

Alternative Vascular Pedicle of the Anterolateral Thigh Flap: The Oblique Branch of the Lateral Circumflex Femoral Artery

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Background: The anterolateral thigh flap is known for variations of its vascular pedicle. This is a prospective intraoperative analysis of the vascular anatomy of the lateral thigh that focuses on clinically important variations that impact flap harvest.

Methods: Eighty-nine consecutive anterolateral thigh flaps were harvested. A detailed intraoperative analysis was performed of the vasculature anatomy and variations of the pedicle encountered during dissection.

Results: Fasciocutaneous flaps were harvested in 82 percent (73 of 89) and myocutaneous flaps were harvested in 17 percent of cases (15 of 89). Sizable perforators were absent in 1 percent of the cases (one of 89). A mean of 1.9 sizable cutaneous vessels were identified. Musculocutaneous perforators were noted in 85 percent of cases and septocutaneous vessels were seen in 15 percent. Most septocutaneous vessels were located in the proximal thigh. In the midpoint of the thigh, musculocutaneous perforators predominate. Those located within 1 cm of the septum characteristically have a short, direct intramuscular course. In contrast, those located more laterally and distally in the thigh characteristically have a tortuous intramuscular course. An oblique branch of the lateral circumflex femoral artery was noted to be present in 35 percent of cases (31 of 88), and the dominant perforator supplying the anterolateral thigh was noted to originate from this branch in 14 percent of cases (12 of 88).

Conclusions: This study further clarified the vascular pedicle anatomy of the anterolateral thigh. The existence of the oblique branch of the lateral circumflex femoral artery in a proportion of patients and its reliability when used as the flap pedicle were demonstrated. (*Plast. Reconstr. Surg.* 123: 571, 2009.)

The anterolateral thigh flap was first described by Song et al. in 1984,¹ but its widespread use was delayed for several years until it was popularized by Wei et al.^{2,3} It has numerous advantages, including a long pedicle, good vessel diameter, the availability of different tissues with large amounts of skin, the fact that it is adaptable as a sensate or flow-through flap, and low donor-site morbidity.²⁻⁶ In our practice, it has evolved into a workhorse soft-tissue flap for a variety of reconstructive needs.² However, confusion about its anatomical variations has thwarted its widespread use. Song et al.¹ actually described this flap as

based on septocutaneous vessels that were subsequently known to be present in only a minority of cases. The early article by Koshima et al. reported absent septocutaneous perforators in five of 13 patients.⁷ These cases were abandoned, as intramuscular dissection to mobilize perforators was considered unsafe then. Subsequently, with the development of perforator flaps, previously “unusable” musculocutaneous perforators can now be reliably incorporated into flaps.^{2,8} Anatomical studies of the anterolateral thigh region have been helpful in providing a roadmap for surgery in this area.^{9,10} Such studies, however, do not address critical decision issues when harvesting the flap. Of relevance, what implications do anatomical varia-

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DOI: 10.1097/PRS.0b013e318195658f

Disclosure: None of the authors has any conflicts of interest with the content of this article.

tions have for the use of the anterolateral thigh flap and how should one proceed when faced with such anomalies? How should we modify our operative strategy to ensure success despite the many variations in this region? This article is a distillation of intraoperative variations that we saw in 89 consecutive anterolateral thigh flaps harvested and how we dealt with such cases.

PATIENTS AND METHODS

This was a prospective intraoperative study to document intraoperative findings of the anterolateral thigh flap harvest. From July of 2007 to May of 2008, 89 consecutive anterolateral thigh fasciocutaneous and myocutaneous flaps were performed. A photographic record was made of all cases during flap harvest at specific stages of the operation, including the following: (1) preoperative skin markings of the cutaneous vessels; (2) intraoperatively at the identification of all sizable vessels and the descending branch of the lateral circumflex femoral artery; and (3) at completion of flap harvest to demonstrate the vascular anatomy. The following information was documented: the location of the sizable skin vessels, the exact course of the skin vessels (musculocutaneous perforators and septocutaneous vessel), their origin, and harvested pedicle dimensions.

