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Distally Based Sural Artery Flap: Simple Measures to Increase Versatility and Reduce Complications

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ABSTRACT

Introduction: One of the major challenging problems, facing the reconstructive surgeons is how to cover soft tissue defects with exposed bones and tendons in the lower third of the leg, ankle, heel, and foot. Numerous solutions have been proposed in last few years including local, distant, and free flaps.

Goal: To evaluate and prove that the distally based sural artery flap is a very versatile flap to be used in coverage and reconstruction of such defects of the lower leg, heel and foot.

Patients and Methods: Thirty three patients were operated in this series with some added and confirmed tips in the flap harvesting technique.

Outcome and Conclusion: Flap survival and success was 87.8% in this series with reasonable low incidence of complications. So, distally based sural artery flap is recommended for coverage of skin and soft tissue defects of the lower leg, heel and foot.

INTRODUCTION

Complex soft tissue defects around the ankle and foot represent a difficult reconstructive problem due to exposure of the bones, joints and tendons. Several reconstructive procedures have been proposed to repair soft tissue defects in these regions, including local cutaneous flaps, pedicled fascial, fascio-cutaneous and muscle flaps **[1]**.

Local flaps in the foot have limitations of reach and reduced amount of soft tissue that can be transported with the added cost of unacceptable donor site morbidity **[2]**.

Micro-vascular tissue transfer provides a large amount of soft tissue at the most desired places and is quiet reliable in experienced hands. But, non-availability of microsurgical expertise and facility at peripheral centers, the cost and, sometimes, patient-related factors may preclude the option of free tissue transfer. So, better understanding of regional flap designs and their applications have sometimes provided easier and more cost-effective alternatives for soft tissue coverage of the injured lower extremity **[3]**.

In 1981, Ponten introduced the concept of a local neuro-veno-cutaneous flap for coverage of lower limb defects. As an extension of this concept, Masquelet et al, described skin island flaps supplied by the vascular axis of superficial sensory nerves. This eventually evolved into the distally based sural artery flap **[4,5]**.

Today, this flap is increasingly accepted as an alternative to free flaps for defects of the distal third of the leg and ankle areas. Questions regarding its reliability remain, however, with reported flap failure rate ranging from 0 to 36%. This, in part, can be attributed to variations in surgical technique of flap harvesting **[6-14]**.

The inclusion of the sural nerve and the short saphenous vein along the entire length of the flap is crucial to maximize the reliability of this flap.

Actually, there is no proper replacement for this flap as wounds around the ankle and heel are difficult to treat by any other flap. A study conducted by Baumeister, 2003 **[15]** reported a very high complication rate for this flap. In this work, some technical tips are presented, supported with the results of utilizing this versatile flap for coverage of different defects of the lower third of the leg.

PATIENTS AND METHODS

This study was carried out at the Plastic and Reconstructive Surgery Unit, Zagazig University Hospitals over a period of 2 years from July 2013 to June 2014. It included 33 patients having skin and soft tissue defects of lower third of the leg,

heel and dorsum of the foot. Patients with scarring or wounds on the posterior calf or the pedicle site were excluded from the study. Table (1) shows demographic data of patients included in this work. An informed consent was obtained from the patient or his/her father and the study was approved by the IRB (Institutional Review Board) of the Faculty of Medicine, Zagazig University.

Table (1): Demographic data

Item	No.	%
Age range:		
<15 years	5	15.2
16-40 years	24	72.7
>40 years	4	12.1
Sex:		
♂	26	78.8
♀	7	21.2
Cause of trauma:		
Recent trauma	21	63.6
Old trauma	7	21.2
Old burn	5	15.2
Co-morbid conditions:		
Hypertension	3	9.1
Diabetes mellitus	6	18.2

Site and size of the defect, flap dimensions and pivoting point distance from the lateral malleolus were all plotted in Table (2).

