



ANALYSIS OF THE REVERSE SURAL ARTERY FLAP AS AN OPTION FOR RECONSTRUCTION OF DEFECT OF LEG AND FOOT

K. Sathish Kumar Assistant Professor, Department of Plastic Surgery, Stanley Medical College, Chennai – 1.

R. Saravanan* Assistant Professor, Department of Plastic Surgery, Stanley Medical College, Chennai – 1. *Corresponding Author

R. Ashik Ahamed Assistant Professor, Department of Plastic Surgery, Stanley Medical College, Chennai – 1.

ABSTRACT **Objective:** To present our experience in soft tissue coverage using reverse sural flap for lower third leg, ankle region, heel pad and dorsum of foot and analysis of the cases in respect to result.

Methods: This study was conducted at a tertiary care plastic surgery department between January 2017 and December 2018. 34 patients who underwent reverse sural artery or extended reverse sural artery flap for reconstruction of defects of leg and foot were included. The results were analyzed based on Survival of flap, Complication, Hospital stay and Time of total healing.

Results: In the 34 patients, complications were observed in 5 patients.

Conclusion: This flap is a robust flap for coverage of soft tissue defect in Anteromedial aspect of lower 3rd leg, Hind foot Dorsum, and Non-weight bearing aspect Heel when executed meticulously.

KEYWORDS : Reverse Sural Flap, Sural Artery, Peroneal Perforators.

INTRODUCTION:

Pedicle flap plays an important role in the armamentarium of plastic surgery for soft tissue reconstruction in many areas with minimal complication even in the era of microsurgery. One such pedicle flap is reverse sural flap described by Masquelet et al based on the communication between peroneal vessels and the median sural vessel. It is used for soft tissue coverage of medial aspect and anterior aspect of lower 3rd leg, dorsum of hind foot, tendoachilles region and posterior aspect or non-weight bearing aspect of heel region. With certain modifications in the flap it is used to provide soft tissue coverage in forefoot dorsum, lateral aspect of the foot below lateral malleolus and weight bearing aspect of heel. (1,2,3)

As the name of the flap depict it as a reverse flow flap and the chance of venous congestion is more. This paper provides few techniques to overcome this problem to make this a robust flap.

MATERIALS AND METHODS:

Between January 2017 and December 2018, 34 patients presented with soft tissue defects around the ankle, lower 3rd leg, and dorsum foot and heel region. These defects were resurfaced with reverse sural flap and they were included in this study. Out of 34 patients, 33 sustained injuries due road traffic accident and 1 patient had melanoma in heel. In patients with fractures, external fixator was applied and resurfacing was done later. Patients were taken up for surgery under regional anesthesia. Conventional Reverse sural flap was done in 23 patients and Extended Reverse sural flap was done in 11 patients. Under tourniquet control with loupe magnification thorough debridement was done and planning for reverse sural flap was done after assessing the post debridement defect. Mostly surgery was performed in prone position and in few it was performed in lateral decubitus position with hip knee flexed and leg with ankle supported. Preoperative Doppler was performed only if the peroneal perforator site was in the zone of injury or if patient is a diabetic or older age or if patient is a chronic smoker. Once the patient is positioned on table, flap axis marked and distal limit of flap marked. Flap harvested and inset given and donor area covered with SSG with immobilization of ankle with POP slab. In all cases where extended flap was done delay of the random portion was first done and flap harvested one week after the delay. Patients were given the instruction for strict foot end elevation for a week. All patients were under clinical observation for 3 weeks. Complications such as infection, venous congestion, and flap dehiscence were noted. Division and Inset done at the end of 3 week, discharged at end of 4 weeks. Patients were advised for follow up in orthopedic and physiotherapy department and later reassessed at the end of 6 to 8 weeks for donor site scar and suture line healing of the flap. The results were analyzed in regard to survival of flap, Mean hospital stay, occurrence of complication and time of total healing.

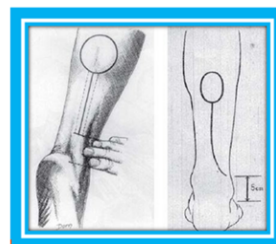
VASCULAR ANATOMY OF THE FLAP:

The reverse sural flap is supplied by peroneal septocutaneous perforators emerging in between tip of lateral malleolus and tendoachilles that communicates with arteriosomes that supplying sural nerve and also by means of arteriosomes that supplying the lesser saphenous vein which accompany along the sural nerve.

