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Reconstructive

Arborization of Musculocutaneous Perforators in the Skin and Subcutaneous Tissue

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Background: The arborization of musculocutaneous (MC) perforators in the skin and subcutaneous tissue has been well studied using cadaver anatomical studies and preoperative imaging such as computed tomography and magnetic resonance angiography. However, the fine arborization of perforators and anastomoses between fine vessels in the skin and subcutaneous tissue remains unreported. Understanding the peripheral arborization and characteristics of these vessels is essential for advancing perforator flap techniques. We performed vascular dissection based on the layered structure to examine the vascular network of the subcutaneous tissue.

Methods: In 8 fresh cadavers, the buttocks (single layer of subcutaneous fat) and back (double layer) were examined through radiological and gross observations of MC perforators, with the fine arterial architecture analyzed in relation to the layered structure of the subcutaneous tissue.

Results: Thin blood vessels at the periphery of the MC perforator were visualized. The perforator reached the dermis, forming a subdermal plexus, from which twigs ascended to the epidermis and descended to the subcutaneous fat. The vascular plexus in subcutaneous tissue varied with the adipofascial structure, and twigs connecting the subdermal plexus to deep adipose tissue were also observed.

Conclusions: The thinning of perforator flaps and the elevation of adipofascial flaps depend on the judgment of clinicians. We believe that understanding the arborization and vasculature of MC perforators will enhance perforator flap procedures, ensuring safer and stable blood flow. *(Plast Reconstr Surg Glob Open 2025;13:e6683; doi: 10.1097/GOX.0000000000006683; Published online 25 April 2025.)*

INTRODUCTION

In 1988, Kroll et al[1] first used the term "perforator-based flaps" in the clinical setting, and in 1989, Koshima and Soeda et al[2] reported that a large flap without muscle could survive on a single muscle perforator. This name was subsequently changed to "perforator flap," and numerous reports describing the use of these flaps have been published to date.

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Subsequent advances in surgical techniques, such as supermicrosurgery, have also led to the use of more diverse perforator flaps. Consequently, blood vessels are pursued to the periphery over the deep fascia, and perforator flaps that utilize a portion of the skin and subcutaneous tissue, such as thin, super-thin, pure skin perforator, and adipofascial flaps, are also being developed.[3–11] Although most of these flaps are based on experimental evidence rather than anatomical findings, image analysis of the perforators using magnetic resonance angiography, computed tomography, and photoacoustic tomography in both clinical and anatomical settings has attempted to reveal the arborization of the perforators.[12–18] Nevertheless, these studies treated the subcutaneous tissue as a single layer and could only depict large branches of the perforators due to limitations of resolution. In 1998, we demonstrated the vasculature of the 6 types of vessels that penetrated the deep fascia based on the layered structure of the subcutaneous tissue[19]; however, that study was also insufficient.

In addition to clarifying the detailed arborization of the perforator, elucidation of the vascular plexus based on the layered structure of the subcutaneous tissue is important to create thin perforator flaps, adipofascial perforator flaps, or

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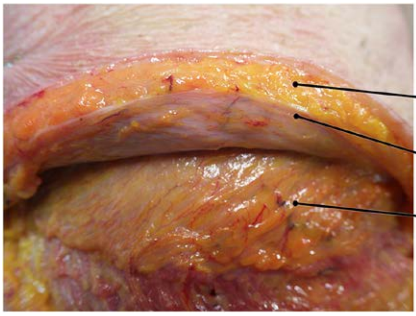

Fig. 1. The basic 2-layered structure of the subcutaneous tissue. The PAFS layer above the superficial fascia consists of round fat lobules and tight fasciae. The LAFS layer between the superficial and deep fasciae consists of flat fat lobules and movable fasciae. Good vascular continuity of the LAFS layer was also observed.

Takeaways

Question: What exactly is fine arborization of the perforator and anastomoses between the fine vessels in the skin and subcutaneous tissue?

Findings: We performed vascular dissection based on the layered structure and examined the vascular network of the subcutaneous tissue. As a result, 3 types of vascular plexuses were formed, which differed from the conventional concepts.

Meaning: We believe that this anatomical knowledge will enable clinicians to shift from empirical, serendipitous perforator flap–making to evidence-based flap-making, and will be useful in clarifying the discrepancies in the existing research on perforator flaps.

perforator flaps whose pedicles consist of a finer branch of the perforator. The subcutaneous tissue is considered a 2-layered structure, represented by Camper fascia and Scarpa fascia in the abdomen, and differences in the morphology of these 2 layers have been reported.[20–24] In 2004, we also studied these 2 layers throughout the body and named the superficial layer the protective adipofascial system (PAFS) and the deep layer, the lubricant adipofascial system (LAFS), based on the morphology and mechanical properties of the adipofascial tissue (Fig. 1).[25] In most regions of the body, the subcutaneous tissue consists of both PAFS and LAFS layers, but in the areas where we do not want them to slip, such as the buttocks, soles, and palms, the subcutaneous tissue consists only of the PAFS layer. Therefore, we conducted an anatomical investigation of the detailed vasculature of the musculocutaneous (MC) perforator in the different subcutaneous tissues and examined the vascular architecture in the dermis, PAFS, and LAFS.