The flaps were raised with a technique as described previously.²⁻⁴ A line is drawn between the anterior superior iliac spine and the upper outer border of the patella. The midpoint of this line was marked and handheld Doppler examination performed. In each case, attempts were made to identify three audible and pulsatile Doppler signals along this line. One is located in the vicinity of the midpoint and the other two proximal and distal to the first cutaneous vessel. These correspond to vessels A (most proximal), B (middle), and C (most distal) as described by Yu.^{11,12} The medial incision was made first and the flap elevated with the intramuscular septum between the rectus femoris and the vastus lateralis. The septum is then opened and the descending branch of the lateral circumflex femoral artery located. Sometimes, a distinct vascular pedicle located lateral to the descending branch exists in the proximal thigh. This branch, which we designate as the oblique branch of the lateral circumflex femoral artery, when present, is recorded and its dimensions at its origin and pedicle length recorded. The skin vessels to be included with the flap are selected and dissected. In the harvest of our myocutaneous flaps, we routinely unroof the perforators supplying the skin component from the point at which they en-

ter the deep fascia to their origin. This enabled us to determine the exact course and origin of the vessels supplying the skin regardless of whether we were harvesting myocutaneous or fasciocutaneous flaps. The information as stated above was then documented sequentially.

RESULTS

We attempted to harvest 89 flaps from the anterolateral thigh region. Myocutaneous flaps were harvested in 15 cases (17 percent). Fasciocutaneous flaps were harvested in 73 patients (82 percent). Of these 73 fasciocutaneous flap, 62 cases (85 percent) were perforator flaps (based on musculocutaneous perforators) and 11 (15 percent) were based on septocutaneous vessels.^{13,14} In one case (1 percent), sizable (>0.5 mm) cutaneous vessels were absent from the anterolateral thigh and harvest was abandoned. A free radial forearm flap was used.

At least three audible Doppler signals were located in 80 cases (91 percent). Intraoperatively, a mean of 1.92 sizable (>0.5 mm) skin vessels were seen (range, zero to four). Remaining perforators identified by Doppler examination were noted to be too small (<0.5 mm) to be useful intraoperatively. Except for the case with no skin vessel in the anterolateral thigh, all 88 anterolateral thigh flaps were raised successfully. Of these, the overall flap success rate was 97 percent, with three flap failures. Two failures were caused by venous thrombosis and one was caused by kinking of the pedicle. All 88 flaps were viable before division from the donor site, and failures were not related to technical problem of the harvest.

Musculocutaneous Perforators

Consistent with previous studies, the anterolateral thigh flap is commonly supplied by musculocutaneous perforators (85 percent of cases in this study).⁵ We found that, as reported by Yu, perforators tend to occur in clusters in the lateral thigh, designated A, B, or C by the author.¹¹ The B perforator is located in the vicinity of the midpoint between the anterior superior iliac spine and the upper outer corner of the patella. The A and C perforators are located proximal and distal to the B perforator, respectively. The midpoint B perforator is the most consistently present sizable vessel. It was noted in 48 cases. Perforators in this position that were located within 1 cm of the intermuscular septum have a characteristic short and superficial intramuscular course toward their origin. Therefore, intramuscular dissection is

quite short and can be performed quite easily. More laterally sited musculocutaneous perforators tend to take a more tortuous course, often running lateroposteriorly and caudally before turning cephalically and medioanteriorly toward their origin. More distally located perforators in the C location tend to be located more laterally on the vastus lateralis muscle. These are the more arduous perforators to dissect, as they tend to take a very long and tortuous intramuscular course (12 perforators dissected; mean intramuscular course, 9.7 cm; range, 7 to 13.5 cm). However, they are reliable and reward the surgeon with a very long pedicle (>15 cm) and should be the choice perforator when a long pedicle is needed.

Septocutaneous Vessels

The skin vessel supplying the flap traverses entirely within the intramuscular septum, usually originating from the descending branch of the lateral circumflex femoral artery. This is a very favorable situation, making flap harvest quick and easy. However, this anatomy occurs in only a minority (15 percent) of cases.⁵ Most of these septocutaneous perforators are located more proximally in the thigh (A position) (nine of 11). Although it is easy in most cases, sometimes, particularly in the elderly patient, the septum is heavily infiltrated with fat. Such “intrafat” dissection can be time consuming and should be performed carefully. Compared with intramuscular dissection, intrafat dissection presents a more indistinct plane of dissection and is laden with fragile tiny vessels that bleed easily.

