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Original Paper

The Distally Based Superficial Sural Artery Angiosome Flap Concept: Anatomy, Indications, Surgical Technique, Results, Complications and Technical Aspects to Minimize Complications

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REZUMAT

Conceptul lamboului pediculat distal bazat pe angiozomul arterei surale superficiale: anatomie, indicații, tehnica chirurgicală, rezultate, complicații și aspecte tehnice pentru minimizarea complicațiilor

Introducere: În ultimele două decenii, lamboul neurocutanat pediculat distal a devenit cel mai utilizat lambou neurocutanat al gambei. Atunci când expertiza microchirurgicală nu este disponibilă sau posibilă, lamboul sural a devenit un mijloc principal de reconstrucție la nivelul distal al gambei, gleznei și piciorului.

Material și metodă: Seriile mari de cazuri publicate în literatura de specialitate, inovațiile, modificarea tehnicii chirurgicale precum și identificarea factorilor de risc au fost urmate de creșterea în popularitate a acestui lambou. Au fost analizate și prezentate rezultatele a 64 de publicații pe această tema din literatura internațională. Anatomia relevantă prezentată în studiile anatomice este analizată pentru înțelegerea circulației și compoziției tisulare a lamboului sural. Tehnica chirurgicală standard precum și modificările ulterioare sunt subliniate, astfel încât indicațiile chirurgicale să fie judicios făcute și complicațiile reduse. Cazuri clinice din experiența proprie a autorului sunt prezentate.

Concluzii: Lamboul neurocutanat sural pediculat distal oferă o tehnică sigură și versatilă, alternativă trans-

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ferului liber de țesuturi, pentru acoperirea defectelor complexe de la nivelul gambei, gleznei și piciorului, aplicabilă atât pacienților sănătoși cât și celor cu probleme vasculare.

Cuvinte cheie: angiozom; lambou pediculat distal; lambou fasciocutanat; lambou neurocutanat; lambou sural

ABSTRACT

Background: Over the past two decades, the distally based neurocutaneous sural flap has become the best known neurocutaneous flap of the leg. When microsurgical expertise is not available or feasible, the sural flap has become the mainstay of reconstruction for lower leg, ankle and foot defects.

Matherial and method: The large series of cases published in the medical literature, innovations, technique modifications along with risk factors identification has been followed by this flap rise in popularity. 64 publications on the sural flap subject, in the international literature, were summarized in this study. The relevant anatomy reviewed in anatomical studies is presented in order to understand the circulation and tissue composition of the sural flap. The surgical technique and its various modifications are highlighted, in order to make proper indications and minimize complications. Risk factor identification is presented in order to preclude unfitted patients from this flap. Several clinical cases from the senior author are ilustrated.

Conclusion: The distally based neurocutaneous sural flap offers a reliable and versatile technique, alternative to free flap transfer, for the treatment of complex lower limb defects in healthy or vascularly compromised patients.

Key words: angiosome; distally based flap; fasciocutaneous flap; neurocutaneous flap; sural flap

BACKGROUND

Located between the popliteal fossa and the midportion of the calf, centered over de midline raphe, between the medial and lateral heads of the gastrocnemius muscle, the sural flap is the best known neurocutaneous flap of the leg. [1,2]

The sural angiosome was first introduced in practice by Ponten in 1981, when he reported the use of 23 fasciocutaneous proximally based flaps for soft tissue defects.[3] Donski and Fogdestam described the anatomy of the distally based sural flap and presented three clinical cases in 1982. [4]

It took another 9 years for the sural distally based flap based on the sural nerve angiosome to be reintroduced by Masquelet, including the complete anatomical and surgical description. [5]

Nowadays the distally based sural flap (from now on referred to as sural flap) has become a mainstay in the reconstruction of the lower leg, ankle, heel and foot. [6]

Initial enthusiasm was tempered by higher complications rates, especially related to age and comorbidities. Risk factors for complications were well described. [7,8,9]

Several flap modifications regarding anatomical architecture and surgical technique were described in order to improve flap viability, defects requirement and to decrease complications and donor site morbidity [6, 10]. When microsurgical expertise is not available or possible, the sural flap is shown to be very utile. [6,8,10]

Surgical anatomy

The sural nerve originates from the lateral and medial sural cutaneous nerves, branches from the tibial nerve and common fibular nerve, respectively. The sural nerve is supplying the tegument of the distal third of the leg and the lateral aspect of the foot. The junction of the two nerves is usually located at the midcalf. Sometimes the two nerves do not unite and the sural nerve is most often the extension of the medial sural nerve. A constant anatomical landmark is the location of the sural nerve at about 1,5 cm bellow and parallel to the posterior marginof the lateral malleolus. [11,12]

