

Lateral flap of the thigh based upon the lateral superior genicular artery: an anatomic and histomorphometric study and clinical applications

ARNALDO VALDIR ZUMIOTTI¹, HSIANG WEI TENG², NAIRET C. QUEIPO BRICEÑO³, PRISCILLA HELENA LOTIERZO⁴,
LUIS HENRIQUE ISHIDA⁵, EDUARDO MONTAG⁵, MARCUS CASTRO FERREIRA⁶.

SUMMARY

The lateral genicular artery flap is a fasciocutaneous flap used for knee reconstruction with low donor site morbidity.

We performed an anatomical and histomorphometrical study of the lateral genicular artery flap in eighteen fresh cadavers (thirty-six anatomical regions). Four clinical results of knee reconstruction are demonstrated.

We found a constant vascular pedicle (100%), with intramuscular perforators in 40% of dissections. The perforator was situated at 7,40cm \pm 2,77 above lateral condyle of the femur, be-

tween vastus lateralis muscle and the biceps femoris muscle. The pedicle measured 6,09 \pm 1,91 cm of length from the popliteal artery.

This flap was done and succeeded in four patients.

This flap showed constant anatomy and is reliable for coverage of defects at superior and lateral portions of the knee and the proximal part of the lower leg.

Keywords: Anatomy, Perforator flap, Lateral genicular artery flap, Lateral genicular superior artery.

INTRODUCTION

In 1990, Hayashi and Maruyama⁽⁶⁾ described the fasciocutaneous flap of the lateral superior genicular artery (LSGA) for reconstruction of defects around the knee, popliteal region, lower third of the thigh, and upper third of the leg. The flap vascularization is based upon the skin perforators of the lateral superior genicular artery (LSGA), the right branch of the popliteal artery.

At that time this flap was not widely accepted, possibly because of the pathway variability of its pedicle, that is found to perforate the local musculature in many cases. During the nineties, when the dissection technique of perforator flaps has become widely known, clinical indications of the LSGA flap were reviewed^(2,14).

The present study aims to reevaluate the previously described anatomic findings by describing dissection parameters in cadavers that can be used in preoperative planning in clinical practice. In addition, it aims to determine the characteristics of the flap, such as skin thickness, pedicle length, and rotation arch. An initial series of four clinical cases is presented, as well as the results obtained in the analysis.

MATERIAL AND METHODS

Eighteen formol-untreated adult cadavers were dissected with a total of 36 anatomic specimens. The time period following death was lower than 24 hours. The mean age of the 15 male and 3 female cadavers was 61.3 \pm 11.60 years, the mean weight was 68.2 \pm 16.04 kg, and the mean height was 1.72 \pm 0.07 m.

The cadaver was placed in a lateral decubitus and the following anatomic parameters were marked: skin projection of the greater trochanter of the femur, lateral condyle of the femur, and lateral intermuscular septum of the thigh. A skin rectangle of the lateral region of the thigh was lifted by dissecting the subfascial plane from the lateral projection of the gluteal fold to the lateral region of the knee. The dissection limits were defined as the lateral vastus muscle anteriorly and the biceps femoris muscle posteriorly. Dissection was extended up to the skin perforator branch of the lateral superior genicular artery (Figure 1). The perforator pathway was dissected toward the posterior side of the femur up to its origin in the popliteal artery.

The following anatomical parameters were evaluated: a) presence of the pedicle; b) pedicle pathway (intramuscular or septal), c) distance of the perforator up to the skin projection of the

Study carried out at the Department of Orthopedics and Traumatology and Plastic Surgery Division of the FMUSP

1. Associate Professor responsible for the Traumatology Division of the Department of Orthopedics and Traumatology.
2. Assistant Doctor at the Traumatology Division of the Department of Orthopedics and Traumatology.
3. Plastic Surgeon.
4. Resident at the Plastic Surgery Division
5. Postgraduate Student at the Plastic Surgery Division
6. Chairman at the Plastic Surgery Division

Mail address:
Luis Henrique Ishida
Al. Rio Claro, 189 – Bela Vista
ZIP Code 01332-010
São Paulo - SP - Brasil
E-mail: hap@uol.com.br

Received on February 19, 2004 and approved on December 17, 2004

greater trochanter and lateral condyle of the femur; d) length of the pedicle up to the femur and also to its origin in the popliteal artery; e) thickness of the middle and distal flap areas, the latter in the projection of the skin perforator of the lateral superior genicular artery, as well as the dermoepidermal thickness of its lateral face (Figure 2).

