

Different Methods for Improving the Outcomes of Distally Based Sural Flap for Foot and Ankle Reconstruction

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Abstract:

Introduction: Reconstruction of soft tissue defects of the lower third leg and foot presents a great challenge for the reconstructive surgeons. The distally based sural flap provides a good option for coverage. However, some complications usually occur specially venous congestion and edema, different modifications had made to reduce complications and to increase the reliability and outcomes of the flap. Our goal is to describe the most frequent errors and methods to overcome the incidence of these complications. Some of these methods are supercharging the flap, delaying the flap, exteriorize the lesser saphenous vein, leg elevation, orientation of the flap, increasing the width of the pedicle, incorporating a gastrocnemius muscle cuff around sural pedicle, lowering the pivot point or any other methods to overcome the incidence of complication. **Patients and methods:** A total of 30 patients, there were 24 were males(80%) and 6 were females(20%), the average patient age was 37 yrs (ranges from 5 to 69yrs), in 14 patients defects were post traumatic skin defects (46%), in 6 patients defects were due to unsteady scars(20%), in 5 patients skin defects were due to diabetic ulcers(16.5%) , in 4 patients defects were trophic ulcers (13.5%) , and one patient had post amputation raw area with exposed bone(4%).The reconstructed sites were the weight-bearing heel in 20 patients, the dorsum of the ankle in 4 patients, the dorsum of the foot in 3 patients, and the mid foot in 1 patient, lower third of the leg in 2 patients. **Results:** All patients were followed up for a period from 6 to 12 months (mean= 9 months), minor complications had occurred such as three cases (3cases) with superficial epidermolysis (10%) (three cases need debridment one of them healed by secondary intention and two need skin graft) , two cases (2cases) complicated with loss of the graft on pedicle which need another skin graft(7%), one case (1case) with partial flap necrosis at the distal part which need debridment and healed by secondary intention(3.5%), and two cases (2cases) with partial dehiscence of the flap which treated by debridment and restitch (7%) .The flaps usually healed eventually by 3rd to 4th week but full weight bearing on them postponed up to 6th or 8th week and the patients were satisfied with the functional and aesthetic outcomes. **Conclusion:** The distally based the sural flap is a versatile flap for the reconstruction of soft tissue defects of the lower leg and heel. Despite its complications, some modifications are available to overcome these complications and increase its reliability.

Introduction:

The reconstruction of the soft tissue defects of the distal third of leg and foot represents a great challenge for the reconstructive surgeons. This region is characterized by lack of

tissue availability and relatively poor skin circulation and frequent exposure to trauma. Different methods for coverage include skin grafts, local flaps, distant flaps but their use is limited because of their complications. Free flaps are considered the standard for this region but they need surgical experience and longtime procedure.

However, fasciocutaneous flaps; first reported by

Ponten in 1981; are excellent option in the repair of these soft-tissue defects, (1).

The distally based suralfasciocutaneous flap was; introduced by Donski and Fogdestam in 1983; one of the earliest fasciocutaneous flaps used.(2).The sural flap acts as an axial flap and has 3 sources of nutrition: the vascular plexus of the deep fascia; the median superficial sural artery, which follows the medial sural nerve; and the arteries that follow the lesser saphenous vein. Venous return is ensured by the lesser saphenous vein, which may be used as a distal pedicle to provide reverse flow. This vein must be preserved at least as high as the caliber perforator of the fibular artery, which is located 5 cm above the lateral malleolus and spreads with the medial superficial sural artery,(3).Masquelet, et al then reintroduced the sural flap in 1992 with a complete concise description of the relevant anatomy and the surgical procedure. After the work of Masquelet, et al the distally based suralfasciocutaneous flap has become a mainstay in the reconstruction of the lower leg, heel and foot, (4).

An advantage of the sural flap over other flaps of the lower leg is that it does not utilize any of the three major arteries to the distal extremity. The greatest morbidity of the flap is division of the sural nerve, which is usually very well tolerated. The flap is reliable in young healthy patients. However, in older patients; especially those with medical comorbidities or peripheral vascular disease; the flap is less predictable. In these patients, surgical delay procedure or venous supercharging through microvascular venous anastomosis may be considered. Venous congestion rather

than arterial ischemia tends to be a greater problem with this flap especially if designed as an island flap, (5).

