Alternative Regional Flaps When Anterolateral Thigh Flap Perforator is not Feasible

Joon Pio Hong · Eun Key Kim · Hoon Kim ·
Hyun Woo Shin · Chang Hun Hwang · Moo Young Lee

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Abstract This paper presents the scheme to select alternative flaps limited to the region of the ipsilateral thigh when the perforator of the anterolateral thigh flap is not feasible. Total of 564 consecutive microsurgery cases using anterolateral thigh perforator flap was reviewed from March of 2001 to January of 2009. Total of 12 cases used a contingent flap due to anatomical and technical complications of the anterolateral thigh perforator. The alternatives were skin perforator flaps adjacent to the initial flap (3 cases of upper anterolateral thigh flap, 4 cases of anteromedial thigh flap), vastus lateralis muscle flap with skin graft (2 cases), and anterolateral thigh flap as septocutaneous flap without a prominent perforator on the septum (3 cases). All flaps survived and provided coverage as planned but one case using septocutaneous flap without a prominent perforator was noted with partial necrosis. Adjacent flaps around the anterolateral thigh perforator flap may provide useful alternative flaps in cases of failed elevation. Limiting the contingent secondary flap to this region may reduce further donor site morbidity and still provide an adequate flap for reconstruction.

Keywords Alternative to anterolateral thigh perforator flap · Perforator flap

Introduction

The anterolateral thigh flap was first introduced by Song et al. in 1984 as a septocutaneous flap [1]. As technology and knowledge of the flap evolved, it was evident that perforators were the dominant source of blood supply rather than a random pattern of supply. The anterolateral perforator flap is based on a cutaneous perforator that usually originates from the descending branch of the lateral femoral circumflex artery. The main perforator is usually traced on the mid portion of the line drawn between the anterior superior iliac spine and lateral border of the patella of the donor thigh [2–7]. By definition, the cutaneous perforator artery penetrates the outer layer of the deep fascia to supply the overlying subcutaneous fat and skin [8]. The perforator may have different pathways such as septocutaneous, musculocutaneous, septomusculocutaneous, and the axial pattern leading ultimately to the source vessels. It is also known that certain number of flaps is observed without perforators (failure to capture perforators within the flap) or perforators too small and unreliable to elevate [9–11]. Introduction of intuitive methods for preoperative perforator evaluation may prove to be valuable in predicting the status of the highly variable perforator but can be sophisticated, invasive and expensive [12]. Although in current practice we are increasing the utilization of CT angiograms to evaluate vascular status, the simpler ultrasonic Doppler tracing remains to be the mainstay for preoperative perforator assessment despite lacking information of exact pathway or the diameter of the perforator. This may increase the risk to capture a healthy pedicle within a flap.

The purpose of this paper is to introduce a scheme to use alternative flaps adjacent to the initial anterolateral flap when the use of this flap is not feasible due to anatomical

J. P. Hong (✉) · E. K. Kim · H. Kim · H. W. Shin ·
C. H. Hwang · M. Y. Lee
Department of Plastic and Reconstructive Surgery,
Asan Medical Center, University of Ulsan College of Medicine,
388-1 Pungnap-dong, Songpa-gu,
Seoul, Korea 138-736
e-mail: joonphong@amc.seoul.kr

factors or technical errors while limiting the donor site to the ipsilateral thigh to prevent further donor site morbidity.

Material and Method

Total of 564 consecutive microsurgery cases using anterolateral thigh perforator flap was reviewed from March of 2001 to January of 2009. Among the reviewed cases, total of 12 cases were switched to other flaps during operation due to anatomical or technical reasons. All flaps were planned based on routine preoperative evaluation with Doppler tracing. But 8 cases did not have a feasible perforator within the boundaries of the flap and 4 cases suffered injury to the perforator while elevating. The 12 cases are focused on this report.

Operative Technique

The elevation technique of the anterolateral thigh flap has been described numerous times by various authors thus in this paper the technical aspect of flap elevation will be limited to identifying the perforator [2–7].

A line was drawn between anterior superior iliac spine and superior lateral border of the patella on the donor thigh. The perforator branches are identified with Doppler near the midpoint of this line. According to our clinical experience, about 90% of perforators are found within 3cm. diameter drawn at the midpoint of the line. These findings are similar with other reports [2–7, 13–15]. The skin flap is designed to include the perforator and then elevated from the medial border of the flap. The incision is made through the deep fascia then the flap is raised till the intermuscular septum between the rectus femoris and vastus lateralis muscle is reached. About 10 to 15% of the time you will be able to see the perforator making its path on the layer of the intermuscular septum leading to the descending branch of the lateral femoral circumflex artery but if not observed one should start elevation of the lateral margin. From the lateral margin elevating the flap with the deep fascia attached, you will come across perforators piercing through vastus lateralis muscle. If there are no perforators from both approaches, search for an alternative flap should begin. But identification of the perforator should be thorough especially including the proximal portion of the flap where deep fascia may be tightly adhered to the underlying muscle thus hiding the pedicle in existence. A note should be made not to violate the intermuscular septum attaching to the deep fascia of the flap before a reliable perforator is identified. The septum itself will be able to provide blood supply to the flap and this attachment can be useful especially in cases where prominent perforator is not found supplying the flap. You may inset the flap

back to the donor site or consider using it as a septocutaneous flap.