A histomorphometric analysis was carried out in 20 samples collected from the lateral superior genicular artery.

The study samples were fixed in buffered 10% paraformaldehyde solution for 12 hours and 70% ethyl alcohol and included in paraffin perpendicularly to the section plane so as to assure the reliability of analysis (Figure 3). 5- μ m sections were stained by hematoxylin-eosin (HE). The study was double-blind and slides were evaluated and analyzed by an independent observer. A Zeiss microscope Axioplan(was used. The images were sent through an analogic video camera coupled to a computer with an image digitalizing plate Oculus TCX[®]. The images were then showed on the screen of a Trinitron video. The software Optimas 4.10 was used to study the samples.

Oblique sections were returned to the processing unit and new sections were obtained according to the previously described technique (Figure 3).

The outer diameter of the artery (distance from lumen to the external elastic layer of the tunica media) and the area of the tunica intima (luminal area of the artery) were measured⁽⁶⁾.

RESULTS

The skin perforator of the lateral superior genicular artery was found to be present in all specimens (100%) with an intramuscular course in 40% of dissections.

The mean distance between the skin perforator branch of the lateral superior genicular artery and the skin projection of the greater trochanter of the femur was 27.39 ± 6.46 cm and that between the LSGA and the skin projection of the lateral condyle of the femur was 7.40 ± 2.77 cm(Figure 4).

The mean length of the pedicle was 2.57 ± 0.87 cm up to the lateral intramuscular septum of the thigh, 4.69 ± 1.77 cm up to the femur, and 6.09 ± 1.91 cm up to the origin of the popliteal artery (Tabela 1).



Figure 1 - Exposure of the skin perforator of the LSGA through retraction of the lateral vastus muscle superiorly and biceps femoris muscle inferiorly. **AB**: length of the artery from the subcutaneous tissue up to its origin in the popliteal artery.



Figure 2 - Thickness of the lateral flap of the thigh based upon the pedicle of the LSGA: **A**: Subcutaneous tissue in the proximal region. **B**: Subcutaneous tissue in the distal region.

The mean proximal thickness of the flap was 1.12 ± 0.10 cm; the mean distal thickness was 0.65 ± 0.56 cm; and the mean dermoepidermal thickness was 0.99 ± 0.33 mm (Figure 5).

The histomorphometrical analysis showed that the mean outer diameter was 0.521 ± 0.012 mm up to the lateral intermuscular septum of the thigh, with a mean area of the tunica intima of 0.010 ± 0.0492 mm²; in the femur, the value was 1.144 ± 0.07 mm with a mean area of the tunica intima of 0.050 ± 0.0731 ; in the origin of the popliteal artery, the outer diameter was 1.161 ± 0.012 mm and the area of the tunica intima was 0.079 ± 0.0186 mm² (Figure 6 and 7).

Clinical Cases

From May 01, 2001 to July 01, 2003, the lateral flap of the thigh based upon the LSGA was used in four patients (Table 2, Figures 8, 9, and 10).

No complication was seen in three cases while a partial loss of the distal end of the flap was seen in one patient and was treated with debridement and skin graft.

DISCUSSION

Several muscular and musculocutaneous flaps have been used to repair soft tissue defects of the knee and surrounding areas^(2,7,8,10), such as the gastrocnemius muscle flap^(3,9,10), vastus medialis muscle flap^(1,9,10), vastus lateralis muscle flap^(9,10,13), and sartorius muscle flap^(9,10).

