European Review for Medical and Pharmacological Sciences 2023; 27 (3 Suppl): 11-17

Regenerative potential of the sural neuroadipofascial flap in the treatment of chronic ulcers of the lower third of the leg

A.L. COSTA[1], V. VINDIGNI[1], C. TIENGO[1], T. BRAMBULLO[1], F.A.G. PEROZZO[1], M.R. GALEANO[2], M.R. COLONNA[2], F. BASSETTO[1]

[1]Department of Neurosciences, Clinic of Plastic Reconstructive and Aesthetic Surgery, Padua University Hospital, Padua, Italy
[2]Department of Human Pathology of the Adult, the Child, and the Adolescent, University of Messina, Messina, Italy

M.R. Galeano and M.R. Colonna contributed equally to this work. Each author has participated sufficiently in the work

Abstract. – OBJECTIVE: Surgical reconstruction of soft tissue defects in the distal third of the lower limbs has always been challenging for surgeons. The adipofascial flaps are made up of vascularized adipose tissue, which plastically conforms to the site to be reconstructed with its rich presence of stem cells. In this study, we resumed our case history of reverse neuroadipofascial sural flap, and we evaluated the stability of the scar to verify if this type of reconstruction can ensure long-term results and its regenerative power.

PATIENTS AND METHODS: In this retrospective cohort study, we analyzed 32 patients who had undergone lower limb reconstruction with the sural neuroadipovenous flap.

RESULTS: A total of 32 patients were included in the study. The average age was 62.2 years. Chronic skin ulcer was the cause of the defects in 13 (40.6%) patients, chronic wound after trauma in 7 (21.9%) patients, wheel bedsores in 4 (12.5%) patients, osteomyelitis in 5 (15.6%) patients, exposed internal hardware in 2 (6.3%) patients, dog bite in 1 (3.1%). The site defect comprised 11 heels (34.4%), 4 external malleoli (12.5%), three medial malleoli (9.4%), 12 lower third of the leg (37.5%), and two dorsa of the foot (6.3%). In all cases, defects were covered with reverse sural island flap. The dimension of the flap ranged from 5 to 9 cm in length and from 3 to 7 in width. Six patients showed early or later postoperative complications.

CONCLUSIONS: The neuroadipofascial sural flap is versatile, fast, and easy-to-perform to cover a chronic defect in the distal part of the lower limb, including both the malleoli and the heel, due to its long vascular pedicle. Consistent with the studies carried out in other districts, the present study confirms the remarkable regenerative power of the vascularized adipose tissue at the level of complex wounds of the lower third of the leg.

Key Words:
Diabetes, Chronic wound, Trauma, Regenerative surgery.

Introduction

Surgical reconstruction of soft tissue defects in the distal third of the lower limbs has always been a challenge for surgeons. It is a poorly vascularized area with structures of various kinds, exposed to high-energy trauma or affected by local manifestations of general diseases which, if not treated adequately, leads to the formation of chronic ulcers and unstable scars (Figure 1). The heel is also a load-bearing region whereby an unstable scar exposes chronic skin ulceration with impaired walking and quality of life. There are many reconstructive options, including some less invasive ones such as the application of grafts on granulation tissue, which however leads to the presence of unstable scars that tend to ulcerate. Other more complex reconstructive options have been affirming themselves in recent years, such as free flaps which are burdened by longer operating times[1-4]. However, patients suffering from these chronic wounds often have various contraindications to complex microsurgical reconstruction. The reverse neuroadipofascial sural flap still stands today as an adequate compromise to ensure healing of chronic wounds[1]. In this study,

Corresponding Author: Alfio Luca Costa, MD; e-mail: alfiolucacosta.alc@gmail.com

Figure 1. Chronic wound after trauma.

we resumed our case history of this flap, and we evaluated the stability of the scar to verify if this type of reconstruction is able to ensure long-term results.