The regional alternatives when perforators are not found, not feasible or injured can be any skin perforators adjacent to the flap (free style), vastus lateralis muscle flap with skin graft, and the anterolateral thigh flap as septocutaneous flap without a prominent perforator.

Adjacent Perforator Flaps

Common perforator flaps adjacent to anterolateral thigh perforator flap are; 1) upper anterolateral thigh flaps originating from transverse branch of lateral femoral circumflex artery and 2) medial thigh perforator flap originating from medial branch of the descending branch of the lateral femoral circumflex artery or originating directly from the femoral artery itself.

Exploration of adjacent perforator begins by searching perforators nearest to the skin excision margin. By dissecting the layer between the muscle and deep fascia, perforators may be located. Doppler tracing can aid in locating the nearest perforators. If the proximal portion of the anterolateral thigh flap was spared from the initial design, it is likely that you can find a perforator from this region and elevate a new flap. It is worth noting that perforators should be identified first followed by elevation to prevent further damage. Usually the perforator from the upper anterolateral thigh or lateral thigh originates from the transverse branch of the lateral femoral circumflex artery. The next alternative would be to search the medial side of the thigh for perforators in the plane between deep fascia and muscle. The perforator of the anteromedial thigh flap may originate from various source vessels but commonly from the medial branch of the descending branch of the lateral femoral circumflex artery or directly from femoral artery [16–18]. Once the perforator is identified the manner of elevation is similar to any perforator flap.

Vastus Lateralis Muscle Flap with Skin Graft

While isolating the source vessel, numerous branches supplying the vastus lateralis can be seen from the descending branch of the lateral femoral circumflex vessel. This muscle flap can provide sufficient bulk and can be utilized when a skin paddle is not required. Full thickness skin was harvested from the discarded skin paddle of anterolateral thigh flap.

Anterolateral Thigh Flap as Septocutaneous Flap without a Prominent Perforator

If no prominent perforators are observed from both medial and lateral approach, fine vasculatures are often

noted on the intermuscular septum. This can be identified with surgical loupes. The flap should include the intermuscular septum from proximal to distal point of the flap, the deep fascia in accordance with the skin paddle, and a fascial cuff along the descending branch of the lateral femoral circumflex pedicle. If microvasculature is scarce on the intermuscular septum with loupe magnification, this alternative should not be considered.

Results

Among the 564 consecutive cases, 494 cases had musculocutaneous perforators (87.6%), 62 cases were septocutaneous perforators (11%), and 8 cases failed to identify a perforator within the flap boundaries (1.4%). Including the eight cases without an identifiable perforator, four more cases with perforator injury beyond repair required alternative flaps. All were successfully substituted with flaps from the same region limiting the donor morbidity to a single thigh. The alternative flaps were skin perforators adjacent to the flap, vastus lateralis muscle flap with skin graft, and septocutaneous anterolateral thigh flap without a prominent perforator (Table 1). The adjacent perforator flaps were used in seven cases; three cases of upper lateral thigh perforator flaps all originated from the transverse branch of the lateral femoral circumflex artery, four cases of anteromedial thigh flap where two perforators originated from the medial branch of the descending branch of the lateral femoral circumflex and two perforators originated from the femoral artery. The vastus lateralis muscle flap and skin graft were used in two cases and provided a reliable coverage. When the intermuscular septum was intact with multiple microvasculature, the flaps were used as a septocutaneous flap. This flap however was not able to be debulked and required secondary debulking procedure. Among the three cases, one case resulted in partial loss of 20% but eventually healed with conservative care.

Patient Cases

Case 1

A 66-year-old male with diabetic foot ulceration and concurrent osteomyelitis of the first metatarsal bone was referred for debridement and reconstruction. Initial plan involved debridement of the ulcerative lesion and bone, metatarsophalangeal joint fusion, and coverage with anterolateral thigh perforator flap. Despite confirmation of the perforator by Doppler tracing of the flap, a prominent perforator was not noted within the 6×5 cm. flap. The intermuscular septum remained attached to the deep fascia of the flap during elevation. Exploration of the medial thigh between the deep fascia and muscle revealed a reliable perforator. The anteromedial thigh flap was designed around the perforator with the same dimension and elevated. The perforator led to the medial branch of the descending branch of the lateral femoral circumflex vessels. The anterolateral thigh flap maintaining its attachment to the intermuscular septum was rotated to repair the donor site. Both flaps survived without any incident (Fig. 1).