METHODS

This investigation was conducted using 8 fresh cadavers donated to the Keio University School of Medicine. All cadavers were analyzed after obtaining the consent of the families of the donors. This study was approved by our institutional ethics committee at the School of Medicine (IRB No. 20070026).

A lead oxide–gelatin mixture was injected into the entire body of the 4 fresh cadavers. The skin and underlying soft tissues of the gluteus maximus muscle, where the subcutaneous tissue shows a typical single-layer structure, and the latissimus dorsi muscle, where the subcutaneous tissue shows a 2-layer structure, were raised just over the deep fascia. Arborization of the perforator was radiographically observed in cross-sectional specimens. In addition, to confirm the continuity of the blood vessels in plain view, subcutaneous specimens of the latissimus dorsi muscle were divided into the PAFS and LAFS layers, and each layer was evaluated using radiographic images.

In 3 of the 4 other fresh cadavers, vascular continuity in the PAFS and LAFS layers was observed under a microscope. In the fourth cadaver, the vascular plexus was observed from the undersurface of the LAFS layer after injecting Microfil (Flow Tech, Inc., Boulder, CO) through the dorsal thoracic artery.

RESULTS

On the buttocks, where the subcutaneous tissue is thicker and consists of a single PAFS layer, the MC perforator arborized after penetrating the deep fascia, and its relatively large branches ascended toward the dermis. The branches toward the dermis were named the adipocutaneous branches, and perforators up to the point of bifurcation were named the main trunk. The adipocutaneous branches further arborized and reached the dermis. Some branches were also given off toward the PAFS before reaching the dermis, and these were termed the adipofascial branches (Fig. 2). Then, vessels that reached the dermis ran nearly parallel to the skin, giving off very fine ascending and descending vessels, approximately 50–100 μm in diameter. The fine ascending vessels were named "dermal twigs" because they were arborized in the dermis. The dermal twigs appeared to anastomose with each other approximately in the middle of the dermis (Fig. 3). Two types of descending fine vessels were observed: one descended into the very shallow portion of the PAFS layer just below the dermis, and we named them the "descending twigs." The other type descended further and anastomosed with blood vessels in the deeper PAFS layer; these were named "linking twigs" (Fig. 3). Fine vessels from the adipofascial branches terminated to wrap around the fat lobules in the PAFS layer. Therefore, we named the fine vessels of the adipofascial branches the "surrounding twigs" based on their morphological characteristics (Fig. 4).

The arborization of the MC perforator in the back, where the subcutaneous tissue consists of the PAFS and LAFS layers, was composed of adipocutaneous branches, adipofascial branches, and their peripheral twigs (Fig. 5), similar to the arborization observed in the buttock. However, the adipofascial branches in the back were thinner compared with those in the buttocks, running in a linear and horizontal direction, and the fine vessels of the adipofascial branches were, therefore, referred to as "linear twigs." On the latissimus dorsi muscle, which has a thin deep fascia, many twigs did not reach the PAFS layer but

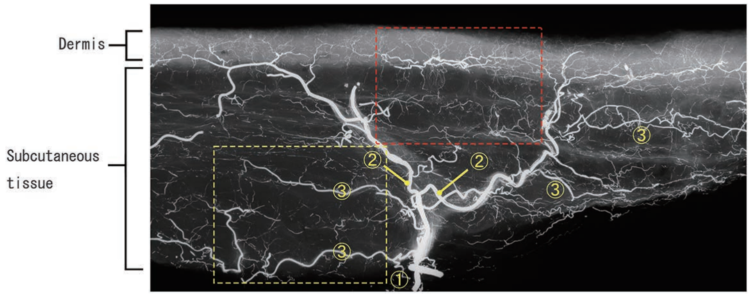

Fig. 2. Cross-sectional angiogram of a perforator in the buttock where the subcutaneous tissue consists of a single PAFS layer. The typical arborization of a perforator was observed. 1, The main trunk of a perforator; 2, adipocutaneous branches; and 3, adipofascial branches.

