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Empirical Evidence on the Reliability of Lateral Supramalleolar Flap over Reverse Sural Flap for Local Soft Tissue Coverage of Dorsum of the Foot and Ankle Defects

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Abstract

Background Soft tissue coverage of the distal foot and ankle region has been an area of debate due to the paucity of local flap options. To provide empirical evidence on the reliability of an underreported local alternative for foot and ankle defects, we aim to compare the lateral supramalleolar flap (LSMF) to the reverse sural flap (RSF).

Methods During 2016–2019, 48 patients were divided randomly into two equal groups, LSMF and RSF groups respectively. The patients' demographic, surgical, and clinical outcome details were recorded and analyzed.

Results Flap necrosis was found in five patients in the group treated with RSF and none in the LSMF group. The mean total number of stages in RSF group was significantly higher than in LSMF group ($p < 0.05$). The mean operative time for patients in LSMF group was 85.8 ± 18.5 and 54.2 ± 11.2 in RSF group ($p < 0.05$). Five patients in the RSF group needed additional procedures following flap complications. Nine patients in the LSMF group reported satisfaction outcomes to be "excellent," five patients reported "good" whereas, in the RSF group, 14 patients reported "excellent," 5 reported "good," 3 reported "fair," and 2 reported "poor" outcomes. Compared to the RSF (46.4 ± 4.3) group, the LSMF group had significantly better foot function indices (34.03 ± 3.9).

Conclusion The lateral supramalleolar flap for foot and ankle defects offers better results, reduced complications as well a lesser number of stages and secondary procedures over the traditionally used reverse sural flap.

Keywords
- foot defects
- lateral supramalleolar flap
- reverse sural flap
- distal leg
- fasciocutaneous flap

Introduction

The repair of soft tissue defects involving the ankle and foot is a challenging task for a plastic surgeon owing to limited local soft tissue availability.[1] Although reverse-flow island flaps have the advantage of providing adequate coverage in such defects, their utility is often associated with problems such as venous congestion, in addition to the risk of increased donor site complications.[1] The introduction of free flaps for coverage of foot and ankle defects has proven to be feasible to address such challenging defects, yet their utility is not