Oblique Branch of the Lateral Circumflex Femoral Artery

The oblique branch of the lateral circumflex femoral artery is a previously unnamed branch that when present runs between the descending and the transverse branches of the lateral circumflex femoral artery (Fig. 1). In our 88 cases, a distinct oblique branch was noted in 31 patients (35 percent) (Fig. 2). The vessel is usually visible lateral to the descending branch in the upper part of the thigh once the intermuscular septum is opened. It runs for a variable distance in the intermuscular septum before piercing the substance of the vastus lateralis muscle, usually in the proximal third of the muscle. It may take origin from (1) the descending branch, (2) the transverse branch, (3) the lateral circumflex femoral artery, (4) the profunda femoris, or (5) even directly from the femoral artery. Based on its origin, we

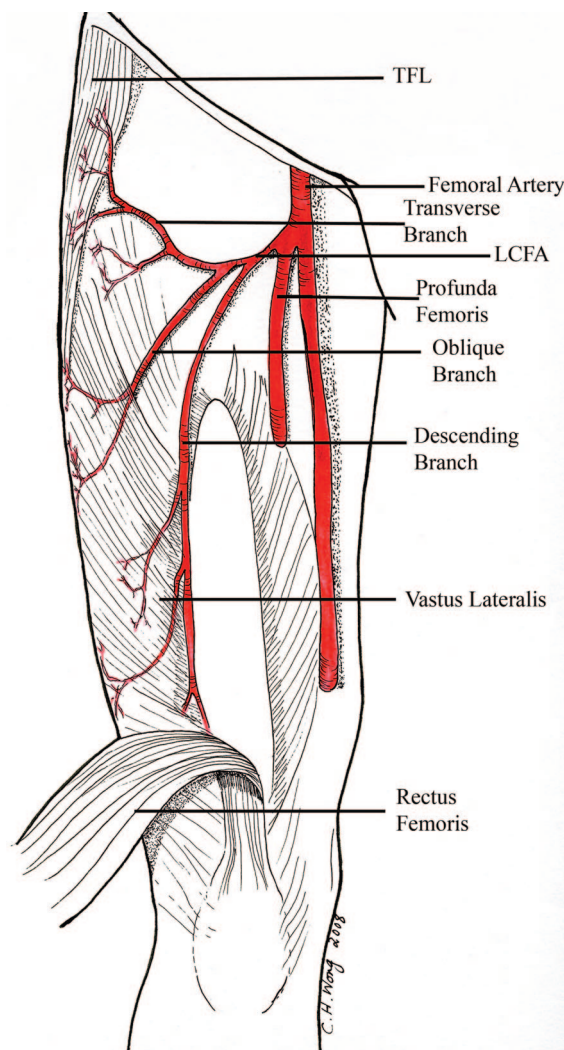


Fig. 1. Diagram illustrating the location of the oblique branch of the lateral circumflex femoral artery in the lateral thigh. This is a true vascular branch with an artery accompanied by two venae comitantes. It was present in 35 percent of cases. The oblique branch can reliably be used as the pedicle for flaps. TFL, tensor fasciae latae; LCFA, lateral circumflex femoral artery.

classified the oblique branch into types 1, 2, 3, 4, and 5 as shown in Figure 3. Types 1 and 2 are the commonest types, collectively accounting for 87 percent of our cases. The mean diameter of the artery of the oblique branch was 1.5 mm (range, 0.5 to 3.0 mm) at its origin and the mean pedicle length was 12 cm (range, 8 to 17 cm). It is accompanied by paired venae comitantes of comparable dimensions and usually accompanied by a branch of the motor nerve to the vastus lateralis. Of all anterolateral thigh flaps harvested, 12 of 88 (14 percent) were harvested based on the oblique branch. Of the 73 flaps harvested as fasciocutaneous flaps, 10 used the oblique branch as the flap

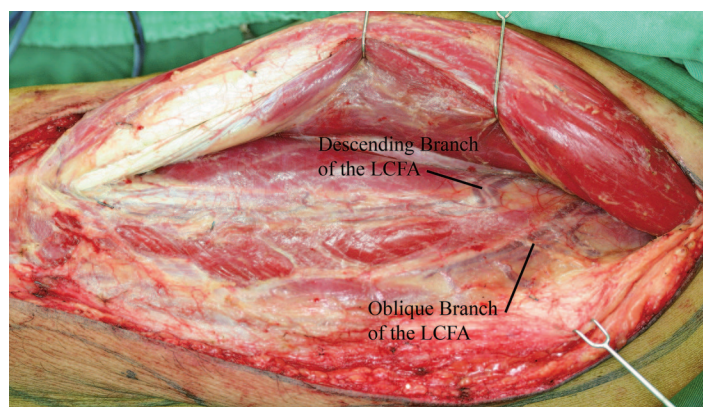


Fig. 2. The oblique branch can sometimes be very sizable. In this case, the oblique branch measures 3 mm and was the same caliber as the descending branch. Clearly, this is a vascular *branch* and not a perforating nutrient artery.

