

VERSATILITY OF MEDIAL SURAL ARTERY PERFORATOR FLAP IN LOWER LIMB RECONSTRUCTION

Plastic Surgery

Dr Debraj Saha	MBBS, MS(General Surgery), MCh (Plastic Surgery), Institution-IPGMR, SSKM Hospital, Kolkata.
Dr Souvik Adhikari	MBBS, MS(General Surgery), MCh (Plastic Surgery), Institution-IPGMR, SSKM Hospital, Kolkata.
Dr Sweta	MBBS, MS(General Surgery), MCh(Plastic Surgery), Institution-IPGMR, SSKM Hospital, Kolkata.

ABSTRACT

Background: Gastrocnemius muscle flap is most commonly performed coverage option in proximal third leg defects and around knee joint. Having constant anatomy, a longer pedicle and decreased donor site morbidity, the Medial Sural Artery perforator flap represents a very good and reliable reconstructive alternative for lower limb reconstruction. **Methods:** This is a case series retrospectively examining outcomes of all patients receiving pedicled Medial Sural Artery Perforator Flap for lower limb reconstruction. Eleven cases of Medial Sural Artery perforator flap were performed in lower limb reconstruction. Six patients had exposed upper third tibia, two patients had middle third of exposed tibia and three patients had popliteal region defect that were reconstructed by this flap. Etiology of exposed tibia were road traffic accident and Post burn flexion contractures of the knee were due to accidental thermal burn. **Result:** The Mean distance of a dominant perforator is 9.13 cm from the mid-popliteal line. Average pedicle length was 6.77 cm. Donor sites were closed with split thickness skin graft in all cases. All our pedicled Medial Sural Artery Perforator Flap survived without any complications. 6week follow up, clinical examination revealed complete flap integration, satisfactory take of skin grafted donor areas in all cases with preserved function of gastrocnemius muscle and no sensory neuropathy such as hypoesthesia or neuroma. **Conclusion:** The Medial Sural Artery Perforator Flap is reliable and provides ideal tissue for soft-tissue reconstruction around the popliteal region and lower extremity mainly proximal two-thirds of tibial defects with minimal donor-site morbidity.

KEYWORDS

Medial Sural Artery, Perforator flap, Lower limb Reconstruction

Table 1 Summary Of Patient Data

Case	Age (yr)	Sex	Defect etiology	Site	Defect size	Pedicle length(cm)	Complications		Operative time (minutes)	Perforator dissected
							Flap related	Donor site related		
1	35	M	Trauma	Upper 1/3 tibia	25	6.5	Nil	Nil	110 mins	One
2	30	M	Trauma	Upper 1/3 tibia	30	6	Nil	Nil	115 mins	One
3	40	M	Trauma	Upper 1/3 tibia	36	6.5	Nil	Nil	120 mins	One
4	45	M	Trauma	Upper 1/3 tibia	30	6	Nil	Mild graft loss	105 mins	One
5	35	M	Trauma	Upper 1/3 tibia	36	6	Nil	Nil	110 mins	One
6	25	M	Trauma	Upper 1/3 tibia	25	6.5	Nil	Nil	106 mins	One
7	32	M	Trauma	Middle 1/3 tibia	30	7	Nil	Nil	110 mins	One
8	30	M	Trauma	Middle 1/3 tibia	25	7.5	Nil	Nil	120 mins	One
9	28	M	Burn	Popliteal region	36	7	Nil	Mild graft loss	125 mins	Two
10	34	F	Burn	Popliteal region	56	7.5	Nil	Nil	115 mins	Two
11	36	F	Burn	Popliteal region	42	8	Nil	Nil	110 mins	One

INTRODUCTION

Soft tissue defects around the upper third of leg with exposed bones, tendons and defects around popliteal region following release of burn scars always pose great challenge to reconstructive surgeons. Stable soft tissue coverage with full functional recovery is the primary goal. The Gastrocnemius muscle flap has proven reliable for reconstruction of soft tissue as a first choice flap [1, 2]. Whereas the functional consequences of muscle harvest seem to be minimal on normal gait, deficits in more demanding tasks such as fast or uphill walking have been identified [3,4]. Regional alternatives to this flap are distally based Vastus lateralis or gracilis flap, the proximally based peroneus longus muscle turn-over flap, distally based vastus medialis perforator flap, and the proximally based sural artery flap [5-11]. Their use has been infrequent because of the limited reliability, inadequate size for larger defects and poor aesthetic outcomes. Free flaps are safe, but their use is usually indicated if local flaps are not an option [12].