Our goal is to describe the most frequent errors and to share important details that might decrease the incidence of these complications. Some of these methods are supercharging the flap, delaying the flap, leave the lesser saphenous vein without stitching as a drain to evacuate the congested blood, leg elevation, orientation of the flap, increasing the width of the pedicle, incorporating a gastrocnemius muscle cuff around sural pedicle, lowering the pivot point or any other methods that help in improvement the flap outcomes and reliability.

Patients and Methods:A prospective study was done From April 2016 to March 2017 in the plastic surgery department, qena faculty of medicine south valley university. ,on 30 consecutive patients with soft tissue defects of the foot or ankle treated with modified distally based sural artery flaps. Patients with chronic wounds that had not improved despite more than 3 months of conservative treatment and post traumatic wounds with exposed structures in the area of foot and ankle were included in our study. Patients with evidence of scar or damage on the posterolateral side of the ankle in the area of the peroneal perforators(zone of injury) were excluded. Ischemic findings such as cold and pulseless feet with thin, hairless, and shiny skin and any peripheral vascular disease were also considered a contraindication for the distally based sural flap. Of 30 patients, there were 24 males(80%) and 6 females(20%) , the average patient age was 37 yrs (ranges from 5 to 69yrs), in 14 patients defects were post traumatic skin defects with exposed underlying structures(46%), in 6 patients defects

were due to unsteady scars(20%), in 5 patients skin defects were due to diabetic ulcers(16.5%) , in 4 patients defects were trophic ulcers (leprotic, history of fracture spine and myelomeningocele) (13.5%) , and one patient had post Amputation raw area with exposed bone(4%).The reconstructed areas were the weight-bearing heel in20 patients, the dorsum of the ankle in 4 patients, the dorsum of the foot in 3 patients,and the mid foot in 1 patient,lower third of the leg in 2patients.Preoperative assessment included:I.clinical evaluation of peripheral pulses and perfusion of skin. Presence of 1 or more peroneal perforators in the area posterior and proximal to the lateral malleolus was confirmed with Doppler ultrasound in all cases.II. Radiological: 1. Arterial and venous Duplex was done in every case to detect the patency of superficial and deep venous system and arterial system.2. X_ray was done in some cases especially diabetic patient to detect the presence of osteomyelitis.

Surgical technique: Procedures were done under spinal anesthesia with all patients in the prone position. A handheld Doppler was used before flap marking to predetermine the perforators of the peroneal artery. Preoperative antibiotics (I.V. Cephalosprins) were administrated. For easily dissection application of pneumatic tourniquet and use of (3.5 X) loupe magnification.

Debridement of the recipient area is done first. Then, the flap is marked with a line drawn from a point midway between the Achilles tendon and the lateral malleolus to the midline between two heads of the gastrocnemius muscle. This roughly delineates the course of sural nerve and lesser saphenous vein. After that the larger peroneal perforator detected by handheld Doppler is marked, which is

often located approximately 5 cm superior to the tip of the lateral malleolus. The template of the defect of recipient area is made. The flap is then outlined and centered over the sural nerve. This flap can be located anywhere in the lower two-thirds of the posterior aspect of the leg according to the need of pedicle length.

An incision is made along the superior border of the flap. At midcalf, the sural nerve and lesser saphenous vein are identified suprafascially. The sural nerve, artery and lesser saphenous vein are divided and ligated with preservation of long proximal stump of the vein and included within the flap. The dissection is then continued distally in the subfascial plane. Musculocutaneous perforators from the underlying gastrocnemius muscle are identified and coagulated. Distally a longitudinal strip of the fascia and subcutaneous fascial pedicle, which includes the sural nerve and lesser saphenous vein, is elevated with a width of 2–4 cm to protect the neurovascular axis.

The lateral extent of dissection is up to fibula and the medial extent is the lateral border of Achilles tendon. The dissection is stopped 5 cm above the lateral malleolus where perforators from the peroneal artery communicate with the vascular plexus. The pivot point of the flap is also 5 cm above the tip of lateral malleolus. Division of the skin bridge between the donor site and the defect is done to avoid the risk of compression of the pedicle (no subcutaneous tunnel). After the flap is inset into the defect, the tourniquet is deflated and hemostasis is achieved. Then we used one of our modifications as (I.)venous supercharging (venous anastomosis) is performed between the free end of the lesser saphenous vein and any superficial leg or foot vein as a recipient vein found close to the defect

under (3.5 X) loupe magnification in 3 cases using 9/0 nylonsutures.

