



# Reverse sural artery flap: a reliable alternative for foot and ankle soft tissue reconstruction

Anastasios Korompilias<sup>1</sup> · Ioannis Gkiatas<sup>1</sup> · Maria Korompilia<sup>1</sup> · Dimitrios Kosmas<sup>1</sup> · Ioannis Kostas-Agnantis<sup>1</sup>

Received: 3 October 2018 / Accepted: 23 October 2018 / Published online: 29 October 2018  
© Springer-Verlag France SAS, part of Springer Nature 2018

## Abstract

**Introduction** Soft tissue defects of foot and ankle are challenging due to the susceptibility of the area to trauma and the complexity of the region. Several flaps have been described for wound coverage after surgical debridement at this location. The purpose of this study is to present the reverse sural flap for covering soft tissue defects at the ankle and foot.

**Materials and methods** From July 2014 to November 2017, ten patients with soft tissue defect at the ankle and foot were retrospectively reviewed. There were nine men and one woman with a mean age of 40.5 years (range 17–71 years). Seven patients were smokers and five were diabetics. The mean size of the defect was 50.5 cm<sup>2</sup>. All operations were performed by the same microsurgical team. At a mean follow-up of 21 months (range, 18 to 24 months), we evaluated wound healing and complications.

**Results** In nine patients, the soft tissue defect was successfully covered. In four patients, venous congestion was noticed, whereas in one patient, there was total necrosis of the flap. In all cases, the donor site was healed uneventfully.

**Conclusion** The reverse sural artery flap is a reliable alternative for wound coverage at the ankle and foot, with low complication and morbidity rate. Nevertheless, it is a demanding microsurgical operation that requires knowledge of the anatomy and surgeons' experience.

**Keywords** Soft tissue deficits · Reverse sural artery flap · Foot and ankle · Microsurgery

## Introduction

Soft tissue defects of the lower one-third of the leg and the calcaneal region remain crucial issues. This area is easily susceptible to trauma, and defects of this area, despite advancements in microsurgical techniques, remain a challenge for surgeons. The complexity of this region comes from the tightness and limited mobility of the overlying skin and frequently, the poor circulation. Common defects in the distal parts of the leg may be chronic and diabetic ulcers, pressure sores, unstable scars and Achilles tendon rupture with exposure of viable structures (neurovascular bundles, tendons and bone) [1].

Surgical debridement and early wound coverage are the gold standard approach of those cases. The flap chosen should be easy to execute relatively quickly with minimal

discomfort to the patient and should provide durable coverage for the defect. Several local and local–regional flaps have been described over the years, but they are not reliable, due to their dependence on local vascularity, which is altered from any possible underlying disease (diabetes mellitus) or trauma [2].

Many anatomic studies [3–5] have been performed which highlight the importance of reverse sural flap in confrontation of these problematic defects. It is a reversed neurofasciocutaneous flap which was first described by Masquelet et al. [6], who published their experimental work involving skin island flaps supplied by the vascular axis of sensitive superficial nerves. They reported a flap based on reverse flow through the anastomosis of superficial sural artery and the lowermost perforator from the peroneal artery for the coverage of the defects. This was followed by Hasegawa et al. [7] with a series of 21 distally based superficial sural artery flaps for the reconstruction of similar defects with almost no complications. Later, in 1996, Cavadas and Bonanad [8] described the use of the reverse-flow sural island flap in varicose legs. As a result, the popularity of the sural flap

✉ Ioannis Gkiatas  
john.gkiatas@gmail.com

<sup>1</sup> Department of Orthopaedic Surgery, School of Medicine, University of Ioannina, Ioannina, Greece

has increased noticeably, rendering microsurgical free flap as the mainstay of treatment for the traumatized lower limb.

Over the last decades, sural flap has gained wide use in the reconstruction of moderate- to large-size defects for lower limb salvage [3, 4, 9, 10]. This flap has been used for the coverage of defects of the posterior and inferior surface of the heel, the Achilles tendon, the middle and the distal one-third of the leg, dorsum of the foot and lateral, medial malleolus. Advantages of this procedure are thin flap with ideal contouring, preservation of major vessels, short operative time in one stage, durable soft tissue coverage, no need for vessel micro-anastomosis, low rate of complications and minimal morbidity for the patient [1, 3].

The purpose of this study is to present our experience with the use of distally based reverse sural flap for the reconstruction of complicated wounds on the distal third leg, ankle, dorsum of the foot and weight-bearing heel with a minimum follow-up of the patients of 18 months postoperative.