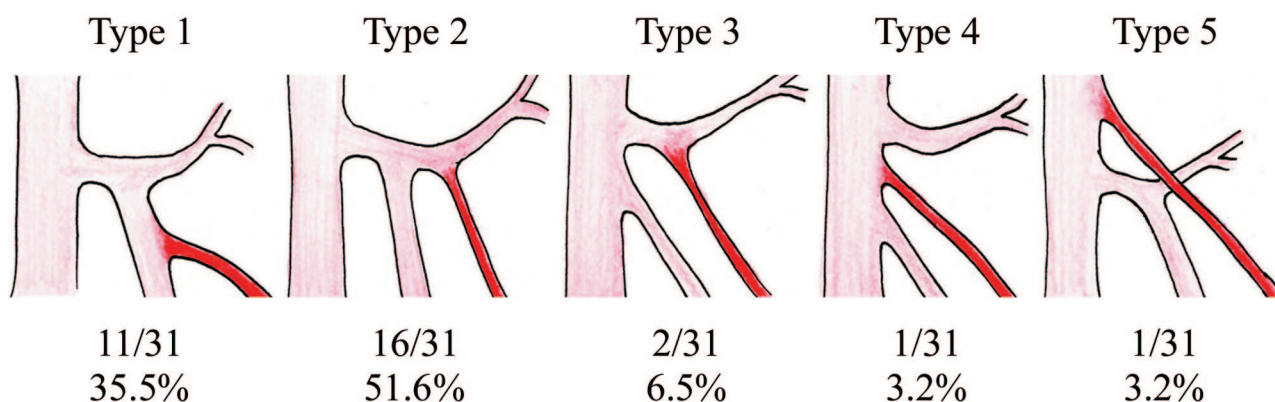


Fig. 3. Based on its origin, the oblique branch was classified into five types. Type 1 originated from the descending branch, type 2 originated from the transverse branch, type 3 originated from the lateral circumflex femoral artery, type 4 originated from the profunda femoris, and type 5 originated from the femoral artery. Types 1 and 2 were by far the commonest variants.

pedicle (Fig. 4). Perforators supplied by the oblique branch are commonly located proximal to the midpoint of the line between the anterior superior iliac spine and the patella. Of our 10 cases, six were A perforators, two were B perforators, and two were harvested with two perforators that were in the A and B positions. Of the 15 musculocutaneous flaps harvested, two were harvested with the oblique branch as the pedicle, as it was the dominant blood supply to the skin and muscle (Fig. 5). All flaps transferred based on the oblique branch of the lateral circumflex femoral artery were successful.

Absent Perforator

We noted only one patient (1 percent) with absence of sizable perforators in the lateral thigh within our flap design. Despite the reliability of handheld Doppler examination, such situations

do occur rarely. Depending on the reconstructive requirements, several options are available in these instances. Flaps in the vicinity of the incision, such as the anteromedial thigh flap or the tensor fasciae latae free flap, can be harvested. Alternatively, the opposite thigh or a different flap may be used.²

DISCUSSION

The anterolateral thigh flap is usually supplied by the descending branch of the lateral circumflex femoral artery.² The oblique branch is a variably present vessel in the lateral thigh that has not been clearly documented in the past despite its relatively high occurrence and clinical significance. In this series, the only contraindication to the harvest of an anterolateral thigh flap was the absence of sizable skin vessels in the lateral thigh. Technical skills needed for such versatility when harvesting