(II.) Venous catheterization is performed in 3 cases with 20 gauge cannula. (III.) **In the delayed procedure:** we elevate the skin paddle of the flap with ligation of the vessels and nerve and then restitch it again and leave it for 3 weeks and after that we elevate it again and continue our surgical operation as will be described (2 cases). (IV.) **Infasciomusculocutaneous flap:** we take a cuff of gastrocnemius

muscle with its perforators at the midline (2 cases). The pedicle and the donor site are covered with a split thickness skin graft except in one case. A well-padded dressing is applied making sure that there is no compression on the pedicle with a window left exposed for observation. A leg elevation is maintained at 45° to enhance the venous return. The dressing is changed on 3th postoperative day.

| No. | Age (yrs) | Sex | Etiology of the defect | Site of defect | Size of flap (cm) | Technique of flap | Donor site closure |
|-----|-----------|-----|---|-------------------------|-------------------|--------------------------------------|--------------------|
| 1. | 45 | M | P.HMA raw area with exposed bone (D. ptn) | Rt. Midfoot | 7×4 | Delayed | S.G |
| 2. | 5 | F | Tr. ulcer (history of myelomeningocele) | Lat.Aspect of rt.heel | 3×3 | L.S cannulation | 1ry closure |
| 3. | 67 | F | Diabetic ulcer | Lt.Heel | 8×6 | Supercharged | S.G |
| 4. | 40 | M | Tr. ulcer in paraplegic ptn (P.T #spine) | Med.aspectlt. Heel | 3×4 | L.S. cannulation | S.G |
| 5. | 37 | M | Tr. ulcer in leprotic patient | Lat.aspectrt.H eel | 6×5 | L.S. cannulation | S.G |
| 6. | 48 | M | P.T. unsteady scar(3yrs) | Med.aspectlt. Heel | 10×6 | Supercharged | S.G |
| 7. | 25 | M | P.T skin defect with exposed calcenous | Rt.Heel | 8 × 7 | L.S. cannulation | S.G |
| 8. | 43 | M | P.T. raw area with exposed plate | Lower 1/3 of rt.the leg | 4×4 | Delayed | 1ry closure |
| 9. | 18 | M | P.T. unsteady scar (2yrs) | Lt.Heel | 3×2 | L.S. cannulation | 1ry closure |
| 10. | 62 | F | Diabetic ulcer | Lt.Heel | 5×6 | L.S. cannulation | S.G |
| 11. | 43 | M | Diabetic ulcer | Rt.Heel | 4×5 | L.S. cannulation | S.G |
| 12. | 23 | M | P.T. skin defect with exposed tendons | Dorsum of rt.ankle | 5×3 | Supercharged | S.G |
| 13. | 53 | M | Diabetic ulcer | Rt.Heel | 4×3 | Delayed | S.G |
| 14. | 44 | M | P.T unsteady scar (3yrs) | lat. Aspect of lt.heel | 6×5 | Supercharged | S.G |
| 15. | 58 | M | Diabetic ulcer | Rt.Heel | 3×4 | L.S. cannulation | S.G |
| 16. | 22 | M | P.T skin defect | Dorsum of lt.ankle | 6×6 | Supercharged | S.G |
| 17. | 16 | F | P.T unsteady scar | Rt.Heel | 7×6 | Short wide pedicle | S.G |
| 18. | 38 | M | Tr. ulcer (P.T. # spine) | Rt.Heel | 4×4 | L.S. cannulation | S.G |
| 19. | 18 | M | P.T. skin defect with exposed tendons | Dorsum of lt.foot | 7×6 | Supercharged | S.G |
| 20. | 6 | F | P.T. unsteady scar | Rt.Heel | 6×6 | Short wide pedicle | S.G |
| 21. | 5 | M | P.T. raw area with exposed tendons | Dorsum of lt.foot | 4×6 | Short wide psdicle& L.S. cannulation | S.G |
| 22. | 8 | M | P.T. raw area with exposed tendons | Dorsum of rt.foot | 4×5 | Short wide pedicle | S.G |
| 23. | 24 | M | P.T. skin defect with exposed tendons | Dorsum of lt.ankle | 3×5 | Supercharged | S.G |
| 24. | 20 | F | P.T. skin defect with exposed calcenous | Rt.Heel | 5×6 | L.S. cannulation | S.G |
| 25. | 48 | M | P.T. unsteady scar (1.5 yrs) | Med.aspect of rt.heel | 4×4 | Supercharged | S.G |

| | | | | | | | |
|-----|----|---|--|-------------------------|-----|--|-------------|
| 26. | 26 | M | P.T. raw area with exposed calcaneous | Rt.Heel | 3×3 | Short wide pedicle with cuff of muscle | 1ry closure |
| 27. | 19 | M | P.T. # calcaneous with exposed plate | Lt.Heel | 3×2 | L.S. cannulation | 1ry closure |
| 28. | 43 | M | P.T. skin defect with exposed plate | Lower 1/3 of rt.the leg | 4×5 | Short wide pedicle with cuff of muscle | S.G |
| 29. | 10 | M | P.T. skin defect with exposed tendons | Dorsum of rt.ankle | 3×3 | Short wide pedicle | 1ry closure |
| 30. | 25 | M | P.T. skin defect with exposed calcaneous | Rt.Heel | 5×6 | Short wide pedicle with cuff of muscle | S.G |

