

Versatility of delayed reverse-flow islanded sural flap for reconstructing pretibial defects among high-risk patients

Bilsev Ince, Mehmet Daaci, Zeynep Altuntas, Tugba Sodali, Fatma Bilgen, Mustafa Kursat Evrenos

From the Department of Plastic, Reconstructive and Aesthetic Surgery, Faculty of Meram Medicine, Necmettin Erbakan University, Konya, Turkey

Correspondence: Bilsev Ince · Department of Plastic, Reconstructive and Aesthetic Surgery, Faculty of Meram Medicine, Necmettin Erbakan University, Konya 42080 Turkey · T: +905552776488 bilsevince@yahoo.com

Ann Saudi Med 2014; 34(3): 235-240

DOI: 10.5144/0256-4947.2014.235

BACKGROUND AND OBJECTIVE: Reconstructing defects related to the leg soft tissue may be quite difficult because the soft tissue over the bone is rather thin and the tendons lie right under the skin. Distal pedicle sural neurocutaneous flap with its long pedicle composed of skin, subcutaneous tissue and fascia is suitable for superficial defects. This study aimed to determine the usability of the delayed reverse-flow (distally based) islanded sural flap for correcting tibial and ankle defects.

DESIGN AND SETTINGS: A prospective clinical trial conducted from 2012 to 2013 in Plastic & Reconstructive and Aesthetic Surgery clinic, Necmettin Erbakan University, Turkey.

METHOD: Eleven patients with pretibial defects and a visible open bone who underwent reconstruction with reverse-flow islanded sural flap between 2012 and 2013 were included in the study. All patients who had defects between the middle of the tibia and the foot underwent surgery in 2 sessions under spinal anesthesia. In the first session, necrotic tissues were debrided and cultures were taken, and the flap was delayed. Reconstruction was performed in the second session.

RESULTS: The biggest flap was 16×11 cm and the smallest one was 5×6 cm. The longest pedicle was 27 cm long and the shortest one 21 cm. A total of 6 patients were smokers and 3 had diabetes mellitus. One patient had partial necrosis of the flap, and the necrosis was healed secondarily. No complications were seen in other patients.

CONCLUSION: Delayed reverse-flow islanded sural flaps can be used as an easy, quick, and secure surgical alternative to free flaps for correcting in leg defects involving an exposed bone between the middle portion of the tibia and the heel.

The frequency of defects related to the lower extremities is increasing because of the increasing number of traffic accidents. In addition, reconstructing defects related to the leg soft tissue may be quite difficult because the soft tissue over the bone is rather thin and the tendons lie right under the skin.^{1,2}

Grafting and use of local flaps in the anterior tibia and ankle defects is highly limited, so alternative flaps need to be prepared for correcting defects in these locations. Although the reconstruction methods with muscle flaps have reduced morbidity, they cannot be used for correcting all defects because the muscle flap has a short pedicle. The use of perforator flaps is also limited because using them requires experience, and perforators are not found in all patients or found in different places. Free flaps are a good option for repairing

lower extremity defects without involving local, muscle, and perforator flaps. However, complete or partial loss of flap in the cases of free tissue transfer due to vascular problems leads to serious clinical problems. Further, surgery involving free flaps causes morbidity, requires special surgical equipment and experience, and is time consuming. Moreover, because of comorbidities such as serious heart, pulmonary or kidney diseases, and/or injuries seen in most patients, long-term surgical procedures cannot be performed.^{1,2}

The distal pedicle sural neurocutaneous flap with its long pedicle composed of skin, subcutaneous tissue, and fascia is suitable for correcting superficial defects. It can reach up to the ankle and calcaneus, and the foot base. The main disadvantage of using this flap is the loss of sural nerve sensation.^{3,4} The reverse-flow islanded sural



Figure 1a. Appearance of open wound on the tibia in patient 1.



Figure 1b. Appearance of flap on the 15th day after surgery in patient 1.



