walk 2 weeks later than the patients with forefoot ulcers. One of the flaps over the heel presented with necrosis at the end of first week; it was maintained in situ like a biological tissue dressing. Three weeks later it was simply debrided. After debridement, we saw that the abductor hallucis muscle flap adapted very well to the defect area under the LSMF. This muscle flap was covered with a split-thickness skin graft.

Discussion. Diabetic foot ulcer is a serious problem because of social importance and the related high costs of treatment. Fifteen percent of diabetics will develop foot problems during their lifetime.[16] Formerly, amputation was considered to be the natural sequel to foot ulceration, but today the diabetic patient with a properly treated ulcer can heal, and amputation can be avoided.[17] Strategies to reduce the risk of lower-extremity amputation may generate substantial economic benefits and should be a standard component of routine diabetes care.[18] The possibilities for the coverage of such defects are few and debridement with skin grafting is the most widely used technique. Approximately 10-33% of the patients will heal in 12-20 weeks with standard care.[19] Wound size, site, and grade, effect of the healing time of diabetic foot ulcers receiving standard treatment.[19,20] However, the management of large and deep defects are difficult with conventional wound care. Local and free flaps have been used for coverage of those defects.[1-9] Free flaps are indicated for large defects, but they require specialist surgical skills and an experienced surgical team.[2,8] The local flaps are not always suitable as they depend on local vascularity, which is most often altered due to systemic disorders such as diabetes mellitus. There are some papers in the literature on the reconstruction of "moderate sized" diabetic ulcers with local flaps;[1,2,8,9] however, there is little published on the results of reconstruction of "large-sized and deep" diabetic foot ulcers with distal based fasciocutaneous flaps. Two fasciocutaneous pedicled flaps may be used in these situations. These are the lateral supramalleolar artery flap (LSMAF) and the sural neurocutaneous flap.[2] The distally based sural neurocutaneous flap is especially indicated for coverage of the posterior aspect of the heel and the region of the lateral malleolus, but is not suitable for the dorsum of the foot. The sural flap offers the possibility of successfully covering extensive defects, is easier to execute and has limited aesthetic and functional sequelae compared with the LSMAF.[2,10,21,22] The LSMAF is a thin and vulnerable, and is not indicated in the weight-bearing area of the heel. It has a wide range of coverage, which includes the whole dorsum of the foot, the medial and lateral arches, and the heel region.[12] We performed a LSMAF for coverage of the non-weight bearing lateral areas of the heel in 2 patients. The sural neurocutaneous flap was not feasible for coverage of another large heel defect as preoperative angiography and Doppler evaluation did not demonstrate the patency of the pedicle. However, Doppler ultrasound and angiography demonstrated flow of the peroneal artery. Thus, we performed LSMAF as its pedicle is derived from here. We also performed LSMAF with an abductor hallucis flap at the weight-bearing area of the heel in another patient. A strong pedicle arterial inflow with Doppler was encountered in all patients. The flaps adapted to the defect area very well and fast even in diabetic patients. We think that fast adaptation and rich vascularization of this flap help the eradication of infection in the recipient area. Typically, patients who undergo standard wound care have an ulceration recurrence rate of 50% over 2 years.[23] In our study; we did not see any recurrence of infection after the flap procedure. Also, lower-extremity amputation was not performed over the 4 years follow-up. Comparing the average healing time and recovery of full weight bearing of diabetic ulcers with conservative local wound care, we think that they are much shorter in reconstruction with pedicle fasciocutaneous flaps. Standard angiography was carried out in one patient with decreased ischemic index and insufficient flow in Doppler evaluation of the major arteries. The ischemic index is an essential baseline test for prediction of healing of the ulcer.[14,15,17,24,25] An ischemic index of 0.6 is a strong indicator in predicting healing of an ulcer.[2]5 We suggest that there is a strong correlation between ischemic index and flap survival. When the values of ischemic index were higher than 0.6, there was no problem in viability of flaps. Based on our experience, Doppler and ischemic index, are sufficient diagnostic tools for application of distally based fasciocutaneous flaps in diabetic foot ulcers. Routine angiography is not mandatory because of its cost effectiveness in our country. If Doppler ultrasound and ischemic index give diminished arterial flow, angiogram should be performed strictly. The most common complication of LSMF in our study is related to delayed healing of

the donor site. Donor-site dehiscence of the skin graft and over-granulated soft tissue were the major problems that we met. However, these problems did not delay full weight bearing in our patients. We think that meticulous handling of skin grafting will probably minimize this problem.

In summary, LSMF is a reliable option for the reconstruction of "large-sized" diabetic ulcers on the dorsum of the foot. It can also be used in conjunction with local muscle flaps such as the abductor hallucis for covering deep and large heel defects when the sural neurocutaneous flap is contraindicated.