Table (1): Cases with flap modifications.

| No. | Complications | Patients | Percentage | Treatment |
|-----|--|----------|------------|--|
| 1 | Partial flap necrosis at the distal part And partial dehiscence of the flap. | 1 case | 3.5 % | Frequent dressing, debridment and healed by secondary intention after 4 weeks |
| 2 | Superficial ischemia of the flap (superficial epidermolysis) at the distap part of the flap. | 3 cases | 10 % | Frequent dressing and debridment, two cases need skin graft and one healed by secondary intention. |
| 3 | Partial dehiscence of the flap at the periphery of the flap. | 2 cases | 7 % | debridment and restitch |
| 4 | Loss of the graft on pedicle. | 2 cases | 7 % | Regrafting |

Table2: complications and its percentage and management.

Results:

All patients were followed up for a period from 6 to 12 months (mean= 9 months), minor complications had occurred such as three cases with superficial epidermolysis (10%) (three cases need debridment one of them healed by secondary intention and two need skin graft) , two cases complicated with loss of the graft on pedicle which need another skin graft(7%), one case with partial flap necrosis at the distal part which need debridment and healed by secondary intention(3.5%), and two cases with partial dehiscence of the flap which treated by debridment and restitch(7%)
The rate of venous congestion which is considered the most important complication and other complications related to methods of modification specially in high risk patients:**I.Delayed procedure:** three cases of three cases (100%) (one case complicated with partial flap necrosis at the distal part and two cases

complicated with partial dehiscence of the flap).

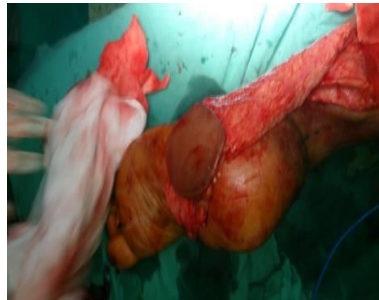
II.Lesser saphenous drainage: one case of ten cases (10%) (complicated with superficial epidermolysis) (two cases complicated with loss of the graft over the pedicle or donor site but these complications not related to the flap modifications method).

III.Supercharged technique: 0% (one patient complicated with loss of the graft over the pedicle which is not related to flap modifications).**IV.Short wide pedicle and taking a cuff of gastrocnemius muscle:** 0% (these cases were young and fit patients not high risk).The flaps usually healed eventually by 3rd to 4th week but full weight bearing on them postponed up to 6th or 8th week and the patients were satisfied with the functional and aesthetic outcomes.

Cases presentation :Case 1 :A 37-years-old man with leprosy sustained a chronic trophic ulcer at the lateral aspect of the left heel but there was no healing despite several months of dressing. After debridement, there was a large soft-tissue loss with bone exposure. suralfasciocutaneous flap with lesser saphenous drainage was planned, 6×5 cm in size, was harvested from the upper calf to cover the defect and the donor site was closed with skin graft .postoperatively, There was normal flap monitoring during follow up and healed within 3 weeks. there was no complications and patient began walking with silicon heel after 6 weeks.



A.Preoperative marking of the flap with detection of perforators



B.Elevation of the flap with long stump of LSV for



C.Cannulation of the LSV



D.color of the flap and pricking blood after 3 weeks



E.Late postoperative photo after 8 months

Fig.1: case 1 presentation photos.

Case 2:

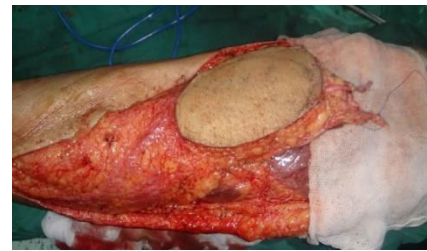
A 48-years-old man with post traumatic unsteady scar (3yrs ago) at the medial aspect right heel, after debridement, there was a large soft-tissue loss with bone exposure. supercharged suralfasciocutaneous flap was planned, 10×6 cm in size, was harvested from the upper calf to cover the defect and the donor site was closed with skin graft .postoperatively, There was normal flap monitoring signs during follow up but the pedicle graft was lost and dehiscence on pedicle donor site occurred which needed another graft and there was no other complications and patient began walking with silicon heel after 7 weeks with no complications.