Figure 2a. After tissues with necrosis were debrided, appearance of open wound and exposed plaque on the tibia in patient 2.

flap can be used in tissue reconstruction involving 1 or 2 to 3 sessions with a delay. The survivability of the flaps was found to increase with the delay.^{5,6}

While many studies have focused on the use of sural flaps for reconstructing soft-tissue defects around the heel and ankle, no study has reported the use of the reverse-flow islanded sural flap for reconstructing leg defects between the middle portion of the tibia and ankle, to the best of our knowledge. Therefore, this study aimed to determine the usability of the delayed reverse-flow (distally based) islanded sural flap for correcting tibial and ankle defects.

METHOD

Eleven patients with pretibial defects and a visible open bone that underwent reconstruction with reverse-flow islanded sural flap between 2012 and 2013 were included in the study. Pretibial defects of all dimensions were included. Patients with foot or heel defects, peripheral vascular diseases, or injuries to the gutter area (5 cm proximal to the lateral malleolus) were excluded. All patients who had defects between the middle of the tibia and the foot underwent surgery in 2 sessions under spinal anesthesia (**Figure 1a, 1b**). In the first session, necrotic tissues were debrided and samples were taken for culturing (**Figure 2a, 2b**), and the flap was delayed (**Figure 2c**). If the culture was positive, appropriate antibiotic treatment was started. The culture was repeated after 1 week, and in the case of negative culture results, reconstruction was performed in the second session (**Figure 2d**).

Surgical Technique

Patients lay in the prone position under spinal anesthesia for the surgery. Tourniquet dissection was not performed. Doppler ultrasonography was performed to confirm the presence of viable perforators from the peroneal artery in the gutter area to ensure perfusion of the reverse-flow flap. In the first session, the flap was designed along the line joining the midpoint of the popliteal fossa with the lateral malleolus. The size of the defect was detected after debridement of the open wound. For designing the flap, a point 5 cm proximal to the lateral malleolus was considered the point of origin. From this point, the pedicle length needed to close the defect was determined with the help of gauze. The flap was designed to be 20% larger than the defect. If necessary, the skin of the proximal three-fourth portion of the leg was included to the flap in large defects. Skin, subcutaneous tissue and muscle fascia of the flap that was to be elevated were incised from the proximal, medial, and lateral sides; the sural vein was left connected. Then, the

skin and subcutaneous tissue were sutured. At the distal flap, the skin and subcutaneous tissue were incised but the fascia was not, so at least 3 cm of the pedicle was protected. Ten days later, the flaps were elevated, including the superficial and deep fascia, sural nerve, minor saphenous vein, and sural vein pedicle. The skin flaps on the pedicle were elevated thinly and Z-shaped to obtain 3-cm-long pedicles that were previously protected at the proximal end of the flap. Distally, the flap pedicles were widened to 5 cm and set 5 cm proximal to the lateral malleolus to protect the perforators around the ankle. The tunnel was prepared in the lateral side of the tibia for the passage of the flap. The tunnel was set at least 2 cm wider than the flap pedicle medially and laterally. We attempted to reduce the pressure of the tunnel to the pedicle. The defects were closed with the flaps that passed through the tunnels. Flap donor areas were closed with partially thick skin grafts.

In the postoperative phase, the patients were immobilized for 7 days in their beds, the patients' legs were elevated to prevent venous congestion, and the flap viability was monitored.

Findings

In all, 11 patients (9 male, 2 female) were included in the study (Table 1). The mean age of the patients was 39.7 years (min, 21; max, 57). The mean follow-up period was 13 months (min, 9; max, 20), and the mean hospitalization time was 18 days (min, 13; max, 20). The biggest flap measured 16×11 cm and the smallest one, 5×6 cm. The longest pedicle was 27 cm long and the shortest one 21 cm (mean length=24.5 cm). Six patients (54.5%) were smokers and 3 (27.2%) had diabetes mellitus; 7 patients (63.6%) who were in car accidents experienced fractures. The fractures were fixed by an external fixer in 3 patients (Figure 3a, 3b) and by plaque in the other 4. The plaques were exposed in the patients who had plaque fixation (Figure 1d). Reconstruction with local flaps was attempted in 4 of these patients (36.3%) previously in another health center, but the procedure was not successful. One patient (9%) had partial necrosis of the flap, and the necrosis healed secondarily. No complications were seen in other patients.

