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Original Article

Vascular anatomy of the anteromedial thigh flap

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ABSTRACT

Introduction: The anteromedial thigh flap (AMT) lies adjacent to the anterolateral thigh flap (ALT) area and can be used as a backup whenever the ALT is not feasible. Literature published on the AMT flap is limited, and the vascular anatomy of the AMT flap is not well understood. Clarification of the vascular anatomy will be useful for safe and efficient planning and raising of the AMT flap.

Method: Fourteen cadaveric lower limbs were injected with latex dye and dissected to study the skin perforators larger than 0.5 mm in the anterolateral and anteromedial thigh. We demonstrate the application of the AMT flap in a clinical case where a combined ALT and AMT flap was used to reconstruct a tongue and floor of mouth defect post cancer resection.

Results: Perforators that supplied the rectus femoris muscle and the overlying skin were present in all specimens and 12/14 (85.7%) specimens had rectus femoris branches (RFBs) originating from the descending branch of the lateral circumflex iliac artery. In total, 82.4% of AMT perforators are musculocutaneous (14/17 specimens), and they pierce the muscular fascia along a line drawn from the mid-inguinal point to the superomedial pole of the patella. The perforators congregate at the one-quarter mark and the midpoint of this line. This line is useful for the preoperative planning of the AMT flap.

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Conclusion: The anatomy of the RFB, which is critical in the blood supply of the AMT flap, is constant and predictable. The location of the perforators is predictable, which aids preoperative planning.

Introduction

The anterolateral thigh (ALT) flap is the workhorse flap in reconstruction, frequently being utilised to cover defects in the head and neck, lower limb and even for breast reconstruction.[1] There are still limitations to the ALT flap such as in patients who had previous surgery or trauma to the lateral thigh region, instances where there are no sizeable perforators to the ALT flap or when patients require very large soft tissue cover.[2] The anteromedial thigh (AMT) flap is just adjacent to the ALT flap, but its anatomy is not well understood. Previously, Yu et al demonstrated that the AMT flap is best described as a flap that is supplied by a branch coming off the descending branch (DB) of the lateral circumflex femoral artery (LCFA) called the rectus femoris branch (RFB).[3] However, the anatomy of the RFB and how it supplies the skin is unclear. Consequently, we are unable to reliably surface mark such perforators, which makes flap design and preoperative planning difficult. We believe the row of perforators supplying the AMT flap will be in between the row of perforators of the ALT and the medial thigh (gracilis and adductor longus), and hence, we approach our thigh dissection study from lateral to medial to further define the vascular anatomy of the anteromedial thigh flap.

Method

Fourteen cadaveric lower limbs attached to the pelvis from Science Care Inc. (USA) were used for cadaveric dissection.

Preparation of specimen

Cadaver lower limbs were obtained as fresh frozen specimens and stored at −4 °C to ensure high tissue quality. Specimen preparation was done within 3 days of delivery. Latex was injected through the dorsalis pedis artery, posterior tibial artery, the long saphenous vein and the short saphenous vein. These vessels were first cannulated distally in the ankle and foot with 18G/20G cannulas. Seventy millilitres of water was used to flush the vessels until clear effluence void of clots and blood was seen exiting the open vessels in the pelvis. Air was then pushed through the vessels to ensure that they were emptied. Leaking vessels in the pelvis were identified and ligated. The arteries were dyed with red latex, while the veins were dyed with blue latex. The specimens were stored at −20 °C for 1 week. The specimens were then thawed for 24 h prior to dissection.

The line joining the anterior superior iliac spine to the super lateral corner of the patella (AP line) was used as a guide for the initial incision. An incision 2 cm lateral to the AP line was made to incorporate as many perforators as possible along the AP line. The incision was deepened and a dissection continued on the subfacial plane overlying the tensor fascia lata and the vastus lateralis. A sizeable perforator is defined to be larger or equal to 0.5 mm. The position at which the perforator exits the fascia into the soft tissue is marked on the overlying skin (Figure 1). We continue to deglove the thigh as medially as possible. A second skin incision is made 2 cm medial to the medial border of the rectus femoris to fully isolate and identify the medial row of perforators.

After identifying the skin perforators that pierce the deep fascia, we dissect along its path to trace the path of each perforator proximally and examine the vessel's branching patterns and origin. External vessel calibres were measured with a stainless steel ruler (Shinwa Measuring Tools Corp.), which was accurate up to 0.05 mm.