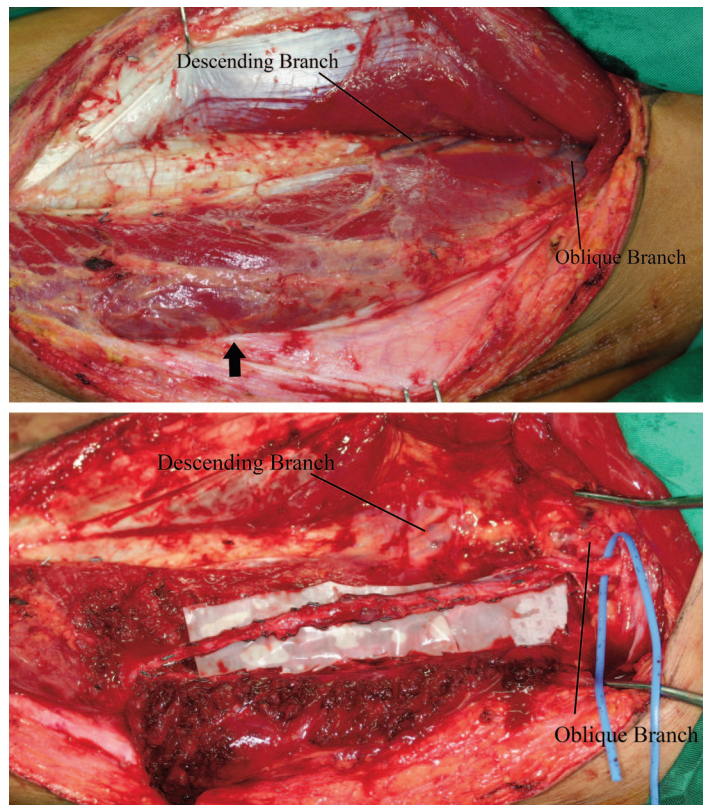


Fig. 4. Harvest of an anterolateral thigh perforator flap based on the oblique branch of the lateral circumflex femoral artery. When the intermuscular septum was opened, a descending branch and an oblique branch were noted. When the sizable skin perforator (*arrow*) was dissected intramuscularly, it was noted to originate from the oblique branch, with no vascular connections to the descending branch. The flap was transplanted successfully based on the oblique branch, leaving the descending branch completely in situ.

the anterolateral thigh flap include experience with retrograde intramuscular dissection of small musculocutaneous perforators and comfort in performing microsurgical anastomosis with vessels as small as 1 mm. This is important because the flap may have to be based on the oblique branch, which is usually smaller than the descending branch. Techniques of overcoming donor-recipient vessel size discrepancy including the use of end-to-side anastomosis should also be among the techniques used by the surgeon.^{15,16}

In their dissection study, Kimata et al. noted eight branching patterns of perforators that supply the skin of the anterolateral thigh.¹⁷ In Kimata types 1, 2, and 3, the perforator arises from the descending branch of the lateral circumflex femoral artery. These were the commonest types and constituted 84 percent of their cases. Kimata types 4, 5, 6, 7, and 8 variously described a “nutrient

perforating artery” that arose directly from the lateral circumflex femoral artery, profunda femoris, or femoral artery itself. Collectively, they accounted for 16 percent of their cases and their description was consistent with perforators that in fact originated from the oblique branch described in this article. Similarly, Shieh et al.¹⁸ in their article noted that 32 percent of “perforators” arose directly from the transverse branch (Shieh types 2 and 4), again consistent with the presence of an oblique branch. It is evident then that a previously unnamed, innominate branch exists in a significant proportion of patients. Previous articles have elected to call this a “perforator” that arose directly from a source other than the descending branch. We prefer to call this the oblique branch of the lateral circumflex femoral artery because this vessel (when present) is sizable and can reliably be used as the flap pedicle. Labeling this as