DISCUSSION

Our study showed the successful usage of the delayed sural flaps for reconstructing soft tissue defects localized between the middle portion of the tibia and ankle. Further, surgical delay increased the survivability of the sural flap, and the likelihood of success increased when the pedicles were 5 cm proximal to the lateral malleolus



Figure 2b. Flap was delayed.



Figure 2c. Appearance of flap on the 60th day after surgery in patient 2.



Figure 3a. Bone fractures were fixed by external fixer in patient 3.

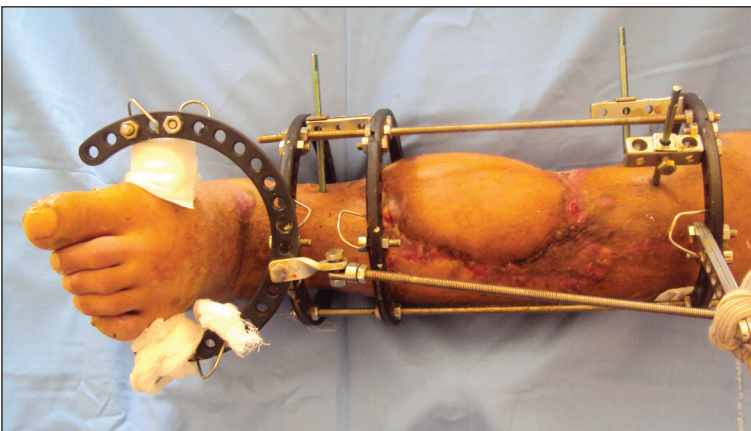


Figure 3b. Appearance of flap on the 30th day after surgery in patient 3.

and 5 cm wide.

The use of flaps is necessary for reconstructing tissue defects with exposed vital structures in the cases of high-energy injuries to the lower extremities. Alternative flaps are necessary because local flaps are generally unsuitable for correcting defects in the lower extremities. Free flaps are the gold standard for reconstructing lower leg wounds if indicated.⁷ However, using free flaps involves the use of special surgical equipment and experience and also associated with morbidity.^{1,2,8}

Several muscle flaps that can be used for filling deep defects and covering the infected or exposed bones are defined for the use in defects related to the lower extremities. The use of muscle flaps is quite limited for correcting defects related to the middle and distal tibia, whereas they can be used for correcting defects in the feet. However, they have a limited usage area because the

used feet muscles are small and the length of the pedicles is small.^{3,4}

Le Fourn et al,³ who showed the relation between the vascular axle of the sural nerve and gastrocnemius muscles, created a musculocutaneous sural artery flap. The musculocutaneous sural flap was proposed to be an alternative to free muscle flaps for the treatment of infection and filling gaps.⁹ This flap can be used for correcting defects that are deep and large, and has low donor-field morbidity.⁴

The superficial sural artery flap, which is one of the flaps used in reconstructing the lower extremities, can be lifted and connected to the lateral and medial perforators. This flap can be used to correct defects in the knee and proximal tibia.¹⁰ However, the disadvantages of using this flap are as follows: high experience is needed for dissecting this flap, it has a short pedicle, and not all patients have perforators.^{11,12}

Masquelet et al¹³ created a distal pedicled reverse-flow sural artery flap using the relation between the median superficial sural artery and the bottom perforator branch of the peroneal artery. The sural artery flap, which is fasciocutaneous, can be used for correcting soft-tissue defects of the ankle, foot base, and heel.^{14,15}

The distal pedicled sural neurocutaneous flap, which is used in reconstructing the lower extremities, differs from other flaps owing to its long pedicle. It allows reconstructing feet, legs, ankle, and heel in the distal area where the flap is elevated. It can be elevated easily and quickly without disrupting the main artery flow of the lower extremity. It can be used securely in ischemic limbs. Although sural nerve sensory loss is an important disadvantage,^{3,4} this problem may not occur in patients with neuropathy and trauma owing to prior deterioration of sense in these cases. In addition, one study reported a case of reconstruction without adding the sural nerve to the flap.¹⁶

Unlike the muscle and free flaps, reconstruction methods involving the reverse-flow islanded sural flap do not cause harm to the existing muscles and have less morbidity because only the skin, subcutaneous tissue, and fascia are used.^{3,4} This method can be used for correcting not only in large defects but also cavity defects if a part of the flap is depithelized. Moreover, this method can be used for lower extremities because the flap has a long pedicle, its localization is the same for all patients, and the procedure can be learned quickly by the performing surgeon. The other advantages include the short surgical procedure and reduced morbidity.