The general impetus for the use of perforator flap is to spare muscle tissue and thereby limit functional donor site morbidity. In contrast to traditional, often random-pattern fasciocutaneous flaps performed with limited mobility and frequent tip necrosis as a result, perforator-based flaps have a reliable blood supply and are associated with an excellent range of motion. The Medial Sural Artery Perforator Flap (MSAPF) provides thin fasciocutaneous tissue most similar to the normal soft tissue in the upper third leg, knee region and therefore its use leads to improved contour reconstruction and eliminates the sacrifice of muscles [13, 14]. Also, the arc of rotation of the MSAPF is increased after intramuscular dissection to main pedicle and the donor site closed with skin graft (STSG) without any sequel in many cases.

The anatomic basis of the MSAPF has previously been described [15-18], and it has mainly been used as a free flap for head and neck reconstruction but also for extremity reconstruction [19-21].

FLAP TERRITORY

The medial sural artery perforator (MSAP) fasciocutaneous flap was first described by Cavadis (2001) as a refinement of the medial gastrocnemius flap. The territory approximates to the medial half of the upper third of the posterior calf, an area of about 8x12 cm. It can be extended anteriorly to 2/3rd of the distance from the midline to the anterior tibial margin. It is a useful alternative to the radial forearm flap providing thin hairless tissue with relatively little donor site morbidity particularly when compared to the posterior tibial artery flap. Caution should be exercised in patients with peripheral vascular disease or diabetes mellitus. An analogous lateral sural artery perforator flap can be raised in most patients as an alternative.

VASCULAR ANATOMY

The Medial Sural Artery commonly arises from the popliteal artery (from a common sural trunk in up to 30%). After a few centimeters, the vessel enters and goes through the medial belly of the gastrocnemius muscle and some branches 'perforate' through to the skin. The Medial Sural Artery usually divides into lateral and medial branches, this usually occurs in the substance of the muscle (85%). Many surgeons prefer to use the lateral (nearer the midline) row of perforators due to the fact that it is usually dominant. Muscle devascularisation and function are not major concerns as there are other vascular supplies to the muscle apart from the Medial Sural Artery and the nerves are separated from the pedicle during dissection.

There are usually 2-4 perforators of about 1 mm diameter that are concentrated at an area 4.5 cm from the midline and 8-12 cm from the popliteal fossa crease. The first perforator is usually 8 cm along a line drawn from the middle of the popliteal crease to the medial malleolus. Markings should be made with the patient lying on their back and the knee flexed to 90 degrees. Note that frog-legging (external rotation of the hip) distorts the skin and vessel positions.

The artery is about 2 mm in diameter at its origin. Depending on the perforator chosen and amount of retrograde dissection, the pedicle ranges from 9-16 cm. The posterior cutaneous nerve of the thigh can be also harvested in instances where a sensate flap is required [31].

The Aim of the present study is to present the versatility of pedicled MSAPF in the soft tissue reconstruction of upper leg and popliteal defects from the result of a retrospective analysis of consecutive series.

MATERIAL AND METHODS

This is a case series retrospectively examining outcomes of all patients receiving pedicled Medial Sural Artery Perforator Flap for lower limb reconstruction and versatility of MSAPF. Between Jan 2020 to Jun 2020, 6 cases of exposed tibia in the upper third of leg with soft tissue defects, 2 cases of exposed tibia in the middle third of leg with soft tissue defects and 3 cases of soft tissue defects following release of post burn flexion contracture in the popliteal region were reconstructed by pedicled Medial Sural Artery Perforator Flap (MSAPF). Among eleven patients, nine were male and two were female. Three cases had post burn flexion contracture in popliteal region and eight cases had exposed tibia in all cases due to Road traffic accidents (RTA). Patient age ranged from 25 to 45 years (Mean- 33.63). The defect size ranged from 5x5 cm² to 8x7 cm² (TABLE 1) with mean value 33.72 cm².