Table (2): Wound-related information

Item	Description	No.	%
Site of defect	Lower third of the leg	15	45.5
	Dorsum of the foot	11	33.3
	Heel	7	21.2
Size of defect	Moderate defects (<7x11cm)	21	63.6
	Large defects (>7x11cm)	12	36.4
Exposed structures	Lower tibia	15	45.5
	Ankle joint	6	18.2
	Tendons around the ankle	5	15.1
	Heel	7	21.2
Pivoting point (Distance from lat malleolus)	4-6cm from LM	14	42.4
	6-8cm from LM	19	57.6

Technique:

Under general or spinal anesthesia flap dissection and elevation was done according to the classical original technique. The following steps were adopted in this study to ensure flap survival and reduce incidence of complications;

1- Preoperatively, exact determination of the most distal perforator of the peroneal artery, which is the flap pivot point of the flap, was done with the help of Dupplex machine. Also, skin marking of the course of the sural vessels accompanying the sural nerve in the leg was done.

2- The flap was usually designed about 1cm larger than the defect to allow for postoperative swelling.The reach of the flap is also given an additional 2cm for this purpose (Figs. 1-3).

3- To increase flap dimensions with safe blood supply;

- Loose fibro-areolar tissue which existed between the two heads of the gastrocnemius was included to attain an extra-length for the flap.
- For flaps more than 12cm in transverse axis, the pedicle was kept more than 5cm in its transverse axis and the pivot point to be 7-8cm proximal to the lateral malleolus. This was to preserve all cutaneous perforators in this area (Fig. 4).

4- Because this flap is famous for venous congestion (Fig. 2), we tried to reduce the occurrence of this complication by;

- Leg elevation was done routinely in this study to improve venous return from the flap.
- Saving the short saphenous vein distally and incorporating it into the pedicle. This improves the venous return of the flap and maximizes its safety and reliability.
- Proximal tracing of the short saphenous vein for one to two centimeters keeping it marked and ready for either hourly phlebotomy (done in two cases) or making micro-anastomosis to a nearby vein to improve venous drainage of the flap (done in three cases).
- Routine postoperative prophylactic anticoagulant in the form of low molecular weight heparin was administered during the period of immobilization (for 5 days).

5- The flap was transposed through an open incision (Fig. 4) instead of being tunneled to reach the recipient site. This open incision was covered by Split-Thickness Skin Graft (STSG).

RESULTS

Total flap survival occurred in most cases of this study (29 out of 33) with 87.8% success rate. Total operative time needed and number of operative sessions and total post-operative complications rate, all are plotted in Table (3). Most of patients needed a second step surgery that was flap separation, flap debulking and STSG. Those who were operated in a single session, their operative times were less than two hours (8 cases/24.2%).

Out of the 33 harvested flaps, marginal flap necrosis (less than 2cm from the edge) occurred in 4 cases only (12.2%). These areas of marginal flap necrosis were managed conservatively by bedside debridement and repeated daily dressing till healing occurred by second intention. Early flap congestion was noticed in 5 cases. Two cases were managed by hourly phlebotomy and the remaining three cases were saved by doing micro-anastomosis of the proximal end of the short saphenous vein to one of the dorsal veins of the foot. All five flaps were saved without complications.

Wound infection and dehiscence occurred in 2 patients (6.1%). One of them was diabetic and the other was a smoker. They were successfully treated by stitch removal, repeated dressing and proper antibiotic therapy (according to Culture and Sensitivity).

Regarding donor-site morbidity, there were no problems in healing of both STSG and its donor site in the thigh apart from three cases (9.1). There was partial graft loss over the back of the leg. Re-grafting was needed in only one case while the other two healed conservatively. Regarding donor site aesthetic look, only 10 patients reported their concern about its look (seven cases were females and three were males). Sensory loss over the lateral aspect of the foot was troubling to only three cases but this improved over time (6 months of surgery).

Table (3): Surgery-related information

Item	No.	%
Total operating time:		
Less than 120min.	8	24.2
120-180min.	12	36.4
>180min.	13	39.4
No. of operative sessions:		
One session	8	24.2
Two sessions	15	45.5
Three sessions	10	30.3
Post-operative complications:		
Marginal flap necrosis	4	12.1
Flap congestion	5	15.2
Wound infection	2	6.1
Donor site morbidity	3	9.1
Poor aesthetic look	10	30.3
Sensory loss troubles	3	9.1

Fig. (1-A): Skin and SC tissue defect of the heel.