The gastrocnemius muscle flap has currently been one of the first choices in the repair of this type of defect. Its rotation arch is limited for treatment of proximal and lateral defects of the skin. Although no significant functional walking deficit⁽¹⁵⁾ occurs, this flap may lead to a variable damage during the rehabilitation period and for the development of high-performance physical activities. The use of this flap results in a depressed scar in the donor site, requiring skin graft in the receptor site.

The lateral superior genicular artery flap (LSGA) described by Hayashi and Maruyama⁽⁵⁾ is a local alternative for reconstruction of injuries affecting the knee and the proximal third of the leg. However, few studies evaluating the use of this flap have been published^(4,5,12).

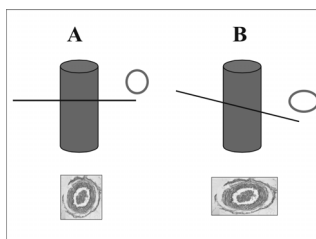


Figure 3 - Diagram showing the section plane of the specimens of the skin perforator of the lateral superior genicular artery (LSGA) for histomorphometric analysis. **A**: Transverse section of the artery confirmed by the longitudinal course of the nucleus within the muscle cells of the tunica media and symmetrical thickness of the tunica media in four diametrically opposite points. **B**: Oblique section of the artery, returned to the Department of Pathology for new section and inclusion.

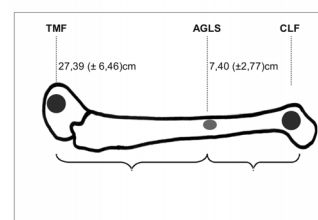


Figure 4 - Diagram showing the distance of the skin perforator of the lateral superior genicular artery (LSGA)

The flap vascularization is supplied by the skin perforator of the lateral superior genicular artery (LSGA), the right branch of the popliteal artery^(11,14). This artery is found within a triangle limited anteriorly by the vastus lateralis muscle, posteriorly by the short head of the biceps femoris muscle, and inferiorly by the lateral condyle of the femur. It enters the deep fascia of the lateral region of the thigh near the knee joint and ends as a skin perforator in this region⁽¹¹⁾. According to Hayashi and Maruyama⁽⁶⁾, the artery can be located with the patient in lateral decubitus at a proximal distance of 10 cm from the lateral condyle of the femur.

PEDICLE	PEDICLE	STANDARD DEVIATION
Length of the pedicle up to the lateral intermuscular septum of the thigh	2,57	± 0,87
Length of the pedicle up to the femur	4,69	± 1,77
Length of the pedicle up to the popliteal artery	6,09	± 1,91

Table 1 - Mean length of the pedicle measured in centimeters from its identifiable portion in the subcutaneous tissue up to the lateral intermuscular septum of the thigh, the femur, and the popliteal artery (n = 36)

Local muscles are not adversely affected by the removal of this artery and the primary closure of the donor site is possible. It has a rotation arch appropriate for reconstruction of the lateral region of the knee and the proximal region of the leg. However, it is not indicated for reconstruction of medial defects of the skin.

In the present anatomic study, the skin perforator of the lateral superior genicular artery (LSGA) was identified in all specimens at a mean distance up to the lateral condyle of the femur of 7.40 ± 2.77 cm, thus confirming the constant location of the pedicle. In 40% of the study cases, an indirect skin perforator was identified

Patient	Sex	Age	Diagnosis	Evolution
1	F	70	Sarcoma of soft tissue	Satisfactory
2	M	45	Dissecting trauma	Satisfactory
3	M	41	Dissecting trauma	Partial defect
4	M	22	Pressure ulcer	Satisfactory

Table 2 - Characteristics of clinical cases (n = 4)

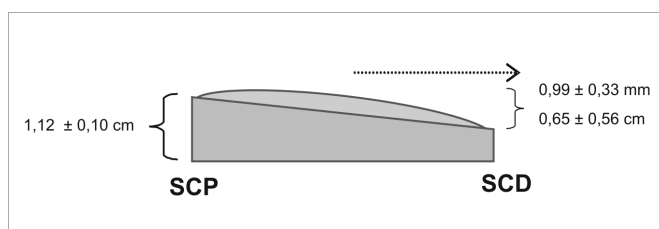


Figure 5 - Diagram showing the thickness of the subcutaneous tissue in the lateral face of the flap. SCP: Proximal subcutaneous tissue measured in the middle region of the flap. SCD: Distal subcutaneous tissue measured in the projection of the skin perforator of the lateral superior genicular artery.