Popliteal artery in the popliteal region gives of medial and lateral sural branches that supplies the two head of gastrocnemius muscle and another constant branch median sural artery arises in these area from popliteal artery and run downward sub fascially and accompany the sural nerve just above or near the upper 3rd and middle 3rd junction of posterior aspect of leg and penetrates the deep fascia to run supra fascially with lesser saphenous vein. Lesser saphenous vein dips inside the deep fascia often where sural nerve along with plexus exit the deep fascia which guide as a land mark while dissecting the distal most seem line of flap Branches from the median sural artery form a plexus around the sural nerve and supply the skin subcutaneous tissue of the mid-3rd of the calf region. These suprafascial plexus arborizes both longitudinally and radially and anastomoses with septocutaneous perforators of peroneal artery in the distal 3rd of the leg laterally. This vascular network forms the basis of the reverse sural flap. The peroneal septocutaneous perforators are about 1 to 8 in number and a constant sizeable one is given off well within 5cm proximal to the tip of lateral malleolus (3,4,5).

MARKING FOR AXIS OF FLAP:

A point is marked, 5 to 7 cm proximally to a point marked between tip of lateral malleolus and tendoachilles where there will always constant perforator communications exist between the sural plexus and peroneal vessel.



PIVOT POINT MARKING 3 FINGER BREADTH OR 5 CM ABOVE
A POINT PLACED BETWEEN TIP OF LATERAL MALLEOLUS AND
TENDO ACHILLES



Fig 1: Axis of the flap

Another point is marked in midline (line between midpoint of popliteal crease and midpoint between two malleolus) at the junction of upper 3rd and middle 3rd.

A line connecting these two points forms the axis of the flap. Flap can be harvested in the middle 3rd of posterior aspect of leg with longitudinal axis in the center and pedicle being in the lower 3rd region

The posterior aspect of the leg was divided into equal thirds by marking a line between midpoint of popliteal crease and midpoint between two malleolus. The middle 3rd region in the posterior aspect of leg is the flap harvesting area supplied by sural vessels. The junction between upper 3rd and middle 3rd in the posterior aspect of leg is taken as the distal most site for harvesting the flap. Beyond that region if flap is need than delay procedure is done (6, 7).

OPERATIVE TECHNIQUE:

Procedure was done in regional anesthesia in prone position or lateral decubitus position. Under tourniquet control, with loupe magnification, thorough debridement of wound done and planning in reverse done, for Reverse sural flap. Once planning is completed deflate the tourniquet and patient is positioned either in prone with a sand bag in thigh or in lateral decubitus position with a pillow placed between two legs supporting the flexed hip ,flexed knee and the leg. Draping done and lint marking taken and flap markings done along the axis of the flap in the middle 3rd calf region.

After inflating the tourniquet skin incision is done in the upper 3rd and middle 3rd junction of posterior calf region and the subcutaneous tissue is gently teased out for the identification of lesser saphenous vein. Once it is identified it is ligated and cut between the sutures and secured. Diathermy to be avoided. Then carefully incise the deep fascia and search for the sural nerve if it not in the suprafascial plane. The sural nerve will be seen in between the gastrocnemius muscle belly somewhat deeper which should not be left out and raise the flap.

If we left out the sural nerve and raise the flap below the deep fascia, we will encounter the nerve within a few mm of raising the flap piercing the deep fascia. If it happens so then we have to ligate the nerve between suture and divide it.

After identifying and ligating both lesser saphenous vein and sural nerve once again reassess the axis of the flap whether the marked axis is in the midline of flap going to be harvested. Reassessment of axis is done by the sural nerve and lesser saphenous (i.e.) the both structures should be in midline of flap.