Fig. (1-B): Skin marking and flap design.

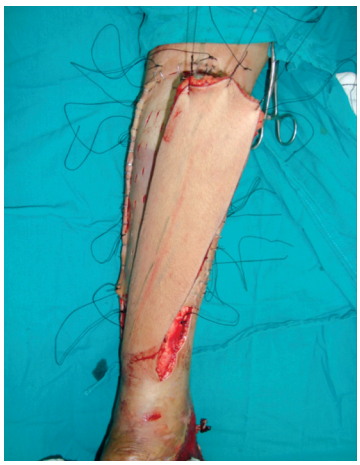

Fig. (1-C): Flap harvested.

Fig. (1-D): Flap inset and graft applied.

Fig. (1-E): Early postoperative, before pedicle separation.

Fig. (1-F): Late, 3 months postoperatively, after pedicle separation.

Fig. (2-A): Posttraumatic scar over lt ankle with distal tethering of Ext. hallucis longus.

Fig. (2-B): Flap harvested and graft applied.

Fig. (2-C): Flap after insetting with distal marginal flap congestion and necrosis

Fig. (2-D): Final late PO view.

Fig. (3-A): Post-burn Scar over the Lt ankle.

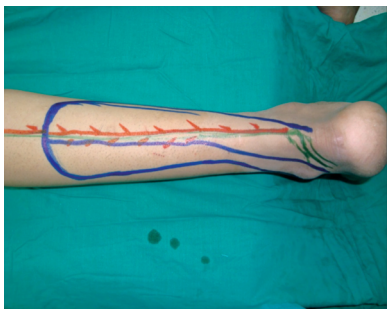

Fig. (3-B): Skin marking and flap design.

Fig. (3-C): Flap harvested.

Fig. (3-D): Flap inset with the de-epithelised ready for tunneling.

Fig. (3-E): Early postoperative result.

Fig. (3-F): Late postoperative result.

Fig. (4-A): Dorsal foot defect with exposed bones.

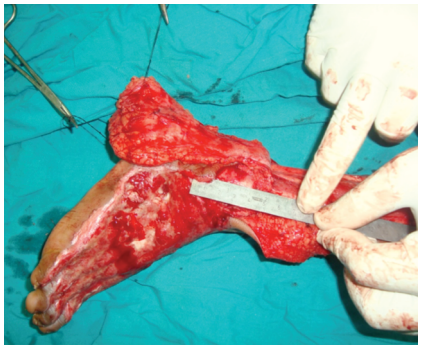

Fig. (4-B): Flap harvested and pivoting point measured about 5cm from the lateral malleolus.

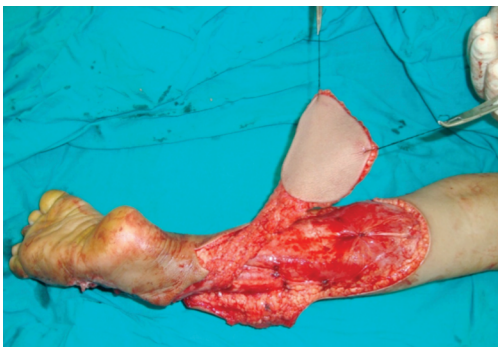

Fig. (4-C): Flap harvested.

Fig. (4-D): Flap inset without tunneling.

Fig. (4-E): Final early PO result.

DISCUSSION

One of the major challenging problems, facing the reconstructive surgeon is how to cover soft tissue defects having exposed bones and tendons in the lower third of the leg, ankle, heel, and foot **[16]**. Numerous solutions have been proposed in last few years. Local, distant, and free flaps, each one have its advantages and disadvantages. The distally based sural neuro-fascio-cutaneous flap is one of local flaps that were used for coverage of such defects. The reported reliability of this flap varied between 64 and 100% **[17]**. This wide variation in outcome was related primarily to the difference in techniques used by different authors to harvest this flap.