Surgical Technique

We used handheld Doppler probe for preoperative identification of the perforator vessel in all cases. For orientation, a straight line between middle of the popliteal fossa and the medial malleolus was drawn [13] (Fig.1A, Fig.1B).

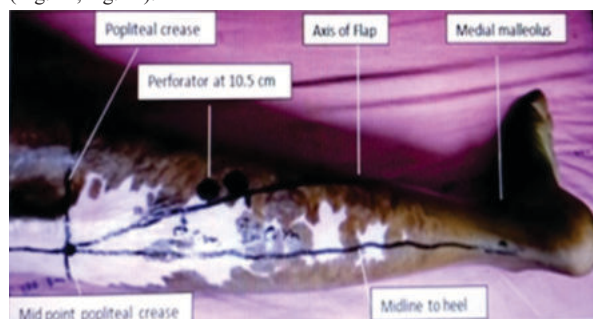


Fig .1A (Markings of the axis of Medial sural artery perforator flap and location of the perforators)



Fig .1B (Doppler is used to locate the perforator preoperatively)

After perforator identification, the requisite flap was drawn with the perforator in the midline in the proximal part of the flap so that maximum freedom of mobilization could be obtained. The patient placed in a lateral, prone or supine position according to the defect. The defect zones were debrided in eight cases of exposed Tibia and release of post burn flexion contracture of popliteal region also made. Then flap dissection begins and once the perforator vessel identified, the flap design verified and dissection completed (Fig.2A, Fig2B, Fig.2C).



Fig .2B (Flap inset done)



Fig .2A (MSAPF dissected with perforator to cover defect upper third left tibia)



Fig .2C (Donor site split thickness skin grafting done)

Microsurgical intramuscular preparation of the perforator and the pedicle was then performed until flap could easily be transferred into the defect (Fig.3A, Fig.3B, Fig. 3C).



Fig .3B (Immediate result after flap integration and full take of split thickness skin graft)



Fig .3A (Two perforator dissected of MSAPF to cover middle third tibia defect of right leg)



Fig .3C (Follow up after six months showing nice contour of flap)

Intramuscular dissection was tedious because numerous side branches of the perforator had to be ligated.

RESULTS

The average duration of operation was 113.27 minutes (Range is 105mins to 125mins). Perforator location were estimated in all cases from mid popliteal line. The Mean distance of the perforator is 9.13 cm from mid popliteal line with the range being 8cm to 10.5cm. Average pedicle length was 6.77 cm (Range being 6cm to 8cm). The donor sites were closed with split thickness skin grafting in all cases. We dissected two perforators in two cases one in middle third tibia defect and in one case of popliteal fossa reconstruction after release of post-burn flexion contracture of knee for better flap survival. All our pedicled Medial Sural Artery Perforator Flap survived without any tip necrosis or any venous congestion in the flaps (Fig.4A, Fig.4B).



Fig .4A (Excellent contour reconstruction of popliteal defect after release of post burn flexion contracture of knee by MSAPF)



Fig .4B (Follow up after six months showing good functional recovery)

No other Flap related complications happened. Donor site complications occurred in two cases in the form of mild graft loss that were managed conservatively by dressings only. The hospital stay after flap surgery was 7 days in all cases as we discharged all patients after two postoperative dressings. At the 6 week outpatient follow up examination, clinical examination revealed complete flap integration, satisfactory take of skin grafted donor areas in all cases, preserved function of gastrocnemius muscle and no sensory neuropathy such as hypoesthesia or neuroma. None of the patients required flap thinning or any other correction of the contour or scar. Walking of all patients without support were satisfactory (Fig.5A, Fig 5B). The mean duration of follow up was 6 months.



Fig .5A (Six month follow up , acceptable flap integration, and contour as well as minimal donor site distortion)



Fig .5B (Nice functional recovery in terms of motions around knee)

DISCUSSION

Perforator flaps replace muscle or musculocutaneous flaps in many different reconstructive areas. About the knee , the gastrocnemius flap has been largely accepted as the first choice for flaps [1]. However, as in the elbow, in the knee thin, soft, and pliable tissue is needed for optimal functional and aesthetic outcomes [22,23]. Many randomized controlled trial have proved that Muscle flap have got no extra benefit over Fasciocutaneous flap in terms of coverage of exposed bones of extremity.

