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Anatomical study of perforators of posterior upper and middle third of leg to assess feasibility of combined gastrocnemius flaps

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ABSTRACT

Introduction: A common problem seen in the plastic surgery referrals for management of fractures of the leg is the loss of tissue cover over the tibia. This is probably due to the fact that the anterior border of tibia is subcutaneous and prone to loss of tissue following road traffic accidents. To solve this problem a large amount of tissue is required which is mostly available on the posterior aspect of the leg. In order to move this tissue without risk of necrosis the flap must be supplied by an adequate number of perforator vessels. Therefore we decided to study the anatomy of perforators of the sural artery along with the posterior tibial and peroneal system so that the anatomical basis of a combined flap may be defined.

Materials and Methods: We performed cadaveric dissection in 20 legs to note the location of the proximal and distal most perforators arising from the sural, peroneal and posterior tibial arteries on the posterior aspect of the leg extending from the intercondylar line up to 8cm proximal to the medial an lateral malleolus. The area of medial belly of gastrocnemius with the adjacent posterior tibial perforators was designated as the medial flap and the area over lateral belly of gastrocnemius with adjacent peroneal perforators was designated as lateral flap.

Results: In the area defined as the medial flap we found an average of 2.5 perforators arising from the medial sural artery and 1.7 arising from the posterior tibial artery. In the medial flap the distal most perforator was the posterior tibial septocutaneous perforator, which was at an average 23.3cm from the intercondylar line, around 6.8 cm farther away from the distal most medial sural perforator. In the lateral flap region we found an average of 1.7 lateral sural perforators along with 1.5 peroneal perforators. In this flap the distal most perforator was the peroneal septocutaneous, at an average distance of 23.1cm distal to the intercondylar line and at an average of 7.3cm further away from the distal most lateral sural perforator.

Conclusion: On examination of the anatomical basis of the combined medial and lateral flap it is possible to raise long flaps of around 25-30 cm, which would be ideal to resurface long defects on the anterior aspect of leg. Raising these flaps with the gastrocnemius muscle in the flap would help to increase the axis of rotation of the flap allowing the flap to move to the anterior aspect of leg and even for resurfacing large defects over the knee.

1. Introduction

Lower extremity reconstruction following traumatic injuries has always posed a challenge to reconstructive surgeons. One of the issues faced is the possible injury to one of the two major arteries of the leg along with loss of tissue from the anterior aspect as it mostly bears the brunt of trauma. One of the most popular methods of reconstruction was the cross leg flap described by Hamilton in 1841 but with the subsequent discovery of fascicutaneous flaps by Ponten in 1981 the options for available in the lower limbs increased greatly.[1,2] Following this most of the flap research was based on elevating flaps based on single perforator vessels, which were either septocutaneous or myocutaneous.[3] On examination of the factors which make for an ideal flap, there should be minimal morbidity to the patient, the flap should come from the same segment as the injured area

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and the anatomy of the vascular supply should be constant so that it can be harvested reliably.[4,5] With these criteria in consideration we analyzed the problem of covering long defects over tibia with tissue from posterior aspect of leg (Figures 1, 2 and 3). We studied the perforator anatomy of the fasciocutaneous territory over the gastrocnemius muscle along with the posterior tibial and peroneal perforator system with the object of designing a combined flap that maybe harvested with the gastrocnemius perforators in order to cover long defects of tibia. This combined flap may be raised with the gastrocnemius muscle as well in order to increase the axis of rotation of the combined flap. We planned to record the number and the distance of the standard posterior tibial perforators, running between soleus and flexor digitorum longus, the medial and lateral gastrocnemius perforators and the peroneal perforators, running between soleus and flexor halluces longus, from the intercondylar line/ knee joint. This data can help determine the reliability of large flaps raised from the posterior aspect of the leg in order to cover exposed tibia in cases of open fractures.

Fig. 1: Tibial defect over upper and middle aspect of anterior leg about 20 cm in length

Fig. 2: Territory of medical combined flap

Fig. 3:

2. Materials and Methods

This study was conducted by dissecting twenty legs of seven males and three female cadavers.

Anthropomorphometric data of each individual was recorded and during dissection the following parameters were recorded.

1. Number of perforating vessels arising from the lateral and medial sural arteries travelling through the two heads of gastrocnemius muscle along with diameter of the vessels.
2. Number of septocutaneous perforators arising adjacent to the medial and lateral gastrocnemius muscle belly along with diameter of the perforators.
3. Distance of the perforating vessels from intercondylar line/ Knee joint.

2.1. Dissection

Dissection started by drawing a rectangle on legs posterior portion, representing the area of a fasciocutaneous flap. The proximal margin of the flap dissection was upto the intercondylar line at the knee.[6] The lateral incision was given 2cm posterior to the lateral subcutaneous border of the fibula. The medial incision was given 2cm posterior to the medial subcutaneous border of the tibia. The distal incision was made around 8 cm proximal to the ankle malleolus.