The reverse-flow islanded sural flap can be used for tissue reconstruction in 1 session, or it can be elevated more securely by delaying the procedure with 2 sessions.

Table 1. Data of patients.

Patient	Gender-age	Type of trauma	Comorbidity	Previous surgery	Pedicle length (cm)	Flap size (cm)	Result
1	M-36	Car accident	Smoking	-	24	7×11	Thorough
2	M-56	Car accident	Diabetes mellitus	+	26	5×8	Thorough
3	M-24	Gunshot wound	Smoking	-	25	7×9	Partial necrosis
4	M-21	Car accident	-	-	27	11×16	Thorough
5	M-57	Gunshot wound	Diabetes mellitus	+	26	6×7	Thorough
6	F-32	Car accident	Smoking	-	23	5×6	Thorough
7	M-41	Gunshot wound	Smoking	-	25	5×10	Thorough
8	F-29	Gunshot wound	-	+	21	8×9	Thorough
9	M-33	Car accident	Smoking	-	24	12×14	Thorough
10	M-54	Car accident	Diabetes mellitus	-	26	5×7	Thorough
11	M-43	Car accident	Smoking	+	23	6×10	Thorough

When elevated in 1 session, the complication rate among patients with no comorbidity was 16%; this rate increases up to 33% in the cases of patients with comorbidities like smoking, diabetes mellitus, and peripheral artery disease.⁵ In our series 9 out of 11 patients (81.8%) had comorbidities: 6 patients were smoking and 3 had diabetes mellitus. However, the complication rate was 9% (1/11). We believe that the main reason behind such a low complication rate was the surgical delay.

Surgical delay involving 2 sessions is beneficial, as seen in our study, but in some cases, the surgery is completed in 3 sessions.⁶ A 2-day delay is beneficial for increasing the survivability of the flap, and secondary surgery is not needed in such cases.

Some authors performed the procedure using the flap skin and flap and then elevated the flap.¹⁷ In our study, the flap was designed as an island flap and was set in the required location in full harmony with the surrounding tissues. Survivability of the flap was not affected by the island shape of the flap.

Placing an expander under the flap is also suggested for filling large defects.¹⁸ In addition to obtaining large flaps for large defects, surgical delay can also be achieved by placing the expander under the flap and the flap's resistance to ischemia can be increased. It was reported that large defects can be reconstructed by placing an expander under the flap; however, flaps bigger than the largest flap used in that study were elevated successfully in our study. Almost the entire posterior leg can be used for obtaining the sural flap base, when surgical delay is involved.

Reverse-flow islanded sural flap can be used for reconstructing a large area, e.g., from the middle portion of the leg to the foot, in a short period because it has a long pedicle. All flaps in our series were sufficient for closing tissue defects without secondary surgery. However, the flap could be damaged because it is located in the lower extremity trauma zone, so in such cases, the flap may not be of any use. The circulation of the flap can be disrupted, if the surgery is not performed in 2 sessions. Patients should be made aware of the fact that the sural nerve will be damaged when this flap is used and that the surgery will be performed in 2 sessions. The first session of the surgery involves debridement and culturing of the wound. If the culture was positive, appropriate antibiotic treatment was started. The culture was repeated after 1 week, and in case of negative culture results reconstruction was completed by elevating the flap. There are no cases of growth in second cultures after antibiotic treatment. The flap was elevated 10 days after the delay process in culture-negative patients, whereas the flap was elevated after 15 days in culture-positive patients. It is known that the delay period occurs between 7 and 21 days.¹⁹ For this reason, 1 week period of waiting for culture results had no effect on flap survival. Further studies are required to explore the creation of the flap without creating the sural nerve.