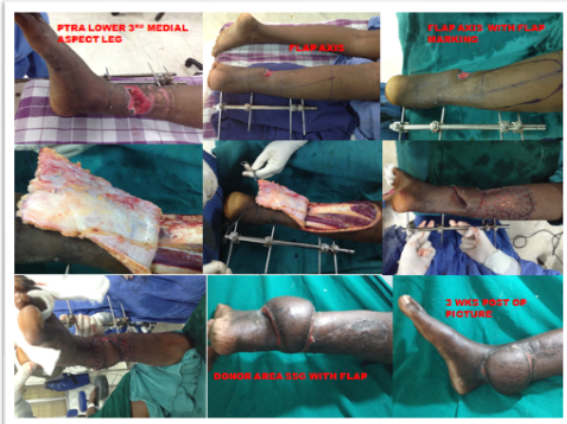


Fig 2: Case 1 – Medial Aspect of Lower 1/3rd leg

After reorienting the axis, flap incision are made incising skin subcutaneous tissue and deep fascia and two tagging suture including deep fascia are taken in the seam line of flap and these tagging suture to be hold with straight artery by the assistant. Now the flap can be raised below the deep fascia and any sizeable perforator or vein has to be ligated and divided. Never cauterize them. Never touch or hold the flap undersurface with the gloved hand as it may lead to contusion of all arborized plexus and leads to flap edema. We always used to have flap pedicle width not less than 4 cm. Once the flap elevation reaches the mid-3rd and lower-3rd junction pedicle width to be maintained. Narrowing the pedicle leads to congestion of flap as there are venous channel running parallel to lesser saphenous vein which will bypass

the LSV valve and drain directly into the deep peroneal vein .pedicle can be harvested either as fasciocutaneous or adipofascial and pedicle dissection should be stopped just above the pivot point marked area or at any point flap length is adequate. Once the flap elevated fully the under surface should be in prominent yellow color without any red streak. After elevating the flap it is replaced in position and saline soaked roller bandage is applied and tourniquet is released. Wait patiently for 20 minutes and assesses the viability. There should be slow sustained bleeding in dermal edge of the seam line of flap and more over there should not be edema in flap. If gross edema noted then the probability of venous congestion will be more going to be a complicating. Flap inset is given using 4-0 ethilon dermal sutures and donor area covered with SSG and secured with dressing.



Fig 3: Case 2 – Anterior aspect of ankle

Mild compression bandage dressing applied in pedicle area to avoid flap kinking with a window to inspect flap and the leg immobilized in BK slab. In our center, we raise the foot end of the cot to provide elevation and instruct the patient for lying in prone position. Flap is reassessed at 48 hours and 5th post-operative day. If there is no congestion problem on 4th or 5th day most likely flap settles well and division inset done after 3 weeks and referred to physiotherapy /orthopedic management.



Fig 4: Case 3 – Skin pedicle for tendoachilles region



Fig 5: Case 4 – Adipofascial pedicle for tendoachilles region



Fig 6: Case 5 – Dorsum of hind foot



Fig 7: Case 6 - Extended flap for weight bearing heel

RESULTS:

Out of total 34 patients, in 23 (68%) patients conventional reverse sural flap were done and in 11(32%) patients modification of reverse sural with delay procedure were done (depicted in Pie chart).

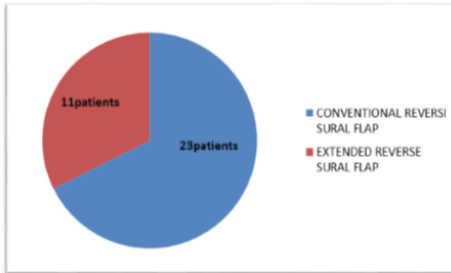


Fig 8: Types of RSA flaps done

Out of the 23 patients managed with conventional Reverse sural flap in 15 patients flap harvested with skin pedicle and in 8 patients flap harvested with adipofascial pedicle (depicted in Pie chart).

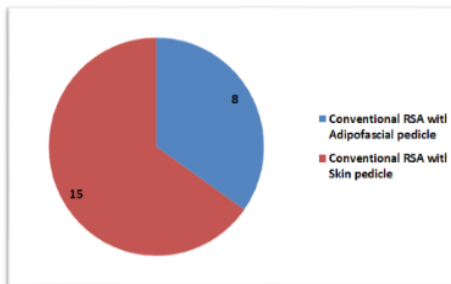


Fig 9: Types of pedicle used in conventional RSA flap

Out of these 23 patients where conventional reverse flap was done in 23(96%) patient flap settled well and in only 1(4%) patient had complication due to infection and dehiscence managed by debridement and advancement & appropriate antibiotics. Out of the 11 patients where modification of reverse sural flap done, in 7(63%) patients flap settles well and in 4(37%) patients had complications and in all these there was partial flap loss due venous congestion & they were managed by Cranes principle (depicted in Histogram).