The flap was harvested under loupe magnification from distal to proximal and location of the gastrocnemius perforators marked in centimeters from the intercondylar line of the knee. The number of posterior tibial septocutaneous perforators near the medial gastrocnemius perorators and the number of peroneal septocutaneous perforators adjacent to the lateral gastrocnemius perforators were also noted. This region was divided in to two combined flaps. The region of medial gsastrocnemius with the posterior tibial septocutaneous perforators was designated as the medial flap. The region overlying the lateral gastrocnemius with the peronela septocutaneous perforators was designates as the lateral flap. This division was done to study the viability of raising a combined gastrocnemius myocutaneous flap with adjacent septocutaneous perforators included as well. The diameter of the vessels was determined by calculation based upon the external circumference. The vessels were opened longitudinally and opened flatly and the length of the circumference was measured by means of a sliding caliper. Only vessels with a diameter of more than 0.2 mm were considered.

3. Results

Data from the cases revealed that on an average there are 2.5 perforators (range 1-4) arising from the medial head of the gastrocnemius and 1.7 perforators (range 1-3) arising from the lateral head (Figure 4). The proximal most perforator in

the medial belly was 6.9 cm distal to the intercondylar line (range 4.8-8.4) and the distal most perforator 16.5cm distal to the intercondylar line (range 14.8-18.2cm) On the lateral belly the proximal most perforator was 6.7 cm distal to the intercondylar line (range 4.8-9.4cm) and the distal most perforator 15.8 cm distal to the intercondylar line (range 14.6-17.2cm). The mean diameter of the perforators arising from the medial head was 1mm (range 0.7-1.3) and those from the lateral head were 0.8mm (range 0.7-1.2mm).

The number of posterior tibial septocutaneous perforators supplying the combined medial skin flap was 1.7 (range 1-3) with an average diameter of 1.09mm (range 0.7-2mm). The average number of peroneal artery perforators supplying the combined lateral skin flap in the dissection of the skin flap was 1.5 (range 1-2) with an average diameter of 1.29mm (range 0.7mm-2.3mm).

The location of the distal most posterior tibial artery perforator from the intercondylar line was 23.3cm (range 21- 27cm) and the proximal most was 8.5cm (range 6-12cm) in the medial skin flap. The distance of the distal most peroneal artery perforator from the intercondylar line was 23.1cm (range 19 -26 cm) and the proximal most was 8.4 (range 6-11cm) in the lateral skin flap. [Figure 5] [Table 1]

Fig. 4:

4. Discussion

There has been extensive study on the vascularity of the lower leg with respect to the presence of vascular axis. According to the angiosome concept it is possible to capture the territory of the adjacent angiosome by ligating the source vessel of the adjacent angiosome and allowing choke vessels

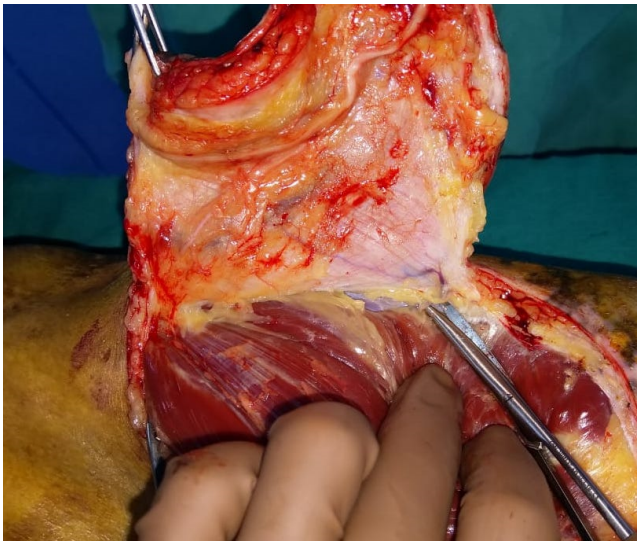

Fig. 5: Distal most peroneal subcutaneous perforator

to open up.[7] In animal studies the limit of flap survival was usually up to the junction of the second and the third territory and to capture the third territory usually a delay would be required.[8] This is essentially where the problem with elevating long proximally based posterior tibial or peroneal perforator flap lies, which is, that tissue beyond the second perforator is always at risk for necrosis if there has been no delay. The problem with this concept is that in a clinical situation we cannot get an estimate of the quantum of tissue that can be raised based on a single perforator irrespective of the source artery. So according to this theory we cannot explain how perforators from two different source arteries (sural and posterior tibial) could be communicating with each other.