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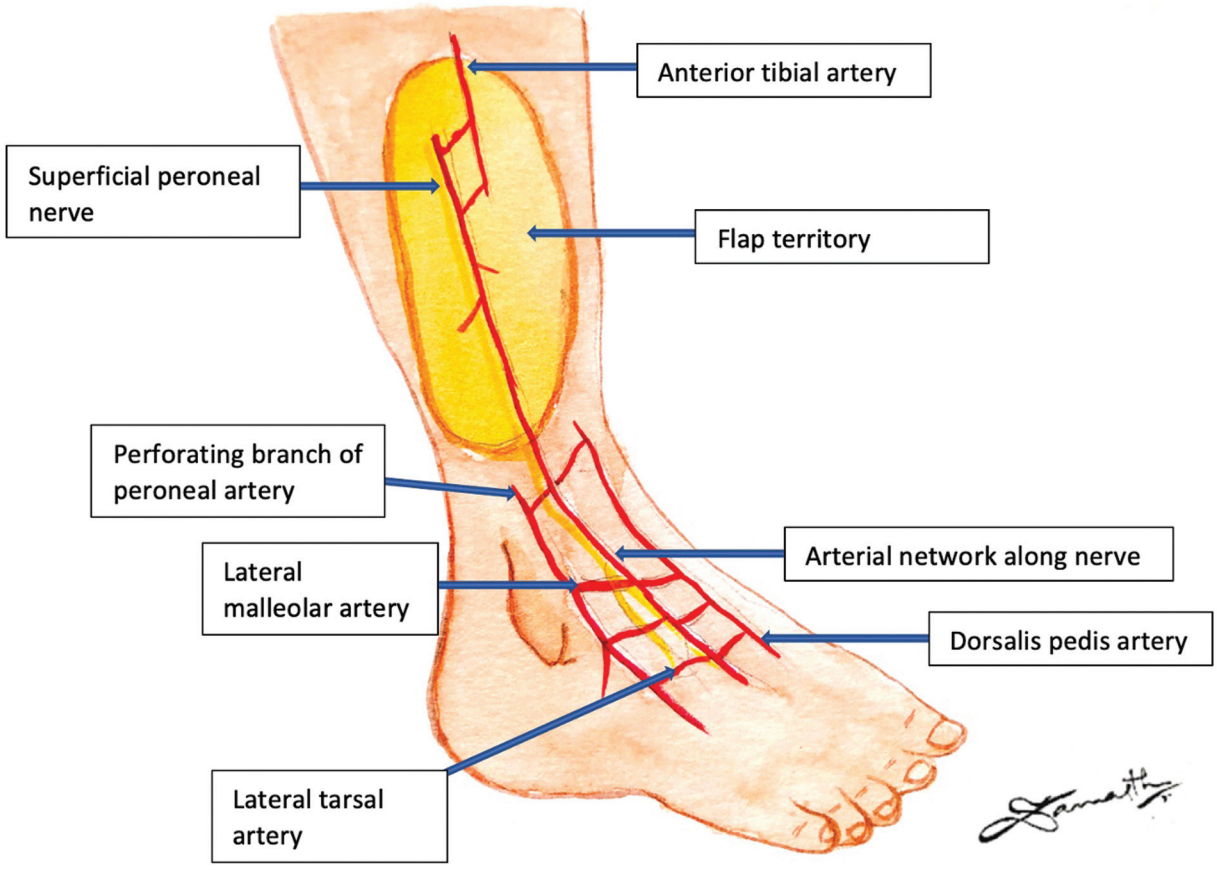

Fig. 1 An illustration demonstrating the arterial basis of the LSMF.

without obstacles; bulkiness of the flaps requires subsequent secondary procedures and the risk of vascular compromise in free tissue transfer procedures along with a steep learning curve for microsurgical techniques. Further, many times a pedicled option seems a more feasible option for a patient who may not be physically fit for extensive surgery.[1] The lateral supra malleolar flap has been found to be a useful flap in reconstructing foot and ankle defects however, it has not been widely published in the literature.[2] To provide empirical evidence on the reliability of an underreported local alternative for foot and ankle defects, we aim to compare the lateral supramalleolar flap (LSMF) to the reverse sural flap (RSF) for the reconstruction of the dorsum of the foot and ankle defects.[3]

Methods and Patients

A total of 48 patients were recruited for this study and randomly divided into two groups–the LSMF group ($n = 24$) and the RSF group ($n = 24$). The study period ranged from 2016 to 2019 and was approved by the Hospital Institutional Review Board. Randomization was performed using freely available, computer-generated "Randomization allocation software" to distribute the patients into two groups.

Patients above the age of 18 years, presenting with healthy wounds in the ankle, dorsum of the foot or sole region were included in the study. Patients with a history of failed flap surgery were excluded from this study. One patient who was operated on for RSF and suffered from Marjolijn's ulcer was included in the LSMF group. Patients with larger defects not suitable for pedicled flaps were excluded from the study.

A thorough debridement was carried out and accompanying fracture presentations of the foot and ankle region were treated. The flap was usually performed on the same day unless the wound was precarious for immediate flap reconstruction.

We collected the following variables: age, gender, smoking status, medical history, wound etiology, associated fracture presentation, site and size of the defect, surgical details (flap used, flap viability), postoperative details (number of subsequent surgeries before ambulation, requirement of repeat surgeries [yes/no], mode of secondary reconstruction, functional outcomes details [excellent/good/poor]) and follow-up.

