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Original Article

Comparison of Distally Based Sural Fasciocutaneous Island Flap with a nd without Inclusion of Sural Nerve

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ABSTRACT

Objectives: To compare the inclusion and exclusion of the sural nerve in fascio-cutaneous flap repair for lower extremity reconstruction in terms of flap survival, flap size, recovery of skin sensation and complications.

Study Design: Prospective comparative study

Place and Duration of Study: Department of Plastic Surgery, Combined Military Hospital, Rawalpindi Pakistan, from Jul 2017 to Mar 2020.

Methodology: A total of 54 patients (27 in each Group) requiring distal lower limb flap reconstruction and meeting the inclusion and exclusion criteria were included. Patients with a higher probability of flap complications and those with complications during the procedure were excluded. Group-A patients underwent fascio-cutaneous flap repair with sural nerve preservation, while Group-B patients underwent the same technique, but the sural nerve was transected and raised with the flap. All patients were followed for flap survival, flap size and degree of sensory recovery and flap-related complications.

Results: Varying degrees of return of sensation were seen in 25(92.6%) patients of Group-A after six months, which was 23(63.1%) in Group-B (p<0.001). Flap survival was comparable in both groups: 26(96.3%) and 25(92.6%) patients in Groups A and B, respectively (p=0.552). The complications were also comparable, 4(14.8%) in Group-A and (25.9%) in Group-B, which was not statistically significant (p=0.209).

Conclusion: Preservation of the sural nerve results in little or no sensory loss in the lateral part of the foot, with complication rates and flap survival comparable to cases where the nerve is sacrificed.

Keywords: Distally based sural fascio-cutaneous Flap, Distal lower limb flap coverage, Sural nerve preservation.

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INTRODUCTION

Injuries to the lower limb are caused by various mechanisms, but are usually high energy, are often associated with major skin loss, and reduced underlying tissue vitality.[1,2] Notorious for poor wound healing, the lower limb has a difficult anatomy when sourcing flaps for reconstructive surgery. The scarcity of overlying skin and its limited mobility translates to the necessity for flap coverage, even in small defects.[3,4]

Distally based sural flaps are classically designed for the posterior surface of the heel, dorsum of the foot, and defects around the malleoli; the pedicle contains the lateral sural artery and fasciocutaneous perforators from the peroneal and popliteal artery.[5] Other structures include the sural nerve, which may or may not be sacrificed, depending on the technique involved.[6,7] However, severing the sural nerve may result in surgically induced paresthesia of the lateral part of the foot, which may or may not be distressing to the patient.[8,9]

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Sural nerve preservation is a practical option that requires skilled microdissection. This can prevent sensory loss of the lateral foot that can occur with standard surgery.[10] Distally based sural flaps with or without nerve inclusion are commonly used surgical techniques in our institutions. Therefore, we conducted this study intending to compare sural nerve preservation versus sural nerve sacrifice for a distal third of the tibia, ankle and heel defects reconstruction in terms of flap survival, size, sensory recovery and frequency of post-surgery complications. In addition, we also studied the frequency of different anatomical variants of the sural nerve in our patients.

METHODOLOGY

This study was conducted from July 2017 to March 2020 at the Department of Plastic Surgery, Combined Military Hospital, Rawalpindi Pakistan, after approval from the Ethical Review Committee of Combined Military Hospital, Rawalpindi (Approval Certificate Number 46). Written informed consent was taken from every patient included in the study. The sample size was calculated by using the WHO sample size calculator with Power of test (1 - β)=95%, Level of

significance (α)=5%, population standard deviation (σ)=78, population variance (σ2)=6084, test value of the population mean=159.8, and anticipated population mean=88.7.[11] The sample size was calculated as 27±27 =54 patients. The sampling technique was non-probability consecutive sampling.

Inclusion Criteria: Patients of either gender, aged 18-60 years who underwent fasciocutaneous flap repair of the lower limb who were graded ASA class I to III were included in the study.

Exclusion Criteria: Patients who were deemed to have a higher risk for flap complications (which included diabetics, smokers, peripheral vascular disease or previous injury or surgery affecting the flap area) and those who had aberrant anatomy of the sural nerve were excluded from the study.

Patients were divided into two equal groups (Group A and B) consisting of 27 patients each. Group-A patients underwent fasciocutaneous flap repair with sural nerve preservation, while Group-B patients underwent fasciocutaneous flap repair without sural nerve preservation.