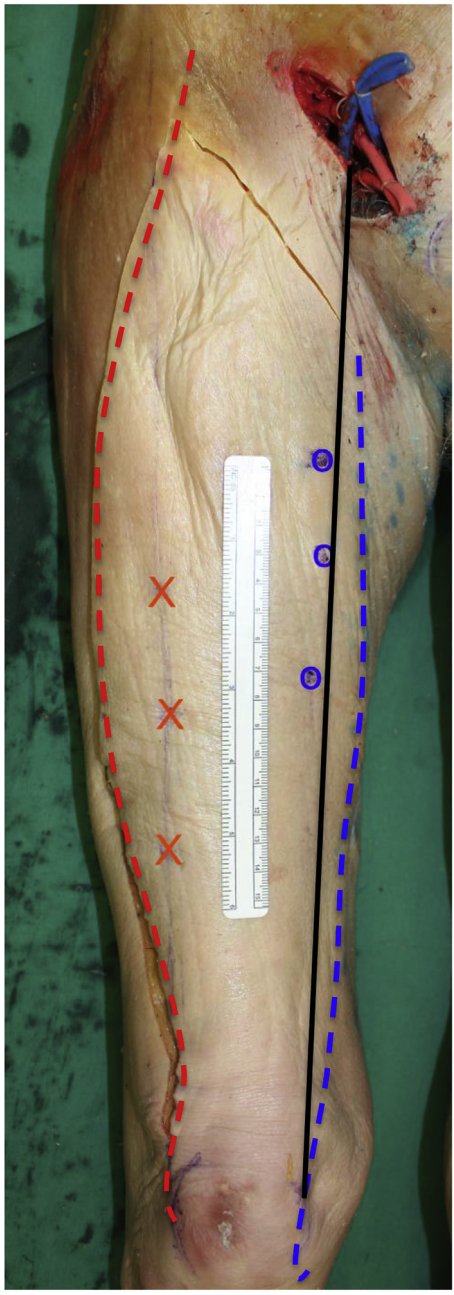


Figure 1. Dissection of thigh. Dissection of the right thigh showing the Anterolateral thigh (ALT) perforators (red X) and the Anteromedial thigh (AMT) perforators (blue circle). The dissection starts with the lateral incision line (broken red line) to expose the ALT perforators and the descending branch of the lateral circumflex femoral artery followed by the medial incision line (blue broken line) to fully isolate the AMT perforators. The imaginary line between the mid-inguinal point and the medial patella named as the 'MP line' is denoted by the black solid line.

One investigator to eliminate inter-observer variability performed all dissections and measurements.

Results

AMT perforators

In our dissection, we identified all the perforators supplying the skin overlying the anterior thigh. A total of 56 perforators were identified in the anterior thigh of 14 limbs. Thirty-nine perforators supply ALT flap, while 17 perforators supply the AMT flap. A summary of the perforators can be found in Table 1. There is no relationship between the AMT and ALT perforators.

We noticed that the thigh perforators are arranged in vertical rows. The anterolateral row of perforators supplies the ALT flap (Figure 1). The anteromedial row of perforators can be divided into the proximal and distal half. The proximal half of the anteromedial row of perforators specifically supply the AMT flap (Figure 2).

The musculocutaneous (MC) perforators of this proximal half of the anteromedial row are present in 13/14 specimens (92.9%) and have a short intramuscular course through the rectus femoris (Figure 3). In total, the proximal half of the anteromedial row had 17 perforators of which 14 were MC and 3 were septocutaneous (SC) perforators. An average of 1.2 (0–2) perforators were present in the proximal half of the anteromedial row. Compared to the MC perforators, the SC perforator occurs less frequently and is present in only 3/14 of our specimens (21.4%) (Figure 4). When a SC perforator is present, there is always a separate MC perforator supplying the skin. The AMT perforators, which are defined to supply the anteromedial thigh flap, originate from the DB of the LCFA in 11/14 specimens. The mean pedicle length of the cutaneous perforator of the RFB was 8.9 ± 1.3 cm, as measured from the exit of the fascia to the hilt of the RFB branch off its origin artery.

In the distal half of the anteromedial thigh, there were fewer perforators. A total of 13 significant perforators were identified, with an average of 0.93 (0–1) perforators present per thigh specimen. These perforators were musculocutaneous and ran a deep course through the vastus medialis muscle originating from the superficial femoral artery (SFA) or the descending genicular artery (Figure 5).

The anteromedial row of perforators pierces the fascia in the vicinity of an imaginary line drawn from the mid-inguinal point (femoral artery position) to the superomedial pole of the patella. We call

Table 1
Lateral and medial row perforator summary.