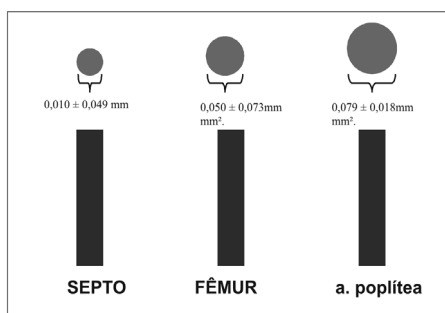


Figure 6 - Diagram showing the area of the tunica intima (lumen area) of the skin perforator of the lateral superior genicular artery (LSGA), measured at different levels of dissection; SEPTUM: Lateral intermuscular septum of the thigh; FEMUR: Posterior side of the femur; Popliteal a.: Popliteal artery

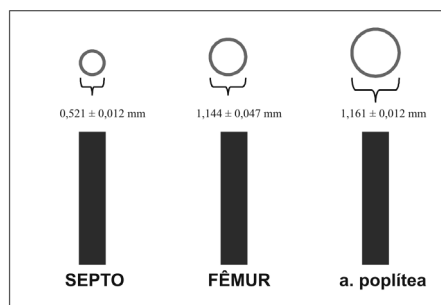


Figure 7 - Diagram showing the outer diameter of the skin perforator of the lateral superior genicular artery (LSGA) SEPTUM: Lateral intermuscular septum of the thigh; FEMUR: Posterior side of the femur; Popliteal a.: Popliteal artery.



Figure 8 - Appearance of the lateral region of the knee following resection of a soft-tissue sarcoma and after the lateral superior genicular artery (LSGA) flap was marked for repair of the skin surface.



Figure 9 - Lateral flap of the thigh based upon the pedicle of the LSGA. Detail of the dissection of 2 perforators of intramuscular pathway



Figure 10 - Aesthetic and functional result 6 months following surgery of the lateral region of the knee with the use of the lateral flap of the thigh.

when it emerged from the biceps femoris muscle while the perforator was direct in 60% of cases when it was found in the lateral intermuscular septum of the thigh⁽²⁾. In clinical cases the Doppler ultrasonography is recommended to identify the artery before surgery so as to assure a safer dissection of the flap.

Depending on the dimensions and site of the defect, different lengths of the vascular pedicle can be dissected up to its origin. It is accompanied by loose areolar tissue in its more superficial plane up to the femur. This assure greater reliability in the artery individualization. From this point, dissection is more difficult since the vascular pedicle enter a plane of dense connective tissue, the posterior fascia of the thigh, being in close contact with the posterior side of the femur, up to its origin in the popliteal artery. Whenever needed, the pedicle can be dissected toward the popliteal artery (6.09 ± 1.91 cm), thus providing a greater rotation arch and greater safety in the transfer of the flap.

Hayashi and Maruyama⁽⁵⁾ described the diameter of the skin perforator of the lateral superior genicular artery and recommended the use of the flap in the microsurgery form. However, measurements of small structures ($< 10^{-2}$ mm) are very inaccurate with macroscopic techniques with the help of digital caliper. In the present study, we used the histomorphometric evaluation of arteries for this purpose, thus increasing the precision of diameter measurements. Our findings (diameter of 1.161 ± 0.012 mm) allow one to use the flap by means of microsurgery transfer. However, one must emphasize that other free flaps are available, having longer and larger pedicles, and should be considered those of first choice for microsurgical reconstructions.