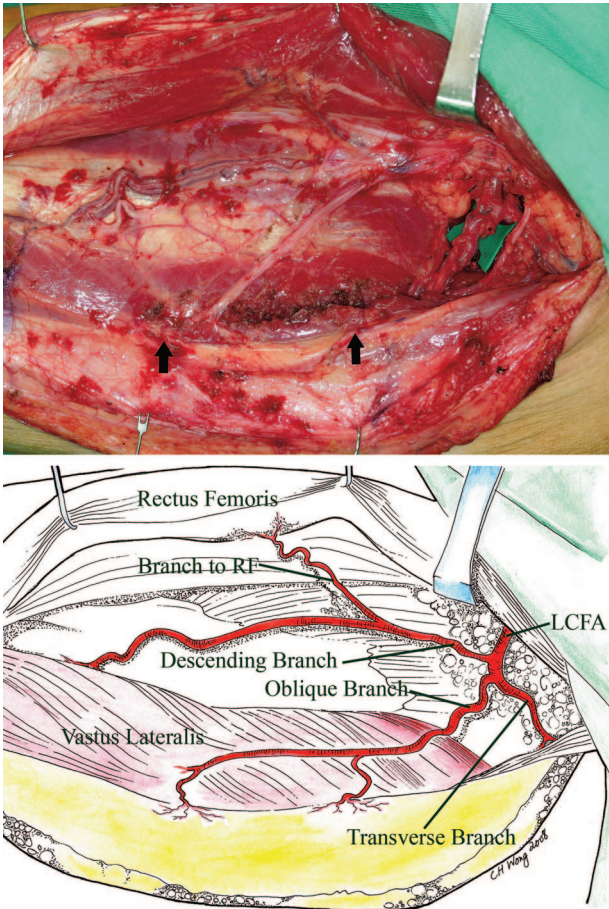


Fig. 5. Intraoperative view of a planned anterolateral thigh myocutaneous flap. The *arrows* indicate the location of sizable perforators. Unroofing the perforators revealed that both perforators arose from the oblique branch, which in turn originated from the transverse branch. This myocutaneous flap was transferred successfully based on the oblique branch of the lateral circumflex femoral artery.

merely a perforator would imply that it is much smaller and would require perforator-to-perforator “supramicrosurgery” for successful anastomosis.¹⁹ This is inaccurate and misleading.

When more than one skin vessel is available in the anterolateral thigh, several factors should be considered in vessel selection. These include the size of the perforator at the suprafascial or subfascial level and the length and size of the pedicle needed. In considering the length and size of the pedicle, a perforator that originates from the descending branch of the lateral circumflex femoral artery is preferred because it tends to be significantly larger and longer than the oblique branch. Occasionally, sizable perforators in the lateral thigh originate exclusively from the oblique branch. This variant compels the surgeon to use

the oblique branch as the flap pedicle. If a longer pedicle or a larger caliber is preferred, the oblique branch can be dissected proximally into the groin area to include higher order branches. In our classification, this can be done for types 1, 2, and 3 oblique branches. However, proximal dissection necessitates ligation of the descending branch or the transverse branch of the lateral circumflex femoral artery. Excessive ligation of large muscle branches in this process (in particular, the rectus femoris branch) may cause necrosis of the rectus femoris muscle.¹⁷ In types 4 and 5, the oblique branch originates directly from the profunda femoris and femoral artery, respectively, and cannot be sacrificed. Increasing pedicle diameter by harvesting a higher order branch is not feasible in these instances. These variants are fortunately rare.

The clinical implication of the presence of an oblique branch in the harvest of an anterolateral thigh myocutaneous flap is also significant. Although the vastus lateralis muscle is almost always vascularized by the descending branch of the lateral circumflex femoral artery, the skin component may be reliant solely on the oblique branch for its perfusion. The presence of this anomalous situation may explain the occasional encounter of a viable muscle with a nonviable skin component in a musculocutaneous flap harvested by including a block of vastus lateralis muscle with a skin flap based on the descending branch of the lateral circumflex femoral artery.²⁰ This is because the oblique branch that supplies the skin has been ligated with proximal transection of the muscle. To safeguard against this anatomical variation, we now routinely unroof all perforators to be included with the musculocutaneous flap to determine their origin. This can be performed safely with perforator flap techniques. Unroofing is technically simple and quick. Furthermore, in the vastus lateralis muscle, most large muscle branches emanating from the myocutaneous perforators run medially, laterally, and posteriorly. Very few run in the anterior direction. This makes unroofing quite bloodless and minimally devascularizes the muscle.²¹ Usually, the perforators originate from the descending branch and the flap harvest can be completed in the usual manner. If the skin is supplied by the oblique branch, flap harvest needs to be modified. If the oblique branch is sizable and multiple branches can be seen supplying the muscle, the myocutaneous flap with a small piece of muscle can be harvested based on the oblique branch alone. In contrast, if a large piece of muscle extending into the distal thigh is

needed, both the descending branch and the oblique branch may need to be included with the flap. This can be performed by tracing the pedicles more proximally to a point where the oblique branch and the descending branch converge into a single pedicle (feasible for types 1 and 2). In situations where the descending branch and the oblique branch do not converge (types 3, 4, and 5), two sets of microanastomoses may be needed.

Wei and Mardini²² and Mardini et al.²³ pioneered the free-style flap harvest concept. With this approach, any cutaneous vessel that can be located by a handheld Doppler probe can potentially be harvested by retrograde dissection as a free or pedicle flap, regardless of regional anatomy. When applied to the anterolateral thigh flap, this concept stresses that the flap may not necessarily be harvested based on the descending branch of the lateral circumflex femoral artery but can be safely based on whichever pedicle our selected skin feeding vessel takes us. In this study, we demonstrated that the oblique branch can reliably be used as the pedicle.

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