All patients were operated on under spinal anaesthesia in the prone position. The most distal perforator of the peroneal artery was located with a doppler ultrasound and marked percutaneously about 5cm above and behind the lateral malleolus. Next, a straight line was drawn from a point midway between the lateral malleolus and the Achilles tendon up to the middle of the popliteal fossa marking the course of the sural nerve. Next, using a template of the wound, the flap was marked on the posterolateral aspect of the calf along a line drawn from the lateral malleolus to the middle of the popliteal fossa. Surgery was performed with a tourniquet inflated on the thigh. The flap was dissected to expose the sural nerve and accompanying vessels, followed by flap raising in a proximal-to-distal direction.

The sural nerve was visualized in Group-A and carefully separated from the surrounding vessels. In Group-B, the structures mentioned above were ligated (as needed) and severed. Anatomical variation of the sural nerve was documented. In both groups, the flap was then rotated over the recipient site and anchored. Post-operatively the operated limb was kept elevated and observed for venous congestion. The patients were discharged on the fifth post-operative day and were followed up in the Out-Patient Department at 1 and 6 months post-surgery.

Post-surgery and during the follow-up visits, assessment for recovery of sensations was carried out using the Mackinnon-Dellon scale, as follows:S0: No recovery of sensibility in the autonomous zone of the nerve, S1: Recovery of deep cutaneous pain sensibility within the autonomous zone of the nerve, S1+: Recovery of superficial pain sensibility, S2: Recovery of superficial pain and some touch sensibility, S2+: Recovery of superficial pain and touch sensibility but with an exaggerated response, S3: Recovery of pain and touch sensibility, with loss of exaggeration, static sense of two-point discrimination (s2PD): >15mm, and motor sense of two-point discrimination (m2PD): >7 mm, S3+: As in S3, but localization of the stimulus is good, s2PD: 7-15, and m2PD: 4-7, S4: Complete recovery, s2PD: 2-6, and m2PD: 2-3.

All patients were followed for flap viability, seroma/hematoma formation, and surgical site infection, i.e. incision site redness and tenderness, post-operative fever, discharge from the surgical wound, an abscess and graft uptake on the flap donor site. Follow-up for complications was conducted on days 1, 7, 14 and 28 post-surgery and was ensured via telephonic communication.

Statistical Package for Social Sciences (SPSS) version 25.0 was used for the data analysis. Mean and SD was calculated for quantitative variables like age and size of flap. Qualitative variables like gender wound location, anatomical variation of the sural nerve, flap survival, degree of sensory recovery, and complications were recorded in frequency percentage. The Chi-square test was applied for qualitative variables. An Independent sample t-test was applied for quantitative variables. The *p*-value of ≤0.05 was considered significant.

RESULTS

A total of 54 patients formed the sample in our study, who were divided into two groups of 27 patients each. The patients included 41 males (75.9%) and 13 females (24. 1%). The mean age of patients was 38.28±9.55 years (range 19-55 years). Flap survival was compared on the fifth post-operative day between both groups, and the difference between the groups was found sto be statistically insignificant (Table-I).

During surgery, it was seen that in 34(63.0%) patients, the sural nerve was formed by the fusion of both the medial and lateral sural cutaneous nerves, 17(31.5%) patients had a sural nerve formed by the medial sural cutaneous nerve, 2(3.7%) had a sural nerve formed by the lateral sural cutaneous nerve, and

1(1.8%) case had parallel running medial and lateral sural cutaneous nerves (Figure-1).

Table-I: General Characteristics of the Patients (n=54)

Characteristics	Group-A (n=27)	Group-B (n=27)	*p*-value
Age (years)	38.93±10.24	37.63 ± 8.94	0.622
Flap Size (cm2)	73.44±42.45	91.56 ± 41.71	0.120
Pivot Point (cm)	7.59±3.25	7.07 ± 3.43	0.571
Pedicle Length (cm)	9.26±3.52	9.51 ± 3.11	0.775
Flap Survival (Yes: No)	26(96.3%): 1(3.7%)	25(92.6%): 2(7.4%)	0.561
Location of Defect			
Dorsal Foot	12 (44.4%)	10 (37.1%)	0.204
Ankle	6 (22.2%)	4 (14.8%)	
Heel	1 (3.7%)	6 (22.2%)	
Lower Leg	8 (29.7%)	7 (25.9%)	