Arterial supply comes from anterograde and retrograde sources. The anterograde supply comes from three fasciocutaneous arteries, namely median, lateral, and medial sural superficial arteries, defining the sural angiosome described by Taylor. [13]

These sources that originate from major arteries

around the knee may or may not be present in its totality, and often intermingle in a rich fascial network. The retrograde arterial supply comes from at least four sources: fasciocutaneous perforators from the peroneal artery and posterior tibial artery, venocutaneous perforators from the lesser saphenous vein and neurocutaneous perforators from the sural nerve. The lateral malleolus artery and the lateral calcaneal artery also provide some branches, quite useful especially in the presence of arteriopathy. [2]

For the distally based sural flap, the three to six septocutaneous perforators from the peroneal artery, located at approximately 5 cm proximal to the tip of the lateral malleolus, between the fibula and the peroneus longus tendon, provide the main supply. The more distal one is the perforator vessel that connects directly with the above-mentioned superficial arteries. The sural nerve and the lesser saphenous vein had an intrinsic blood supply and an extrinsic vascular plexus along their path. (**Fig. 1 a,b**) The fascial network is also connected to the solear and gastrocnemian muscles by means of musculocutaneous perforators. (**Fig. 1c**). Because perforators from the peroneal artery support the sural nerve flap, a preoperative vascular study may be beneficial in assessing patency of this vessel if vascular impairment is suspected. [14]

Venous drainage from the skin and fascia of the flap is provided primarily by the lesser saphenous vein, which drains into the popliteal vein. Classically the valvular system prevents a retrograde flow. The presence of small parallel veins has been described in a latex perfusion study, with anastomotic connections to the lesser saphenous vein, which allow blood to bypass the valves. [6] The final drainage is either back into the lesser saphenous vein or in other concomitant vein. [15] Although the spatial relationship between the sural nerve, lesser saphenous vein and the main median superficial sural artery is largely variable, a common pattern has been described. These spatial relationship helps in understanding the position of these vital structures relative to each other, important to flap planning and execution, accounting to the fact that the sural nerve pierces the fascia in a more distal location that the lesser saphenous vein. [12,13,16,17]

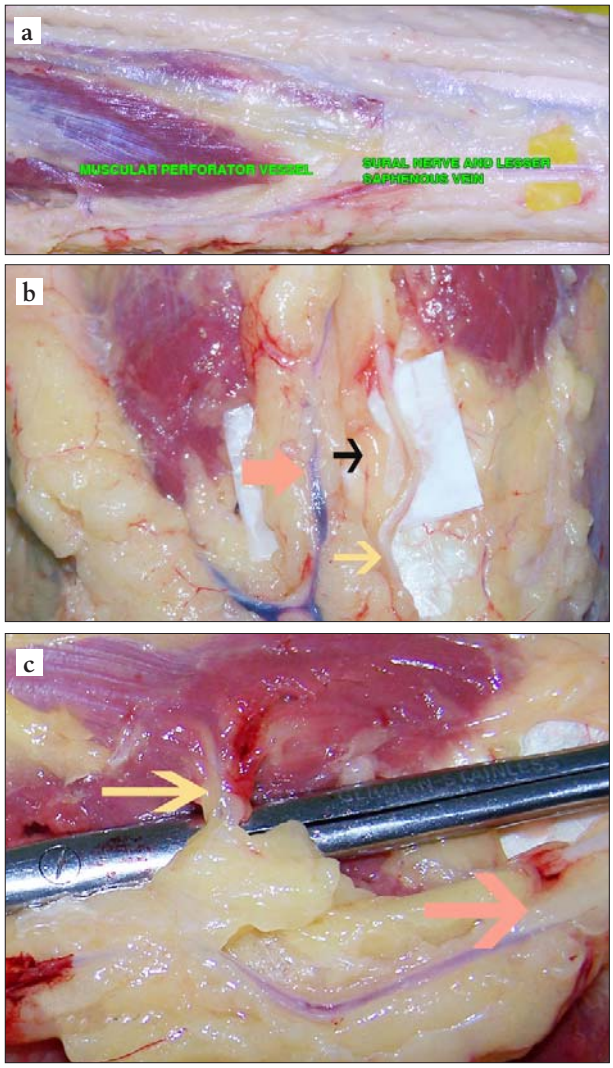

Figure 1. Anatomical details of the sural nerve, lesser saphenous vein, intrinsec and extrinsec sural nerve vascular supply and perforator vessels in a fresh cadaver dissection specimen (personal photographic archive). **(a)** - Sural nerve and lesser saphenous vein path, intrinsec and extrinsec blood supply of the sural nerve, muscular perforator vessels. **(b)** - Macroscopic view of the sural nerve and its intrinsec blood supply (yellow arrow), extrinsec blood supply (black arrow) and lesser saphenous vein (orange arrow). **(c)** - Macroscopic view of the sural nerve and lesser saphenous vein path (orange arrow) and muscular perforator vessel (yellow arrow).