## Patients and methods

The study took place in the Orthopaedic Department of the University Hospital of Ioannina and was approved by the institutional review board (IRB).

We retrospectively reviewed ten patients who were operated with reverse sural flap for soft tissue deficit in

the foot and ankle. After collecting the demographic data, we evaluated the coverage of the deficit, the donor site morbidity and possible complications in the defect site as well as in the donor site.

The patients included in the study were nine men and one woman. The mean age of the patients was 40.5 years (range 17–72 years). In seven cases, the deficit was the result of trauma, in two cases, it was made due to osteomyelitis, and in one case, it was created after dog bite. The mean covered area of the deficit was 50.5 cm<sup>2</sup> (range 20–112 cm<sup>2</sup>). Seven patients were smokers, whereas five of them were taking medication for diabetes. The mean follow-up of the patients was 21 months (range 18–24 months). In four patients, the defect was placed in the posterior aspect of the heel (Fig. 1), in three patients in the medial malleolus, in two patients in the dorsum of the ankle (Fig. 2) and in one patient in the plantar side of the foot and in the posterior aspect of the heel (Table 1).

In nine cases, there was association of the deficit with other problems. In four cases, the deficit was associated with an open fracture type IIIB according to Gustilo and Anderson classification [11] of the lower limb, in one case there was association with an open fracture IIIA, in one case with an open fracture IIIC, in one case with diabetes mellitus, in one with bimalleolar ankle fracture, and in another one the Achilles tendon was exposed. Only in one case, there was not an associated problem along with the soft tissue deficit.

**Fig. 1** **a** Soft tissue defect in the heel as result of osteomyelitis. **b** Intraoperative image of the reverse sural flap. **c** The covered soft tissue defect of the heel right after the end of the operation. **d** The same patient 12 months postoperative



**Fig. 2** **a** Soft tissue defect in the dorsum of the foot. **b** Intraoperative photograph of the reverse sural flap. **c** The covered soft tissue defect on the third postoperative day. **d** Venous congestion of the flap 3 weeks postoperatively. **e** The covered soft tissue defect 18 months postoperatively. **f** The donor site 18 months postoperatively



**Table 1** Demographic data of the patients included in the study

Patient	Age	Sex	Etiology	Defect site	Size (cm)	Associated problems	Complications
1	18	Male	Trauma	Dorsum of the foot	8×7	III b metatarsal fractures	None
2	53	Male	Osteomyelitis	Medial malleolus and lower leg	5×6	Diabetes mellitus	Venous congestion Partial superficial necrosis
3	65	Male	Trauma	Medial malleolus and lower leg	12×8	medial and lateral malleolus fracture	None
4	23	Male	Trauma	Posterior aspect of the heel	6×8	none	None
5	18	Male	Trauma	Posterior aspect of the heel	5×6	IIIC tibial fracture	Venous congestion
6	32	Female	Trauma	Plantar and posterior heel	14×8	III b calcaneal fracture	Venous congestion Partial marginal necrosis
7	72	Male	Trauma	Dorsum of the ankle	7×5	III a distal tibia fracture Diabetes mellitus	Complete necrosis
8	61	Male	Osteomyelitis	Medial malleolus and foot	8×6	III b distal tibia fracture	Venous congestion
9	17	Male	Trauma	Posterior aspect of the heel	5×4	III b distal tibia fracture	None
10	46	Male	Dog bite	Posterior aspect of the heel	6×5	Exposed Achilles tendon	None

## Surgical procedure

The lesser saphenous vein and the perforator branches of the peroneal artery in the lower limb were identified with the use of Doppler ultrasound preoperatively. The patient was placed in prone position, and pneumatic tourniquet was placed in the thigh without exsanguinating the limb. The flap was centered along the center of the lesser saphenous vein. The flap in the donor site was designed bigger than the deficit in order to achieve skin to skin closure at the recipient site [3, 12] (Fig. 3).

All the operations were performed by the same microsurgical operation team supervised by the same senior surgeon. The skin incision is made along the line in which the fascial pedicle will be taken. The sural nerve is exposed along with the sural vessels and the short saphenous vein. Approximately, 2-cm elevation of the pedicle is made in order to include the nerve and the vessels as well. Proximally the vein is ligated, and the accompanying vessels are cut and the nerve as well. The elevation of the skin flap is made along with the deep fascia [7]. The donor site was covered by split thickness skin graft.