The pedicle length and arc of motion of the fasciocutaneous flap are superior in comparison to the gastrocnemius muscle flap, even though the muscle is completely mobilized. The maximum pedicle length in our case series is 8 cm. A maximum pedicle length of 25 cm [13] and 1 to 4 medial sural artery perforator have been consistently described in literature [18,24,25] and make the Medial Sural Artery Perforator Flap very reliable.

Flap dimension and versatility of Medial Sural Artery Perforator Flap offered great advantage to be adapted to the size of the defect, which is not possible with gastrocnemius muscle flap. In our case series maximum defect size was 8x7cm (56cm²) that nearly collaborates with flap dimension. In the literature, flap size of 15 cm width and 23 cm in length have been described [26].

Most of the defects in popliteal area (knee) and upper two-third of leg are shallow and the thin fasciocutaneous tissue like MSAPF leads to optimal flap integration and better contour reconstruction as well (Fig-). Secondary debulking procedures and denervation as seen with muscle flap are unnecessary and were not required in any of the patients of my study, hence suggesting a high level of patient satisfaction.

The great freedom in flap design, as well as dissecting a long pedicle, permits early ambulation and mobilization of the knee and leg without the risk of suture pull-out or skin graft loss.

In this retrospective review of our case series, we confirmed the reliability of the pedicle Medial Sural Artery Perforator Flap in the post traumatic upper two-third leg defect and popliteal defect following release of post burn flexion contractures of knee.

Early case series by Umemoto et al. [27], Shim et al. [28], and Kim et al. [29] confirmed and illustrated the reliability and reach of the pedicled MSAPF in the reconstruction of knee and proximal third of the leg. Although Umemoto et al. did report of a case of middle third anterior leg reconstruction using pedicled MSAP flap , the conventional flap design necessitated the inclusion of tissue over the Achilles tendon distally. In a review by Xie and Chai [30], It was implied that Shim et al. [28] showed that pedicled MSAPF was able to reach three quarters of the anterior leg. A detailed review of the paper by Shim et al. revealed that although one of the diagram in the paper did seem to allude to such claims, no middle-third leg defect case was presented in the paper nor was there a clarity in terms of explaining the technique of flap design to effectively reach the middle third anterior leg defects.

Advantages

On the basis of all these studies, the advantages of Medial sural artery perforator flap (MSAPF) are as follows

- 1] Medial sural artery perforator flap (MSAPF) is a thin fasciocutaneous flap even in the most obese patients, thus avoiding secondary debulking risks and second surgery
- 2] MSAPF is less hair bearing hence providing good aesthetic
- 3] Consistent location of the perforators
- 4] Flap harvest possible in either prone or supine position
- 5] Minimal damage to the medial gastrocnemius muscle.

Disadvantages

Proficient microsurgical skill is mandatory and donor site is closed with split thickness skin graft are the main disadvantages of this flap surgery.

CONCLUSION

The Medial Sural Artery Perforator Flap is reliable and provides ideal soft tissue for soft-tissue reconstruction about the popliteal region and lower extremity mainly proximal two-third of tibial defects with minimal donor-site morbidity. Intramuscular blood-vessel dissection allows an extended pedicle length and arc of rotation with a 360 degree range of motion, which permits adequate coverage of most defects about knee and lower extremity. The use of a Medial Sural Artery Perforator Flap allows the reconstruction of large defects, with a low complication rate. No secondary debulking procedures are necessary. The Medial Sural Artery Perforator Flap is therefore our first choice for pedicled flap soft-tissue reconstruction about the knee and lower extremity and has supplanted the gastrocnemius muscle flap.