Specimen no.	Anterolateral thigh flap perforators/lateral row		Anteromedial thigh flap perforators/medial row	
	Musculocutaneous perforators	Septocutaneous perforators	Musculocutaneous perforators	Septocutaneous perforators
1	2	0	1	0
2	1	1	1	1
3	2	1	1	0
4	2	0	2	0
5	2	1	1	0
6	2	1	0[a]	0
7	2	1	1	0
8	3	0	1	0
9	2[b]	2	1	0
10	2[b]	0	1	0
11	2	1	1	0
12	2[b]	1	1	1
13	3	0	1	0
14	2	1	1	1
Total	29 (74%)	10 (26%)	14 (82%)	3 (18%)
	39		17	

[a] Specimen 6 rectus femoris branch is large but <0.5 mm cutaneous perforators is seen.
[b] Oblique branch of the descending branch of the lateral circumflex femoral artery is present.

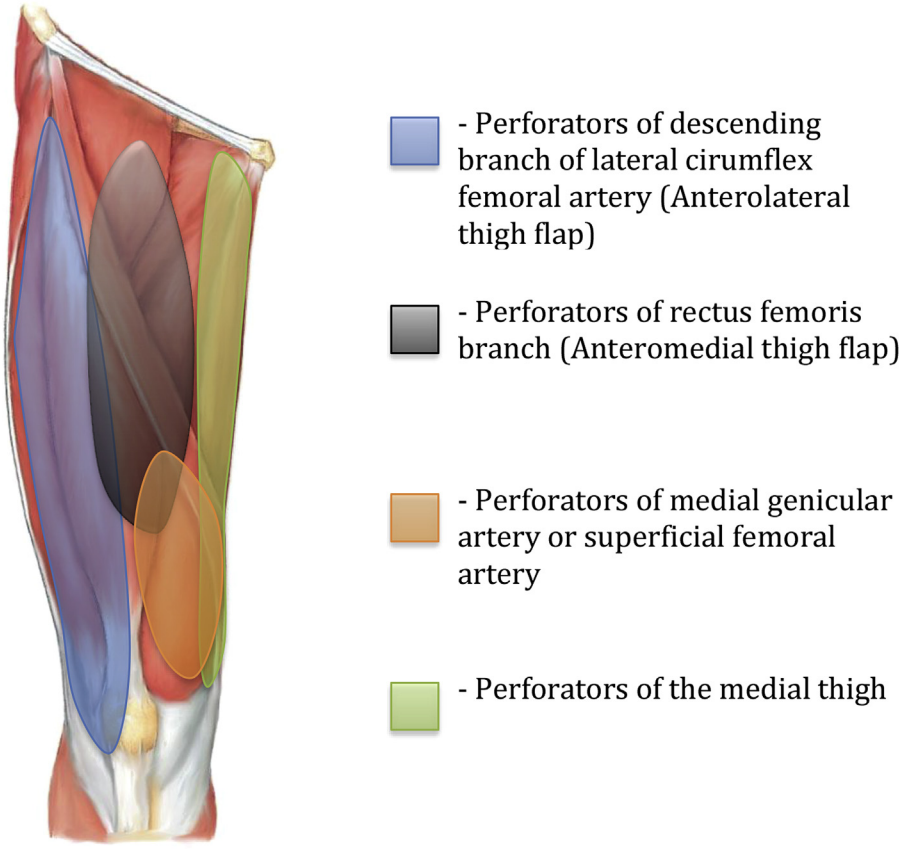


Figure 2. Proposed perforator territories.

this line the MP (mid-inguinal to patella) line. The MP line measured 39.6 ± 2.2 cm. Congregations of perforators are noted to be at the midpoint and proximal one-quarter mark of this line (Figure 6).

Rectus femoris branch

The RFB is a distinct and consistent branch that provides blood supply to the rectus femoris muscle. It is present in all specimens, and an average of 1.3 RFBs are present per specimen.

It originates from the DB of the LCFA in 14 out of 18 (66.7%) RFBs. Two out of 18 (11.1%) RFBs originated from the SFA, and two (11.1%) RFBs originated from the LCFA directly (Table 2). In majority of specimens, the RFB originates from the DB shortly after it comes off the LCFA. The RFB then travels along the medial border of the rectus femoris before piercing the muscle and fascia to supply the subcutaneous tissue and skin (Figure 4). We defined the RFB as the dominant blood supply to the rectus femoris muscle that enters the proximal half of the muscle. In our specimens, the average vessel diameter of the RFB was 1.9 mm (1.5–2.7 mm). According to this definition, some specimens had two RFBs of varying origins (Figure 7). In total, there were 18 RFBs in 14 specimens of which 12 vessels (77.8%) originated from the DB of the LCFA, two (14.3%) were from the SFA and the last two (14.3%) were from the LCFA directly. A summary of the RFB origin is given in Table 2.