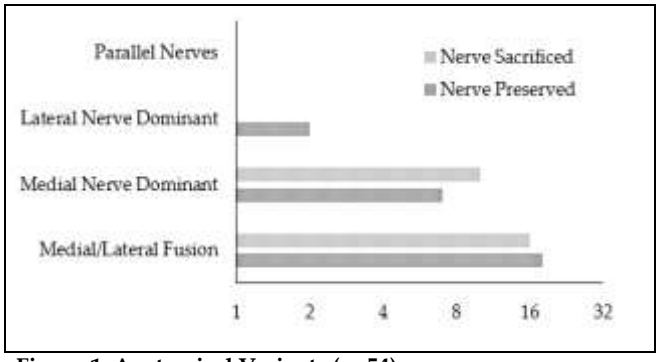

Figure-1: Anatomical Variants (n=54)

The degree of maintenance and return of sensation post-procedure, at one month and six months, was compared between both groups, as measured by the Mackinnon Dellon scale; overall results were better in Group-A (nerve preserved), which showed generally greater maintenance and improvement in sensation, and the difference between both groups was statistically significant at all the time intervals measured (p<0.001) (Table-II). Complications were monitored in both groups for six months (Figure-2).

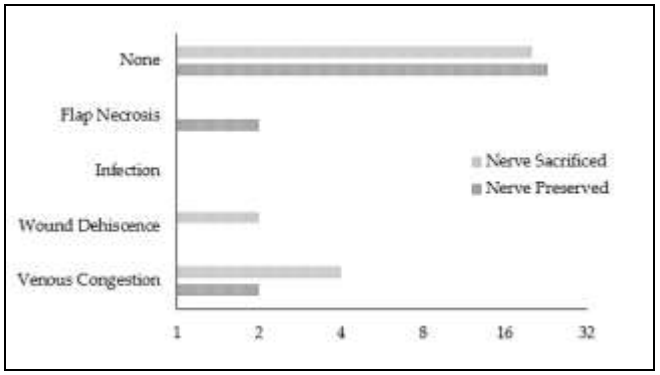

Figure- 2: Complications (n=54)

Table-II: Evaluation of Sensations of the Patients (n=54)

	Group-A (n=27)	Group-B (n=27)	*p*-value
Sensations Post-Procedure			
S0	2(7.4%)	20(74.1%)	<0.001
S1	0(0%)	2(7.4%)	
S1+	1(3.8%)	5(18.5%)	
S2	2(7.4%)	0(0%)	
S2+	8(29.6%)	0(0%)	
S3	8(29.6%)	0(0%)	
S3+	3(11.1%)	0(0%)	
S4	3(11.1%)	0(0%)	
Sensations 1 Month Post-Procedure			
S0	2(7.4%)	12(44.4%)	<0.001
S1	1(3.8%)	6(22.2%)	
S1+	1(3.8%)	4(14.9%)	
S2	2(7.4%)	3(11.1%)	
S2+	3(11.1%)	2(7.4%)	
S3	9(33.2%)	0(0%)	
S3+	6(22.2%)	0(0%)	
S4	3(11.1%)	0(0%)	
Sensations 6 Months Post-Procedure			
S0	2(7.4%)	10(36.9%)	<0.001
S1	0(0%)	5(18.5%)	
S1+	1(3.8%)	3(11.1%)	
S2	2(7.4%)	4(14.8%)	
S2+	2(7.4%)	3(11.1%)	
S3	8(29.6%)	1(3.8%)	
S3+	8(29.6%)	1(3.8%)	
S4	4(14.8%)	0(0%)	

DISCUSSION

Our study showed that preservation of the sural nerve results in little or no sensory loss in the lateral part of the foot, with complication rates and flap survival comparable to cases where the nerve is sacrificed.

In our study, the mean flap size was 73.44±42.45 cm² in Group-A and 91.56±41.71cm² in Group-B, which was statistically non-significant (p=0.120). The mean flap size for the entire study was 82.50±42.67 cm². Li *et al*. showed a total mean flap size of 111.7±84.2cm², with a much larger mean flap size of 159.8±88.7cm² in the Group where the sural nerve was sacrificed versus a mean value of 80.7±67.3cm² in those where the nerve was preserved, the difference being statistically significant (p=0.024).[12]

The pivot point of the flap was measured from the most prominent point on the lateral malleolus. Our study showed a mean pivot point in Group-A of 7.59±3.25cm and 7.07±3.43cm in Group-B with a p=0.571. Li *et al*. reported that the mean pivot point was 5.7±1.9cm in the Nerve-Preserved Group and 4.0±0.6cm in the Nerve-Sacrificed Group (p=0.020). The study discussed how a pivot position >3.5cm

above the lateral malleolus tip was vital to maintain an adequate blood supply to the flap.[12]