Anatomy

The sural flap is an island flap based on the superficial sural artery and several septocutaneous perforating vessels, originating from the posterior peroneal and tibial artery[5]. Specifically, it is supported by a distal reverse flow of the superficial sural artery dependent on perforators of the peroneal arterial system that have different communications with the superficial sural artery. Venous drainage takes place on the small saphenous vein and on the venae comitantes[5]. The flap may possibly include the lateral sural nerve. The superficial sural artery arises from the popliteal artery in the center of the popliteal fossa, descends with two venae comitantes, posteriorly between the two heads of the gastrocnemius muscle and then follows the lateral edge of the Achilles tendon. After a few centimeters from its origin, the artery joins the sural nerve and travels together giving multiple septocutaneous perforators. This vessel also plays an important role in blood supply to the skin in the middle and lower thirds of the leg[6-7]. Eventually, the artery anastomoses with the supramalleolar branch of the fibular artery and the posterior tibial artery.

On the crural fascia, the fasciocutaneous perforating vessels and their venae comitantes, anastomosing with each other, form a vascular plexus. The largest perforating vessel is located 5 cm above the lateral malleolus. This plexus, with many connections to the superficial sural artery and the subcutaneous and subdermal vascular plexus, forms a rich system of longitudinally oriented suprafascial vessels extending from the proximal part of the leg to the lateral malleolus[8-12]. The small saphenous vein originates from the lateral extension of the dorsal venous arch of the foot, continues posteriorly to the lateral malleolus, and rises medially with the sural nerve. The lateral sural nerve originates from the sensory branches of the peroneal nerve, travels longitudinally, passing posteriorly to the lateral malleolus, and gives sensory branches to the lateral portion of the foot up to the fifth toe. This nerve is supplied by the superficial sural artery in the proximal third of the leg and by multiple fasciocutaneous branches of the fibular artery in the distal two-thirds. These vessels travel for a variable distance on the crural fascia before reaching the sural nerve. For this reason, in order to ensure the survival of the distal part of the nerve, a longitudinal strip of fascia must be harvested. Along its path, the sural nerve is also supplied with an intrinsic plexus of longitudinally oriented epineural, perineural and endoneural vessels with many communications with the superficial sural artery proximally and the fasciocutaneous perforators of the fibular artery distally[1,13].

Surgical Technique

Before surgery, the size of the defect is measured. The pedicle is drawn along the course of the sural nerve, approximately delimited by a line drawn from the midpoint between two heads of the gastrocnemius muscle, to the midpoint between the Achilles tendon and the lateral malleolus (Figure 2). Then the larger fibular perforator, which is used as the pivot point, is marked approximately 5 cm above the tip of the lateral malleolus. With the patient in the prone position and the pneumatic tourniquet inflated, the flap is dissected from the proximal margin. The superficial sural artery, the lesser saphenous vein and the sural nerve are dissected proximally and elevated with the flap in a subfascial plane. Dissection continues all around the flap. Below the distal margin, approximately mid-calf, the suprafascial pedicle is identified. The lesser saphenous vein can be used to constitute a supercharged flap as described by Tan et al[14,15]. The musculocutaneous perforating vessels of the gastrocnemius muscle are coagulated. A longitudinal fascia strip is raised distally to protect the neurovascular pedicle. The fatty tissue surrounding the pedicle must be carefully maintained during dissection to promote venous drainage and avoid venous congestion, especially in the lower third of the pedicle (Figure 3). The anatomical

