Non-Islanded Distally Based Sural Artery Flap: A Reliable Solution for an Unreliable Flap

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ABSTRACT

Objective: To assess the reliability of non-islanded distally based sural artery flap, in terms of number of flap failure (partial and major flap necrosis), number of surgeries related to the problem for which flap surgery was performed, hospital stay and return to work, for coverage of soft tissue defects of the distal one-third of leg, ankle and heel.

Study Design: Cohort study.

Place and Duration of Study: Department of Plastic Surgery and Burn Unit, Mayo Hospital, KEMU, Lahore, Pakistan, from January 2003 to March 2014.

Methodology: Distally based sural artery flaps in 87 patients requiring coverage of distal lower limb were studied, retrospectively. They were divided into two groups. G1 included 46 cases in which distally based sural artery flap was islanded. G2 included 41 cases in which flap was not islanded and pedicle was raised. The variables that were measured in two groups included age, gender, size and cause of defect, co-morbidities, number of surgeries, total hospital stay, return to work and flap related complications. Independent sample t-test and tests of proportions were used for comparison with significance at p < 0.05.

Results: The mean age of patients was 38.4 ±16.2 years in G1 and 35.1 ±18.6 years in G2. In G1, 34 cases were traumatic, 5 caused by diabetic ulcers and another 7 cases were trophic ulcers in paraplegic patients caused by pressure sores. In G2, the cause was trauma in 32 cases, diabetic ulcers in 7 cases, trophic ulcers in 2 cases. The mean number of surgeries in G1 was 3 ±1 and 2 ±1 in G2 (p < 0.001). The mean hospital stay in G1 was 43.1 ±3.6 days while 27.9 ±2.1 days in G2 (p < 0.001). There was epidermolysis in 21 out of 46 islanded distally based sural artery flaps (G1) and in 9 out of 41 non-islanded flaps (G2) (p=0.0203). Partial necrosis occurred in 12 of flaps in G1 and in only 3 of G2 flaps (p=0.024).

Conclusion: Distally based sural artery flap can be made more reliable and with lesser complications by raising the pedicle with skin rather than islanding the flap.

Key Words: Sural artery flap. Epidermolysis. Flap necrosis. Flap complications.

INTRODUCTION

Soft tissue defects in the lower one-third of leg, ankle and heel offer a definite challenge for the reconstructive surgeons. The not-so-reliable blood supply to the local tissues and high demands for durable and robust soft tissue coverage in this region pose an even stiffer task for the surgeons.¹

The distally based sural artery flap, first described as a distally based neuro-cutaneous flap by Masquelet et al., is a skin island flap supplied by the vascular axis of sural nerve.² It is one of the most commonly used flaps for soft tissue defects of lower one-third of leg, ankle and heel. There has been considerable debate over the reliability of this flap. There are a number of reports about the high complication rates associated with these flaps, which range from epidermolysis and partial flap necrosis to complete flap loss.³ Anatomical studies have shown the consistency of the blood supply for this flap, so most of these complications are attributed to the venous insufficiency to which the flap is subjected after its inset in its lower than original anatomical location.⁴⁻⁶ A number of modifications have been applied and tested to increase the reliability and decrease the complications in this flap.⁷ In the authors' experience, if the distally based sural artery flap is not islanded and skin paddle is maintained over the pedicle, it potentiates the venous drainage through the sub-dermal venous plexus and thus improves the reliability of this flap and reduces the complication rate. There has been no study to compare islanded and non-islanded distally based sural artery flaps. To critically analyze the above observation, the authors conducted this comparative study on the distally based sural artery flaps performed in their department for soft tissue defects of distal lower limbs in terms of performance, hospital stay and complications.