Case 2

A 46-year-old male diagnosed with malignant melanoma of the right plantar surface was scheduled to undergo wide excision and anterolateral thigh perforator flap. A 9×8 cm. flap was designed but the perforator was injured while elevating. Multiple feeding vessels to the vastus lateralis muscle were observed leading to the descending branch of the lateral femoral circumflex vessel at this point of operation. The muscle was elevated enough to cover the defect of the sole and a full thickness skin graft was harvested from the discarded anterolateral thigh flap. No additional incision was needed other than the incision made from harvesting the anterolateral thigh flap and primary closure of the donor site was achieved. The flap survived uneventfully (Fig. 2).

Table 1 Alternative flaps used when the perforator of anterolateral thigh flap was not feasible

Perforator flap		Vastus lateralis muscle flap		Anterolateral thigh fasciocutaneous flaps without prominent perforator
AMT		Upper ALT		
Medial descending Br.	Direct femoral			
2	2	3	2	3

AMT anteromedial thigh flap, VL vastus lateralis muscle flap with skin graft

Fasciocutaneous: Anterolateral thigh fasciocutaneous flap without prominent perforator

Medial descending Br.: Medial branch of Descending Branch of lateral femoral circumflex

Fig. 1 A 66-year-old male with diabetic foot ulceration and concurrent osteomyelitis of the first metatarsal (**a**). Note the anterolateral thigh flap with intermuscular septum attachment and no prominent perforator rotated to close the donor site (**b**). The flap at 5 months without any recurrence

Case 3

A 46-year-old male with a defect on the dorsum of the left foot from a burn injury was planned for coverage using anterolateral thigh perforator flap. Despite confirmation of the perforator by Doppler tracing of the flap, a prominent perforator was not noted within the 12×7 cm. dimension. However, despite the absence of a prominent perforator, the intermuscular septum was observed with multiple microvasculature with loupe magnification. The septum attached to the deep fascia from the proximal to distal edge of the flap was elevated as a septocutaneous flap. Multiple microvessels were seen connected with the descending branch. The pedicle was elevated with a fascial cuff surrounding the pedicle. Partial flap necrosis, about 20%,

was noted toward the medial margin. The flap healed eventually with conventional treatment (Fig. 3).

Discussion

The introduction of perforators has increased the knowledge of anatomy and physiology of flaps in reconstructive microsurgery. The choice for skin flap selection can be theoretically from anywhere based on a perforator (free style). Among these perforator flaps, the anterolateral thigh perforator flap, deep inferior epigastric perforator flap, thoracodorsal artery perforator flap, and superior gluteal artery perforator flap are the used with increased frequency due to its reliable pedicle (source vessel) anatomy.

Fig. 2 A 46-year-old male diagnosed with malignant melanoma of the right plantar surface (a). The vastus lateralis muscle flap was used as an alternative after pedicle injury. A full thickness graft was harvested from the skin paddle of the anterolateral thigh flap to graft the surface of the muscle flap. The flap with good contour at 5 months after reconstruction (b)

However, the risk for a difficult dissection still remains to be a problem.

Usually a simple ultrasound Doppler will be enough to map the perforator preoperatively. There are advanced method of evaluation such as noninvasive color duplex imaging or an invasive angiogram which can provide accurate information but the use is not warranted in low risk cases due to technical skills required, cost, and time consumed [12]. It should be reserved for patients with high risk with systemic disease such as arthrosclerosis or diabetes [6]. Therefore, as long as the use of ultrasound Doppler remains the choice for preoperative evaluation to locate perforators remains, 1–2% of anterolateral thigh perforator flaps is likely to have insufficient perforators after positive Doppler tracing. It is in this 1–2% of the cases or when perforator is injured that one has to consider an alternative flap. A surgeon usually has a plan B but simply turning to the other side of the thigh or another donor site will increase the morbidity caused by donor sites. Using adjacent reginal flaps in primary donor site, the other side of leg can be saved without

Fig. 3 A 46-year-old male with burn on the dorsum of the left foot (a). Despite confirmation of the perforator by Doppler tracing of the flap, a prominent perforator was not noted within the 12×7 cm. dimension of the flap (b). Reconstructed with a septocutaneous flap partial flap necrosis is noted (c). The flap healed eventually with conventional treatment

damage, and if the first flap was failed, contralateral thigh could be a good salvage option. Therefore, a reasonable option would be to seek an alternative flap within the adjacent region.