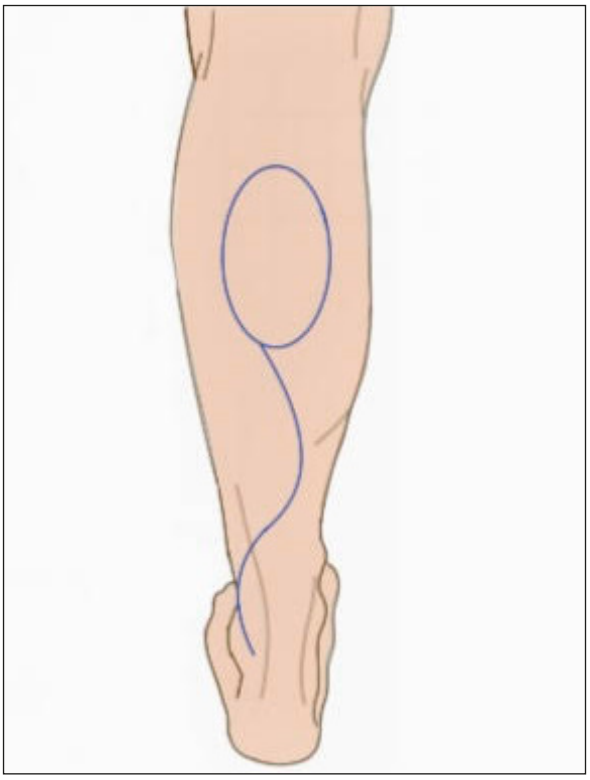

Figure 2. Design of the flap.

landmarks of the dissection are the fibula laterally and the Achilles tendon medially. By reaching the point of articulation, where the largest perforators of the fibular artery are located, the dissection is stopped. The flap is rotated up to 180° with respect to the defect through a subcutaneous tunnel or by dividing the skin, especially if there is risk of compression of the pedicle. The tourniquet is deflated, and the viability of the flap is checked. The donor site and any uncovered site can be repaired with a partial thickness skin graft. The donor site is then covered with a partial thickness skin graft. In order not to compress the pedicle, a full-leg posterior brace with well-padded dressing is applied, leaving a window for clinical observation of the flap. Full flap loading is granted in the sixth week after surgery.

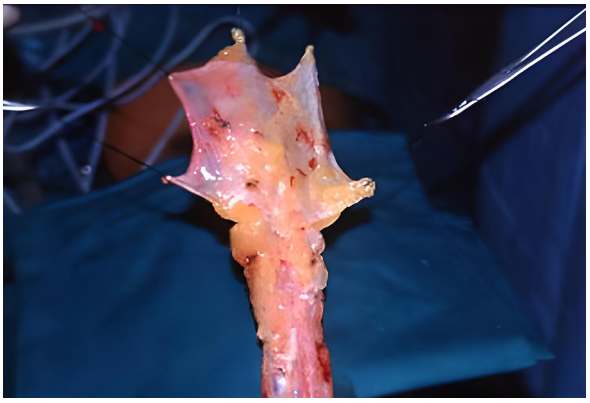

Figure 3. The pedicle.

Patients and Methods

This was a retrospective cohort study. The medical records of 32 patients undergoing reconstructive surgery of the lower limb, between 2000 and 2011, with sural bundle-skin flap were reviewed and analyzed. Informed consent to participate in the study was obtained from all patients. Assessment tools were pre-established and used during the patient's recovery time and follow-up visits. The study included patients with chronic soft tissue and bone defects in the lower limb who required reconstructive surgery, obtained using a fasciocutaneous sural flap. The basic principles of the surgical approach were to undertake reconstruction in order to ensure definitive healing, avoid limb amputations and obtain immediate adequate tissue coverage. For each patient, we recorded age, sex, etiology, defect location, wound size, comorbidity, flap survival, sensitivity recovery (touch and temperature), complications, and scar stability at 10-year follow-up (Figure 4).

Statistical Analysis

A descriptive statistical analysis was performed by processing the quantitative data with the mean and the qualitative data with the per-

Figure 4. Stable scar in long-term follow-up.

centage. Data was recorded with Microsoft Excel for Mac OS, Ver. 16.45 (©2021 Microsoft), and statistical analysis was provided by SPSS® Statistics for Mac OS, Ver.25 (IBM Corp., Armonk, NY, USA). The Kolmogorov-Smirnov test evaluated the non-normal distribution of the variables. The power calculation was also performed. Preoperative and intraoperative variables were considered to identify predictive factors. Univariate analysis with hypothesis tests was performed to identify relationships between variables and outcomes (two-tailed Fisher's exact test for two independent samples or two-tailed Chi-Square test for n>2 samples, for categorical variables; two-tailed Mann-Whitney U test for two independent samples or Kruskal-Wallis two-tailed test for n>2 independent samples, for linear continuous variables). *p*-values <0.05 were considered statistically significant.

