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Anatomical study on perforators of the medial and lateral sural artery in Asians

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SUMMARY

Forty-seven formolized lower limbs of adult Asians were used. The number and location of perforating vessels clearly coming from the medial and lateral sural arteries (not from the superficial sural arteries or peroneal artery) were recorded in the present study. From one to five perforating branches from the medial sural artery were found in all specimens. However, perforating branches from the lateral sural artery were absent in 57% of the specimens. In the medial sural arteries, no perforators were found more than 5 cm above or 17.5 cm below the popliteal crease. All perforators gathered in an area between 0.5 cm and 4.5 cm from the midline of the gastrocnemius muscles. Due to the differences in the length of the muscle berry, the distribution of perforating branches from the medial sural artery might be different between white people and Asians. Since the distribution of the perforators from

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medial and lateral sural artery and the anatomical comparison of the perforators of the medial sural artery between Asians and Caucasians were clarified in this study, the safe elevation of this flap in Asians should therefore now be simpler to perform.

Key Words: perforator flap, medial sural artery, lateral sural artery, Asian, anatomy

INTRODUCTION

Soft tissue coverage of the upper and lower extremity after a trauma or the management of a malignant tumor has been an ongoing challenge for the plastic and reconstructive surgeon. The medial or lateral gastrocnemius muscle or musculocutaneous flap has been widely accepted as being useful for soft tissue coverage in a lower extremity.

The principle that the skin overlying certain muscles can be transferred reliably with that muscle as a musculocutaneous flap has been well recognized. This is the result of the presence of musculocutaneous perforators. If those perforators were dissected carefully separate from the muscle, all muscle could be excluded from the skin flap and function would be preserved [1, 2].

To provide a reconstructive site with esthetic and functional refinement in a single stage, many authors have described several perforator flaps and covering a tissue defect in a distal limb. Thin perforator flaps from an extremity or the back are useful for resurfacing shallow defects of the distal limbs [3, 4].

The medial and lateral sural arteries, which supply the each head of the gastrocnemius muscle, give off some myocutaneous perforators that supply the skin of the posterior calf. A perforator flap can be raised with this vessel without sacrificing the gastrocnemius muscle [5-7].

However, there have been a few anatomical studies comparing the medial and lateral sural artery perforator flap in the West [5, 8, 9]. There has so far been no large anatomical study comparing the medial and lateral perforator of the sural artery.

The differences of physical structure between Caucasians and Asians are great. Asians tend to be of shorter and lower skeletal muscle mass than Caucasians [10, 11]. Asian operations based upon Caucasian anatomical data may run the risk of injury to important perforators, or the flap design may result in failure. The purpose of this article was to clarify the anatomy of the perforator of the medial and lateral sural artery and to facilitate sculpturing of the perforator flap in Asian patients.

MATERIALS AND METHODS

Forty-seven formolized lower limbs from cadavers of adult Asians were used for the study. The skin was incised along the posterior midline following the cleft between the medial and lateral heads of the gastrocunemius muscles and then retracted in a subfascial plane that essentially was traversed only by deep fascial perforators. The number and location of perforating vessels were recorded, expressed in centimeters, from the popliteal crease and from the posterior midline. Only perforating vessels clearly coming from the medial and lateral sural arteries (not from the superficial sural arteries or peroneal artery) were recorded in the present study (Figure 1). The length of each pedicle and diameter of each perforator were then measured. The origin of the sural artery was investigated based on the number of vascular pedicles coursing into the gastrocnemius muscle bellies.

The present study was conducted within the parameters of the written permissions we received from the donors and their surviving relatives. The protocol for the present research did not include any specific issues that needed to be approved by the Ethics Committees of our institution. The present work conformed to the provisions of the Declaration of Helsinki in 1995 (as revised in Edinburgh in 2000).

Figure 1. In this specimen, there were four perforators from medial sural artery (**) and one perforator from lateral sural artery (++). * = medial sural artery; + = lateral sural artery; ◎ = perforators from superficial sural artery.