## Postoperative care

After the operation, the limb was placed elevated with a round pillow under the knee for 2–3 weeks. The patient was given anticoagulant therapy (subcutaneous low molecular weight heparin injections) for 30 days. The stitches were removed 3 weeks after the operation. The patients started active and passive rehabilitation program after 2–3 weeks postoperative. For the defects that were in the heel, partial weight bearing was advised after the removal of the stitches and full weight bearing 6 weeks after the operation.

## Results

In nine out of ten cases the flap survived successfully and provided good coverage for the soft tissue defect. No complications were observed concerning the wounds such as



**Fig. 3** Patient positioning and design of the flap. The flap is designed long enough in order to be able to be transferred to the deficit area in the forefoot

infection of the wound neither at the site of the deficit nor at the donor site.

In four cases, venous congestion was noticed (Fig. 2d), and in one of these cases, there was complete necrosis of the flap 6 weeks after the operation (Table 1). In one of the cases with venous congestion, partial superficial necrosis was noticed, and in another one partial marginal necrosis. In the case with complete necrosis of the flap, after the debridement of the foot deficit-free fasciocutaneous anterolateral thigh (ALT) flap was used for its coverage.

At the time of follow-up, all patients were able to ambulate well and they were satisfied by the result. There was no weakness in heel-lifting force in all the patients. Moreover, at the last follow-up, there was no evidence of recurrence of ulceration. There was uneventfully healing of the donor site during the last follow-up for all the patients (Fig. 3f).

## Discussion

Coverage of soft tissue defects of the lower one-third of the leg, ankle, dorsum of the foot and heel is always a difficult problem to tackle. There are many possibilities for the coverage of these defects, such as skin graft, cross-leg flap, local flaps, distally based muscle flap and free flap. Multiple free flaps can be used for lower limb defects, such as latissimus dorsi muscle flap, rectus abdominis muscle flap, anterolateral thigh flap, and scapular flap. They are characterized with good vascularity itself, and with no limitation on its use as far as size of the defect sites, despite the disadvantage of prolong surgical time and the demanding microsurgical anastomoses [13]. Moreover, many reverse flaps have been proposed for foot coverage, for example, the peroneal artery flap, the anterior tibial artery flap and the posterior tibial flap. The fact that of sacrificing major vessels of the limb as well as the bulkiness should be taken seriously into consideration in the use of these flaps, due to the risk of the whole vascularity of patient's limb [14–16]. Reverse-flow sural flap has been proved a valuable tool in the reconstruction of these problematic defects [17]. This flap receives a favorable judgment in the international literature and is recommended for many types of defects of the distal third of the lower leg and the ankle region [18].

Donski and Fogdestam [19] introduced first the distally based sural fasciocutaneous flap. Since then, the vascularity of the calf and sural region of the posterior lower leg has been investigated by many authors. Masquelet et al. [6] described the use of a sural neurocutaneous island flap for the reconstruction of soft tissue loss in the distal third of the leg and ankle. In 1994, Hasegawa et al. [7], proposed the term “distally based superficial sural artery flap,” and later in 1996, Cavadas and Bonanad [8] described the surgical intervention of varicose legs with reverse-flow island sural flap.

Le Fourn et al. [20] performed an anatomic study involving 25 cases, using distally based sural fasciomuscular flap for the treatment of calcaneal osteomyelitis. Almeida et al. [21] agreed to the term of reverse-flow sural flap with their series of 71 patients, persisting on the anatomic importance of pedicle of sural flap. In 2008, Uygur et al. [22] used twelve distally based reverse flow flaps for lower extremity reconstruction after the release of postburn flexion contractures, with success in all twelve cases. One year later, Chang et al. [9] proposed a modified technique with including the distal portion of the gastrocnemius muscle component for complicated wounds of the lower third leg and weight-bearing heel. According to the authors, this technical modification offers a wider range for applications of the distally based sural fasciocutaneous flap in the coverage of soft tissue defects of the lower extremity. Even in high-energy trauma, such as the war injuries, where there are complex soft tissue deficits, the reverse sural artery flap has proved to be a reliable solution [23].

Several authors concentrated mainly in the use of sural flap for covering weight-bearing surfaces. Recently, Larrañaga et al. [24] presented their retrospective study of patients with melanoma resection on weight-bearing heel and mid-foot using reverse sural flap. The authors reported 100% flap survival without partial necrosis after a minimum follow-up of 5 years. The same year Li-You et al. [25] presented the use of reverse-flow sural flap for covering soft tissue defects in the heels of children resulting from spokes injury, with satisfactory results.