Results

A total of 32 (8 were female and 24 were male) patients included in the study. The mean age was 62.2 years (range 31-79). **Supplementary Table I** summarizes the details. A chronic vascular skin ulcer was the defect in 13 patients (40.6%), a chronic wound after trauma in 7 patients (21.9%), heel pressure sores in 4 patients (12.5%), osteomyelitis in 5 patients (15.6%), exposure of synthetic means in 2 patients (6.3%), dog bite in 1 patient (3.1%). The site defect included 11 heels (34.4%), 4 external malleoli (12.5%), three medial malleoli (9.4%), 12 thirds of the lower leg (37.5%), and 2 dorsa of the foot (6.3%). In all cases, the defects were covered with a reverse sural island flap. The flap size ranged from 5 to 9 cm in length and 3 to 7 cm in width. The average length was 7 cm and the width measured 4.8 cm. Several patients had comorbidities; in particular, 24 patients had cardiovascular and/or endocrinological diseases (75%), which reduce the chances of survival for all autologous reconstructive surgery procedures. Six patients (18.7%) had early or late postoperative complications, and notably, three patients (9.4%) had delayed surgical site healing, one had partial flap loss (3.1%), and two had complete flap loss (3.2). Both flaps, which did not survive, were performed on patients with diabetes and other cardiovascular diseases. At the 10-year follow-up, the scars were stable over time. Statistical analysis revealed a statistically significant correlation between the presence of comorbidities and flap survival with a *p*-value <0.001. The presence of comorbidities was also correlated in a statistically significant way with the onset of complications and partial flap loss with a *p*-value of 0.006. The correlation between comorbidities and sensation recovery instead was correlated in a non-statistically significant way with comorbidities with a *p*-value of 0.112. No other variable was significantly related to the onset of complications, flap loss, or sensation recovery.

Discussion

The development of chronic wounds in the lower limbs is high in the population with various comorbidities including diabetes[16]. The control of chronic pathologies such as diabetes, the possibility of implementing prostanoid therapies in vasculopathic patients has led to a reduction in the indications for amputation of the lower limbs. Different reconstructive modalities are possible in these patients and in recent years, reconstructions with free flaps and propeller flaps are becoming increasingly popular. In the case of complex wounds, the current reconstructive algorithm has surpassed the reconstructive ladder and reconstructive elevator model. In recent times, the "toolbox" philosophy has become the standard approach. In the case of complex patients, therefore, it is possible to choose of the safest flap that has fewer complications. All available reconstructive options have different types of risks and disadvantages and must be known by the experienced surgeon to avoid complications, wasting time and unnecessary surgical procedures[16]. Skin grafts are very easy and quick to perform, but they cannot be used on exposed tendons and bones. Cross leg flaps are scarcely tolerated and are not indicated in a poorly vascularized area[17]. Free flaps are a new and widely used option, but they are costly in terms of resources, require high microsurgical skills and dedicated special instruments[7,9,18-20]. Free flaps are recommended for extensive skin defects or in cases where poor vascularization or trauma precludes other possibilities[8,11,12,21-23]. Local flaps may be the only option for limb salvage if the patient is not a candidate for a challenging reconstruction such as a microsurgical flap. There is a great variety of pedicled flaps, but they require good anatomical knowledge to make the best choice. The sural flap is one of the most used flaps. The lateral supramalleolar