RESULTS

Perforating branches from the medial sural artery were found in all 47 specimens, the mean being 2. 4, range 1-5 (Table Ⅰ). No perforators were found more than 5 cm above or 17. 5 cm below the popliteal crease (Figure 2). The musculocutaneous perforating branches were located a mean (SD) of 11. 7 (2. 7) cm from the popliteal crease. In the most frequent situation (38. 3%) in which 2 perforators were found, the proximal one was an average 9. 6 cm (range, 5. 5 cm to 12. 5 cm) away from the popliteal crease and the distant one an average 13. 1 cm (range, 9. 3 cm to 16. 2 cm). All perforators were gathered in an area between 0. 5 cm and 4. 5 cm from the midline of the gastrocnemius muscles (Figure 3) and 102 out of 111 arose between 0. 5 cm and 3 cm from the midline. However, several perforators arising

Table Ⅰ. Number of perforators.

Number of perforators	Number(%) of cases (medial sural artery)	Number(%) of cases (lateral sural artery)
0	0 (0)	27 (57.4)
1	11 (23.4)	11 (23.4)
2	18 (38.3)	5 (10.6)
3	10 (21.3)	4 (8.5)
4	6 (12.8)	0 (0)
5	2 (4.3)	0 (0)

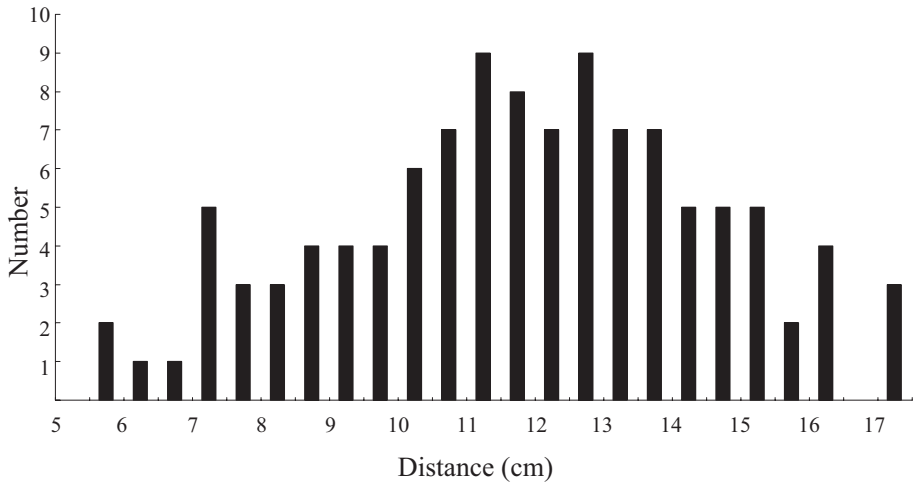

Figure 2. Distribution of perforators from medial sural artery according to distance from popliteal crease.

near the midline traversed a variable distance toward the skin over the midline of the gastrocnemius muscles. The external diameter of the vein in the perforating bundle was slightly larger (mean, 0. 9 mm; range, 0. 2 to 2. 0 mm) than the artery (mean, 0. 8 mm; range, 0. 2 to 2. 0 mm).

Perforating branches from the lateral sural artery were absent in 27 specimens (57. 4%) (Table Ⅰ). In other specimens, perforators ranged from one to three in number. The perforating branches were located between 2. 0 cm and 17. 0 cm from the popliteal crease (Figure 4), between zero cm and 4. 0 cm from the midline of the gastrocnemius muscles (Figure 5).

According to Potparic's classification [12], Type 1; a single artery (medial or lateral sural artery) supplying the ipsilateral gastrocnemius muscle belly, was present in 89% (Table Ⅱ).