In our study, 26(96.3%) flaps survived in Group-A, while 92.6% of flaps survived in Group-B at six months, the difference being statistically non-significant (p=0.561). The total flap survival rate for the study was 94.4%. Total flap survival in Li *et al.* was 78.3%, with 88.9% and 71.4% surviving in nerve sacrifice. Nerve preserved groups, respectively, p=0.611.[12] While another study showed that the sural nerve was not required for the survival of the distally based sural flap, stating that while the perineural vascular network was helpful to maintain flap vascularity, it was not essential, a conclusion that we share.[13]

In our study, 34(63.0%) patients had a sural nerve formed by the fusion of both the medial and lateral sural cutaneous nerves (Type 1), 17(31.5%) formed by the medial sural cutaneous nerve with a rudimentary lateral sural cutaneous nerve (Type 2), 2(3.7%) formed by the lateral sural cutaneous nerve (Type 3), and 1(1.8%) case with parallel running medial and lateral sural cutaneous nerves (Type 4). Choi *et al*. found 73.8% Type 1, 22.5% Type 2, and 3.8% Type 3 sural nerves in their sample size of 40, not identifying a single Type 3 variant. The results were largely comparable with our study.[6] Another study showed anatomic subtypes of the sural nerve and found 63% Type 1, 27% Type 2, 7% Type 3, and 3% Type 4 variants.[14] Our results agree with existing literature, with minor variations.

Group-A cases showed good recovery of sensations in the immediate post-operative period, with only 2(7.4%) cases showing a complete absence of sensation with no improvement throughout the follow-up. In Group-B, 20(74.1%) had no sensations post-procedure. However, this Figure improved to 12(44.4%) cases in one month and 10(36.9%) cases after six months. A study reported that paresthesias associated with nerve sacrifice on the lateral border of the foot disappeared completely in all cases within two months.[15]

Venous congestion was seen in 2(7.4%) cases from Group-A and 4(14.8%) cases from Group-B (11.1% of the total sample). 2(7.4%) cases in Group-B suffered from wound dehiscence, while 1(3.7%) suffered from infection. 2(7.4%) cases in Group-A suffered from graft necrosis, likely because both patients had diabetes. There were a total of 11(20.4%) cases with complications. Another study observed that partial necrosis was seen in patients with the sural nerve severed, while venous congestion was seen in those in whom the pedicle passed under a subcutaneous tunnel.[16] Another study noted a very high complication rate of 30%, but this can be attributed to the high-risk patient population upon which the study was conducted, which included patients with diabetes mellitus, peripheral vascular disease, and venous insufficiency.[17] Most of the complications in this study were caused by venous congestion. Venous congestion was also the most common complication seen in another study.[18] In addition to the causes mentioned above, other risk factors for complications included vasculitis and age over 40.[19]

The distally based sural flap is an important instrument in the arsenal of the plastic surgeon. It is a safe and reliable method for coverage of defects of varying sizes affecting the lower leg and foot. Preservation of the nerve results in an improved sensory outcome, a variable where patient preference must be considered. Other advantages include acceptable donor site morbidity, a wide arc of flap rotation, and preservation of major vasculature. While it has been proposed that including the nerve in the flap increase survival, this requires further study. Possible disadvantages include venous congestion, limitation of length, and occasional flap necrosis. Further research will help delineate optimal practices, especially with regard to pedicle length, pivot points and the role of microsurgery to improve outcomes further.

CONCLUSION

While preserving the sural nerve may not affect the survival of the sural flap, sparing it prevents donor site anaesthesia and the possibility of using the nerve as a donor for lower extremity nerve reconstruction if and when required. The flap can be safely elevated with a sufficiently sized pedicle making it a practical and feasible option for reconstructing the foot, ankle and heel. It must be noted that despite the severing of the nerve, some cases saw the recovery of sensation. While the difference in sensory recovery remained statistically significant, this aspect may need further long-term study.

Conflict of Interest: None.

Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

TS & SH: Data acquisition, data analysis, drafting the manuscript, critical review, approval of the final version to be published.

AM & SHN: Study design, drafting the manuscript, data interpretation, critical review, approval of the final version to be published.

SF & FM: Concept, critical review, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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