

Anatomical Variations of Medial Sural Artery and Its Perforators in Indian Population: A Prospective Clinical Study

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Abstract:

Introduction: MSAP flap is a versatile fasciocutaneous flap and has been being effectively used in treatment of small to moderate size defects especially in head and neck region by plastic surgeons worldwide. It is thin and pliable; therefore, it is a suitable alternative to Radial Forearm flap with much lower donor site morbidity. Previous anatomic studies have sought to identify the location of the medial sural artery and its perforators. This study's detailed metrics offer a user-friendly insight into the distribution of perforators and the branching pattern of the medial sural artery.

Objective: The present study was undertaken to describe the anatomical variations of medial sural artery and its perforators in the Indian population. The information gleaned from this clinical study on the vascular anatomy of the medial sural artery will aid plastic surgeons in developing practical approaches for harvesting the MSAP flap.

Methods: A prospective observational study for a period of 2 years was devised. 19 individuals (17 males and 2 females) who underwent reconstruction of tissue defects with MSAP flap were included in the study. Subjects were of ages ranging from 6 to 71 years.

Results: An average of 1.47 perforators (range 1 to 3) were found to pierce the medial gastrocnemius muscle in each lower limb. At least one major perforator (≥ 1 mm) was identified in all individuals. Average pedicle length from division of medial sural artery up to emergence of perforators was 7.42 cm (range 4.5 to 10 cm). Average perforator distance from popliteal crease was 9.18 cm (range 4 to 16 cm). The distance of perforators from the posterior midline was 2 cm.

Discussion: Despite benefits of MSAP flap, reservations hindering its application relate to the variability in vascular anatomy of medial sural artery and the necessity for intramuscular dissection. Thus, understanding the anatomy of the medial sural artery is crucial for effectively raising a sufficient MSAP flap. The utilization of handheld Doppler emerges as a valuable tool for identifying primary perforators at anatomical sites.

Conclusion: Challenges associated with the MSAP flap include the extensive intramuscular dissection and the need to ligate muscular branches, contributing to the potential tediousness of the procedure. Another limitation is that the vascular anatomy of medial sural artery perforators was not consistent and exhibited variability among different patients.

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Introduction

The first efforts to determine the vascular anatomy of the medial sural artery perforator (MSAP) flap specifically as a "perforator flap" were initially by Cavadas et al [1]. MSAP flap is a versatile fasciocutaneous flap and has been being effectively used in treatment of small to moderate size defects especially in head and neck region by plastic surgeons worldwide. It is thin and pliable; therefore, it is a suitable alternative to Radial Forearm flap with much lower donor site morbidity. Previous anatomic studies have sought to identify the location of the

medial sural artery and its perforators.

The medial sural artery originates from the middle third of popliteal artery [2] and is the dominant supply of the medial head of gastrocnemius muscle. It divides into two branches in the substance of the muscle, a medial and a lateral branch [3], forming an inverted 'V'. Perforators of about 1 mm diameter arise from medial sural artery which supply the skin [1]. Number of perforators arising from medial sural artery is variable and the distance of perforators from the midline and popliteal fossa

crease is also variable among different populations. The first perforator is usually 8 cm along a line drawn from the middle of the popliteal crease to the medial malleolus [4] Although their approximate distances from the popliteal crease and midline have been described in many studies, still it remains difficult to predict its location preoperatively.

This is particularly important when a small flap is needed, as the flap needs to be centered exactly over the dominant perforator. There is a notable absence of comprehensive studies on the vascular anatomy of the medial sural artery and its perforators in the Indian context. This study's detailed metrics offer a user-friendly insight into the distribu-

tion of perforators and the branching pattern of the medial sural artery. Such information serves as a valuable resource for surgeons, facilitating the development of convenient strategies for harvesting the medial sural artery perforator (MSAP) flap within the Indian population.

Objective

The present study was undertaken to describe the anatomical variations of medial sural artery and its perforators in Indian population. The information gleaned from this clinical study on the vascular anatomy of the medial sural artery will aid plastic surgeons in developing practical approaches for harvesting the MSAP flap.