Conflict Of Interest- Nil

REFERENCES

- 1] Rao AJ, Kempton SJ, Erickson BJ, Levine BR, Rao VK. Soft tissue reconstruction and flap coverage for revision total knee arthroplasty. *J Arthroplasty*.2016 Jul; 31(7):1529-38. Epub 2016 Mar 31.
- 2] Tetreault MW, DellaVella CJ, Bohl DD, Lodha SJ, Biswas D, Wysocki RW. What factors influence the success of medial gastrocnemius flaps in the treatment of infected TKAs, *Clin Orthop Relat Res*. 2016 Mar;474(3):752-63. Epub 2015 Nov 16.
- 3] Lasserre G, Cornu JY, Vidal C, Laveaux C, Lepage D, Obert L, Pauchot J, Tropet Y.[Baropodometric analysis of the functional donor-site morbidity after gastrocnemius or soleus muscle flap procedure].*Ann Chir Plast Esthet*.2011 Jun;56(3):180-93. Epub 2011 Mar 26. French.
- 4] Kramers-de Quervain IA, Lauffer JM, Kach K, Trentz O, Stussi E. Functional donor site morbidity during level and uphill gait after gastrocnemius or soleus muscle-flap procedure. *J Bone Joint Surg Am*. 2001 Feb; 83(2):239-46.
- 5] Wagner T, Hupkens P, Slater NJ, Ulrich DJO. The proximally based long peroneal muscle turnover flap: a novel salvage flap for small to medium-sized defects of the knee. *J Plast Reconstr Aesthet Surg*. 2016 Apr; 69(4):533-7. Epub 2015 Nov 25.
- 6] Aurgean JC, Begue T, Tomeno B, Masqualet AC. Distally based Vastus lateralis muscle flap: a salvage alternative to address complex soft tissue defects around knee. *Orthop Traumatol Surg Res*. 2010 Apr; 96(2); 180-4
- 7] Sahasrabudhe P, Panse N, Baheti B, Jadav A, Joshi N, Chandanwale A. Reconstruction of complex soft-tissue defects around the knee joint with distally based split vastus lateralis musculocutaneous flap: a new technique. *J Plast Reconstr Aesthet Surg* 2015 Jan; 68(1):35-9. Epub 2014 Sep 28.
- 8] Mitsala G, Varey AHR, O'Neill JK, Chapman TW, Khan U. The distally pedicled gracilis flap for salvage of complex knee wounds. *Injury*. 2014 Nov; 45(11):1776-81. Epub 2014 Jun 28.
- 9] Zheng HP, Lin J, Zhuang YH, Zhang FH. Convenient coverage of soft tissue defects around the knee by the pedicled vastus medialis perforator flap. *J Plast Reconstr Aesthet Surg*. 2012 Sep; 65(9):1151-7. Epub 2012 Apr 13.
- 10] Tiengo C, Macchi V, Vigato E, Porzionato A, Stecco C, Azzena B, Morra A, De Caro R. Reversed gracilis pedicle flap for coverage of a total knee prosthesis. *J Bone Joint Surg Am*. 2010 Jul 7; 92(7):1640-6.
- 11] Cheon SJ, Kim IB, Park WR, Kim HT. Proximally based sural artery flap for coverage of soft tissue defects around the knee and on the proximal third and middle third of the lower leg: 10 patients followed for 1-2.5 years. *Acta Orthop*. 2008 Jun; 79(3):370-5.
- 12] Hierner R, Reynders-Frederix P, Bellemans J, Stuyck J, Peeters W. Free myocutaneous latissimus dorsi flap transfer in total knee arthroplasty. *J Plast Reconstr Aesthet Surg*. 2009 Dec; 62(12):1692-700. Epub 2008 Dec 13.
- 13] Shim JS, Kim HH. A novel reconstruction technique for the knee and upper one third of lower leg. *J Plast Reconstr Aesthet Surg*. 2006; 59(9):919-26; discussion 927. Epub 2006 Apr 21.
- 14] Umemoto Y, Adachi Y, Ebisawa K. The sural artery perforator flap for coverage of defects of the knee and tibia. *Scand J Plast Reconstr Surg Hand Surg*. 2005; 39(4):209-12.
- 15] Hallock GG. Anatomic basis of the gastrocnemius perforator-based flap. *Ann Plast Surg*. 2001 Nov; 47(5):517-22.