A.preoperative marking



B.Marking the flap with detection of perforators



c.elevation of flap with long stump of LSV for



D.Preparation for microanastomosis



E.color of pricking blood 5 days postoperative



F.late postoperative photos 6 months

Fig.2 :case 2 presentation photos.

Discussion:

A number of studies have suggested many methods to improve venous outflow of distally based sural flap like exteriorizing rather than tunneling the pedicle, delaying procedure and using wide or short pedicle (6). Although this technique may offer a moderate improvement in flap survival rates, they do not solve the basic problem that despite the presence of anastomotic venous collaterals, venous valves prevent the retrograde flow of blood out of the flap, (7).

In our study When performing the flap on patients at high risk for complications, we recommend using one or both of the flap modifications such as a delay procedure, short saphenous vein cannulation, venous

supercharging, short and wide pedicle, take a cuff of gastrocnemius muscle and exteriorization of pedicle. Similarly, if the geometry of the wound being addressed necessitates either a very distal pedicle or a very large flap, one of the flap modifications should be used. If the flap is performed without modification in these situations, an unacceptably high complication rate will result.

By supercharging the sural flap, the venous load of the bulky or large flaps having also normal reverse venous drainage through the suprafascial venous network in the pedicle decreases, and the venous drainage associated with the angulation or compression of the pedicle leading to lack of reverse venous flow is only

maintained antegradely because the lesser saphenous vein is less affected than the suprafascial venous network. Thus larger flaps can be raised safely with this modification.

In the technique of supercharging, the lesser saphenous vein was divided and ligated with a long proximal stump to be with enough length for anastomosis and a superficial vein in the foot or ankle was prepared for microvascular anastomosis with 9/0 nylon sutures under 3.5 x loupe magnifications. This modification greatly improves the venous return as it provides an alternative way for venous drainage that blocked by venous valves. Serious experience in microsurgery was not required for end-to-end anastomoses. We think this modification can be easily practiced and taught. The unique disadvantage of our modification was a slight increase in operation time of 20 min on average. Sometimes it may be difficult to find a satisfactory recipient vein. Outcomes of our four cases were promising; there were no venous congestion or partial or total flap necrosis and all flaps were preserved.

Also, another method to overcome venous congestion in our study was venous cannulation of the proximal stump of the lesser saphenous vein with large pore cannula (20gauges). This method had an effective way for intermittent venous drainage of the vein and prevented the occurrence of congestion. Postoperative close follow up was planned for these cases to drain the vein through the cannula every 2 hours for 3 consecutive days to overcome any congestion. All flaps survived and healed uneventfully.

Delayed procedure was another effective way we have been used in our study to increase the vascularity of sural flap which lead to redirect the

blood flow and decrease the risk of flap necrosis or other complications.

The idea of a delayed sural flap was first introduced in 1984 by Angelats and Albert, who described the case of a 9-year-old boy who was treated with a proximally based cross-foot delayed sural flap. A distally based sural flap delay procedure was not reported in the literature until 2004.(8,9) Since this publication, three additional authors have reported their experience with sural delay procedures. The data reported in these recent publications suggest that delaying the sural flap improves outcomes, especially in patients with significant medical comorbidities. (10-12)

There were two distinct delay procedures have been described.

In the technique of Erdmann et al., the flap is first elevated without completely incising the proximal edge of the skin island. A powder-free glove is then placed between the elevated fascia and the gastrocnemius muscle, and the skin is closed. Two weeks later, the flap is completely elevated and transferred into the defect site.(12) This procedure has the goal of redirecting blood flow in a longitudinal direction before complete elevation of the flap (sural flap delay procedure). other technique used by Kneser et al., the flap is raised in its entirety and then sutured back into its donor site. The flap is then transferred into its recipient site as a second procedure. This technique allows the flap to become viable on its distal vascular pedicle before causing the additional trauma of transferring the flap, which can potentially compromise that pedicle (11).

In our study we used the second procedure described by Kneser et al, in which we elevate the flap completely and then resuture it back on the donor

site and leave it for 3 weeks then transfer the flap to the recipient site.