METHODOLOGY

Files and case notes of all the patients who underwent distally based sural artery flap between January 2003 and March 2014 were retrieved from the data library of Plastic Surgery Department and Burn Unit of Mayo Hospital, KEMU, Lahore. A total of 113 cases were...
found. Then those cases were shortlisted according to inclusion criteria in which patients were requiring soft tissue coverage of lower one-third of leg, ankle and heel with no peripheral vascular disease. All cases in which flap was extended beyond junction of upper and middle thirds of lower leg, flaps in which primary delay was done and flaps in which modification like taking muscle cuff or super charging was carried out during primary flap harvest and inset, were excluded. This shortlisted to 95 distally based sural artery flaps in 94 patients. These patients were contacted by phone and were invited to be included in the study. Three patients could not be contacted while another 5 patients lived in far off areas and did not wish to come for interview, so they were also excluded from the study. So 87 patients were called in clinic for follow-up and informed consent was taken to be included in the study.

Case notes were studied of all these patients and they were divided into two groups – G1 and G2. In G1, all cases were included in which distally based sural artery flap was islanded and pedicle included only subcutaneous fat and fascia. In G2, all those cases were included in which flap was not islanded and pedicle was raised with the skin. The variables that were measured in 2 groups included age, gender, size and cause of defect, co-morbidities (diabetes mellitus, hypertension and venous insufficiency), number of surgeries, total hospital stay, time for return to work and flap related complications including epidermolysis, partial flap necrosis, wound dehiscence, major flap necrosis and complete flap loss.

Amongst these variables, return to work was confirmed on the follow-up when the patients were called to be included in study. The size of defect for each group was averaged. Venous insufficiency was diagnosed on Doppler scan. The number of surgeries was considered to be the surgeries related to sural artery flap including the flap surgery itself. Hospital stay included only the flap surgery itself. Hospital stay included the Plastic Surgery Ward for the sural artery flap surgery and related issues. Epidermolysis was considered when there was just partial skin loss of flap, leaving a graftable bed. Partial flap loss was considered when there was full thickness necrosis of flap of more than distal 1cm and less than half of length of flap along long axis including the wound dehiscence. Major flap necrosis and complete flap loss was considered when more than half of the flap was necrosed.

The reliability of the method of flap harvest was determined by number of flap failure (shown by partial and major flap necrosis), number of surgeries related to problem for which flap surgery was performed, hospital stay, and time to return to work.

SPSS software was used for the statistical analysis. Independent sample t-test was used to determine the independent variables, mean difference in age, number of surgeries, hospital stay, and return to work between both groups. Pearson's chi-square and Fisher's exact tests were used to compare the proportion of diabetes mellitus, hypertension, venous insufficiency, epidermolysis, partial necrosis and complete necrosis. The difference was considered to be significant when the p-value was less than 0.05.

RESULTS

There was no significant difference in mean age and gender of patients between two groups. In G1, mean age of patients was 38.4 ±16.2 years with youngest patient aged 11 years and oldest 59 years. In G2, the mean age was 35.1 ±18.6 years with youngest patient being 13 years and oldest of 67 years of age. In G1, 38 (83%) patients were males and 8 (17%) were females while in G2, there were 36 (88%) males and 5 (12%) females. The average size of defect in G1 was 10 x 12 cm² with the largest defect measuring 13 x 15 cm². The average size of defect in G2 was slightly bigger, measuring 11 x 14 cm² with largest defect also slightly bigger 16 x 14 cm². The major cause of defect in each group was trauma, amongst which road traffic accident and wheel spoke injury was most common. In G1, 34 (74%) cases were traumatic, 5 (11%) by diabetic ulcers and another 7 (15%) cases were trophic ulcers in paraplegic patients caused by pressure sores. In G2, trauma was the cause in 32 (78%) cases, diabetic ulcers in 7 (17%) cases while, 2 (5%) cases were of trophic ulcers. The difference in the frequency of co-morbid diseases was also not significant. Seven (15%) patients in the G1 had diabetes mellitus, 3 (7%) had hypertension while, 4 (9%) had venous insufficiency involving lower limbs. In G2, 10 (24%) patients had diabetes mellitus, 2 (5%) had hypertension and 6 (15%) patients had venous insufficiency involving lower limbs.

Table 1: Comparison of non-complication related factors between two groups.

