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

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SUMMARY

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

We performed an anatomical and hystomorphometrical stu-
dy of the lateral genicular artery flap in eighteen fresh cadavers
(thirty-six anatomical regions). Four clinical results of knee re-
construction are demonstrated.

We found a constant vascular pedicle (100%), with intramus-
cular perforators in 40% of dissections. The perforator was situ-
ated at 7.40 cm ± 2.77 above lateral condyle of the femur, be-
tween vastus lateralis muscle and the biceps femoris muscle.

The pedicle measured 6.09 ± 1.91 cm of lenght from the popli-
teal artery.

This flap was done and succeeded in four patients.

This flap showed constant anatomy and is reliable for cove-
rage 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 Maruyama6 described the fasciocu-
taneous 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 popli-
teal 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 reviewed2,14.

The present study aims to reevaluate the previously des-
cribed anatomic findings by describing dissection parameters
in cadavers that can be used in preoperative planning in clini-
cal practice. In addition, it aims to determine the characteris-
tics of the flap, such as skin thickness, pedicle length, and
rotation arch. An initial series of four clinical cases is presen-
ted, 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 de-
ath was lower than 24 hours. The mean age of the 15 male and
3 female cadavers was 61.3 ± 11.60 years, the mean weight
was 68.2 ± 16.04 kg, and the mean height was 1.72 ± 0.07 m.

The cadaver was placed in a lateral decubitus and the follo-
wing 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 la-
teral vastus muscle anteriorly and the biceps femoris muscle pos-
teriorly. Dissection was extended up to the skin perforator bran-
ch of the lateral superior genicular artery (Figure 1). The perfora-
tor pathway was dissected toward the posterior side of the fe-
mur up to its origin in the popliteal artery.

The following anatomical parameters were evaluated: a) pre-
sence of the pedicle; b) pedicle pathway (intramuscular or sep-
tal), c) distance of the perforator up to the skin projection of the

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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 dermoeipidermal 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-µm 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.

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).

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 dermoeipidermal 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 intramuscular 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 mm² 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, such as the gastrocnemius muscle flap, vastus medialis muscle flap, vastus lateralis muscle flap, and sartorius muscle flap.

The gastrocnemius muscle flap has currently been one of the first choices in the repair of this type of defect. Its rotation arc is limited for treatment of proximal and lateral defects of the skin. Although no significant functional walking deficit 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 flat (LSGA) described by Hayashi and Maruyama 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.

The histomorphometrical analysis showed that the mean outer diameter was 0.521 ± 0.012 mm up to the lateral intramuscular 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 mm² 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).
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 (5), 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.

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.

<table>
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<th>Patient</th>
<th>Sex</th>
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<th>Evolution</th>
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<tbody>
<tr>
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<td>70</td>
<td>Sarcoma of soft tissue</td>
<td>Satisfactory</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>45</td>
<td>Dissecting trauma</td>
<td>Satisfactory</td>
</tr>
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<td>4</td>
<td>M</td>
<td>22</td>
<td>Pressure ulcer</td>
<td>Satisfactory</td>
</tr>
</tbody>
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Table 2 - Characteristics of clinical cases (n = 4)

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\(^3\). 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 assures greater reliability in the artery individualization. From this point, dissection is more difficult since the vascular pedicle enters 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 arc 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 (\(<10^\text{mm}\)) 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 flap 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