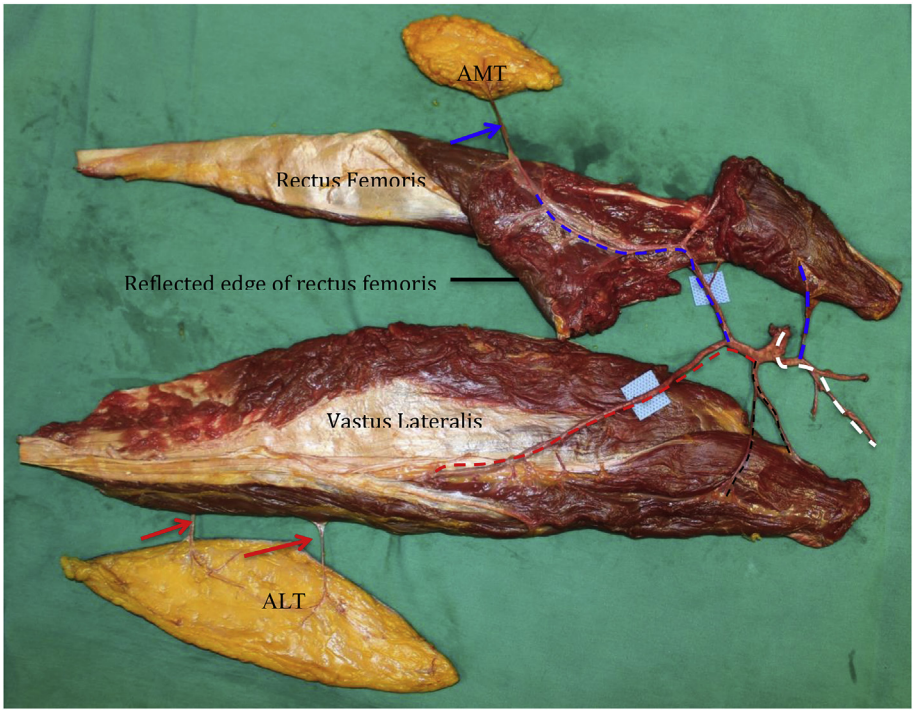


Figure 3. Anteromedial thigh (AMT) flap with musculocutaneous (MC) perforators and the anatomy in relation to the Anterolateral thigh (ALT) flap. The arterial vascular anatomy of the ALT and AMT flaps are shown here. The Descending branch (Red broken line) comes off the lateral circumflex femoral artery (LCFA) (white broken line), entering the vastus lateralis to give off perforators (red arrows) supplying the ALT flap. The ascending branch of the LCFA supplying the tensor fascia lata muscle (black broken line) is also seen in this specimen. There are two RFB's (blue broken line) of which one comes off the descending branch of the LCFA coursing through the Rectus femoris muscle before piercing the muscle fascia to become a perforator (blue arrow) supplying the AMT flap. This is a type I AMT flap.

Figure 4. Left thigh septocutaneous anteromedial thigh flap perforator. Medial aspect of left thigh: Septocutaneous rectus femoris branch (RFB) perforator (white arrowhead) originating from the descending branch of the lateral circumflex femoral artery.