In this study, we believed that skin marking was fundamental in the preoperative phase because pre-established landmarks, based on previous anatomical studies, are out of date. Bocchi et al., **[18]** stated that the constant use of a Doppler probe during the preliminary evaluation provides more safety to the surgical procedure and increases the success rate of the sural artery flap. In this work, Doppler was used to determine the pivoting point of the flap and skin marking of the course of the sural nerve accompanying vessels in the lower leg. In 1994, Hasegawa et al., **[11]** affirmed that the pivot point of the flap must be at least 5 cm above the tip of the lateral malleolus, but, as demonstrated by Zhang et al., **[19]** in 2005, the vascular pivot point of the distally based sural flap can be safely designed even 1.5cm proximal to the lateral malleolus. In this study, the pivoting point of the flap was variable between different age groups. In children and young females (14 cases, 42.4%), it was found to be 4-6cm proximal to the lateral malleolus while in adult males (19 cases, 57.6%) it was 6-8cm. So, we agree with Yeng and Wei, 1997 **[20]** who mentioned that preoperative Doppler examination to identify perforators and their distance from the lateral malleolus is crucial to detect the variable vascular anatomy in this area and reduce failure rate.

Some authors raised the flap without inclusion of the sural nerve with the aim to reduce donor morbidity by preserving lateral foot sensation. Although success is reported with this technique, it is generally accepted today that the inclusion of the sural nerve is crucial for maximizing flap reliability. Harvesting the flap in the conventional manner in the sub-fascial plane, the medial sural nerve would be cut once it pierces the deep fascia at approximately the midpoint of the posterior leg **[21]**.

Harvesting the sural nerve with the surrounding adipo-fascial tissue attaching the nerve to the deep

fascia preserves the neuro-cutaneous contribution to the tip of the flap that increases the blood supply to the flap. Most authors included the sural nerve in their flaps. Only the suprafascial part is harvested within the flap, leaving the flap entirely dependent on the short saphenous vein and its accompanying vasavasorum in the distal part of the flap **[22]**. Al-Qattan had demonstrated favorable results with the inclusion of a cuff of midline gastrocnemius muscle within the tip of the flap **[22-23]**. This maneuver incorporates the medial sural nerve and its vasa-nervorum within the flap, giving an additional supply to the tip of the flap. Inclusion of portion of the gastrocnemius adds bulkiness to the tip of the flap and increases donor morbidity. In this work, routine inclusion of a cuff of gastrocnemius muscle was found to be unnecessary, and by dissecting in the groove between the medial and lateral heads of the gastrocnemius, one can reliably locate and include the medial sural nerve within the flap. This has the same benefit as including a cuff of muscle with less donor morbidity. Also, this reduces bulkiness of the tip of the flap and facilitates flap in-setting.

When this flap was compared to another local flap, namely the lateral supra-malleolar flap, the reversed sural flap was found easier to execute, having a highly reliable angiosome, its pedicle is less liable to anatomical variation with the added advantage of having a relatively wide skin territory **[24-29]**. Arnez, 2003 **[30]** reported that this flap is suitable for small and medium sized skin and soft tissue defects in the distal one third of the leg, over malleoli and the posterior calcaneal region. In this work, flaps with big dimensions were harvested (up to 10x15cm) to cover big defects in this area. The technique used in this study enabled us to include the skin over the proximal 1/3 of the back of the leg in the flap. This increased the reach of the flap to cover most of the dorsum of the foot and the proximal 2/3 of the planter aspect without compromising its blood supply.

Venous congestion is one of the main problems with the distally based sural artery flap. It has been postulated that ligating the short saphenous vein distally prevents venous congestion by preventing inflow of venous blood from the foot into the flap **[18,19]**. However, many authors and we believe that the short saphenous vein should not be ligated for the following reasons. First, ligating the vein potentially cuts off the veno-cutaneous contribution to the arterial supply of the flap. The contribution of the vasavasorum of the short saphenous vein is particularly important when a long flap, extending into the proximal leg, is needed. Second, ligating the vein may paradoxically have a deleterious effect on venous drainage because it directly cuts off the reverse flow mechanism. Finally, keeping the vein patent provides an additional outlet for ante-grade venous drainage by supercharging if suitable recipient veins are available in the vicinity of the defect or by phlebotomy through an externalized segment of the short saphenous vein, if recipient veins are unavailable **[31-34]**.