Delayed reverse-flow islanded sural flaps can be used as an easy, quick, and secure surgical alternative to free flaps for correcting leg defects involving an exposed bone between the middle portion of the tibia and the heel.

REFERENCES

1. Sherman R, Law M. Lower extremity reconstruction. Achauer BM, Eriksson E (eds.), *Plastic Surgery Indications, Operations and Outcomes*. 2nd ed. St. Louis: Mosby; 2000.
2. Mackenzie DJ, Seyfer AE. *Reconstructive surgery: Lower extremity coverage*. Mathes SJ (ed.) *Plastic Surgery Vol 6-2*. 2nd ed. Philadelphia: Saunders Elsevier; 2006.
3. Le Fourn B, Caye N, Pannier M. Distally based sural fasciomuscular flap: Anatomic study and application for filling leg or foot defects. *Plast Reconstr Surg* 2001;107:67-72.
4. Miller OF. Management of diabetic foot ulcers. *J Cutan Med Surg* 1998;3:13-7.
5. Parrett BM, Pribaz JJ, Matros E, Przylecki W, Sampson CE, Orgill DP. Risk analysis for the reverse sural fasciocutaneous flap in distal leg reconstruction. *Plast Reconstr Surg* 2009;123:1499-504.
6. Tosun Z, Ozkan A, Karacor Z, Savaci N. Delaying the reverse sural flap provides predictable results for complicated wounds in diabetic foot. *Ann Plast Surg* 2005;55:169-73.
7. Karanas YL, Nigriny J, Chang J. The timing of microsurgical reconstruction in lower extremity trauma. *Microsurgery* 2008;28:632-4.
8. 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;94:834-40.
9. Chen SL, Chen TM, Chou TD, Chen SG et al. The distally based lesser saphaneous venofasciocutaneous flap for ankle and heel reconstruction. *Plast Reconstr Surg* 2002; 110:1664-72.
10. Umamoto Y, Adachi Y, Ebisawa K. The sural artery perforator flap for coverage of defects of the knee and tibia. *Scand J Plast Reconstr Surg Hand Surg* 2005;39:209-12.
11. Wong MZ, Wong CH, Tan BK, Chew KY, Tay SC. Surgical anatomy of the medial sural artery perforator flap. *J Reconstr Microsurg* 2012;28:555-60.
12. Wolff KD, Bauer F, Kunz S, Mitchell DA, Kesting MR. Superficial lateral sural artery free flap for intraoral reconstruction: anatomic study and clinical implications. *Head Neck* 2012;34:1218-24.
13. Masquelet AC, Romana MC, Wolf G. Skin island flaps supplied by the vascular axis of the sensitive superficial nerves: anatomic study and clinical experience in the leg. *Plast Reconstr Surg* 1992;89:1115-21.
14. Hollier L, Sharma S, Babigumira E, Klebuc M. Versatility of the sural fasciocutaneous flap in the coverage of lower extremity wounds. *Plast Reconstr Surg* 2002;110:1673-79.
15. Yilmaz M, Karatas O, Barutcu A. The distally based superficial sural artery island flap: Clinical experiences and modifications. *Plast Reconstr Surg* 1998;102:2358-67.
16. Motamed S, Yavari M, Mofrad HR, Rafiee R, Shahraki FN. Distally based sural artery flap without sural nerve. *Acta Med Iran* 2010;48:127-9.
17. Kneser U, Bach AD, Polykandriotis E, Kopp J, Horch RE. Delayed reverse sural flap for staged reconstruction of the foot and lower leg. *Plast Reconstr Surg* 2005;116:1910-7.
18. Kose R, Mordeniz C, Sanli C. Use of expanded reverse sural artery flap in lower extremity reconstruction. *J Foot Ankle Surg* 2011;50:695-8.
19. Demirel M, Heper AO, Yormuk E. Comparison of pharmacologic delay operation by local VEGF injection with other surgical delay procedures on rat dorsal skin flap. *Turk Plast Surg* 2010;1:24-30.