skin flap is another option that offers similar coverage. It has no particular advantages, but compared to the sural flap, it has four times the complication rate, is much more difficult to perform, and cannot be used to cover loading areas[24]. The sural flap, on the other hand, has proven its reliability, even in complicated cases. The choice of the neuroadipofascial sural flap allowed us not to sacrifice or damage the main axes for the foot, which in our patients were partially compromised due to underlying comorbidities, trauma, or repeated interventions. This latter advantage was particularly important in the choice of the flap in patients whose lower limbs had suboptimal vascularity directed to the foot. The posterior tibial perforating flap and the medial distal septocutaneous flap are other very reliable options, but a larger learning curve is required[21,25]. Georgescu et al[3] published a series of 25 cases in diabetic patients where the lower limb defect was reconstructed *via* propeller flaps based on tibial artery perforators[3]. However, the use of propeller flaps, despite its advantages on the sampling site, is certainly technically more complex and its indications seem to be limited to more proximal and less extensive losses of substance compared to the neuroadipofascial sural flap which seems to be endowed with great versatility of use and reliability[3]. The sural flap, compared to others, is easier to design and perform and can reach a large area from the distal tibia to the posterior foot. It does not require microvascular procedures or tools and preserves the greater vascularity of the lower limbs. It is currently used in patients with various comorbidities, such as diabetes and cardiovascular disease, although the number of complications is obviously higher. In our study the average age was 62.2 years, slightly higher than that usually described in the literature, where it was between 31.5 and 54[18,19,25]. In our series we faced chronic wounds, compared to what is usually reported in literature where acute trauma represents 64.7-88% of the causes[7,8,12,26].

The complete necrosis rate was 6.3%, slightly higher than that reported in the literature. However, interventions performed in young patients with small traumatic defects have a higher success rate than in patients with chronic ulcers and comorbidities[8,18,28]. The complication rate has been associated with comorbidities as described in the literature[12,18,27].

Age has also been found to be a major risk factor for complications and delayed procedure is suggested in patients over the age of 60[29]. Smoking and diabetes have not been associated with an increased risk of complications[30]. In our experience, the inclusion of adipose tissue, especially suprafascial tissue in the lower third of the pedicle, keeps all mesenteric structures around the medial sural cutaneous nerve and its accompanying vessels intact and improves outcome. Bringing the skin and adipose tissue of the posterior region of the leg, similar in quality to the skin of the areas to be reconstructed, allowed for stable results over time. This stresses consideration is supported by other authors[31]. Several studies[32,33] have demonstrated the plasticity of adipofascial flaps, which not only bring vascularized adipose tissue to the site to be reconstructed but carry an important component of stem cells which gives the adipofascial flaps a significant regenerative power. Furthermore, *in vivo* studies[32] have shown through biopsies that the neotissue has new nerve endings as evidence of the plasticity of the adipose tissue, which differs into a variety of different cell types. Based on the final results, the skin is soft with good recovery of sensitivity.

In our opinion, adipose tissue not only allows greater protection of the mechanical of the pedicle but also improves venous drainage through the vascular network present in the adipose tissue, thus helping to prevent typical venous vascular congestion of flaps with inverted flow. This type of drainage is so efficient that the entire flap can be maintained without large venous vessels. According to the literature[20,24,34,35], complications increase with flap size, especially venous congestion, and skin necrosis of the posterior leg. This reason and the risk of pedicle compression mean that some surgeons do not tunnel the graft[11]. Finally, larger flaps require large free skin grafts to cover the donor area. There is minimal comorbidity at the donor site, with a relationship to the size of the flap, such as minimal depressive deformity in the early postoperative period.

Limitations

This is a retrospective study presenting a relatively homogeneous patient population for the chronic wound type, but heterogeneous for the initial noxae. The study lacks a control case, which, however, is difficult to apply in clinical surgical practice in this type of patient in which the best reconstructive choice related to our experience has been proposed for specific local

and/or general conditions. In this specific case, the use of alternative reconstructive techniques such as microsurgical free flaps would have led to over-treatment or, in the case of grafts, to undertreatment.

Conclusions

The neuroadipofascial sural flap is a versatile, fast, and easy to perform flap to cover a chronic defect in the distal part of the lower limb, including both the malleoli and the heel, thanks to its long vascular pedicle. It has a low rate of complications of which the most frequent is venous congestion and compression of the pedicle for subcutaneous tunneling. In our opinion, it can be very useful to include adipose tissue, in particular the suprafascial tissue in the lower third of the pedicle, in order to keep intact all the mesenteric structures around the medial sural cutaneous nerve and its accompanying vessels and to prevent venous congestion, improving the reliability of the flap. The sural flap can be a valid alternative to microsurgical flaps for loss of substance in the lower third of the leg, malleolus and heel and allows to cover more distal and larger wounds than propeller flaps. The sural flap remains a workhorse of reconstructive surgery and a valuable tool in the toolbox for a reconstructive surgeon.