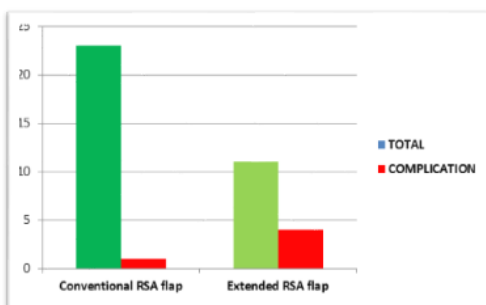


Fig 10: Complications observed

The Average total time of healing in conventional Reverse sural flap was about 40 days where as in Extended Reverse sural flap was about 53 days. The duration of Hospital stay in conventional Reverse sural flap patients was 20 days where as in extended flap patients was 27 days.

The areas of resurfacing by conventional Reverse sural flap and Extended Reverse sural was analyzed (depicted in Pie chart).

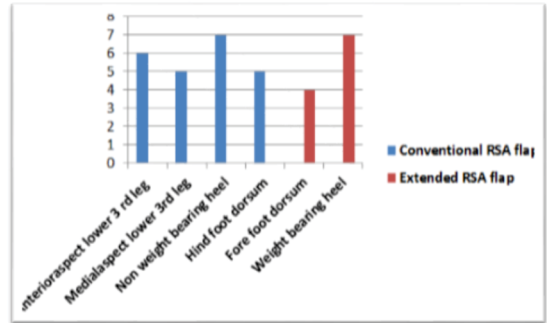


Fig 11: Defects covered by RSA flap

DISCUSSION:

In the angiosomal concept described by Taylor he mentioned vessels hitchhikes along with nerves. Based on this concept, vascularization of the superficial nerves of the leg was studied by Taylor and Ham. But little attention was paid at the time and Masquelet et al reported using colored latex injection in 1992 that the arteries accompanying the cutaneous nerve gives of several cutaneous arterial branches along the supra-fascial course and described the concept of neuro-skin island flap(1,2).

Median sural artery a constant branch arising from popliteal artery accompany the sural nerve just above or near the upper 3rd and middle 3rd junction of posterior aspect of leg and penetrates the deep fascia , runs supra fascially with lesser saphenous vein. Branches from the median sural artery form a plexus around the sural nerve and supply the skin subcutaneous tissue of the mid-3rd of the calf region. These suprafascial plexus arborizes both longitudinally and radially and anastomoses with septocutaneous perforators of peroneal artery in the distal 3rd of the leg laterally. This vascular network forms the basis of the sural flap. Apart from the above blood supply, the arteriosomes that supplying the lesser saphenous vein which accompany along the sural nerve also take part in providing vascularity for that area. Hence the reverse sural flap has three type of vascularity pattern (i.e) peroneal septocutaneous perforator, arterial plexus around sural nerve, arteriosomes of lesser saphenous vein. Yang and Morris reported that the size of vascular territory of the flap was relatively constant and upper margin of the flap was localized at a level 10 cm below the knee(3,4,5).

As the term REVERSE sural flap indicate, that the vascularity is by the reverse flow through the anastomosis between the peroneal artery and the vascular plexus accompanying sural nerve. Moreover, the venous drainage of the flap has to be established by the reverse flow pattern by the increasing pressure in venous return causes the venous valves to have back flow pattern which is a main disadvantage causing congestion in the flap.



Fig 11: Case 1 - Venous Congestion in flap

Imanishi *et al* , discovered a small caliber network of veins that surround the sural nerve, which allow the bypass of valves of the lesser saphenous vein. The lesser saphenous vein which drains into popliteal vein contains numerous valves that prevent retrograde blood flow. However, one or more smaller collateral veins that run parallel to the lesser saphenous vein have anastomotic connections to the lesser

saphenous vein, which can allow blood to bypass the valves of lesser saphenous vein and flow in a retrograde fashion and can drain directly from this small vein into the concomitant vein of a perforator from the peroneal artery or it can drain back into the lesser saphenous vein, which then drains into a similar concomitant vein (6,7).

Advantages of this flap are easy to raise with minimal blood loss, preservation of major vascular structure, long pedicle length with 90-180 deg arc of rotation.

Disadvantages of the flap are 1) patient has to lie in prone position causing discomfort, 2) loss of sensation in sural nerve distribution, 3) aesthetic problem and as stated above & 4) more prone for venous congestion (7,8,9,10).



Extended Reverse Sural Flap with Distal Necrosis in Weight bearing Heel.