SURGICAL TECHNIQUE

Surgical landmarks. The medial posterior line, the lateral malleolus and the path of the sural nerve and lesser saphenous vein are drawn. Most authors favour a pivot point located at no more than 5 cm from the lateral malleolus tip, but 2 cm and 10 cm distances have been reported. [6, 10,18,19,20] Identification of the perforator vessels may be used to identify the optimal pivot point, usually with Doppler ultrasonography. Subtraction angiography has been proposed in patients with arteriopathy. [21,22] The skin island is outlined approximately 10% larger than the defect. (**Fig. 2**) Positioning the flap on the leg depends on the pivot point. The most

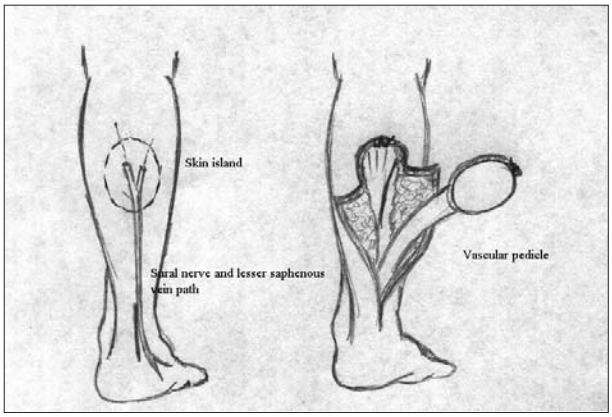

Figure 2. Diagrams showing how the flap is planned and raised. Left - sural nerve and lesser saphenous vein path, designed skin island skin island. Right - vascular pedicle.

common strategy is to keep the pivot point as distally as possible, allowing a shorter fascial pedicle. [23,24,25] Another option is to take the pivot point higher, keeping more perforators. The maximal surface of the flap is around 400 cm^2. [26]

Flap composition is strongly correlated to the defect configuration. More superficial defects accommodate well thinner flaps composed by skin and fascia or fascia and subcutaneous tissue. Muscle tissue can be added to the flap composition to provide bulk to the flap, based on the small perforating arteries between the fascial network and the gastrocnemius muscle. Muscle can be incorporated in the pedicle in order to preserve more vascular supply to the flap. [27,28]

Harvesting sequence. The pivot point is identified at approximately 5 cm proximal to the tip of the lateral malleolus and some 1-2 cm posterior. [10,18] Distances from 10 cm to 1,5 cm has been advocated as safe, depending on the age and general condition of the patient. [19,20] Doppler ultrasonography is currently used in perforator location, on which the pivot point is planned. [29,30] The skin island is centred on the mid-posterior line of the leg to match the recipient site defect, by 10% more. Maximum flap sizes of 12 to 23 cm in length and 8 to 16 cm in width have been reported. [18,24,26] Although two approaches exist depending on the pedicle's length and design, the senior author prefers the short pedicle strategy, keeping the pivot point at 5 cm from the lateral malleolus. [6] Under tourniquet control the flap's skin paddle is incised up to the level of the fascia. The proximal edge of the flap exposes the lesser saphenous vein, the median sural artery and the sural nerve. The sural nerve is transacted and the proximal stump is buried deep in the raphe between the two heads of the gastrocnemius muscle, in order to avoid painful neuromas. The lesser saphenous vein and the median sural artery are ligated individually. The fascia on the lateral edges of the flap is then incised and sutures between the fascia and the sub dermal plane are loosely inserted, to prevent accidentally shearing forces. The width of fascial pedicle preservation is a matter of personal preference, but the authors believe that as long as the medial superficial sural artery and the lesser saphenous vein are preserved the width of the pedicle can be as narrow as 2 cm. As the designed pivot point is approached, dissection proceeds with extreme caution in order to preserve as much of the encountered perforators as possible and meanwhile not to hinder flap rotation. Of course the technique can be modified according to the proposed structure of the flap to include muscle or only fat and fascia. Although it has been demonstrated that fascia does not carry significant vessels it is important to preserve the delicate extrinsic vasculature around it. [31] A muscle cuff around the pedicle has been reported to minimize venous congestion. [32] The skin between the donor site and the defect can be undermined or incised to accommodate the pedicle and facilitate flap inset. It cannot be issued as general rule, but if any minimal sign of venous congestions develops after flap inset with tunnelling, the skin bridge must be incised and the pedicle skin grafted. [33] Once the flap containing the skin island and the fascial pedicle with the corresponding vasculature, is raise it can be inset into the recipient defect. The remaining donor site defect is closed primarily when possible or skin grafted with a split-thickness skin graft. Cross leg sural flap has been reported. [34,35,36,37]