Conflict of Interest
The Authors declare that they have no conflict of interests.

Acknowledgements
None.

Ethics Approval
All procedures performed in studies involving human participants were in accordance with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. All the study was based on hospital data obtained consulting clinical records, therefore, ethical disclosure was not necessary.

Informed Consent
For this type of retrospective study, informed consent is not required.

Funding
There is no funding for the study.

Authors' Contributions
All the authors have made substantial contributions to the conception and design of the study, data acquisition, or data analysis and interpretation, drafting of the article or critically revising it for important intellectual content, final approval of the version to be submitted.

ORCID ID
Alfio Luca Costa: 0000-0001-6118-4278; Vindigni Vincenzo: 0000-0001-6638-9010; Tiengo Cesare: 0000-0002-7493-563X; Tito Brambullo: 0000-0002-1041-9660; Filippo Andrea Giovanni Perozzo: 0000-0003-2496-2653; Galeano Maria Rosaria: 0000-0002-8553-7485; Colonna Michele: Rosario 0000-0001-5586-4066; Bassetto Franco: 0000-0003-4105-8252.

References

1) Yildirim S, Akan M, Akoz T. Soft-tissue reconstruction of the foot with distally based neurocutaneous flaps in diabetic patients. Ann Plast Surg 2002; 48: 258-264.
2) Ignatiadis IA, Georgakopoulos GD, Tsiampa VA, Polyzois VD, Arapoglou DK, Papalois AE. Distal posterior tibial artery perforator flaps for the management of calcaneal and Achilles tendon injuries in diabetic and non-diabetic patients. Diabet Foot Ankle 2011; 2: 7483.
3) Georgescu AV, Matei IR, Capota IM. The use of propeller perforator flaps for diabetic limb salvage: a retrospective review of 25 cases. Diabet Foot Ankle 2012; 3: 18978.
4) Akhtar S, Ahmad I, Khan AH, Khurram MF. Modalities of soft-tissue coverage in diabetic foot ulcers. Adv Skin Wound Care 2015; 28: 157-162.
5) 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: 1115-1121.
6) Haertsch PA. The blood supply to the skin of the leg: a post-mortem investigation. Br J Plast Surg 1981; 34: 470-477.
7) Yilmaz M, Karatas O, Barutcu A. The distally based superficial sural artery island flap: clinical experiences and modifications. Plast Reconstr Surg 1998; 102: 2358-2367.
8) Almeida MF, da Costa PR, Okawa RY. Reverse-flow island sural flap. Plast Reconstr Surg 2002; 109: 583-591.
9) Ayyappan T, Chadha A. Super sural neurofasciocutaneous flaps in acute traumatic heel reconstructions. Plast Reconstr Surg 2002; 109: 2307-2313.
10) Benito-Ruiz J, Yoon T, Guisantes-Pintos E, Monner J, Serra-Renom JM. Reconstruction of soft-tissue defects of the heel with local fasciocutaneous flaps. Ann Plast Surg 2004; 52: 380-384.

11) Chen SL, Chen TM, Chou TD, Chang SC, Wang HJ. Distally based sural fasciomusculocutaneous flap for chronic calcaneal osteomyelitis in diabetic patients. Ann Plast Surg 2005; 54: 44-48.

12) Jeng SF, Wei FC. Distally based sural island flap for foot and ankle reconstruction. Plast Reconstr Surg 1997; 99: 744-750.

13) Coert JH, Dellon AL. Clinical implications of the surgical anatomy of the sural nerve. Plast Reconstr Surg 1994; 94: 850-855.

14) Tan O, Atik B, Bekerecioglu M. Supercharged reverse-flow sural flap: a new modification increasing the reliability of the flap. Microsurgery 2005; 25: 36-43.

15) Tan O, Aydin OE, Demir R, Barin EZ, Cinal H, Algan S. Neurotized sural flap: An alternative in sensory reconstruction of the foot and ankle defects. Microsurgery 2015; 35: 183-189.