Coverage of soft tissue defects in foot and ankle with an infected bed consists a demanding challenge for the surgeon. In 2007, Fahandezh-Saddi Diaz et al. [26] presented a case report of chronic osteomyelitis in distal tibia where after the debridement of the area, sural fasciocutaneous flap was used for the defect coverage with complete healing. The same year Al-Qattan [27] published a case series of 10 patients suffering from lower limb soft tissue defects. In nine of them there was an underlying infection bed. The patients were treated with reverse sural artery flap, and primary healing was noted in all the patients.

In our study, 90% survivorship of the sural flap is presented. The fact that 70% of the defects in our case series were placed lower of the ankle joint in combination with the fact that most of the patients were smokers and were suffering from diabetes may explain the venous congestion which was noticed in 40% of the patients. The present study focused mainly on soft tissue defects which were placed distal enough from the donor site and more specifically further from the ankle joint. Our results are comparable to those of previous studies which present even 100% in plantar deficits with a long-term follow-up [24, 25]. On the other hand, in a review series with 70 sural artery flaps in healthy patients and in patients with several comorbidities, the authors report

complications in 11% of the healthy patients, 33% in patients with any systemic disease and 60% in patients suffering from diabetes mellitus, venous insufficiency or peripheral arterial disease [18].

Despite the promising results which are similar to those presented in the international literature, the present study has certain limitations. A large number of patients are needed in order to be able to exclude safer conclusions. In addition, it is a retrospective study with a relative short follow-up period.

## Conclusion

The reverse fasciocutaneous sural flap in this selected series of patients has proven to be a reliable choice for reconstruction in deficits which are placed relative distal from the donor site, with low complication and morbidity rate. The use of this type of flap in elective and clean situations may be a factor that positively influences the outcome of these procedures. Nevertheless, a large series of patients are needed in combination with larger follow-up period.

## Compliance with ethical standards

**Conflict of interest** All authors declare that they have no conflict of interest.

**Ethical approval** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

**Informed consent** Informed consent was obtained from all individual participants included in the study.

## References

1. Moran SL, Cooney WP (2009) *Soft tissue surgery*. Lippincott Williams & Wilkins, Philadelphia
2. Touam C, Rostoucher P, Bhatia A, Oberlin C (2001) 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* 107(2):383–392. <https://doi.org/10.1097/00006534-200102000-00013>
3. Köse R, Mordeniz C, Şanlı Ç (2011) Use of expanded reverse sural artery flap in lower extremity reconstruction. *J Foot Ankle Surg* 50(6):695–698. <https://doi.org/10.1053/j.jfas.2011.06.007>
4. Chai Y, Zeng B, Zhang F, Kang Q, Yang Q (2007) Experience with the distally based sural neurofasciocutaneous flap supplied by the terminal perforator of peroneal vessels for ankle and foot reconstruction. *Ann Plast Surg* 59(5):526–531. <https://doi.org/10.1097/01.sap.0000258969.13723.68>
5. Gu H, Xiong Z, Xu J, Li G, Wang C (2013) Clinical and anatomical study of the distally based lesser saphenous veno-lateral sural neurocutaneous flap for lower extremity coverage. *J Orthop Sci*