In this study two of the five patients who suffered mild venous congestion were relieved completely by elevation and intermittent phlebotomy from externalized short saphenous vein while the other three needed veno-venous micro-anastomosis. This is much superior to many previous reports that mentioned a percentage of up to 60 of venous congestion **[35]**. Despite this high percentage of venous congestion, they reported that this was not affecting the final outcome of their work with a partial distal flap necrosis in only 14% of their cases that correlates will with our work (only 12.1%).

Conclusion:

This work recommends strongly the use of the reversed sural adipo-fascio-cutaneous flap in reconstruction and coverage of skin and soft tissue defects of the lower leg, heel and foot. Thorough preoperative planning based on Doppler study, the inclusion of the sub-fascial part of the median sural artery and short saphenous vein with preservation of the mesenteric connection between this vascular axis and the fascial element of the flap, widening the pedicle and incorporation of other perforators by making the pivoting point 6-8cm above the lateral malleolus in case of large flap, all these measures increases flap blood supply and reliability.

REFERENCES

1- Jose Tharayi and Rahul K. Patil: Reverse peroneal artery flap for large defects of ankle and foot; A reliable reconstructive technique. Ind. J. Plast. Surg., 45 (1): 45-52, 2012.

2- Yang Y.L., Lin T.M., Lee S.S., Chang K.P., Lai CSRuan H.J., Cai P.H., et al.: The extended peroneal artery perforator flap for lower extremity reconstruction. Ann. Plast. Surg., 64: 451-57, 2010.

3- Eren S., Ghofrani A. and Reifenrath M.: The distally pedicled peroneus brevis muscle flap: A new flap for the lower leg. Plast. Reconstr. Surg., 107: 1443-8, 2001.

4- Ponten B.: The fasciocutaneous flap: Its use in soft tissue defects of the lower leg. Br. J. Plast. Surg., 34: 215-220, 1981.

5- Masquelet A.C., Romana M.C. and Wolf G.: Skin island flap supplied by the vascular axis of the sensitive superficial nerves: Anatomical study and clinical experience in the legs. Plast. Reconstr. Surg., 89: 1115-1120, 1992.

6- Price M.F., Capizzi P.J., Watterson P.A. and Lettieri S.: Reverse sural artery flap: Caveats for success. Ann. Plast. Surg., 48 (5): 496-504, 2002.

7- Almeida M.F., Da Costa P.R. and Okawa R.Y.: Reverse-flow island sural flap. Plast. Reconstr. Surg., 109 (2): 583-591, 2002.

8- Singh S. and Naasan A.: Use of distally based superficial sural island artery flaps in acute open fractures of the lower leg. Ann. Plast. Surg., 47 (5): 505-510, 2001.

9- Huisinga R.L., Houpt P., Dijkstra R. and Storm Van Leeuwen J.B.: The distally based sural artery flap. Ann. Plast. Surg., 41 (1): 58-65, 1998.

10- Dolph J.L.: The superficial sural artery flap in distal lower third extremity reconstruction. Ann. Plast. Surg., 40 (5): 520-522, 1998.

11- Hasegawa M., Torii S., Katoh H. and Esaki S.: The distally based superficial sural artery flap. Plast. Reconstr. Surg., 93: 1012-1020, 1994.

12- 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 (2): 169-173, 2005.

13- Yilmaz M., Karatas O. and Barutcu A.: The distally based superficial sural artery island flap: Clinical experiences and modifications. Plast. Reconstr Surg., 102: 2358-2367, 1998.

14- Chin-Ho W. and Bien-Keem T.: Maximizing the Reliability and safety of the distally based sural artery flap. J. Reconstruct. Microsurg., 24: 589-594, 2008.

15- Baumeister S.P., Spierer R., Erdmann D., Sweis R., Levin L.S. and Germann G.K.: A realistic analysis of 70 sural artery flaps in a multimorbid patient group. Plast. Reconstr. Surg., 112: 129-42, 2003.

16- Riaz Khan M., Govila A. and El Faki H.: Reversed superficial sural artery adipofasciocutaneous flap: Is it a versatile flap? Eur. J. Plast. Surg., 29: 187-193, 2006.