The average external diameter of the medial and lateral sural artery after separation from the popliteal artery was 2. 5 mm (range 2. 0-3. 5) and 2. 2 mm (range 1. 5-3. 5), respectively. The mean length of pedicle from the bifurcation of the medial and lateral sural artery to the skin was 14. 6 cm (range 7. 7-20. 7) and 12. 6 cm (range 4. 0-15. 8), respectively.

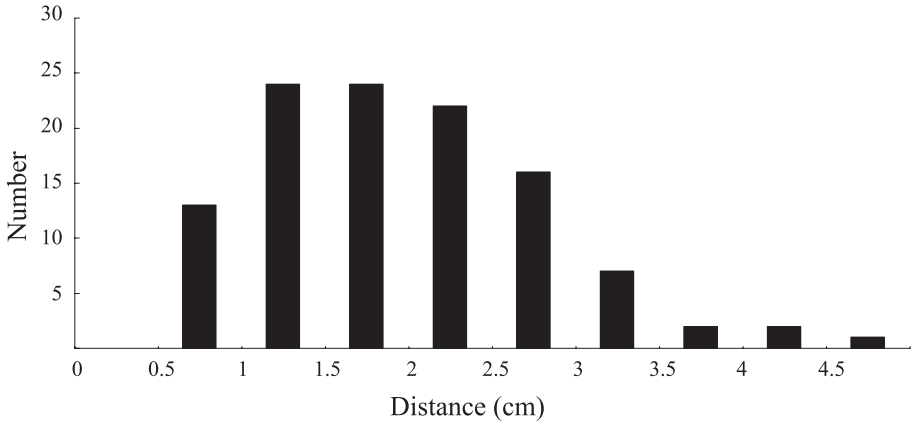

Figure 3. Distribution of perforators from medial sural artery according to distance from posterior midline.

Table Ⅱ. Vascular types of sural artery.

Type	Number(%) of cases
1A	39(83.0)
1B	3 (6.4)
2A	4 (8.5)
2B	1 (2.1)
2C	0 (0)

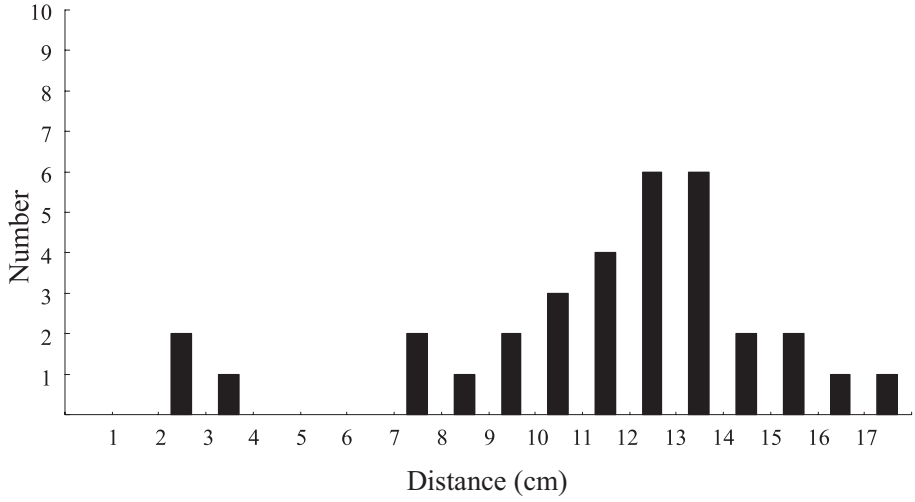

Figure 4. Distribution of perforators from lateral sural artery according to distance from popliteal crease.