Surgical Technique

►**Figure 1** depicts an illustration demonstrating the arterial basis of the LSMF. ►**Figure 2A** depicts an ankle and a sole wound due to a Marjolin ulcer over the previously resurfaced wound with reverse sural flap, for which wide local excision was performed. (►**Fig. 2B**) Skin markings and incisions were

Fig. 2 (**A**) Preoperative image of Marjolijn's ulcer showing wound over the sole. The patient had previously undergone reverse sural flap. (**B**) Figure showing a defect of 16 × 3 cm after wide local excision. (**C**) Flap markings. A 16 × 13 cm flap was marked to resurface the sole defect. (**D**) Figure showing the raised flap. (**E**) Figure depicting the flap inset.

made. (►**Fig. 2C**) On continuing the incision of the deep fascia along the edges of the island flap, a superficial peroneal nerve was usually encountered, which was transacted and its distal part was included in the flap. The flap was dissected both anteriorly and posteriorly up to the level of the anterior septum until the peroneal group of muscles were visible. Following this, the lateral septum was incised at the level of the distal margin of the flap. Using a periosteal elevator, the lateral septum was subperiosteally elevated. The periosteal dissection was further continued up to the lateral malleolus. Finally, the flap was sutured over the defect and the donor area is closed using a skin graft (►**Fig. 2D, E**). ►**Figures 3** and **4** showcase for which an LSMF was used to cover a defect on the dorsum of the foot and ankle respectively.

In the other group, the reverse sural flap was harvested and was pre-conditioned whenever needed, especially for distal defects over the dorsum of the foot. ►**Figure 5** depicts the pivot point and flap elevation in an illustration. ►**Figures 6A**, **B**, and **C** show a wound over the ankle that was debrided and a reverse sural flap was planned. ►**Figures 6D** and **E** depict late postoperative pictures.

The patients were followed up at 2 weeks and thereafter at 3 monthly intervals until the end of 1 year. The foot was immobilized for the first 2 weeks and the patients were encouraged to start partial weight-bearing and subsequently gradually start complete weight-bearing.

Results

The mean age of patients in LSMF group was 36.7 ± 9.8 years (range, 23–61) and 35.5 ± 9.2 years (range, 21–54) in the RSF group. Injuries occurred in the right leg in 50% ($n = 12$) of the cases in LSMF group and 54.1% ($n = 13$) in RSF group. The etiology of wound was traumatic ($n = 20$, 83.3%), Marjolin's ulcer ($n = 4$, 16.6%) in the LSMF group and traumatic ($n = 22$, 91.6%), Marjolin's ulcer ($n = 2$, 8.4%) in the RSF group. A total of 12 patients (LSMF group-6; RSF group-6) (25%) had a history of smoking and 4 patients (LSMF group-2; RSF group-2) (8.3%) suffered from comorbidities such as diabetes and

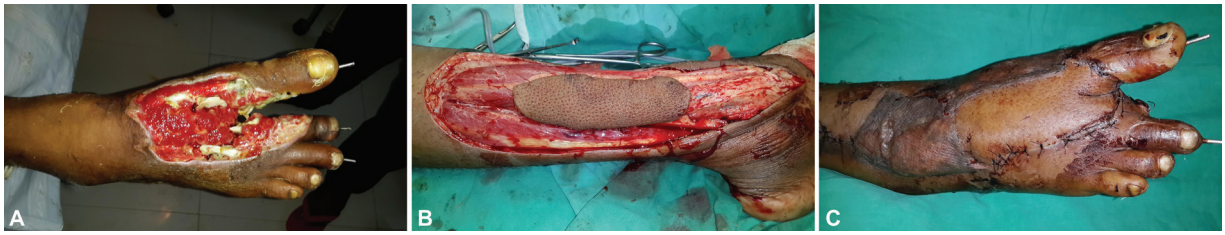

Fig. 3 (**A**) Figure showing a 15 × 8 cm defect over the dorsum that was treated with LSMF. (**B**) Postoperative results of the same patient. (**C**) Late postoperative image.