17- Almeida M.F., Da Costa P.R. and Okawa R.Y.: Reverse-flow island sural flap. Plast. Reconstr. Surg., 109 (2): 583-591, 2002.

18- Bocchi A., Merelli S., Morellini A., Baldassarre S., Caleffi E. and Papadia F.: Reverse: Fascio-subcutaneous flap versus distally pedicled sural island flap: Two elective methods for distal third leg reconstruction. Ann. Plast. Surg., 45: 284-291, 2000.

19- Zhang F.H., Chang S.M., Lin S.Q., et al.: Modified distally based sural neuro-veno-fasciocutaneous flap: Anatomical study and clinical applications. Microsurgery, 25: 543-550, 2005.

20- Yeng S.F. and Wei F.C.: Distally based sural island flap for foot and ankle reconstruction. Plast. Reconstr. Surg., 99: 744-750, 1997.

21- Singh S. and Naasan A.: Use of distally based superficial sural island artery flaps in acute open fractures of the lower leg. Ann. Plast. Surg., 47 (5): 505-510, 2001.

22- Al-Qattan M.M.: 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., 47 (3): 269-274, 2001.

23- Al-Qattan M.M.: Lower-limb reconstruction utilizing the reverse sural artery flap-gastrocnemius muscle cuff technique. Ann. Plast. Surg., 55 (2): 174-178, 2005.

24- Chang S.M., Zhang F., Yu G.R., Hou C.L. and Gu Y.D.: Modified distally based peroneal artery perforator flap for reconstruction of the foot and ankle. Microsurgery, 24: 430-436, 2004.

25- Kneser U., Bach A.D., Polykandriotis E., Kopp J. and Horch R.E.: Delayed reverse sural flap for staged reconstruction of the foot and lower leg. Plast. Reconstr. Surg., 116 (7): 1910-7, 2005.

26- Hollier L., Sharma S., Babigumira E. and Klebuc M.: Versatility of the sural fasciocutaneous flap in the coverage of lower extremity wounds. Plast. Reconstr. Surg., 110 (7): 1673, 2002.

27- Costa-Ferreira A., Reis J., Pinho C., Martins A. and Amarante J.: The distally based island superficial sural artery flap: Clinical experience with 36 flaps. Ann. Plast. Surg., 46 (3): 308-13, 2001.

28- Ahmed S.K., Fung B.K., Ip W.Y., Fok M. and Chow S.P.: The versatile reverse flow sural artery neurocutaneous flap: A case series and review of literature. J. Orthop. Surg. Res., 3: 15, 2008.

29- Touam C., Rostoucher C., Bahatia A. and Oberlin C.: 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. Plastic Reconstr. Surg., 107: 383-392, 2001.

30- Arnez Z.: Commentary on Distally based sural neurofasciocutaneous island flap to cover tissue loss in the distal third of the leg. By Parodi et al., Eur. J. Plastic Surg., 26 (4): 179-180, 2003.

31- Le Huec J.C., Midy D., Chauveaux D., et al.: Anatomic basis of the sural fascio-cutaneous flap: Surgical applications. Surg. Radiol. Anat., 10: 5-13, 1988.

32- Kerrigan C.L., Wizman P., Hjortdal V.E. and Sampalis J.: Global flap ischemia: A comparison of arterial versus venous etiology. Plast. Reconstr. Surg., 93: 1485-1497, 1994.

33- Wong C.H. and Tan B.K.: Intermittent short saphenous vein phlebotomy: An effective way of relieving venous congestion in the distally based sural artery flap. Ann. Plast. Surg. 58 (Mar.), 303-307, 2007.

34- Tan O., Atik B. and Bekerecioglu M.: Supercharged reverse-flow sural flap: A new modification increasing the reliability of the flap. Microsurgery, 25: 36-43, 2005.

35- Boughdadi N.S., Zaki B.M. and Hanafy A.: Hindfoot reconstruction using the distally based hemisoleus muscle versus the distally based sural flap: A comparative study. Egyptian Journal of Plastic and Reconstructive Surgery, 36 (2): 215-224, 2012.