References

1. Valenti P, Masquelet AC, Romana C, Nordin JY. Technical refinement of the lateral supramalleolar flap. ***Br J Plast Surg*** 1991; 44: 459-462.
2. Touam C, Rostoucher P, Bhatia A, Oberlin C. Comparative study of two series of distally based fasciocutaneous flaps for coverage of the lower one-fourth of the leg, the ankle, and the foot. ***Plast Reconstr Surg*** 2001;107: 383-392.
3. Berger A, Kunert P. Free latissimus dorsi muscle transfer in extensive soft tissue defects of the lower leg. ***Eur J Plast Surg*** 1986; 10: 58-62.
4. Karp NS, Kasabian AK, Siebert JW, Eidelman Y, Colen S. Microvascular free-flap salvage of the diabetic foot: A 5 year experience. ***Plast Reconstr Surg*** 1994; 94: 834-840.
5. Russell RC, Guy RJ, Zook EG, Merrel JC. Extremity reconstruction using the free deltoid flap. ***Plast Reconstr Surg*** 1985; 76: 586-595.
6. Cooley BC, Hanel DP, Anderson RB, Foster MD, Gould JS. The influence of diabetes on free flap transfer: I. Flap survival and microvascular healing. ***Ann Palst Surg*** 1992; 29: 58-64.
7. Cooley BC, Hanel DP, Lan M, Li X, Gould JS. The influence of diabetes on free flap transfer: II. The effect of ischemia on flap survival. ***Ann Palst Surg*** 1992; 29: 65-69.
8. Pallua N, Di Benedetto G, Berger A. Forefoot reconstruction by reversed island flaps in diabetic patients. ***Plas Reconstr Surg*** 2000; 106: 823-827.
9. Blume PA, Paragas LK, Sumpio BE, Attinger CE. Single-stage surgical treatment of noninfected diabetic foot ulcers. ***Plas Reconstr Surg*** 2002; 109: 601-609.
10. Yildirim S, Akan M, Aköz T. Soft-tissue reconstruction of the foot with distally based neurocutaneous flaps in diabetic patients. ***Ann Plast Surg*** 2002; 48: 258-264.
11. Masquelet AC, Beveridge J, Romana C, Gerber, C. The lateral supramalleolar flap. ***Plast Reconstr Surg*** 1988; 81: 74-81.
12. Masquelet AC, Gilbert A. Transfers from the lower limb, lateral supramalleolar flap. In: Masquelet AC, Gilbert A, Editors. An atlas of flaps in limb reconstruction, 1st ed. Philadelphia (PA): J.B. Lippincott Company; 1995. p.148-157
13. Voche P, Stussi J D, Merle M. The supramalleolar flap. Our experience in 35 cases. ***Ann Chir Plast Esthet*** 2001; 46: 112-124.
14. Brodsky JW. Outpatient diagnosis and care of the diabetic foot. In: Heckman JD, editor. Instructional course lectures Vol. 42, 1st ed. Massachusetts: American Academy of Orthopaedic Surgeons; 1993. p. 121-139.
15. Brodsky JW. The diabetic foot. In: Coughlin MJ, Mann, RA, editors. Surgery of the foot and ankle, Vol. 2., 7th ed. St Louis: Mosby; 1999. p. 895- 969.
16. Reiber GE, Boyko EJ, Smith DG. Lower extremity foot ulcers and amputations in diabetes. In: Maureen IH, Catherine C.C, Michael PS, Edward JB, Gayle ER, Peter HB, Editors. Diabetes in America. 2nd ed. Bethesda (MD): National Institutes of Health Publication; 1995. p. 409- 428.
17. Miller OF. Management of diabetic foot ulcers. ***J Cutan Med Surg*** 1998; Supp 1: 1-13.
18. Ollendorf DA, Kotsanos JG, Wishner WJ, Friedman M, Cooper T, Bittoni M et al. Potential economic benefits of lower-extremity amputation prevention strategies in diabetes. ***Diabetes Care*** 1998; 21: 1240-1245.
19. Margolis DJ, Hoffstad O, Allen-Taylor L, Berlin JA. Diabetic neuropathic foot ulcers. The association of wound size, wound duration, and wound grade on healing. ***Diabetes Care*** 2002; 25: 1835-1839.
20. Oyibo SO, Jude EB, Tarawneh I. The effects of ulcer size and site, patient are age, sex and type and duration of diabetes on the outcome of diabetic foot ulcers. ***Diabet Med*** 2001; 18: 133-138.
21. Hasegawa M, Torii S, Katoh H, Esaki S. The distally based superficial sural artery flap. ***Plas Reconstr Surg*** 1994; 93: 1012-1020.
22. Oberlin C, Azoulay B, Bhatia A. The posterolateral malleolar flap of the ankle: A distally based neurocutaneous flap. Report on 14 cases. ***Plas Reconstr Surg*** 1995; 96: 400-405.
23. Apelqvist J, Larsson J, Agardh CD. Long-term prognosis for diabetic patients with foot ulcers. ***J Intern Med*** 1993; 233: 485-491.
24. Gould JS, Erickson SJ, Collier BD, Bernstein BM. Surgical management of ulcers, soft-tissue infection, and osteomyelitis in the diabetic foot. Heckman JD, Editor. Instructional course lectures Vol. 42, 1st ed. Massachusetts: American Academy of Orthopaedic Surgeons; 1993. p.147-158.
25. Richardson EG. The diabetic foot - Neurogenic disorders. In: Crenshaw AH, Editor. Campbell's Operative Orthopaedics, 8th ed. Missouri: Mosby; 1992. p. 2815-2830.