Fig 11: Case 2 - Venous Congestion in flap

The operative technique for doing the conventional reverse sural flap is easy to learn and execute. By proper execution, 1) Anteromedial aspect of lower 3rd leg, 2) Posterior heel, 3) Dorsum of hind foot can be resurfaced without complications. In old age individuals, as the peroneal vessels are the last to undergo atherosclerosis, reverse flap can be executed safely. However when we plan to resurface the lateral aspect of foot below lateral malleolus area, weight bearing aspect of foot and forefoot dorsum which requires delay procedure, the chance of complications are expected to be more. In our study also we had complications of (37%) where modifications are carried out. Review of literatures also reveals the same. (10,11)

CONCLUSION:

Reverse sural artery fasciocutaneous flap harvested from its domain without any modification with meticulous surgical technique gives promising results in terms of less complication, less hospital stay, quicker healing time for resurfacing of the Anteromedial aspect of distal 3rd leg, Posterior heel and Dorsum of hind foot. There is no need to identify or isolate the pedicle during dissection of the flap. There is no age predisposition in the flap.

The learning curve for executing the flap is also easy. Its long pedicle helps in distalization of the flap and does not require sacrificing any major arteries. The base of the flap must be placed between 4-5cm & as dissection proceeds distally avoid venous channels damage. Though there is loss of sensation in sural nerve distribution areas and donor area scar is cosmetically unacceptable in female patients, the conventional reverse sural flap can be a workhorse flap for resurfacing the regions as enumerated earlier.

REFERENCES:

- 1). Taylor, G. I., & Palmer, J. H. (1987). The vascular territories (angiosomes) of the body: experimental study and clinical applications. *British journal of plastic surgery*, 40(2), 113-141.
- 2). Dolph, J. L. (1998). The superficial sural artery flap in distal lower third extremity reconstruction. *Annals of plastic surgery*, 40(5), 520-522.
- 3). Masquelet, A. C., Romana, M. C., & Wolf, G. (1992). Skin island flaps supplied by the vascular axis of the sensitive superficial nerves: anatomic study and clinical experience in the leg. *Plastic and reconstructive surgery*, 89(6), 1115-1121.
- 4). Nakajima, H., Imanishi, N., Fukuzumi, S., Minabe, T., Fukui, Y., Miyasaka, T., ... & Fujino, T. (1999). Accompanying arteries of the lesser saphenous vein and sural nerve: anatomic study and its clinical applications. *Plastic and reconstructive surgery*, 103(1), 104-120.
- 5). Yang, D., & Morris, S. F. (2002). Reversed sural island flap supplied by the lower septocutaneous perforator of the peroneal artery. *Annals of plastic surgery*, 49(4), 375-378.
- 6). Imanishi, N., Nakajima, H., Fukuzumi, S., & Aiso, S. (1999). Venous drainage of the distally based lesser saphenous-sural veno-neuroadipofascial pedicled fasciocutaneous flap: a radiographic perfusion study. *Plastic and reconstructive surgery*, 103(2), 494-498.
- 7). Bista, N., Shrestha, K. M., & Bhattachan, C. L. (2013). The reverse sural fasciocutaneous flap for the coverage of soft tissue defect of lower extremities (distal 1/3

- leg and foot). *Nepal Med Coll J [Internet]*, 15(1), 56-61.
- 7). Huisinga, R. L., Houpt, P., Dijkstra, R., & van Leeuwen Storm, J. B. (1998). The distally based sural artery flap. *Annals of plastic surgery*, 41(1), 58-65.
- 8). Baumeister, S. P., Spierer, R., Erdmann, D., Sweis, R., Levin, L. S., & Germann, G. K. (2003). A realistic complication analysis of 70 sural artery flaps in a multimorbid patient group. *Plastic and Reconstructive Surgery*, 112(1), 129-140.
- 9). Muppireddy, S., & R., S. (2016). Distally based reverse sural artery flap as an interpolation flap. *International Journal of Research in Orthopaedics*, 3(1), 61. doi:10.18203/issn.2455-4510.intjresorthop20164787
- 10). Hamdi, M. F., Kalli, O., & Khelifi, A. (2012). Experience with the distally based sural flap: a review of 25 cases. *The Journal of Foot and Ankle Surgery*, 51(5), 627-631.
- 11). Thawerani, S., Ansari, M. N. U. R., & Siddiqui, N. (2011). Minimizing complications in reverse sural artery flaps. *Pak J Surg*, 27(1), 2-7.