Flap delay modifications have been proposed especially in patients with co-morbidities, in order to decrease complications, especially flap necrosis. [38] One approach, favoured by the authors implies elevating the flap from the lateral and proximal edges and placing an interposing material, usually tulle gras, between the flap and the gastrocnemius muscles. Two to three weeks later the flap is fully mobilized and inserted into the defect. Another option is to fully mobilize the flap on its pedicle and suture it back into its donor site; the flap is transferred secondarily into its recipient site at a later time, usually three weeks. [39]

Flap modifications. The most commonly and

useful technique is the fasciocutaneous flap, because the majority of cases have superficial skin and soft tissue defects. Fascial-subcutaneous or pure fascial flaps have been described in cases with sufficient skin for closure but with need for gliding tissue coverage, such as in tendon exposure. [20] Taking advantage of the small perforating arteries from the superficial sural arteries to the gastrocnemius muscle, inclusion of a muscle fragment has been reported, useful for deep defects, especially after bone debridement for osteomyelitis. [40,41] Taking in account that venous congestion is the most likely cause of sural flap necrosis exteriorizing of the pedicle has been advocated. [42] This solution doesn't always solve the problems caused by valvular system that impedes retrograde blood flow from the flap, so Tan et al. described the "supercharching" technique. [43,44] Anastomosing the proximal end of the lesser saphenous vein to a vein in the recipient area, a physiologic flow of the blood is assured. An alternative, used by the authors, is to exteriorize the divided stump of the lesser saphenous vein and drain it intermittently with a temporary catheter. [45] Another alternative is to use leeches. [46]

Indications

The sural flap is one of the most versatile axial pattern fasciocutaneous flaps used in distal third of the leg, heel and foot up to the metatarsus defects coverage.[47] The distally based sural flap was imagined as a means of covering soft tissue defects of the lower leg, malleolus, heel and foot, regions where skin grafts are less likely to take. Easy to harvest, with a high degree of reproducibility, this flap, rotated on its very mobile pedicle, manages to envelope defects of different aetiologies without generating a major functional deficit at the donor site. [48] Exposed bones, tendons, vessels and internal fixation hardware can be covered. Defects of traumatic [23,49,50] (open fractures), chronic osteomyelitis [51], tumoral [52] or vascular origin [46] are the most frequent ones. There are two crucial aspects that must be taken in account: the size and the location of the defect. The size of the defect must not exceed the maximal dimensions of the flap. Flap delay can be used in large defects. Defect location can affect the ability of the flap to reach the defect, by means of fascial pedicle limitations. Although the utility of this flap is well documented, caution is advised in patients older than 40 years and pre-existing medical conditions, especially vascular ones. Shallow or deep defects can be accommodated by flap composition. Comparison with other neurocutaneous flaps has shown that the sural flap is more reliable than the lateral supramalleolar flap or both the saphenous flap and supramalleolar flap. [53,54]

Complications

The spectrum of complications stated in the literature, concerning the usage of the sural flap, is vast and depends on various factors such as age, comorbidities, smoking/non-smoking status of the patient and the surgeon's experience. Complications can be divided in major and minor ones. [9,54] Total flap loss or partial flap loss >20 cm^2 resulting in additional coverage procedure or amputation are major complications. Minor flap complications include marginal necrosis (tip or side), flap or donor site dehiscence or breakdown. [9] Infections (cellulitis or abscess), venous congestion, oedema, persistent osteomyelitis, ambulatory status, union or mal-union for fractures and need for secondary coverage procedures were recorded. [7,9]

According to Baumeister a rate of partial and complete flap necrosis of 36% can be expected, with 19 per cent with complete necrosis. Age over 40 years, general co-morbidities, diabetes mellitus, venous insufficiency and peripheral arterial disease were found as a significant risk factors. Especially the later three, alone or in combination, were showed a necrosis rate of 60%. Age greater than 40 has proven to be an important risk factor in developing flap complications, regardless of the patient's comorbidities. Patients expressing comorbidities other than diabetes mellitus, venous insufficiency and peripheral arterial disease presented a necrosis rate of 33%, while patients with one or more of the above showed a necrosis rate of 60%, leaving the healthy patients with a necrosis rate of 11%. [7] Parrett showed that smokers, obesity, diabetics and patients with peripheral arterial disease had a 33 percent major flap complication rate and a elevated minor complications rate. [9] Based on a multivariate logistic regression analysis the author's suggest to modify with a surgical flap delay, or to avoid the use of sural flap in this population. The same author showed that in both healthy and associating comorbidities patients the postoperative complication rate reached 50%.

