ANATOMIC BASIS OF PERFORATOR FLAPS OF MEDIAL VASTUS MUSCLE

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The purpose of this study was to elucidate anatomical features of perforating branch flaps based on the muscular branches of the medial vastus muscle and to seek a new, applicable technique that could be used in repairing soft tissue defects around human knees. In this study, the origin, the course, the branches, the distribution, and the distal anastomosis of the muscular branch of the medial vastus muscle were observed in 30 sides of adult cadaveric lower limb specimens with the adductor tubercle, the patella midpoint, and the inguinal ligament midpoint as the observation markers. The specimens had been perfused arterially with red gelatin before they were supplied. It was observed that the femoral artery gave constant muscular branches into the medial vastus muscle at the tip of the femoral triangle. The artery entered the muscle via the hilum and ran laterally downwards along the muscular bundle until it reached the lateral patella to anastomose with the arterial circle around the bone. Along its course, it also gave 1–3 (1/77%) musculocutaneous perforating branches (0.5–0.9 mm in diameter). It then extended vertically through the medial vastus muscle into the deep fascia and ran superficially to the overlying skin of the muscle. A flap based on the perforating branch of the medial vastus muscle could be harvested at a size of about 8.5 cm × 15.0 cm and might be transferred retrograde to repair the soft tissue defect around the knee. © 2007 Wiley-Liss, Inc. Microsurgery 28:61–64, 2008.

Soft tissue defects of the knees often ensue from injuries or ulcers, resections of tumors, or surgery for relief of cicatrices. These defects should be repaired with proper flaps as soon as possible if the limb functions are to be saved. For this reason, how the soft tissue defects are to be repaired has been, and is still, a research priority when the treatment of limb injuries is studied. It is standard practice that the knee soft tissue defects are repaired with either a cross-leg flap or a free flap with vascular pedicles. Both options have their own advantages and disadvantages. Though a cross-leg flap can cover a large recipient area, the patient who has such an operation is confined to the bed because his lower limbs must be bandaged and fixed for 3–4 weeks. Though a free flap with vascular pedicles can be transferred to a rather distal recipient area, it is not uncommon that the transposition ends in failure because the operation requires skilled and experienced performance by the surgeon. However, there are recent reports that microsurgical flaps with vascular pedicles have been used successfully to repair soft tissue defects around the knees.1–3 In this study, perforating branch flaps of the medial vastus muscle were designed and transferred retrogradely to repair the soft tissue defects around the knees.

MATERIALS AND METHODS

Thirty sides of adult cadaveric lower limb specimens that had been perfused with red gelatin in the arteries were anatomized to observe the origin, the course, the branches, the distribution, and the distal anastomosis of the muscular branches of the medial vastus muscle. One side of the fresh specimen was selected and stained with ink to measure the size of the flap, and another side was adopted to mimic the procedures of the design, dissection, and transposition of the flaps.

RESULTS

Muscular Branches of the Medial Vastus Muscle

The blood supply in the medial vastus muscle presented superiorly traveling downwards in a segmental distribution, coming from the femoral deep artery, the lateral femoral circumflex artery, the femoral artery, and the descending genicular artery. The main nutrient arteries (3–7 branches) of the muscle originated from the medial femoral muscular branches of the femoral artery. Among them, the constant large muscular branches that sent cutaneous branches were included in the designed flap and carefully observed.

Courses and Branches of the Muscular Branches

The muscular branch of the medial vastus muscle originated from the femoral artery at the tip of the femoral triangle (at 13.1 ± 2.6 cm above the adductor tubercle) or from inside the adductor canal. It was 2.3 ± 0.4 cm in diameter. It entered the muscle via its medial posterior border and ran laterally downwards along the muscle bundle to the lateral patella to anastomose with the arterial circle around the bone (Figs. 1A–1C). Along the course, it sent muscular branches (0.2–0.7 mm in diame-

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ter) to nourish the medial vastus muscle, and muscular perforating branches to run vertically through the muscle onto the deep fascia and then extended superficially to the overlying skin (Figs. 1A–1D; Table 1). There were generally two veins in the muscle, which were as large in diameter as the homonymous artery.

**Body Surface Projection and Perforating Point**

The patient placed with his coxa in lateral circumflex position, the body surface projection line of the muscular branch of the medical vastus muscle fell on the connecting line between the midpoint of the inguinal groove and the boundary crosspoint at the 1/3 middle-inferior segment of the adductor tubercle, and the midpoint of the patella. The point from which the first musculocutaneous perforator ran through the muscle was rather constant. In general, it was located somewhere near the midpoint of the body surface projection line of the medial vastus muscle: to be more exact, at 9.4 \(\pm\) 2.4 cm above the adductor tubercle and 4.1 \(\pm\) 1.0 cm medial to the vertical line on the midpoint of the patella.

**Anastomosis of the Perforating Branches**

After the perforating branch of the medial femoral muscular branch ran superficially out to the overlying skin, it gave ascending, descending, and lateral branches to form three types of anastomoses. Of the three types, some anastomosed with the adjacent musculocutaneous perforators to form a subcutaneous vascular net or chain (Figs. 1E–1G); some nourished the anterior cutaneous branches of the femoral nerves and anastomose with the nutrient branches of the anterior cutaneous branches of the superior 1/3 segment of the femoral nerve (Fig. 1H); others anastomosed with the intermuscular cutaneous arteries that perforate through the anterior sartorius muscle.