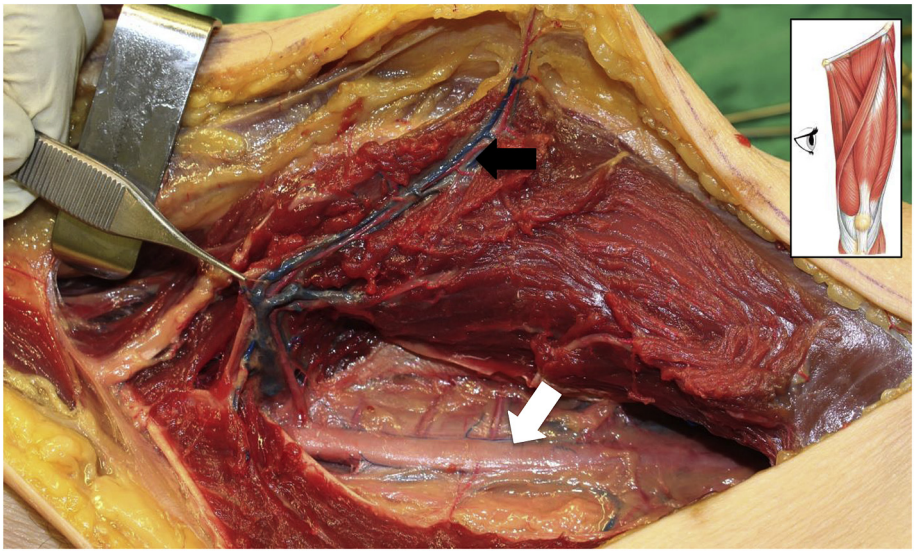


Figure 5. Course and origin of perforators supplying the distal half of the anteromedial thigh. Medial aspect of left thigh: Medial row perforator (black arrow) in the lower half of the thigh with a long intramuscular course through the vastus medialis originating from the Superficial femoral artery (white arrow). This is not part of the anteromedial thigh flap territory.

Muscle blood supply

Blood supply to the rectus femoris is usually supplied by one RFB and several segmental arteries from various sources such as the DB of the LCFA and the SFA. There are many segmental branches, but these branches are small and <1 mm in diameter (Figure 8). In total, 33.3% of specimens had two RFBs. In such scenarios, one will always be supplying the rectus femoris muscle solely without giving off any cutaneous perforators. When there were two RFBs; the origins of each RFB are different. One originated from the DB of the LCFA, while the other could originate from the SFA (two cases) or the LCFA itself (two cases) (Table 2). In instances where there are two RFBs, the RFB originating from the DB of the LCFA is the branch that gives off the perforators to the AMT flap.

Clinical case

A 57-year-old Malay gentleman was diagnosed with right tongue squamous cell carcinoma, which was invading into the floor of mouth. He underwent an extended right hemiglossectomy with resection of the floor of mouth and an ipsilateral modified radical neck dissection. Because of the presence of a large floor of mouth defect, an anterolateral thigh flap was used to provide adequate tissue coverage for the tongue reconstruction and bulk to resurface and bolster the floor of mouth (Figure 9).

A lateral approach was used to raise the ALT flap, but the two perforators of the ALT flap were deemed to be small (<1 mm). The larger perforator was found to be at the periphery of the flap.

The plan was changed to further dissect medially in the upper half of the anteromedial thigh to look for larger perforators. The handheld Doppler confirmed the presence of an AMT perforator. A combined ALT AMT flap was raised based on this AMT perforator and the smaller ALT perforator (Figure 10). The AMT perforator originated from the RFB and the DB of the LCFA (see Figure 11).

The patient had an uncomplicated recovery, and the right thigh donor site healed well. He was started on ambulatory physiotherapy on postoperative day (POD) 5 and was ambulating independently by POD 10.

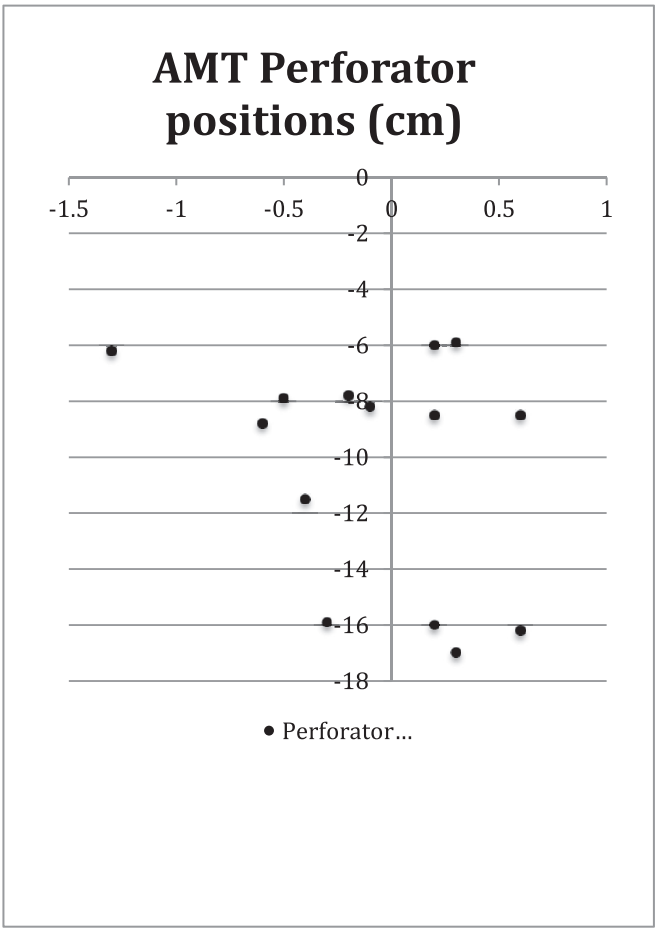
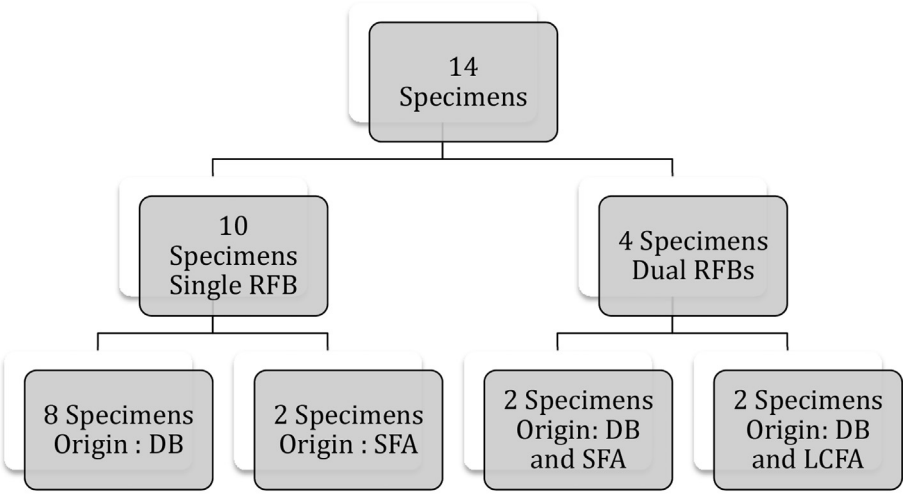