Figure 1:



Figure 2:

A 22 year old male with history of motorcycle wheel spoke injury presented with a defect of 7x6 cm over the medial aspect of right heel. Unhealthy granulation tissue was present over the defect site.

Methods

A prospective observational study for a period of 2 years was devised at Rama Medical College Hospital, Hapur from October 2021 to October 2023. 19 individuals (17 males and 2 females) who underwent reconstruction of tissue defects with MSAP flap were included in the study.

Subjects were of ages ranging from 6 to 71 years. Preoperatively, the path of the medial sural artery and its branching perforators were marked using a handheld audio Doppler study. During the surgical procedure, intra-operative dissection was employed to comprehend the course of the medial sural artery.

Anatomical analysis was conducted using the two aforementioned techniques to identify the location, number and size of medial sural artery and its perforators. Emergence of perforator from lateral or medial branch was noted. Pedicle length was

measured from the division of medial sural artery up to the merging of perforators. The distance of

perforators from the popliteal crease and lateral distance from the midline was recorded.



Figure 3: Perforator marking using Doppler



Figure 4: Intraoperative perforator dissection



Figure 5: Perforator length measurements



Figure 6: Well settled flap 3 months post

Results

Table 1:

Parameter	Range	Mean
Age (in years)	6-71	34.68
Flap length (in cms)	7-18	12.73
Flap width (in cms)	4-8	6.05
No. of perforators/flap (n = 28)	1-3	1.47
Distance from popliteal crease (in cms)	4-16	9.18
Pedicle length (in cms)	4.5-10	7.42
Distance from midline (in cms)	1-4.5	2.175

An average of 1.47 perforators (range 1 to 3) was found to pierce the medial gastrocnemius muscle in each lower limb. At least one major perforator (≥ 1 mm) was identified in all individuals. Majority of the patients (11 out of 19) had one single perforator (57%). 7 out of 19 subjects had 2 sizable perforators (39%). Only one individual had total 3 perforators which was 5.2% of the total cases. The medial sural artery originated from the popliteal artery. After running for a distance of 3 to 6 cm, the

medial sural artery typically divided into two branches (a medial and lateral branch) within the substance of the medial gastrocnemius muscle. 74% of the perforators were arising from the lateral branch. Perforators were given off at intervals along the course of each branch, and these musculocutaneous perforators supplied the skin over the medial calf. Average pedicle length from division of medial sural artery up to emergence of perforators was 7.42 cms (range 4.5 to 10 cm).

Table 2:

Number and percentage of perforators found per flap.		
No. of perforators per flap	Number of cases	Percentage of cases
1	11	57%
2	7	36%
3	1	5.2%

Average perforator distance from popliteal crease was 9.18 cm (range 4 to 16 cm). The distance of perforators from the posterior midline was 2 cm (range 1 cm to ≥ 3 cm) on average. Perforators were more plentiful and larger in the lateral row, which was situated closer to the posterior midline of the leg. 17.8% of the perforators (n = 5) were

arising at 1 cm distance from the posterior midline and 57% of perforators (n = 16) were arising within to 2.5 cm distance from the posterior midline. Only 25% of the perforators were arising at the distance more than or equal to 3 cm from the posterior midline (n = 7). Perforators diminished in numbers while moving away from the posterior midline.

Table 3:

Number and percentage of perforators found according to the distance from midline.		
Distance from midline(in cms)	Number of perforators(Total = 28)	Percentage of perforators(%)
1	5	17.8 %
1.5	3	10.7%
2	11	39.2%
2.5	2	7.1%
>/= 3	7	25%

Discussion

The utilization of free flaps in reconstructive surgery has become widespread. Perforator flaps offer numerous benefits compared to conventional musculocutaneous flaps. They preserve muscle instead of integrating it into the flap, thus there is reduced weakness and morbidity at the donor site.