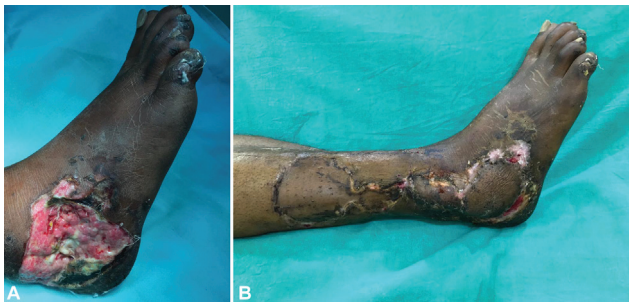

Fig. 4 (**A**) A 10 × 10 cm wound over the ankle. (**B**) Late postoperative images of a patient with an ankle defect for whom the LSMF flap was used.

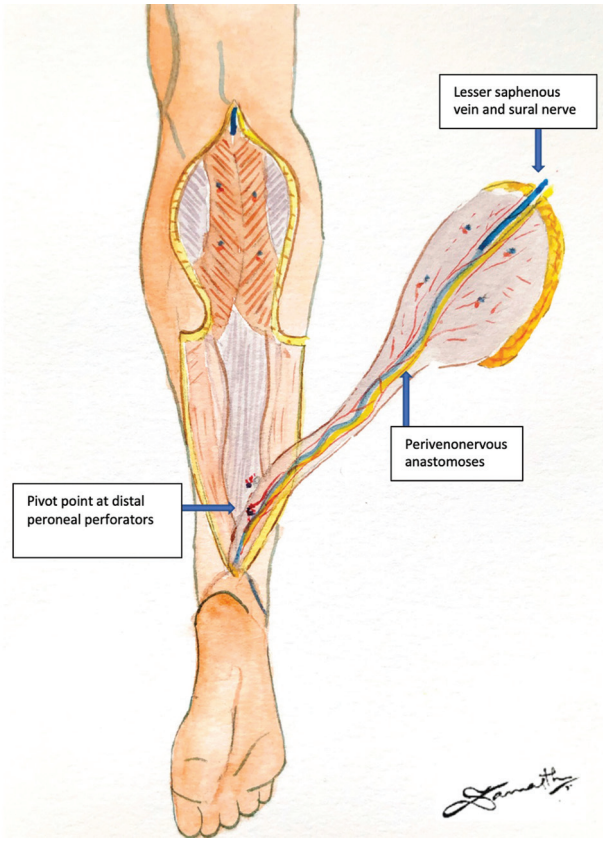

Fig. 5 Pivot point and flap elevation of the RSF in an illustration.

hypertension. Nine patients in the LSMF group were associated with one or more fractures that needed fixation by either open or closed reduction compared to seven in RSF group. Defect sites were classified as dorsal, ankle, sole and distal dorsal defects. ►**Table 1** illustrates demographic details as well as site-based outcomes in the two groups. Flap necrosis was found in five patients (in RSF group) who had defects in either the distal dorsum of the foot or with dorsum plus ankle defects. Venous congestion was found to be associated with all flaps. Partial flap necrosis was observed in four out of five patients. None of the patients in LSMF group suffered from flap necrosis although one patient had suture line dehiscence and another was found to have venous congestion. The mean defect area was $86.8 \pm 35.1\,cm^2$ in LSMF group patients and 88 ± 23.2 in the RSF group. The mean weight-bearing interval was 33.66 days in the LSMF group patients as compared to 34.12 days in the RSF group. The mean total number of stages in RSF group was significantly higher than in the LSMF group patients ($p < 0.05$). The mean operative time for patients in the LSMF group was 85.8 ± 18.5 and 54.2 ± 11.2 in the RSF group and a significant difference was found between the operative times in the two groups ($p < 0.05$). Five patients in the RSF group needed additional procedures following flap complications.