Figure 6. Distribution of Anteromedial thigh (AMT) flap perforators along the MP line. Positions of AMT perforators. Transverse X-axis and longitudinal Y-axis in centimetres. Y-axis corresponds to the MP line. Two predominant groups that congregate at the half way mark and the quarter mark of the MP line.

Discussion

If one were to define the AMT flap based on anatomical location alone, there will be marked variability of the pedicle origin, which makes preoperative planning difficult.[4] Hence, the AMT flap can be separated from other medial thigh flaps such as the transverse upper gracilis flap or the medial geniculate artery flap based on the blood supply. Yu P et al discussed about the anatomy of the anteromedial thigh flap and defined its blood supply to be derived from the RFB because of its longer and larger calibre pedicle.[3] We concur with these findings and believe that the perforators are found in the proximal half of the anteromedial thigh. By defining the AMT flap to be in the proximal half of the anteromedial thigh, the blood supply would be consistently derived from the RFB making preoperative planning simpler and more predictable. On the basis of our findings, our proposed perforator territories are depicted in Figure 2. Yu P et al also discussed about the inverse relationship between the ALT perforators and the AMT perforators, and Wong CH et al discussed about the oblique branch of the LCFA and its relationship with the AMT perforators.[5,6] In our study, we did not find any observable

Table 2
Summary of rectus femoris branch vessel origin.



RFB: rectus femoris branch

DB: descending branch of lateral circumflex femoral artery

SFA: superficial femoral artery

LCFA: lateral circumflex femoral artery

relationship between the AMT perforators and these other vessels. Our frequency of RFB perforators supplying the AMT was also higher than that in the study by Yu P (92.9% vs 51%).

We classify the AMT flap into two main types based on the origin of the RFB. A type I AMT flap will be perfused by a perforator that branches off from the RFB originating from the DB of the LCFA (Figure 3). In Type I AMT flaps, a conjoint ALT and AMT flap based on a single pedicle is possible. Intramuscular dissection of the AMT flap through the rectus femoris is not tedious as the intramuscular course is short, and little muscle needs to be sacrificed so knee extension is not compromised.

A type II AMT flap is perfused by a perforator that branches off the RFB originating from an artery other than the DB of the LCFA (mostly the SFA). Type II AMT flaps cannot be harvested with the ALT flap on a single pedicle.

It is widely believed that the rectus femoris muscle was a Mathes and Nahai classification type I muscle flap.[7,8] However, according to our study, the blood supply is usually derived from 1 to 2 RFBs (Figure 7) and several small segmental branches that may originate from the DB (supplying both the vastus lateralis and the rectus femoris) or from the SFA. With the presence of these segmental branches supplying the rectus femoris muscle, it can be classified as a type IV muscle. Further studies should be conducted to determine the viability of a rectus femoris flap distally on the basis of these segmental branches. In our group's experience of raising chimeric AMT/ALT flaps, there has been no occurrence of compartment syndrome or necrosis of the rectus femoris. There were complaints of knee extension weakness in two of our patients postoperatively, which did not interfere with ambulation. After physiotherapy, this issue was resolved within 3 months.