The study on angiosomes describe multiple possibilities of various perforator flaps [8]. Many papers has been reported to use anteromedial thigh, upper anterolateral thigh, and lateral thigh from the descending branch of the

lateral femoral circumflex system [17–19]. When a large flap is designed on the anterolateral aspect of the thigh, multiple perforators of different angiosomes are included. Thus the risk for absent perforator decreases in larger flaps. In this series, all flaps with dimension over 12×8 cm. had at least one prominent perforator within the flap boundaries. A large flap may have multiple perforators allowing a graceful margin of error when one perforator is injured while elevating the flap. Therefore, it is usually the flaps of moderate or small dimension, under 12×8 cm. in this series, that a contingent flap may be required. A moderate to small flap will spare the adjacent angiosomes that can be used as an alternative flap. The search for a nearby perforator becomes easy once the layer between the deep fascia and the muscle is exposed. Just by tenting the deep fascia, one can see perforators entering the fascia from the muscle or a septum that leads to the skin paddle. Once the perforator is confirmed, flap is designed around the perforator and harvested. This concept has been termed free style free flap harvest by Wei et al and is one of the popular methods of elevating various new perforator flaps [20]. In this series, nearby perforators of choice were upper anterolateral thigh and anteromedial thigh flap. The upper anterolateral thigh is easier to approach and has a predictable perforator leading to the transverse branch. However, the initial design of the anterolateral thigh flap frequently involves this region not sparing enough skin flap to be used. The medial thigh can become the next reliable option. The anteromedial thigh perforator flap is more challenging in the sense that perforators have multiple variations and may lead to various source vessels. In this study, two led to the medial branch of the descending branch of the lateral femoral circumflex artery and two directly to femoral artery. The former ones provide long pedicle length making reconstruction easier than the later. There are papers reporting the variations of the perforator but when harvested proximally, the perforator tends to drain to the medial branch of the descending branch as also seen in this study [16, 21]. Despite the anatomical variations, the perforator can be visually identified first then followed by elevation of the flap making this a reliable alternative. The perforator flaps of the adjacent region can be used as first alternative choices because it provides the same quality and function as the initially planned anterolateral thigh perforator flap.

The vastus lateralis muscle flap is frequently used in combination with the anterolateral thigh flap where bulk is needed to obliterate dead space. The efficacy has been described and has shown to be a reliable flap based on the descending branch of the lateral femoral circumflex [2, 4, 7, 11, 15]. When the perforator to the skin is injured while elevating, this flap can provide muscle coverage with a skin graft harvested from the anterolateral thigh skin paddle. No

additional incision is needed minimizing donor site morbidity. However when the defect requires a thin versatile flap, it is quite difficult to harvest a thin vastus lateralis muscle flap. It would also be difficult to cover extensive defects due to the limited amount of muscle bulk that can be harvested without impairing the function of the knee. Therefore, this flap can be used but it will not provide the function and aesthetic superiority as the anterolateral thigh flap.

The anterolateral thigh perforator flap can be elevated suprafascially. It is a reliable technique but demands more technical skills. I personally find it easier to elevate the flap by including the deep muscle fascia (sub-fascia approach). Other advantage of sub-fascia elevation is wide exposure of the surgical field, perforator and the source vessels. Also the intermuscular septum is not violated by a sub-fascia approach. The blood supply through the microvasculature of the septum to the flap can be useful when a prominent perforator is not identified. As seen in case 1, the septocutaneous flap was rotated to close the donor site of the anteromedial thigh. If a prominent perforator is identified, the deep fascia, intermuscular septum and the deep layer of subcutaneous fat can be debulked anytime and the flap thinned to achieve the versatility of the anterolateral thigh perforator flap. Among the three cases reconstructed with anterolateral thigh septocutaneous flap without a prominent perforator on the septum, two survived without any event. Secondary debulking procedures were needed for the flap to blend with the surrounding tissue. In one case, partial necrosis was noted. How much microvasculature is required in the absence of a prominent perforator to assure survival remains to be studied. The use of this alternative method poses risks and would be justified to close the donor site but rarely to resurface a defect unless the septum is noted with abundant microvasculature. An overall scheme to approach alternative flaps is shown on Fig. 4.

Fig. 4 A scheme to select alternative flaps when the perforator of the anterolateral thigh flap is not feasible

The evolution of microsurgical technique has come to appoint that source vessel may not be needed to anastomose with a sizable recipient vessel. The introduction of supermicrosurgery technique has made perforator flap harvesting a true free style flap only taking the perforator without penetrating the fascia for the pedicle [22, 23]. With this technique, cases needing to explore alternative flaps will dramatically decrease. However this technique requires special skills and instrumentation and has yet to be popularized. This study presented various ways to choose an alternative flap when the perforator of the anterolateral thigh is not feasible. Limiting the contingent flap to its region reduces further donor site morbidity and still provide adequate flap for reconstruction.

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