The MSAP flap, also classified as a free flap, is distinguished by its thin and pliable nature, long vascular pedicle, minimal presence of hair-bearing skin, and ease of dissection. Introduced in 2001 by Hallock [5] and independently by Cavadas [1], the MSAP flap demonstrated considerable promise in addressing regional and distant defects. This flap, known for sparing muscle and minimizing donor morbidity, boasts superior pedicle length and rotation arc compared to the conventional medial gastrocnemius myocutaneous flap [6], thanks to its intramuscular dissection. Its versatility is evident as it serves as a pedicled flap for knee and upper lower leg defects, and as a free flap for head, neck, and limb reconstruction [7]. Despite its benefits, reservations hindering its application relate to the variability in vascular anatomy of medial sural artery and the necessity for intramuscular dissection. Thus, understanding the anatomy of the medial sural artery is crucial for effectively raising a sufficient MSAP flap.

The utilization of handheld Doppler emerges as a valuable tool for identifying primary perforators at anatomical sites. It offers an accessible and uncomplicated mapping method, a sentiment shared by He et al, who also advocated for Doppler sonography in perforator mapping [8]. Shen et al. additionally stated that the handheld Doppler is an affordable and dependable tool for marking perforators [9].

Conclusion

The detailed metrics presented in this study offer convenient insights into the distribution of perforators and the branching pattern of the medial sural artery. Handheld Doppler is a reliable device for mapping the perforators. After studying the vascular anatomy in Indian population, we found that the medial sural artery divides into two branches shortly after it pierces the medial gastrocnemius muscle: a medial and a lateral branch.

These two branches traverse vertically down the muscle and give off on an average 1 to 3 musculocutaneous perforators which are of varying distance (1 to ≥ 3 cm) from the posterior midline of the leg. The lateral row perforators are commonly larger and more dominant. We also discovered the medial sural artery perforators to be located at an average of 9.18 cm from the popliteal crease with average pedicle length of 7.42 cm which is good enough to raise an adequate flap. The advantage is that due to good vascular pedicle length and adequate number of perforators the flap can be completely islanded thus making it useful for regional and distant defects.

The intramuscular dissection is completed in the usual manner using perforator flap techniques. To effectively locate and safeguard the primary perforator during dissection the initial incision should commence from the posterior midline while elevating the flap.

Challenges associated with the MSAP flap include the extensive intramuscular dissection and the need to ligate muscular branches, contributing to the potential tediousness of the procedure. Another limitation is that the vascular anatomy of medial sural artery perforators was not consistent and exhibited variability among different patients. The insights provided into the vascular anatomy of the medial sural artery by this clinical study will assist plastic surgeons in formulating pragmatic strategies for harvesting the MSAP flap in the Indian population.

References

1. Cavadas PC, Sanz-Giménez-Rico JR, Gutierrez-de la Cámara A, Navarro-Monzonis A, Soler-Nomdedeu S, Martínez-Soriano F. The medial sural artery perforator free flap. *Plast Reconstr Surg.* 2001; 108(6):1609-1617.
2. Morain W D. New York, NY: Springer-Verlag; 1983. [Translator], Carl Manchot: The Cutaneous Arteries of the Human Body [Introduction]: 112.
3. 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; 53(3):250-255.
4. 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):1609-1618.
5. Hallock GG. Anatomic basis of the gastrocnemius perforator-based flap. *Ann Plast Surg.* 2001; 47(5):517-522.
 6. 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):919-927.
 7. Kim ES, Hwang JH, Kim KS, Lee SY. Plantar reconstruction using the medial sural artery perforator free flap. *Ann Plast Surg.* 2009; 62(6):679-684.
 8. He Y, Jin SF, Zhang ZY, Feng SQ, Zhang CP, Zhang YX. A prospective study of medial sural artery perforator flap with computed tomographic angiography-aided design in tongue reconstruction. *J Oral Maxillofac Surg.* 2014; 72(11):2351-2365.
 9. Shen XQ, Lv Y, Shen H, Lu H, Wu SC, Lin XJ. Endoscope-assisted medial sural artery perforator flap for head and neck reconstruction. *J Plast Reconstr Aesthet Surg.* 2016; 69(8): 1059-1065.