The patient satisfaction outcome was measured by a patient-filled self-assessment assessment tool in which excellent, good, fair and poor grades were given. Nineteen patients in the LSMF group reported the outcome to be "excellent," five patients reported "good," and none of the patients scored "fair" or "poor," whereas in the RSF group, 14 patients reported functional outcomes to be "excellent," 2 reported "good," 3 reported "fair" and 5 reported "poor."

The functional outcome was measured using the Foot Function Index (FFI) including 23 questions, covering three sub-scales of foot function: Pain, Disability, and Activity Limitation. The LSMF group had significantly better FFI scores (34.03 ± 3.9) in comparison to the RSF group (46.4 ± 4.3 at the end of a one-year follow-up. Post-operative outcomes are depicted in ►**Table 2**.

Discussion

Treating patients with foot defects presents several challenges due to the limited availability of mobile skin.[4–6] The reverse sural flap has been commonly used as a workhorse flap to cover foot defects; however, venous congestion and partial flap necrosis are some of its associated complications.[7,8] As per our experience, the reverse sural flap needs conditioning such as delay, thereby increasing the number of stages and operative costs. It leaves a long scar on the calf and sacrifices sural nerves, reducing the sensation to the lateral foot.[7–9] Masquelet et al described the lateral supramalleolar flap in 1988 and has been applied ever since to reconstruct defects of the foot and ankle. Although Hamdi et al compared the LSMF and the RSF in children and demonstrated the superiority of the former over the latter, this is the first prospective study comparing the outcomes of LSMF and RSF in a wider age group.[10]

Lee and Chung described a flap that could be as an adipofascial one allowing them to close the defect primarily.[11] In a study by Uysal et al, venous congestion was a common problem that needs to be considered while raising an adipofascial flap.[12] In our study, we passed the flap under the tunnel in five cases in the LSMF group and found that none of the patients suffered from venous congestion. Adequate space was ensured to tunnel the defect.[13] To prevent hematoma, Brent and Byrd suggested the use of a small-caliber suction drain to prevent the collection of blood and exudates beneath the flap.[14] We use corrugated drains to tackle the aforementioned problem. The operative time in the LSMF group in our study is longer than the RSF group and is comparable to previously published studies on RSF-based foot and ankle reconstruction.[15]

Fig. 6 (**A**) Figure showing a 10 × 8 cm wound over the ankle region. (**B**) Defect after debridement. (**C**) Reverse sural flap raised. (**D, E**) Late postoperative images of a patient treated with reverse sural flap.

In comparison to previous reports, none of the LSMFs in our study underwent necrosis although one patient was reported to have suture line dehiscence and another suffered from venous congestion, which resolved spontaneously with conservative measures.[16–19] Five patients in the RSF group having undergone reverse sural flap suffered from flap necrosis that eventually needed a secondary procedure; in three patients, the anterolateral thigh free flap was used while split-thickness graft was used for the remaining two patients. There was a significant difference noted in flap outcomes between the two comparison groups ($p < 0.05$). It was reported that flap necrosis was found in patients where the reverse sural flap was used for distal foot defects ($n = 2$) and foot plus ankle ($n = 3$) defects, suggesting the limitations of the flap in larger defects as well as distal defects of foot.[19]

A similar study by Hashmi et al demonstrated better outcomes in the LSMF group compared to the RSF group although both their groups had 15% complications.[20] The flap failure rate was nearly equal in both the groups in their study, while our study demonstrated better flap survival in the LSMF group.

Gong in 2006 stated that LSMF may be better suited for smaller defects and those located over the dorsum of the foot.[21] Although we agree with the defect locations, our study demonstrated that the size of the defect did not play any role in flap outcomes.