16) Demiri E, Tsimponis A, Pavlidis L, Spyropoulou GA, Foroglou P, Dionyssiou D. Reverse neurocutaneous vs propeller perforator flaps in diabetic foot reconstruction. Injury 2020; 51: S16-S21.

17) Oberlin C, Azoulay B, Bhatia A. The posterolateral malleolar flap of the ankle: a distally based sural neurocutaneous flap--report of 14 cases. Plast Reconstr Surg 1995; 96: 400-405.

18) Baumeister SP, Spierer R, Erdmann D, Sweis R, Levin LS, Germann GK. A realistic complication analysis of 70 sural artery flaps in a multimorbid patient group. Plast Reconstr Surg 2003; 112: 129-140.

19) 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: 1673-1679.

20) 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.

21) Costa-Ferreira A, Reis J, Amarante J. Reconstruction of soft-tissue defects of the heel with local fasciocutaneous flaps. Ann Plast Surg 2005; 54: 580-581.

22) Erdmann D, Gottlieb N, Humphrey JS, Le TC, Bruno W, Levin LS. Sural flap delay procedure: a preliminary report. Ann Plast Surg 2005; 54: 562-565.

23) Ríos-Luna A, Villanueva-Martínez M, Fahandezh-Saddi H, Villanueva-Lopez F, del Cerro-Gutiérrez M. Versatility of the sural fasciocutaneous flap in coverage defects of the lower limb. Injury 2007; 38: 824-831.

24) Price MF, Capizzi PJ, Watterson PA, Lettieri S. Reverse sural artery flap: caveats for success. Ann Plast Surg 2002; 48: 496-504.

25) Acikel C, Celikoz B, Yuksel F, Ergun O. Various applications of the medial plantar flap to cover the defects of the plantar foot, posterior heel, and ankle. Ann Plast Surg 2003; 50: 498-503.

26) Fraccalvieri M, Verna G, Dolcet M, Fava R, Rivarossa A, Robotti E, Bruschi S. The distally based superficial sural flap: our experience in reconstructing the lower leg and foot. Ann Plast Surg 2000; 45: 132-139.

27) Rajacic N, Darweesh M, Jayakrishnan K, Gang RK, Jojic S. The distally based superficial sural flap for reconstruction of the lower leg and foot. Br J Plast Surg 1996; 49: 383-389.

28) Akhtar S, Hameed A. Versatility of the sural fasciocutaneous flap in the coverage of lower third leg and hind foot defects. J Plast Reconstr Aesthetic Surg JPRAS 2006; 59: 839-845.

29) Gill NA, Hameed A. The sural compendium: reconstruction of complex soft-tissue defects of leg and foot by utilizing the posterior calf tissue. Ann Plast Surg 2012; 69: 203-208.

30) de Blacam C, Colakoglu S, Ogunleye AA, Nguyen JT, Ibrahim AM, Lin SJ, Kim PS, Lee BT. Risk factors associated with complications in lower-extremity reconstruction with the distally based sural flap: a systematic review and pooled analysis. J Plast Reconstr Aesthetic Surg JPRAS 2014; 67: 607-616.

31) Tsai J, Liao HT, Wang PF, Chen CT, Lin CH. Increasing the success of reverse sural flap from proximal part of posterior calf for traumatic foot and ankle reconstruction: patient selection and surgical refinement. Microsurgery 2013; 33: 342-349.

32) Delia G, Battaglia F, Colonna MR, Barresi V, d'Alcontres FS. Is the adipofascial flap the key to regenerative surgery?. JPRAS Open 2021; 30: 174-175.

33) Pu LL, Yoshimura K, Coleman SR. Fat Grafting: Current Concept, Clinical Application, and Regenerative Potential, Part 2. Preface. Clin Plast Surg 2015; 42: xiii-xiv.

34) 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.

35) Xing J, Fu YH, Song Z, Wang Q, Ma T, Li M, Zhuang Y, Li Z, Zhu YJ, Tang W, Wang SG, Yang N, Wang PF, Zhang K. Predictive model for deep venous thrombosis caused by closed lower limb fracture after thromboprophylactic treatment. Eur Rev Med Pharmacol Sci 2022; 26: 8508-8522.