Another method we use is taking a cuff of gastrocnemius muscle within the flap.

The retrograde venous outflow also can be facilitated by the distally based fasciomusculocutaneous flap. This may be the result of the inclusion of another sources of venous bypass, because the midline cuff of the gastrocnemius muscle can preserve abundant intercommunicating veins known to exist between the heads of the gastrocnemius muscle, as well as the musculocutaneous perforator veins that have branches or direct connections to the venae comitantes of the accompanying arteries of the sural nerve and the lesser saphenous vein, helping bypass the valves and ensuring adequate venous return.(13)

Our experience demonstrates that improving venous drainage through either venous anastomoses or venous cannulation to provide physiological antegrade venous drainage for relieving venous congestion in distally based flaps to cover defects is more safely with lower complication rate especially in patients with comorbidity like diabetis. However, our series is too small, further studies in a larger cohort are needed comparing flaps with and without venous anastomoses.

Conclusion:

The distally based sural flap has become a mainstay for reconstruction of the heel and foot and offers an alternative to free tissue transfer for reconstruction of the lower extremity.

Venous supercharging is a microsurgical technique that should be considered in patients with venous insufficiency. Lesser saphenous drainage is an alternative option when supercharging is not possible. A number of other refinements are available to meet the reconstructive

needs of individual patients as taking a cuff of gastrocnemius muscle or delaying technique. Exteriorization of the pedicle should be standard in all techniques. Surgeon needs to take into account the advantages and disadvantages of each of these modifications techniques before Suggesting the most adapted solution to the patient's comorbidities and to the type of defect.

References :

1. **Ponte'n, B.** The fasciocutaneous flap: Its use in soft tissue defects of the lower leg. *Br. J. Plast. Surg.* 34: 215, 1981.
2. **Donski, P. K., and Fogdestam, I.** Distally based fasciocutaneous flap from the sural region: A preliminary report. *Scand. J. Plast. Reconstr. Surg.* 17: 191, 1983.
3. **Reverse-flow sural flap:** 10 years of clinical experience and modifications; *Rev Bras Cir Plast.* 27(2):309-15.2012
4. **Masquelet, A. C., Romana, M. C., and Wolf, G.** Skin island flaps supplied by the vascular axis of the sensitive superficial nerves: Anatomic study and clinical experience. *Plast. Reconstr. Surg.* 89: 1115, 1992.
5. **Follmar, Keith E. B.A.; Baccarani, Alessio M.D.; Baumeister, Steffen P. M.D.; Levin, L Scott M.D.; Erdmann, Detlev M.D., Ph.D.** The Distally Based Sural Flap. *Plastic and Reconstructive Surgery:* May 2007 - Volume 119 - Issue 6 - p 138e-148e
6. **Maffi, T. R., Knoetgen, J., Turner, N. S., and Moran, S. L.** Enhancing survival using the distally based sural artery interpolation flap. *Ann. Plast. Surg.* 54: 302, 2005.
7. **Imanishi, N., Nakajima, H., Fukuzumi, S., and Aiso, S.** Venous drainage of the distally

- based lesser saphenous-suralveno-neuroadipofascialpedicledfasciocutaneous flap: A radiographic perfusion study. *Plast. Reconstr. Surg.* 103: 494, 1999.
8. **Angelats, J., and Albert, L. T.** Sural nerve neurocutaneous cross-foot flap. *Ann. Plast. Surg.* 13: 239, 1984.
 9. **Karacalar, A., Idil, O., Demir, A., et al.** Delay in neurovenous flaps: Experimental and clinical experience. *Ann. Plast. Surg.* 53: 481, 2004.
 10. **Tosun, Z., Ozkan, A., Karacor, Z., and Savaci, N.** Delaying the reverse sural flap provides predictable results for complicated wounds in diabetic foot. *Ann. Plast. Surg.* 55: 169, 2005.
 11. **Kneser, U., Bach, A. D., Polykandriotis, E., et al.** Delayed reverse sural flap for staged reconstruction of the foot and lower leg. *Plast. Reconstr. Surg.* 116: 1910, 2005.
 12. **Erdmann, D., Gottlieb, N., Humphrey, J. S., et al.** Sural flap delay procedure: A preliminary report. *Ann. Plast. Surg.* 54: 562, 2005.
 13. **Al-Qattan MM.** A modified technique for harvesting the reverse sural artery flap from the upper part of the leg: inclusion of a gastrocnemius muscle 'cuff' around the sural pedicle. *Ann Plast Surg* 2001;47:269–78.