In a personal author series, early or late major complications such as total, partial flap loss leading to amputation were encountered in 4 cases, or 11%,

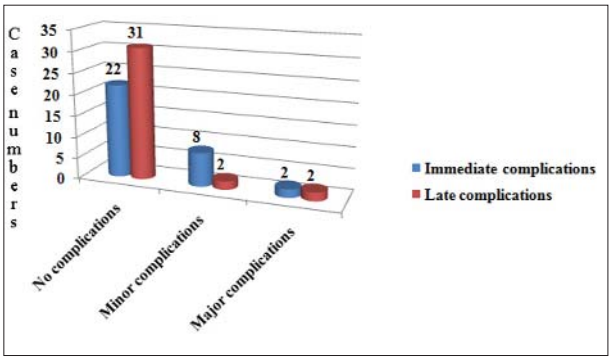

Figure 3. Chart demonstrating early and late, major and minor complication rates for patients with sural flap. [54]

belonging to patients presenting co-morbidities. There were also minor complications reported in 10 cases, or 26%, including marginal necrosis (2 flaps), flap breakdown/ulceration (1 flaps), cellulitis (3 flaps), osteomyelitis (2 flaps), malunion / nonunion (1 flap), neuroma (1 flap). The total complication rate was 37%, significantly larger in over 40 years and vascular pathology patients, over 50%. [54] (**Fig. 3**)

Controversially, a fourth retrospective study, conducted by Hasegawa [18] implying 20 patients, with a total of 21 distally based superficial sural artery flaps, including two fascial flaps, reports a 100% flap survival rate. Transitory venous congestion was noted in almost all the flaps and persistent oedema (2 months) was described in only one case, probably due to its considerable size (10x13cm). [18]

Levante et al., in a retrospective study of 27 cases, most of which were posttraumatic, reported a 70% flap survival rate. In 30% of the cases flap necrosis was observed, mainly partial, involving the skin island, especially with older age or associated comorbidities. One complete flap necrosis lead to mid-leg amputation. [55]

Almeida et al. reported in their retrospective study of 71 cases, both healthy or associating comorbidities, 15 cases of partial flap necrosis, 3 cases of total necrosis, 17 cases of venous congestion and 6 cases of postoperative infection. [56]

Clinical cases

Case 1. A 43-year-old man suffered from a motorcycle accident and distal leg open fracture type III with external fixation device in place, bone exposure and granulation tissue. The defect exposing the bone was debrided and a distally based sural fasciocutaneous flap, 10x12 cm., was used to cover the exposed fracture site. The donor site and the pedicle were skin grafted. At four weeks the flap is viable, the skin grafts integrated with no signs of drainage or infections. The patient is ambulatory after external device removal at 6 months. (**Fig. 4**)

Case 2. A 55-year-old man was admitted to our hospital because of left leg osteomyelitis and draining sinus in the calcaneal bone after a poorly healed fracture 2 years previously. He underwent several orthopedic surgical procedures (bone and sinus debridement) and was on long-term antibiotic therapy according to the cultures. The situation worsened in the last months, when he was injured again in the same leg and a continuous discharge through the skin brought him to seek a surgical solution. Examination revealed a draining sinus on the lateral aspect of the heeel. The patient underwent aggressive bone debridement and wound coverage with a distally based sural musculocutaneous flap. The gastrocnemius muscle cuff is included in the flap. The donor area was closed primarily partially and skin grafted in the rest. Partial muscular necrosis was encountered and the deep part of the wound was debrided two times. Twelve months after surgery, he had no draining sinus. (**Fig. 5**)

Case 3. A 59-year-old woman suffered from a fracture of the distal third of the tibia and fibula after a road accident. The patient also had fracture of the frontal bone and frontal complex wounds, with no neurologic deficit. The open tibial fracture was heavily contaminated. She underwent external