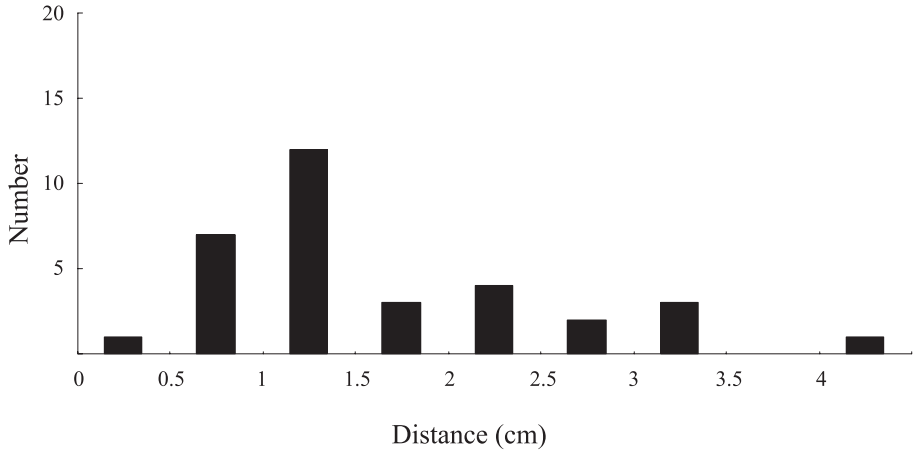

Figure 5. Distribution of perforators from lateral sural artery according to distance from posterior midline.

DISCUSSION

The medial or lateral gastrocnemius musculocutaneous flap has been used extensively for soft tissue coverage of the proximal third of the tibia and anterior and medial aspect of the knee. Although this musculocutaneous flap is reliable and technically easy, it is bulky due to the thickness of the muscle involved. This may sometimes be a disadvantage and the removal of the gastrocnemius muscle results in a weakness of the leg. The morbidity caused by the sacrifice of the gastrocnemius muscle has been reported to account for about a 10% loss of jumping power [5]. The bulkiness and donor-site morbidity often preclude its use for

resurfacing shallow defects in a distal limb.

The concept of perforator vasculature to circulation in flaps was first suggested by Fujino in the 1960s [13]. Perforator flaps were later masterfully developed and became more popular under Koshima [1, 2] and Kroll and Rosenfield [14].

The anatomy of the posterior calf region has been described previously [15, 16]. The blood supply to the skin of the posterior leg is derived from two sources; one is the perforating artery that arises from the popliteal and posterior tibial arteries and the other the axial artery that originates from the popliteal, sural and geniculate arteries that course either above or below the deep fascia [16]. However, less attention has been paid to the distribution of the musculocutaneous perforating branches from the medial and lateral sural arteries. Cavadas [5] first described the anatomical basis of the perforators from the medial and lateral sural arteries and a new type of thin skin flap from the medial aspect of the upper calf: medial sural artery perforator flap. Hallock conducted an anatomical study of the musculocutaneous perforators from the gastrocunemius muscles on 10 fresh specimens [8]. Thione *et al.* performed an anatomical study of the medial sural artery perforator flap on 20 lower limbs in Caucasians [9]. Kim *et al.* and Okamoto et al. described the anatomical study over 40 cases of the medial sural artery perforator flap in Asians [17, 18].

However, there have been no large anatomical studies comparing the medial and lateral perforator of sural artery in the Asian race. There are many differences of physique between Caucasians and Asians. Asians tend to have shorter and thicker legs [10, 11] and the design of the flap and the place of the perforator are very important in the reconstruction. If Asians are operated on based on Caucasians anatomical data, there is a possibility that important perforators may be injured or the design of the flap may result in failure.

A large number of cadaveric studies of the perforators of the medial and lateral sural artery in Asians were presented. This anatomical study attempted to add information to simplify the surgical treatment with these flaps for Asian patients. Perforating branches from the medial sural artery were found in all 47 specimens, but perforators from the lateral sural artery were absent in 57 percent in this study. In the absent cases, the lateral calf skin was supplied from the peroneal artery or the superficial sural artery. Therefore, the medial sural artery perforator flap is recommended instead of the lateral sural artery perforator flap.