- 16] Cavadas PC, Sanz-Gimenez-Rico JR, Gutierrez-de la Camara A, Navarro-Monzonis A, Soler-Nomdedeu S, Martinez-Soriano F. The medial sural artery perforator free flap. *Plast Reconstr Surg*. 2001 Nov; 108(6):1609-15; discussion 1616-7
- 17] Wong MZ, Wong CH, Tan BK, Chew KY, Tay SC. Surgical anatomy of the medial sural artery perforator flap. *Plast Reconstr Microsurg*. 2012 Oct; 28(8):555-60. Epub 2012 Jun 28.
- 18] Kosutic D, Pejovic B, Anderhuber F, Vadrnjak-Donlagic S, Zic R, Gulic R, Krajnc I, Solman L, Kocbek L. Complete mapping of lateral and medial sural artery perforators: anatomical study with duplex-Doppler ultrasound correlation. *J Plast Reconstr Aesthet Surg*. 2012 Nov; 65(11):1530-6. Epub 2012 May 29.
- 19] Hallock GG. Medial sural artery perforator free flap: legitimate use as a solution for the ipsilateral distal lower extremity defect. *J Reconstr Microsurg*. 2014 Mar; 30(3):187-92. Epub 2013 Oct 10.
- 20] Hsiao JC, Deek N, Lin CH, Lin YT, Wei FC, Lin CH. Versatility of the Medial sural artery perforator flap: experience with 200 consecutive cases. *Plast Reconstr Surg*. 2015 Oct; 136(4) (suppl):17.
- 21] Ives m, Mathur B. Varied uses of the Medial sural artery perforator flap. *J Plast Reconstr Aesthet Surg* 2015; 68(6):853-8. Epub 2015 Feb 17.
- 22] Camuzard O, Foissac R, Clerico C, Fernandez J, Balaguer T, Ihrai T, de Peretti F, Baque P, Boileau P, Georgiou C, Bronsard N. Inferior cubital artery perforator flap for soft tissue coverage of the elbow: anatomical study and clinical application. *J Bone Joint Surg Am*. 2016 Mar 16; 98(6):457-65.
- 23] Wettstein R, Helmy N, Kalbermatten DF. Defect reconstruction over the olecranon with distally extended lateral arm flap. *J Plast Reconstr Aesthet Surg*. 2014 Aug; 67(8):1125-8. Epub 2014 May 10.
- 24] Dusseldorp JR, Pham QJ, Ngo Q, Gianoussos M, Moradi P. Vascular anatomy of the medial sural artery perforator flap: a new classification system of intra-muscular branching patterns. *J Plast Reconstr Aesthet Surg*. 2014 Sep; 67(9):1267-75. Epub 2014 May 20.
- 25] Thione A, Valdatta L, Buoro M, Tuinder S, Mortarino C, Putz R. The medial sural artery perforators: anatomic basis for a surgical plan. *Ann Plast Surg*. 2004 Sep; 53(3):250-5.
- 26] Kim KS, Kim ES, Hwang JH, Lee SY. Medial sural perforators plus island flap: a modification of the medial sural perforator island flap for the reconstruction of postburn knee flexion contractures using burned calf skin. *J Plast Reconstr Aesthet Surg*. 2012 Jun; 65(6):804-9. Epub 2012 Feb 9.
- 27] Umemoto Y, Adachi Y, Ebisawa K. The sural artery perforator flap for coverage of defects of the knee and tibia. *Scand J Plast Reconstr Surg Hand Surg* 2005; 39(4):209-12.
- 28] Shim JS, Kim HH. A novel reconstruction technique for the knee and upper one third of lower leg. *J Plast Reconstr Aesthet Surg* 2006; 59(9) 919-26-discussion 927.
- 29] Kim HH, Jeong JH, Seul JH, Cho BC. New design and identification of the medial sural perforator flap: an anatomical study and its clinical applications. *Plast Reconstr Surg* 2006; 117(5):1609-18.
- 30] Xie XT, Chai Y-M. Medial sural artery perforator flap. *Ann Plast Surg* 2012; 68(1): 105-10.
- 31] Dissection Manual, CU Medicine Hong Kong by Tor Chiu chapter 12