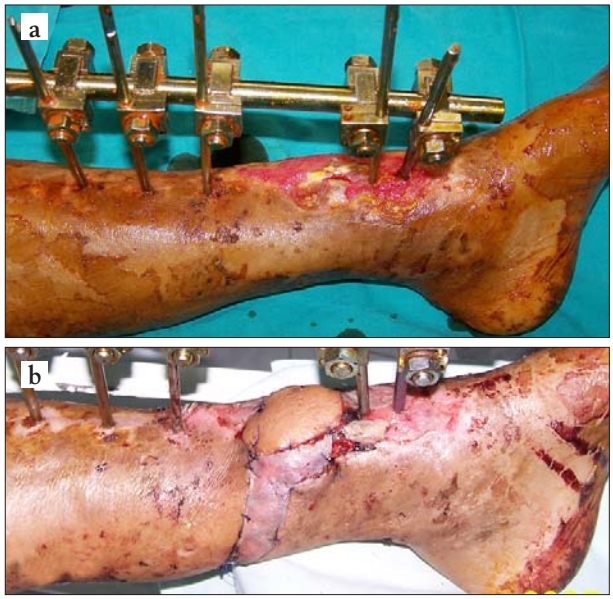

Figure 4. Distal calf defect with exposed frature site and external fixation device - **(a)**. Defect closed with sural flap at 3 weeks - **(b)**

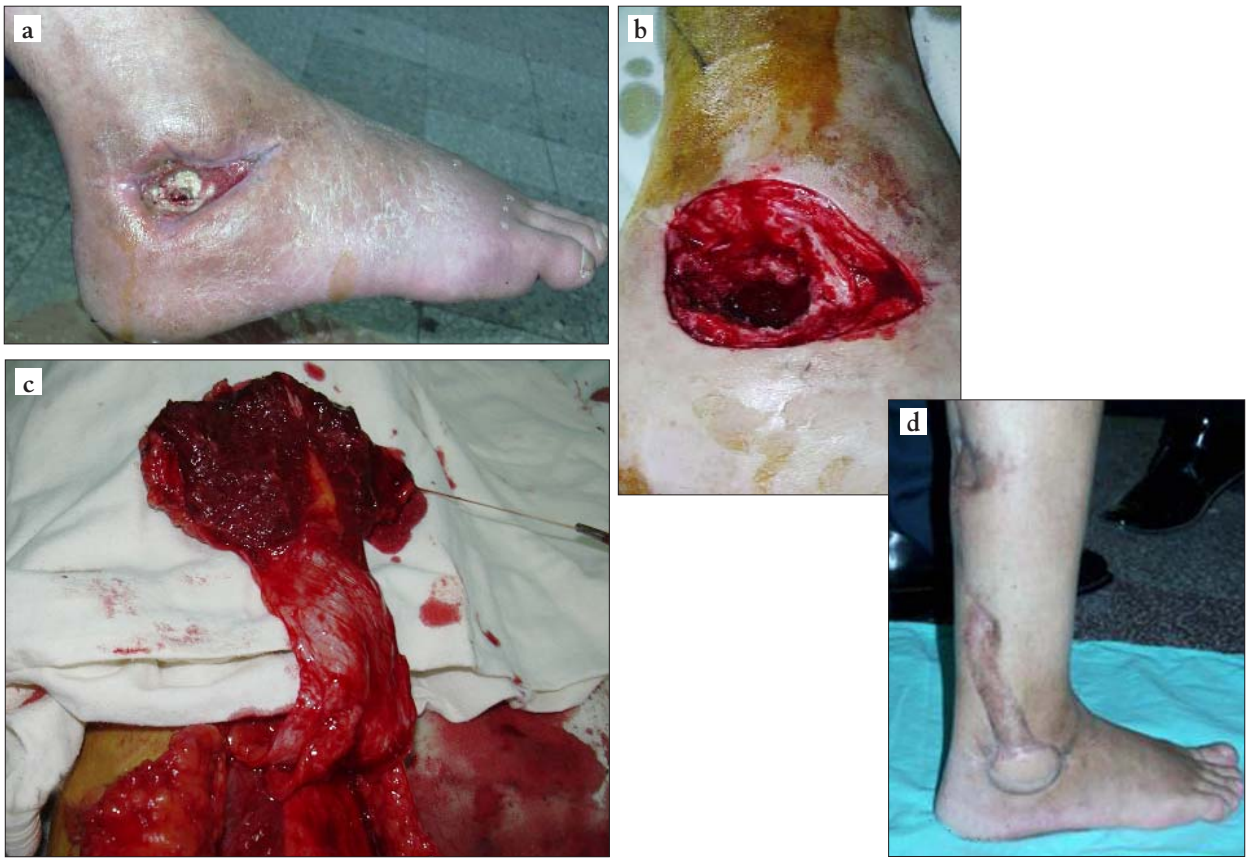

Figure 5. Drainage sinus over the lateral malleolus and calcaneus bone **(a)**. Defect after debridement - **(b)**. Sural musculo-neurocutaneous flap raised - **(c)** - and used for defect coverage, at 1 year - **(d)**.