As for the skin characteristics of the flap, our findings showed thin subcutaneous tissue in its distal region, thus providing

coverage of appropriate outline, with no interference in the joint motility. The flap color and texture are similar to those of the knee area and account for a better quality aesthetic appearance, as compared to muscular or musculocutaneous flaps.

A satisfactory clinical course was seen in three out of the 4 study patients, with the possibility of early physiotherapy and function recovery of the knee. In all cases a stable coverage of the region was obtained and a good quality scar was seen both in the donor and receptor sites. One patient developed a partial loss of the distal portion of the flat on the second day following surgery that resulted from splint-induced extrinsic compression of the flap. Flap debridement was followed by partial skin grafting. The patient had no functional loss since the whole joint area of the knee was protected by the proximal flap.

In conclusion, the lateral genicular artery flap has been shown to be efficacious to recover lateral and superior defects of the knee. The rotation arch, however, was limited for the medial and inferior regions of the knee. In these cases, the gastrocnemius muscle flap is a more appropriate choice to treat such defects.

A disadvantage of the lateral genicular artery flap, as compared to dissection of the gastrocnemius muscle flap, is the need for a more accurate surgical technique, specially if intramuscular dissection is needed. Under these circumstances, the use of optical magnification is recommended to assure greater safety.

In the present study, objective aesthetic or functional evaluations and comparison of reconstruction results with those of traditional techniques were not carried out. Further studies should be made to show the actual advantages and disadvantages of the lateral genicular artery flap in clinical practice.

REFERENCES

1. Arnold PG, Prunes-Carrillo F. Vastus medialis muscle flap for functional closure of the exposed knee joint. *Plast Reconstr Surg* 68:69, 1981.
2. Cormack GC, Lamberty MA. The blood supply of the skin. *Plast Reconstr Surg* 342:354, 1985.
3. Elshahy, NI. Cover of the exposed knee by the lateral head of the gastrocnemius. *Br J Plast Surg* 31:136, 1978.
4. Hayashi A, Maruyama Y. Lateral intermuscular septum of the thigh and short head of the biceps femoris muscle: na anatomic investigation with new clinical applications. *Plast Reconstr Surg* 108:1646, 2001.
5. Hayashi A, Maruyama Y. The lateral genicular artery flap. *Ann Plast Surg* 24:310, 1990.
6. Junqueira LC, Carneiro J. *Sistema Circulatório*. In: Junqueira LC, Carneiro J. *Histologia básica*. 8ªed. Rio de Janeiro:Guanabara Koogan. Pp 178, 1995.
7. Laitung JKG. The lower posterolateral thigh flap. *Br J Plast Surg* 133:139, 1989.
8. Maruyama Y, Iwahira Y. Popliteo-posterior thigh fasciocutaneous island flap for closure around the knee. *Br J Plast Surg* 140:143, 1989.
9. Masquelet A, Gilbert A. *Retalhos na reconstrução dos membros*. São Paulo: Editora Revinter. Pp. 13,1997.
10. Mathes, S.J, and Nahai, F. Thigh. In: *Reconstructive Surgery: Principles, Anatomy & Technique*. 1a ed. New York: Churchill Livingstone. Vol. 2, Pp1261, 1293, 1307 e1391, 1997.
11. Sobotta, J. *Atlas de anatomia humana*. 19ªed. Rio de Janeiro: ed. Guanabara Koogan. p. 70,71,77,203,364, 1993.
12. Spokevicius S, Jankauskas, A. Anatomy and clinical applications of a composite cutaneous-subcutaneous flap based on the lateral superior genicular vessels. *J Reconstr Microsurg* 11:15, 1995.
13. Swartz WM, Ramasastry SS, McGill JR; Noonan JD. Distally based vastus lateralis muscle flap for coverage of wounds about the knee. *Plast Reconstr Surg* 80:255-265,1987.
14. Taylor GI, Palmer JH. The vascular territories (angiosomes) of the body: Experimental study and clinical applications. *Br J Plast Surg* 40:113, 1987.