<table>
<thead>
<tr>
<th></th>
<th>G1 (n=46)</th>
<th>G2 (n=41)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>36.4±16.2</td>
<td>35.1±18.6</td>
<td>0.378</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>38 (83%)</td>
<td>36 (88%)</td>
<td>0.683</td>
</tr>
<tr>
<td>Female</td>
<td>08 (17%)</td>
<td>05 (12%)</td>
<td></td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>07 (15%)</td>
<td>10 (24.39%)</td>
<td>0.506</td>
</tr>
<tr>
<td>Hypertension</td>
<td>03 (7%)</td>
<td>02 (5%)</td>
<td>1.000</td>
</tr>
<tr>
<td>Venous insufficiency</td>
<td>04 (9%)</td>
<td>06 (15%)</td>
<td>0.506</td>
</tr>
<tr>
<td>Average size of defect</td>
<td>10 x 12 cm</td>
<td>11 x 14 cm</td>
<td>0.053</td>
</tr>
<tr>
<td>Cause of defect</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trauma</td>
<td>34 (74%)</td>
<td>32 (78%)</td>
<td>0.6527</td>
</tr>
<tr>
<td>Diabetic ulcers</td>
<td>05 (11%)</td>
<td>07 (17%)</td>
<td>0.4022</td>
</tr>
<tr>
<td>Trophic ulcers</td>
<td>07 (15%)</td>
<td>02 (5%)</td>
<td></td>
</tr>
<tr>
<td>Number of surgeries</td>
<td>03 ±01</td>
<td>02 ±01</td>
<td>&lt;0.001**</td>
</tr>
<tr>
<td>Hospital stay</td>
<td>43.1±3.6</td>
<td>27.9±2.1</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Return to work</td>
<td>17.5±3.1</td>
<td>16.2±1.1</td>
<td>0.0127*</td>
</tr>
</tbody>
</table>

* Statistically significant
The mean number of surgeries in G1 was 3 ±1 while that in G2 was 2 ±1. The highest number of surgeries in a single patient in G1 was 5, and 3 in G2 (p < 0.001). In G2, division and insetting was required as a second procedure in 34 cases; 5 did not require division and insetting while the remaining 2 did not opt for a secondary procedure. The difference in mean hospital stay was also significant (p < 0.001) with mean stay in G1 of 43.1 ±3.6 days with the longest stay in any one patient being 78 days and the shortest being 13 days. The mean hospital stay in G2 was 27.9 ±2.1 days with longest stay of 59 days and the shortest of 13 days. Return to work was also significantly early in G2 (p=0.0127). In G1, the mean time for return to work was 17.5 ±3.1 weeks while in G2 it was 16.2 ±1.1 weeks. The longest stay off work was 32 weeks in a patient from G2 and was attributed to the patient developing myocardial infarction while recovering from the ankle injury.

The most important and significant differences were in the early flap related complications. None of the flaps in either group developed complete flap necrosis. There was epidermolysis in 21 (46%) out of 46 islanded reverse sural artery flaps (G1) while 9 (22%) out of 41 non-islanded flaps (G2) developed this complication (p=0.020). Partial necrosis occurred in 12 (26%) of flaps in G1 and in only 3 (7%) of the G2 flaps (p= 0.024).