fixation with an Ilizarov device and several wound debridements. At the time of reconstruction, she had a 12 x 14 cm open wound. With the Ilizarov device in place, the sural neurocutaneous flap was harvested and tunnelized under the skin to cover the skin defect and to obliterate the area after debridement of the exposed bone. A skin graft was used to cover the skin defect in the distal aspect of the wound and to close the donor area. (**Fig. 6**)

Case 4. A 63-year-old man was admitted to our hospital with a chronic ulceration of the heel, histologically proven squamous cell carcinoma, excised and skin grafted elsewhere. The relapsed tumor whas excised with 1 cm. macroscopic margins, calcaneal bone included. A 10 x 12 cm neuromusculocutaneous sural flap was planned and executed to cover the defect. The donor area and the pedicle were skin grafted. The flap healed with no complications, with normal ambulation. Radiotherapy was innitiated by the oncologist. With initial uneventfull evolution the tumor relapsed after 18 months and leg amputation was performed. (**Fig. 7**)

DISCUSSION

A large number of pedicled fasciocutaneous or muscular flaps are available for lower limb reconstruction. The workhorse for leg and ankle coverage was represented for many years by microsurgical free flaps. [6] The main alternatives to sural flaps are free flaps, lateral supramaleolar flaps and posterior tibial artery perforator flaps. Free flaps reconstruction is still indicated in large defects, despite the fact that they require lengthy operations, micro vascular expertise and instruments. There is a potential, trough low, for flap failure and donor site morbidity. The lateral supramalleolar flap offers the same length of coverage but with a more difficult dissection, a smaller flap area and a larger non-sensitive area. [54] Failure is almost four folds greater for this flap. The posterior tibial artery perforator flap is a reliable flap, indicated especially in reconstruction of the chronic Achilles tendon defects, but requires a more prolonged learning curve and technical demanding dissection.

Figure 6. Open fracture grade IIIb with bone exposure and external fixation device - **(a)**. Sural flap raised and mobilized to reach the defect - **(b,c)**. Postoperative results at two weeks - **(d)** and two months - **(e)**.

The sural flap is a very useful and multi purpose reconstructive option for skin and soft tissues defects of the lower leg, ankle and foot. The sural flap has become increasingly popular for distal leg reconstruction, with most series in the literature reporting good results, on young and healthy patients with traumatic wounds. Correctly executed in the appropriate patient, the sural flap offers a high rate of success. Nevertheless the literature and the senior author personal experience show that necrosis and major complications are not uncommon. [7,9,18,54,56]

Adherence to the standard surface of the flap and to the classical pivot point located 5 cm above the lateral malleolus may prevent catastrophic complications. Very large flaps and distally modified pivot point should be avoided especially in vascular compromised patients. Perforator location and per-