One of the theories that does provide an insight in to this issue is the vasculosome theory which suggests the existence of vascular axes which are fed by cutaneous perforators and the directionality of these axes is dynamic and changes with sequential ligation of “feeder” vessels. Therefore if the entire axis is preserved then the entire tissue flap should survive.[9] From our anatomical dissections it is clear that we can include the medial sural axis with the posterior tibial septocutaneous line and the lateral sural with the peroneal septocutaneous line. Therefore we can consider raising a flap, which includes both these axis. In the flaps raised in the anatomical dissection the distal most posterior tibial or peroneal perforator is much closer to the distal gastrocnemius cutaneous perforator than the proximal most septocutaneous perforator that is spared in flap harvest. It is likely that the distal most region of the flap will survives because of the communication between the medial sural and posterior tibial in the medial side of leg and the lateral sural and peroneal axis on the lateral side of leg. When a gastrocnemius myocutaneous flap is raised

Table 1: Anthropometric data and number of perforators

	Total	Male	Female
No of subjects	10	7	3
Age	62.3	62	63
Average Tibia length	34(27-38)	36(35-38)	29(27-31)
Average No. of PTA perforators in medial flap	1.7	1.8	1.3
Average No. of peroneal Perforators in lateral flap	1.5	1.4	1.6
Average No. of Medial Sural perforators in the medial flap	2.5	2.2	3
Average No. of Lateral Sural Perforators in the lateral flap	1.7	1.8	1.3

Table 2: Details of perforator anatomy in the dissected region

Location from intercondylar line	Medial Sural	Posterior Tibial Septocutaneous	Lateral sural	Peroneal Septocutaneous
Proximal most	6.9cm	8.5cm	6.7cm	8.4cm
Distal most	16.5cm	23.3cm	15.8cm	23.1cm
Average Diameter	1mm	1.09mm	0.8mm	1.29mm

the region beyond the muscle belly is often considered to be the random portion of the isolated flap and according to convention should be raised with a length is to breadth of 1:1.[10] But if a communication between the septocutaneous vascular axes and the sural vascular axes exists in this area could be included in the flap with more reliability and a large flap which could cover both proximal and middle defects of tibia could be produced. We can make this assumption because the distal most posterior tibial perforator in the flap is on an average 6.8 cm distal to the medial gastrocnemius perforator and the distal most peroneal perforator is on an average 7.3cm distal to the lateral sural perforator emerging from the lateral belly of gastrocnemius [Table 2].

The results of our anatomic study were similar to studies by Torres et al and Otani et al which place the distal most medial and lateral gastrocnemius muscle perforators at 16.3 and 17.5 cm distal to the popliteal crease or the intercondylar line.[11,12] Regarding the number of perforators arising from the lateral head our results were different from the study by Otani et al which did not find any cutaneous perforator in 57% of the cases while we found at least 1 cutaneous perforator from the lateral head in 100% of the cadaveric dissections

5. Conclusion

On analysis of the data we found that it could be possible to raise combined flaps which include both the sural perforators emerging through the gastrocnemius muscle and the posterior tibial or the peroneal septocutaneous perforators. These combined flaps could help cover long defects of the tibia which is often exposed in the proximal and middle thirds of the leg following Gustillo 3b fractures of tibia.

6. Source of Funding

None.

7. Conflict of Interest

None.

References

1. Topalan M. A new and safer anastomosis technique in cross leg free flap procedure using the dorsalis pedis arterial system. *Plast Reconstr Surg* . 2000;105(2):710–3.
2. Ponten B. The fasciocutaneous flap: its use in soft tissue defects of the lower leg. *Br J Plast Surg*. 1981;34:215–20.
3. Hallock GG. A paradigm shift in flap selection protocols for zones of the lower extremity using perforator flaps. *J Reconstr Microsurg*. 2013;29(4):233–40.
4. Buncke HJ, Buncke GM, Lineaweaver WC, Oliva A, Alpert BS, Hing DN, et al. The contributions of microvascular surgery to emergency hand surgery. *World J Surg*. 1991;15(4):418–28.
5. Lister GD, Jones NF. Free skin and composite Flaps. In: Green's operative hand surgery. 5th ed. Philadelphia: Churchill Livingstone; 2005. p. 1715–56.
6. Pers M, Medgyesi S. Pedicle muscle flaps and their applications in the surgery of repair. *Br J Plast Surg*. 1973;26(4):313–21.
7. Taylor GI, Palmer JH. The vascular territories (angiosomes) of the body: experimental study and clinical applications. *Br J Plast Surg*. 1987;40(2):113–41.
8. Callegari PR, Taylor GI, Caddy CM, Minabe T. An anatomic review of the delay phenomenon: experimental studies. *Plast Reconstr Surg* . 1992;89(3):397–407.
9. Basu A. The vasculosome theory. *Plast Reconstr Surg*. 2015;135(2):449–51.
10. Cohen BE. Gastrocnemius Muscle and Musculocutaneous Flaps. In: Grabbs Encyclopedia of Flaps. Lippincott Williams & Wilkins; 2009. p. 1385–7.
11. Torres LR, Teixeira WGJ, Setani EO, Wei TH, Zumiotti AV. Retalho cutâneo das artérias perfurantes do músculo gastrocnêmio medial: estudo anatômico. *Acta Ortop Bras*. 2007;15:40–2.
12. Otani M, Okamoto H, Kagami H. Anatomical study on perforators of the medial and lateral sural artery in Asians. *Nagoya Med J*. 2012;52(1):89–98.

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