We observed that the perforators in the anterior thigh can be divided broadly into the anterolateral row and anteromedial row perforators. While the perforators from the anterolateral row are predominantly derived from the LCFA and its DB, the medial row perforators tend to be branches of various origin arteries. The anterior medial thigh flap derives its blood supply from the medial row of

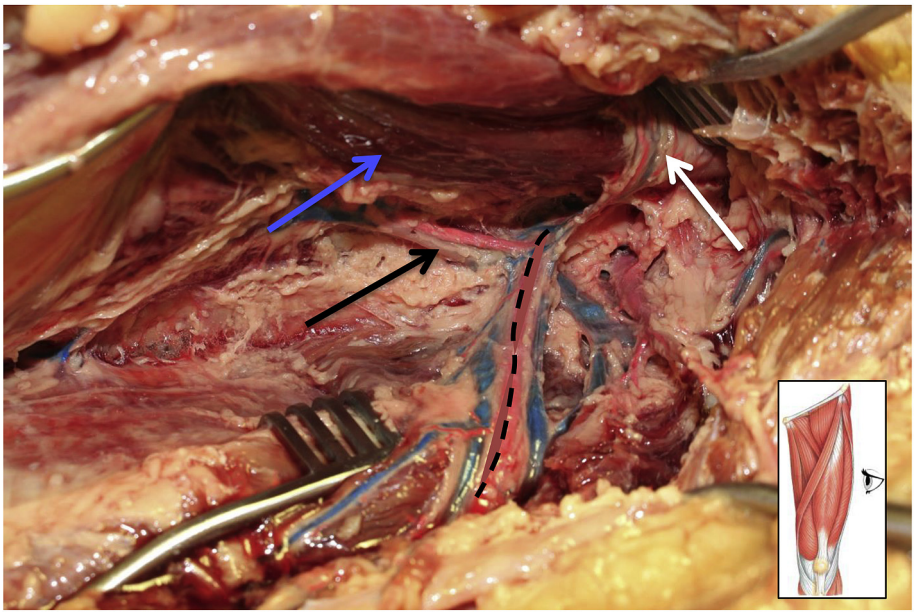


Figure 7. Dual rectus femoris branches (RFB) supplying the rectus femoris muscle. Left thigh looking via lateral aspect. First RFB (black arrow) coming from descending branch (broken black line) of the lateral circumflex femoral artery (LCFA) while the second RFB (white arrow) is originating proximal directly from the LCFA. These two RFB's enter the Rectus femoris (blue arrow) which is retracted upwards.

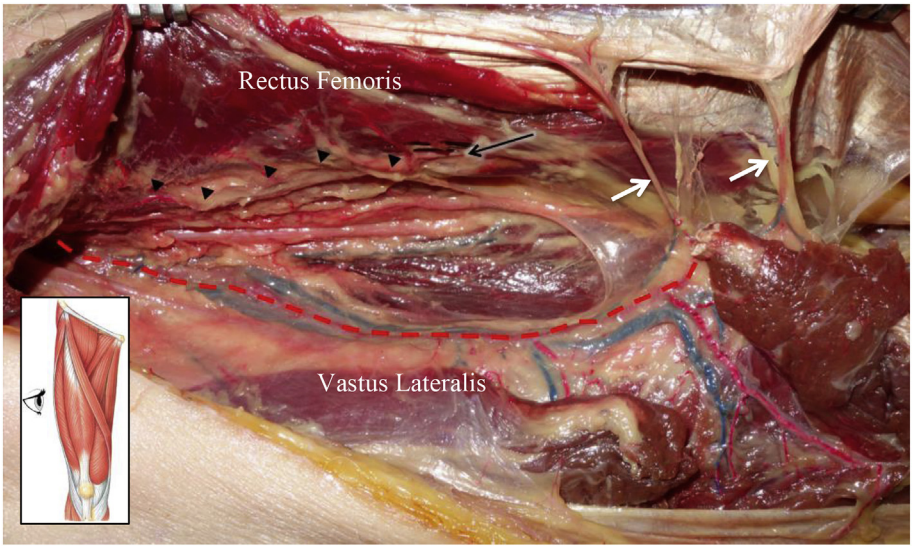


Figure 8. Segmental branches supplying the rectus femoris muscle. Lateral aspect of right thigh: Rectus femoris branch (along black arrowheads) coming off the descending branch (broken red line). Two segmental branches (white arrows) supplying the rectus femoris muscle from the descending branch at its distal half.