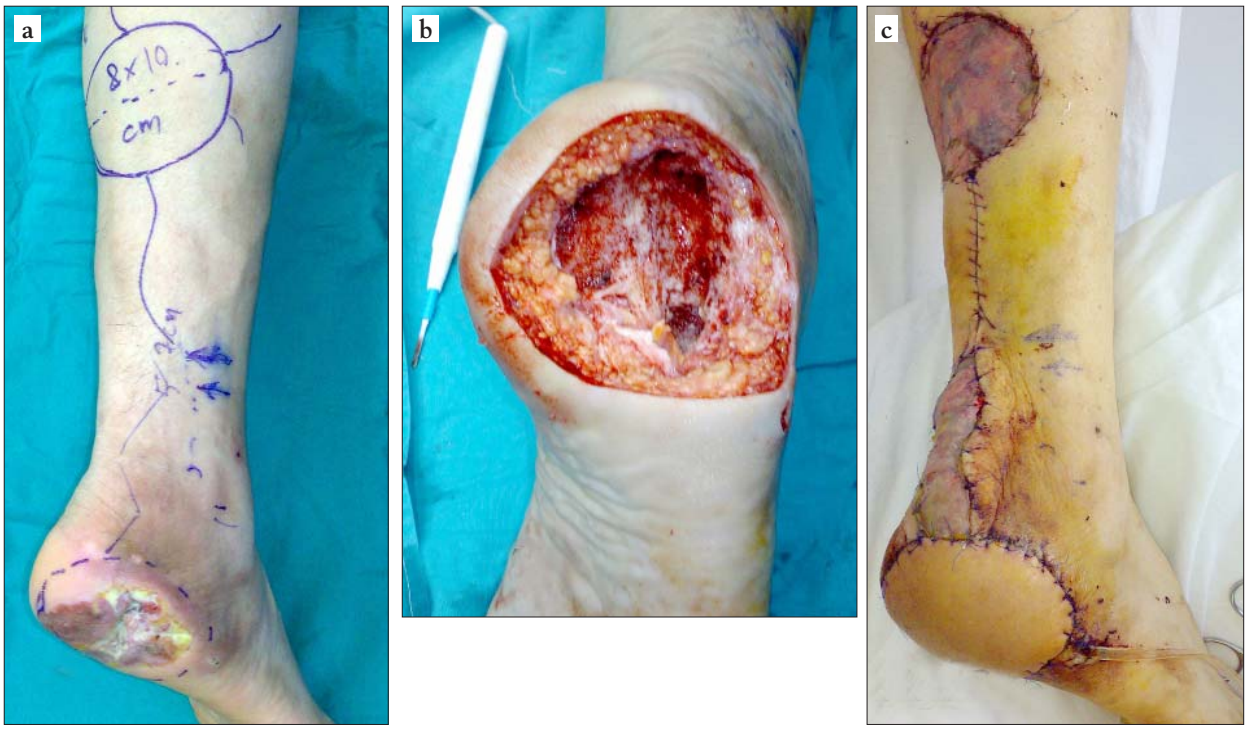

Figure 7. Proposed oncological excision and sural flap planned - **(a)**. Postexcizional calcaneal bone defect - **(b)**. Early postoperative result after sural flap used for coverage - **(c)**.

meability and lesser saphenous vein blood flow can be verified by Doppler ultrasound examination. In peripheral artery disease, diabetes and other vascular patients, subtraction arteriography can be used for proper patient selection. Extremely distally located perforators or alternative sources of vascularization should be approached cautiously as significant complications may arise. Smoking, diabetes, advanced age, obesity, and peripheral arterial disease are risk factors for sural flap complications. Identification of risk factors leads to a better planning of the flap or delay procedure in the presence of a vascular risk factor and to a more realistic prognosis for these patients. [6,7,9]

The size, the pivot point and the anatomical composition of the sural flap should be dictated by the location and geometric characteristics of the defect. Very large, distally located defects, accompanied by existing risk factors, may benefit from flap delay or venous supercharching procedures, in order to acceptably minimize complications. Whenever possible or in doubt the skin bridge between the donor area and the defect should be divided and the pedicle skin grafted. A sound alternative is to keep a narrow skin bridge of 2 cm over the pedicle or to include a muscular cuff around it. During the dissection attention must be paid for preserving the mesentery structure of sural nerve and concomitant artery. Sutures should be loosely positioned in order to avoid unnecessary pressure on the skin. With sural nerve exclusion, the arc of rotation may be estimated from the sural nerve crossing level of the deep fascia. [57,58] The neurotised sural flap is a versatile modification, for the sensory reconstruction of the moderate size foot and ankle defects. [59]

Donor site morbidities include the use of skin graft for donor site closure and sacrifice of the sural nerve. Defects after up to 6 cm flap width can be closed directly, but the donor area morbidity increases in relation to the size of the flap dissected to cover the defect created with a large free skin graft. [60]

Postoperative management of the patient must respect proper positioning, with limb elevation. The dressing should avoid any pressure on the flap or the pedicle. When venous congestion is observed, intermittent venous drainage, with a temporary catheter or leeches can provide definitive relief. Antibiotics should be offered prophylactic preoperative or according to the defect aetiology. In lower extremity trauma or prolonged immobilization deep vein thrombosis prophylaxis should be initiated. [6]

Various osteosynthesis and other reconstructive options techniques can be combined with this flap (external fixation, Ilizarov devices, skin grafts, fasciocutaneous flaps, muscle flaps, cross-leg flaps). [61,62] In very large flaps the delay phenomenon can be used. [63] The sural flap is still indicated in arteritic patients due to the high resistance of the peroneal artery to the arteriopathy and the development of alternative vascular sources. [2] The sural flap offers certain advantages above other options: simplicity in design and execution, preservation of the main vascularization arteries of the limb, one single operation averaging one and a half hour. [64]

CONCLUSIONS

The sural flap should be a part of the reconstructive surgeon's armamentarium. It offers a reliable and versatile technique, alternative to microsurgical free flap transfer, for the treatment of complex lower limb defects in healthy or vascular compromised patients. Because it has been found that the number of patients with chronic disease is currently increasing, the distally based sural artery fasciocutaneous flap is a good alternative to free tissue transfer to consider for reconstruction of the lower leg and foot. The pivot point should be kept at least at 5 cm above the peroneal malleolus, somewhat higher when risk factors are identified. The pedicle should be kept as short and as wide as necessary to mobilize the flap. Despite the considerable incidence of complications, especially when risk factors are identified, the eventual success rate with respect to definitive defect closure is good. Surgical refinements are available to overcome venous congestion and to meet the individual reconstructive needs of each patient. In many cases the sural flap stands as the last alternative to amputation.

Acknowledgments

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