**DISCUSSION**

The mechanics and stability of bony framework and tough and robust skin and soft tissue makes the fact a masterpiece instrument of locomotion whose structural genius is second only to the human hand. Feet arches with ankle joint provide a propelling system, which allows such a wide range of movements from a slow stroll to a marathon. But this extensive use of feet and ankles in everyday life makes them susceptible to extensive wear and tear. Feet and lower legs are also extremely susceptible to injury in traffic accidents. Despite the anatomically very robust blood supply of this region, with advancing age and with systemic diseases like diabetes mellitus, hypertension, peripheral vascular disease and venous insufficiency among many others, the blood supply of feet and ankle region becomes quite compromised, which makes the healing of wounds in this region quite unpredictable.8-11 The lack of availability of reliable loco-regional flaps makes the reconstruction of soft tissue defects in this region quite a challenge for the reconstructive surgeon, especially in case of large defects.12
The sural artery flap, first described as a distally based neuro-cutaneous flap by Masquelet et al., is skin island flap supplied by the vascular axis of sural nerve.1 After an initial excitement about the use of this flap for coverage of soft tissue defects in lower one-third of leg, ankle and heel, there were mixed reports of its reliability and complications associated with it. Baumeister et al. published a data on 70 cases of sural artery flaps and showed that there was a realistic incidence of major flap necrosis of 36%.3 Some other studies also report the partial flap necrosis rate of 25%.12 They attributed this high rate of complication to co-morbid diseases like peripheral vascular disease, diabetes mellitus and age over 40 years. In this study, all these mentioned co-morbidities were seen in flap complications but there was no significant difference in the frequency of these conditions between two groups. There was a relative increase in complication rate in patients of each group with these co-morbidities but group with skin pedicle still had significantly lesser complication rates compared to the group with islanded flap. In another study, Wei et al. assessed data from 179 sural artery flaps to study the flap factors associated with high complication rates, especially partial necrosis. They found an 11.2% partial necrosis rate in these flaps in addition to epidermolysis and wound dehiscence cases.13 Most of these complications occurred in flaps, which were raised more proximally from calf or had a greater length to width ration of pedicle. In this study, the extended flaps were excluded and only those were included which were raised below the junction of upper and middle thirds to minimize the random portion.

Keeping in view the high complication rate of the distally based sural artery flap, a number of modifications have been applied in attempts to make these flaps more reliable. Al Qattan proposed to raise a cuff of each of heads of gastrocnemius muscles with the sural artery flap.7 He suggested that it had improved the arterial supply of the highest or the distal most portion of flap that was often random pattern in blood supply. But that did not significantly improve the venous drainage, which is the main problem in these reverse flow flaps. Foran et al. proposed that all the distally based sural artery flaps should be delayed for 48 hours to 7 days before raising the flaps; and showed quite encouraging results with this maneuver.14 But this method added an extra procedure in complete reconstruction. Yang et al. introduced a short incision technique to harvest the adipo-fascial variety of this flap.15 This improved the cosmetic issue of donor site morbidity but did not address the issue of venous congestion and other complications. In this study, the authors are proposing an alteration in practice in which these flaps are raised, i.e. raising the pedicle with skin pedicle, which in authors’ experience significantly improves the reliability of the flap and reduces the complications associated with venous congestion. Tan and colleagues introduced the concept of supercharging of sural artery flap. It was time-consuming and required microsurgical expertise.

Due to the high complication rate associated with the distally based sural artery flaps, a number of other options were sorted out for soft tissue reconstruction of lower one-third of leg, ankle and heel. Ramesha et al. compared the use of peroneus brevis flap with reverse sural artery flap for reconstruction of lower one-third of leg.17 They have reported comparable results for the use of these two flaps and believe both are good options. But peroneus brevis flap has the limitation of defect size that it can cover and also to the distance it can reach. It is not a feasible option for reconstruction of heel defects. Sural artery flap on the other hand has a good reach and provides an additional advantage of carrying skin with flap and thus avoiding the need for skin graft. There are a number of publications, which have labelled free tissue transfer as gold standard for soft tissue reconstruction of the lower one-third of the leg and ankle and heel.18-20 From experience, the authors hereby agree that free tissue transfer is the gold standard in these zones but there is a definite role of distally based sural artery flap in reconstruction of these zones, especially in ankle and heel defects. By adopting this minor alteration in flap technique, the venous congestion related complications can be considerably reduced. Due to very encouraging results of non-islanded distally based sural artery flaps, we almost totally have moved to raising our sural artery flaps in this fashion.

The limitation of this study is that the patients could not be randomized because of retrospective nature of study, so exact nature of defects and the time span from defect to reconstruction could not be compared between two groups of patients. Also, the return to work could have been affected by presence or absence of fracture and presence or absence of underlying osteomyelitis. The reason for choosing islanded flap or non-islanded flap was totally on the discretion of the surgeon and was not based on patient factors.

CONCLUSION

Distally based sural artery flap is a viable and good option to have in ones armamentarium for coverage of soft tissue defects in lower one-third of leg, ankle and heel. This flap can be made more reliable and with lesser complications by raising the pedicle with skin rather than islanding the flap.

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