- Off J Jpn Orthop Assoc 18(5):740–748. <https://doi.org/10.1007/s00776-013-0434-x>
6. Masquelet A, Romana M, Wolf G (1992) Skin island flaps supplied by the vascular axis of the sensitive superficial nerves: anatomic study and clinical experience in the leg. *Plast Reconstr Surg* 89(6):1115–1121
  7. Hasegawa M, Torii S, Katoh H, Esaki S (1994) The distally based superficial sural artery flap. *Plast Reconstr Surg* 93(5):1012–1020
  8. Cavadas PC, Bonanad E (1996) Reverse-flow sural island flap in the varicose leg. *Plast Reconstr Surg* 98(5):901–902
  9. Chang SM, Zhang K, Li HF, Huang YG, Zhou JQ, Yuan F, Yu GR (2009) Distally based sural fasciomyocutaneous flap: anatomic study and modified technique for complicated wounds of the lower third leg and weight bearing heel. *Microsurg Off J Int Microsurg Soc Eur Fed Soc Microsurg* 29(3):205–213. <https://doi.org/10.1002/micr.20595>
  10. Kansal S, Goil P, Singh J (2011) Surgical review: the versatile reverse flow sural artery flap for lower 1/3 leg and foot defects: clinical series. *Eur J Orthop Surg Traumatol* 21(8):553–556. <https://doi.org/10.1007/s00590-011-0768-z>
  11. Gustilo RB, Anderson JT (1976) Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: retrospective and prospective analyses. *J Bone Jt Surg Am* 58(4):453–458
  12. Yilmaz M, Karatas O, Barutcu A (1998) The distally based superficial sural artery island flap: clinical experiences and modifications. *Plast Reconstr Surg* 102(7):2358–2367. <https://doi.org/10.1097/00006534-199812000-00013>
  13. Kang MJ, Chung CH, Chang YJ, Kim KH (2013) Reconstruction of the lower extremity using free flaps. *Arch Plast Surg* 40(5):575. <https://doi.org/10.5999/aps.2013.40.5.575>
  14. Yildirim S, Akan M, Aköz T (2002) Soft-tissue reconstruction of the foot with distally based neurocutaneous flaps in diabetic patients. *Ann Plast Surg* 48(3):258–264
  15. Yoshimura M, Imura S, Shimamura K, Yamauchi S, Nomura S (1984) Peroneal flap for reconstruction in the extremity: preliminary report. *Plast Reconstr Surg* 74(3):402–409
  16. Hong G, Steffens K, Wang FB (1989) Reconstruction of the lower leg and foot with the reverse pedicled posterior tibial fasciocutaneous flap. *Br J Plast Surg* 42(5):512–516. [https://doi.org/10.1016/0007-1226\(89\)90035-0](https://doi.org/10.1016/0007-1226(89)90035-0)
  17. Osman GMA (2004) Reverse-flow sural flap: clinical experiences and idea and innovation. *AAMJ* 2(2)
  18. Baumeister SP, Spierer R, Erdmann D, Sweis R, Levin LS, Germann GK (2003) A realistic complication analysis of 70 sural artery flaps in a multimorbid patient group. *Plast Reconstr Surg* 112(1):129–140. <https://doi.org/10.1097/01.prs.0000066167.68966.66> (discussion 141–122)
  19. Donski PK, Fogdestam I (1983) Distally based fasciocutaneous flap from the sural region. A preliminary report. *Scand J Plast Reconstr Surg* 17(3):191–196. <https://doi.org/10.3109/02844318309013118>
  20. Le Fourn B, Caye N, Pannier M (2001) Distally based sural fasciomuscular flap: anatomic study and application for filling leg or foot defects. *Plast Reconstr Surg* 107(1):67–72. <https://doi.org/10.1097/00006534-200101000-00011>
  21. Almeida MF, da Costa PR, Okawa RY (2002) Reverse-flow island sural flap. *Plast Reconstr Surg* 109(2):583–591. <https://doi.org/10.1097/00006534-200202000-00027>
  22. Uygur F, Duman H, Ulkur E, Celikoz B (2008) Are reverse flow fasciocutaneous flaps an appropriate option for the reconstruction of severe postburn lower extremity contractures? *Ann Plast Surg* 61(3):319–324. <https://doi.org/10.1097/SAP.0b013e31815acb43>
  23. van Waes OJ, Halm JA, Vermeulen J, Ashford BG (2013) “The Practical Perforator Flap”: the sural artery flap for lower extremity soft tissue reconstruction in wounds of war. *Eur J Orthop Surg Traumatol* 23(2):285–289. <https://doi.org/10.1007/s00590-0-012-1133-6>
  24. Larrañaga JJ, Picco PI, Yanzon A, Figari M (2017) Reconstruction of hind and mid-foot defects after melanoma resection using the reverse sural flap: a case series. *Surg J* 3(3):e124. <https://doi.org/10.1055/s-0037-1604473>
  25. Li-You W, Hong-Wei Z, Gang Z, Guo-Qiang W, Fan Y (2017) Treatment of soft tissue defects in the heels of children in an emergency setting. *J Pediatr Orthop B* 26(2):152–158. <https://doi.org/10.1097/BPB.0000000000000343>
  26. Díaz HF-S, Ríos-Luna A, García-Rey E, Butragueño MJR, Villanueva-Martínez M, Cantero-Yubero ME, del Cerro-Gutiérrez M (2007) Utility of the sural fasciocutaneous flap for the treatment of chronic osteomyelitis of the distal tibia. *Eur J Orthop Surg Traumatol* 17(1):105–109. <https://doi.org/10.1007/s00590-006-0133-9>
  27. Al-Qattan MM (2007) The reverse sural artery fasciomusculocutaneous flap for small lower-limb defects: the use of the gastrocnemius muscle cuff as a plug for small bony defects following debridement of infected/necrotic bone. *Ann Plast Surg* 59(3):307–310