Medial perforators were found in the distal half of the medial gastrocnemius muscle, 5. 5 to 17. 2cm (mean 11. 7) from the popliteal crease and 0. 5 to 4. 5 cm from the posterior midline in the current cases (Figure 6). Cavadas *et al.* found them at 8. 5 to 19 cm (mean 14. 2) from the popliteal crease [5]. This obvious difference in the distances was because of the length of the leg and muscle belly. The mean distance from the popliteal crease to the distal limit of the gastrocnemius medialis muscles was 18. 7 cm and 22. 8 cm in this study of

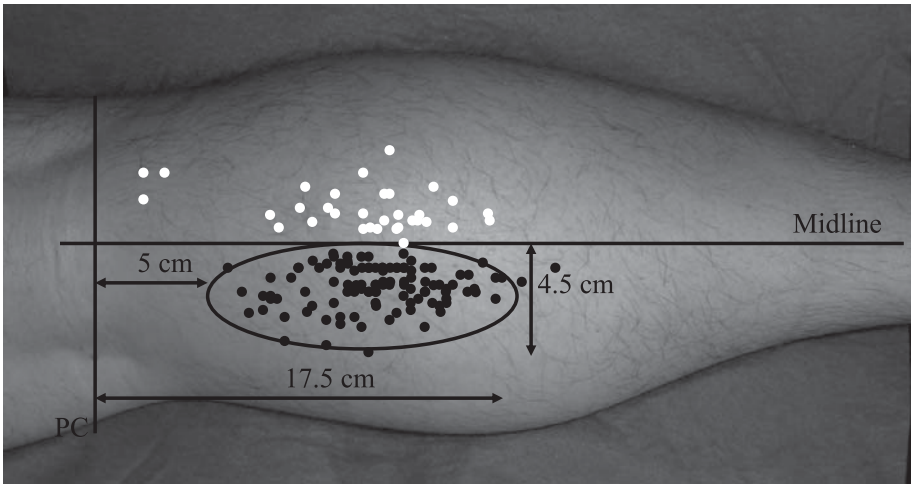

Figure 6. Photograph of distribution of perforators of sural artery. PC = popliteal crease. Black dot = perforators of medial sural artery. White dot = perforators of lateral sural artery.

Asians and that of Cavadas et *al.*, respectively. The ratio of the length of the gastrocnemius muscle to the length of the leg revealed a significant difference between our study and that of Cavadas et al. ($P < 0.01$, data not shown). Because of these differences the distribution of perforators may differ between Caucasians and Asians. The mean external diameter of the perforator of the medial sural artery was 0.8 mm in our study, which was almost the same as those given by Cavadas *et al.* (< 1.0 mm) and Thione *et al.* (0.5 mm), respectively. The number of medial perforators ranged from 1 to 5 and 83% of the specimens had 1 to 3 in the current study, which is consistent with that reported in the literature [5, 8, 9].

The risk of muscle ischemia after the sacrifice of even an entire medial sural artery should be remote, because several sources of secondary vascular pedicles have been described, a proximal secondary pedicle of the medial sural artery (Type 2 of Potparic classification) [12, 18], vascular connections with the lateral gastrocunemius muscle [19] and branches from the posterior tibial and peroneal arteries. In this study, a proximal secondary pedicle of medial sural artery was present in 10.6% (Table Ⅱ). The mean diameter of the medial sural artery (2.5 mm in this study) was suitable for microanastomosis with most of the recipient vessels similar to Caucasians. If a long vascular pedicle is needed, it is possible to dissect near the division of the medial sural artery. The length of pedicle in the current study was 14.6 cm (range 7.7-20.7), which was the same length as Cavadas *et al.* (10-17 cm) and Tione *et al.* (10-17 cm; mean 11.75).

In this way, the medial sural artery perforator flap has definite blood supply and is useful for soft tissue coverage because the function of medial gastrocnemius muscle is maintained,

with a thick and sufficiently long pedicle.

Because the distribution of the perforators from the medial and lateral sural artery and the anatomical comparison of the perforators of the medial sural artery between Asians and Caucasians were clarified in the present study, safe elevation of this flap in Asians should thus now be simpler to perform.

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