Lorenzetti et al established that the distally based peroneus brevis muscle is an excellent option to cover defects on the distal third of the leg.[19,22] However, the flap is near to no use in defects over the foot and sole. Similarly, the distally based sural artery peroneus flap has consistently shown good results in various studies such as the one published by Ebraheim et al. Free flaps have always been a choice in areas where local flaps are not available or possible. Unfortunately, many authors still agree on the high failure rates amounting to up to 17% associated with free flaps and the associated flap loss with those reconstructed after 72 hours of trauma.[23,24]

Propeller flap has been successfully used in the reconstruction of lower limb defects with comparable results however they are usually limited to distal leg and ankle defects.[25]

Table 1 Demographics and site-based outcomes

Variable		Group A (LSMF)		Group B (RSF)	
Age		36.7 ± 9.8		35.5 ± 9.2	
Sex (Male)		15		12	
Side (right)		12		13	
Etiology	Traumatic	20		22	
	Marjolin	4		2	
Smoking		6		6	
Comorbidities		2		2	
Site of defect	Distal dorsum	4	0 flap necrosis	3	2 flap necrosis (66.7%)
			3 healthy (75%)		1 healthy (33.3%)
			1 suture line dehiscence (25%)		
	Dorsum	10	0 flap necrosis	11	0 flap necrosis
			10 healthy (100%)		11 healthy (100%)
	Dorsum +Ankle	5	0 flap necrosis	4	3 flap necrosis (75%)
			4 healthy (80%)		1 healthy
			1 venous congestion (20%)		
	Sole + Ankle	2	0 flap necrosis	0	0
			2 healthy (100%)		0
	Sole	3	0 flap necrosis	6	0 flap necrosis
			3 healthy (100%)		6 healthy (100%)
Presence of fracture		9		7	
Area of defect		86.8 ± 35.1		88 ± 23.2	
Flap length		12.1 ± 6.2		13.2 ± 5.5	
Flap breadth		7.2 ± 5.3		7.4 ± 4.5	
Mean follow-up		5.8 ± 1.3		4.6 ± 1.3	

Table 2 Postoperative outcomes

Variable		Group A (LSMF)	Group B (RSF)	*p*-Value
Number of surgeries		1	2.25 ± 0.4	<0.05
Results	Healthy	22	19	<0.05
	Flap necrosis	0	5	
	Others	2	0	
Operative time		85.8 ± 18.5	54.2 ± 11.2	<0.05
Secondary reconstruction		0	5	
Interval to weight bearing		33.7 ± 19.8	34.1 ± 17.3	=.932289
Patient satisfaction outcome	Excellent	20	14	<0.05
	Good	4	2	
	Fair	0	3	
	Poor	0	5	
Function foot index	Pain scale	35.3 ± 5.1	49.7 ± 5.2	<0.05
	Disability scale	36.4 ± 2.9	37.9 ± 4.3	
	Activity limitation scale	30.4 ± 3.9	51.7 ± 3.4	
	Overall score	34.03 ± 3.9	46.4 ± 4.3	

The authors anticipate blinded-randomized controlled trials to further establish the reliability of the lateral supramalleolar flap for addressing defects of the dorsum of the foot and ankle region. Further, site-based randomization could help understand the versatility of the two flaps to establish the utilization of these flaps more clearly.

Conclusion

In our experience, the lateral supramalleolar flap has proven to be a superior alternative that can be effectively used to reconstruct soft tissue defects of the distal leg, ankle, and dorsum of the foot when compared to the reverse sural flap. It is associated with lower complications and a reduced number of stages and secondary procedures, making the technique feasible and reproducible and reliable.

Authors' Contributions

Conceptualization: all authors; data curation: all authors; formal analysis: all authors; funding acquisition: none; investigation: all authors; methodology: all authors; project administration: all authors; resources: all authors; software: all authors; supervision: K.S.J., P. G., S. G.; validation: all authors; visualization: all authors; writing – original draft: all authors, review & editing: all authors.

Note

This article has not been presented in any regional, national or International conferences/meetings.

Conflict of Interest

None declared.

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