**Size of the Flap**

The range of the blood supply (about 8.5 cm \(\times\) 15.0 cm) was seen on the side of the fresh specimen stained

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**Table 1. Data of the Musculocutaneous Perforaters (\(\bar{x}\pm s\))**

<table>
<thead>
<tr>
<th>Number</th>
<th>Total ((n/%))</th>
<th>Diameter (mm)</th>
<th>Length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>23/77</td>
<td>0.9 (\pm) 0.2</td>
<td>1.4 (\pm) 0.2</td>
</tr>
<tr>
<td>2</td>
<td>5/17</td>
<td>0.7 (\pm) 0.1</td>
<td>1.1 (\pm) 0.1</td>
</tr>
<tr>
<td>3</td>
<td>2/6</td>
<td>0.5 (\pm) 0.1</td>
<td>1.0 (\pm) 0.1</td>
</tr>
</tbody>
</table>
with ink, with its medial border falling on the connecting line between the pubic and the adductor tubercles; its lateral on that between the patellar and the inguinal groove midpoints; its inferior on the horizontal line of the patellar midpoint and its superior on the parallel line 15.0 cm above the patellar midpoint.

**Mimic Transposition of the Perforating Branch Flap of the Medial Vastus Muscle**

**Design of the flap.** The flap was designed with its longitudinal line falling on the body surface projection line of the muscular branch of the medial vastus muscle and its core on the point from which the direct cutaneous vessel originated. In the case that a larger size was required, the longitudinal line of the flap fell on the body surface projection line of the anterior cutaneous branch of the femoral nerve (the line connecting the midpoint of the inguinal ligament with the medial femoral condyle, Fig. 1E), and the direct cutaneous branch was included in its middle-inferior segment (Fig. 2).

**Dissection of the flap.** As had been designed, the flap was incised from its lateral superior border down to the deep layer of the fascia lata and turned medially downwards to the point through which the perforating branch passed. The designed lines of the flap were adjusted as necessary. The muscular fibers were separated along the course of the musculocutaneous perforator and cut off to trace the perforator to the point where it emerged from the medial femoral muscular branch. Certain perivascular muscle sleeves were retained, and the second or the third perforater included if it was present in the cases.

**Liberation of the flap.** The flap was pulled back to where it had been located and temporarily sutured. Then its other borders were incised one after another from under the fascia lata, where the perforating branch ran superficially out until the whole flap was separated (except for its vascular pedicles). The adjacent anterior cutaneous branches of the femoral nerve were separated for a suture if necessary.

**Retrograde transposition of the flap.** At the proximal end of the flap, the muscular branch of the medial vastus muscle was cut off before it sent out the perforating branch, and traced along the vascular course in the intermuscular septum until the pedicle was long enough for a proper transposition. The borders of the separated flap had been examined carefully once more before the flap was transferred retrogradely to the defective area.

**DISCUSSION**

**Anatomic Basis for Flap Design**

The muscular branches of the medial vastus muscle give out constant perforating branches. These perforators send branches to anastomose with the adjacent intermusculocutaneous branches and the musculocutaneous perforators. They also send branches to anastomose with the anterior cutaneous branches of the femoral nerve that pass through the flap to form the longitudinal nutrient vascular plexus around the cutaneous nerves. On the basis of these, a cross-area blood supply is constructed so that a large flap might be harvested. The muscular branches of the medial vastus muscle anastomose with the arterial branches around the patella to form a vascular circle, so that the blood supply might be guaranteed in the retrograde flap pedicled with the perforating branches and the muscular branches of the medial vastus muscle. The anterior cutaneous branches of the femoral nerve run through the flap area, so that they might serve as its sensory nerves.

**Key Points of Applied Anatomy**

First, since the design of the flap depends on the distribution of the perforating branch of the medial femoral muscular branch, the point where the perforating branch passes through should be confirmed with the Doppler. If necessary, the course of the muscular branch of the medial vastus muscle, the distribution of the perforating branches of the medial femoral muscular branches, and their anastomosis with the arterial circle around the patella should be observed and determined in the DAS radiographs taken by arteriography. Second, the flap should be incised from its superior border and turned medially.

**Figure 2. Mimic transposition of the perforating branch flap of the medial vastus muscle. A) Design of the flap. B) Exposure of the vessels. C) Harvest of the flap. D,E) Retrograde transposition of the flap. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]**
downwards to trace the perforating branches between the
imbricated intermuscular bundles. Third, a flap of this
type could be made a muscular one with part of the
medial vastus muscle as its pedicle. It enjoys such advan-
tages as anti-infection and ability to pack the cavity so
that it might be transferred to repair a sinus trauma that
ensues from chronic osteomyelitis around the knee or
from osseous exposure. Fourth, the flap might be made a
sensory one, the anterior cutaneous branches of the femo-
ral nerve in it sutured with the nerves in the recipient
area. Fifth, it should be used with great caution if the
arterial circle around the knee is damaged.

Characteristics of the Flap

First, the muscular branch of the medial vastus mus-
cle enjoys such constant anatomic characteristics and has
such a large diameter that a flap pedicled with it proves
easy and safe to harvest and transfer. Second, the donor
flap is generally located in the concealed area, where the
overlying skin of the upper leg tends to be loose, and the
width of the flap amounts to, at most, 9 cm, so that the
donor area could be sutured immediately in most cases.

Third, the donor area is located at the segment superior
to the knee joint, so that the cicatrix that ensues from the
incision might not affect the articular flexion and exten-
sion. Fourth, the flap is generally fine in quality without
swelling, so that it could be made a sensory one. Fifth,
its pivot point is located lower than that of the nutrient
vascular flap based on the anterior cutaneous branch of
the femoral nerve. Sixth, since the donor area is rela-
tively insufficient, the flap is just suitable for a wound of
median size.

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