Figure 9. Right extended hemiglossectomy and floor of mouth defect. Defect extending from base to tongue tip including a large floor of mouth defect.

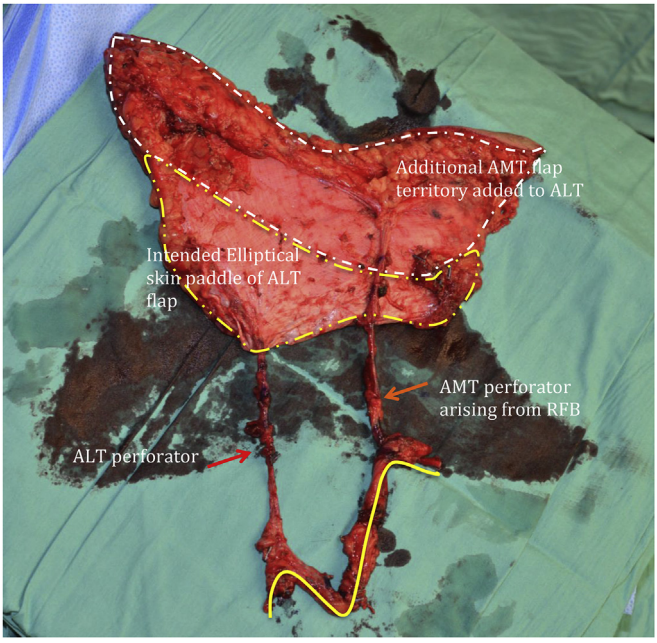


Figure 10. Anterolateral (ALT) and anteromedial thigh (AMT) perforator conjoint flap. This flap was raised to include both the ALT and AMT perforators as the ALT perforator was small and at the periphery. The AMT flap perforator came from the rectus femoris branch (RFB) which originated from the descending branch of the lateral circumflex femoral artery (yellow solid line). Hence the AMT and ALT perforators were branches of the same descending branch pedicle making a combined AMT and ALT flap possible.

Figure 11. Reconstructed right tongue with anterolateral thigh (ALT) and anteromedial thigh (AMT) flap. Reconstructed right tongue using the ALT/AMT flap which provided enough skin coverage to recreate the sulcus in the floor of mouth as well as the bulk necessary to fill the floor of mouth defect that communicated with the neck.

perforators, and these perforators come from the RFB, which are located in the proximal half of the thigh. The medial row perforators in the distal half of the thigh may be branches of the superficial femoral artery. The medial row of perforators tends to pierce the fascia in the vicinity of an imaginary line drawn from the mid-inguinal point (femoral artery position) to the superomedial border of the patella. We call this the MP line. As mentioned previously, congregation of perforators can be seen at the proximal one-quarter mark and the midpoint. Visconti et al conducted CT angiographic studies to define the perforators and found that most of the RFB perforators were lateral to the sartorius muscle.[4] Cigna et al found inconsistencies between perforators found in among his clinical cases and cadaveric dissections.[9] However, we find that using the MP line to surface mark the perforators with the help of a pen Doppler is consistent and reproducible. Furthermore, when we restrict the definition of the AMT flap to be one that is supplied by perforators coming from the RFB, it makes the flap more consistent and solves the problem of 'inhomogeneity' of the origin of perforators in their study.[9] Perforators along the lower half of the MP line are not favourable for flap raising as the perforators run a near vertical course towards the deep plane through the substance of the vastus medialis making dissection very difficult (Figure 8). This is similar to the findings of a study conducted by Scaglioni et al where perforators tend to be branches of the SFA or the descending genicular artery with a course through the vastus medialis.[10] This information is useful when trying to surface landmark the AMT flap perforators using a pen Doppler kit during preoperative planning. While the incidence of absent or unusable perforators of the ALT flap is not common (4.8%), understanding the anatomy of the AMT flap is useful in instances where there are anatomical variations of the ALT flap or when a large flap is needed.[11]

Furthermore, the anteromedial thigh flap should be further studied through perforator injection studies so that the perforasome size can be elucidated. This will further help surgeons in the safe raising of the AMT flap.

Conclusion

The AMT flap is defined as a flap in the proximal half of the anteromedial thigh supplied by the RFB in majority of cases. Understanding this definition and the detailed vascular anatomy of the RFB and its perforators allows for the safe and effective use of the AMT flap.

Conflict of interest

There is no conflict of interests.

Acknowledgements

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