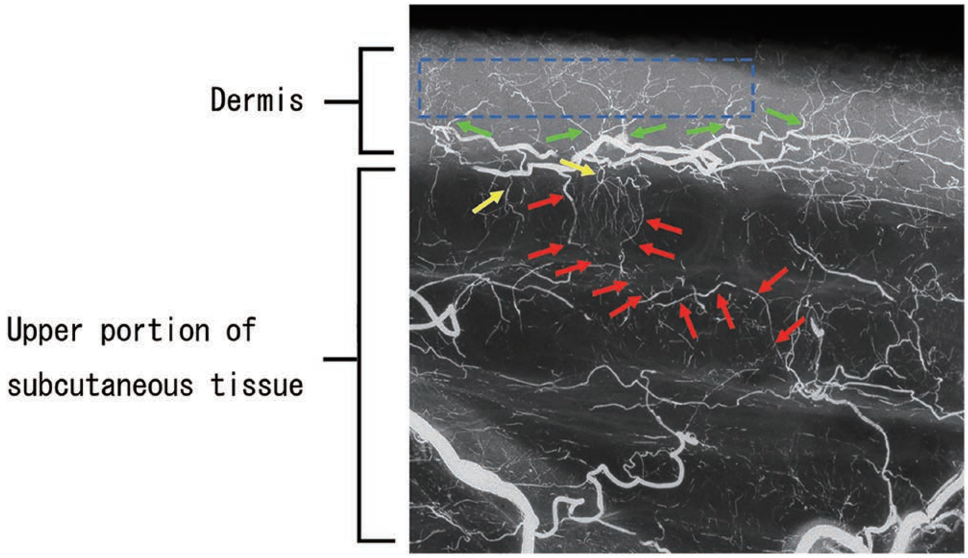

Fig. 3. Enlarged image of the area enclosed by the red dotted line in Figure 2. Various twigs were observed. The green arrows indicate dermal twigs; the yellow arrows indicate the descending twigs; and the red arrows indicate the linking twigs. The blue dotted area indicates blood vessels in the middle of the dermis.

arborized within the LAFS layer. These twigs were named "musculofascial twigs." The linear twigs and musculofascial twigs are intimately anastomosed with each other, forming a dense vascular network within the LAFS layer (Figs. 6–8). This vascular network appeared to envelop the adipose lobules. In the PAFS layer, the surrounding twigs, which are the terminations of the adipofascial branches, were similarly recognized as in the buttocks. However, angiography revealed that the vascular network in the PAFS layer was more sparse, and the horizontal vascular continuity was less pronounced compared with the LAFS layer (Figs. 6, 8). A relatively thick fascia, often described as the superficial fascia, lies between the PAFS and LAFS layers. Small blood vessels from the PAFS and LAFS layers were observed to invade this fascia, but no dense vascular network was found (Fig. 5). Linking twigs were also observed in the PAFS and LAFS 2-layer regions, connecting the dermal and subdermal vascular network to the LAFS layer vascular network. The results of the vascular dissection are represented by a schema (Fig. 9).

DISCUSSION

We believe that different subcutaneous tissue layers have different vascular architecture, so we investigated the perforators in relation to the layered structure of the skin and subcutaneous tissue and revealed the arborization of the perforators, the forms of vascular twigs, and the anastomoses between twigs radiographically and macroscopically.

In 2004, we reported that subcutaneous adipose tissue in the human body is primarily composed of 2 types: the PAFS and LAFS layers and the PAFS-only layer. The fascia separating the PAFS from the LAFS is referred to as the superficial fascia, whereas the fascia separating the LAFS from the muscular layer is called the deep fascia.[25] These layers are described with different terminology in various studies. Ashton,[26] for example, designated the layers numerically in a hierarchical order, where layer 2 corresponds to the PAFS and layer 4 corresponds to the LAFS. Similarly, Goh et al[27] referred to these layers as superficial fat and deep fat. In the present study, detailed arborization

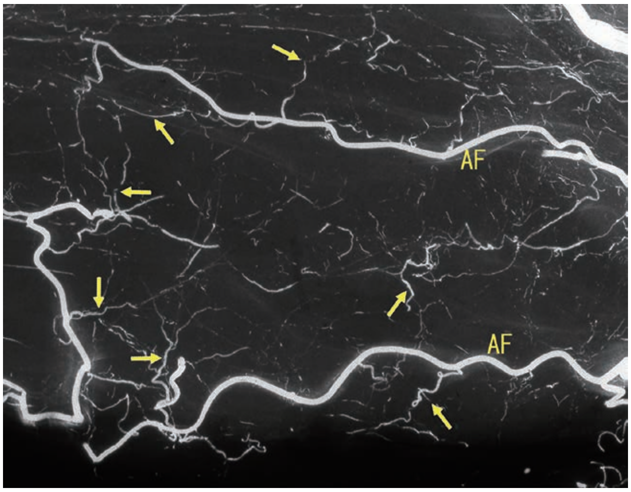

Fig. 4. Enlarged image of the area enclosed by the yellow dotted line in Figure 2. The arrows indicate surrounding twigs from the adipofascial branches (AF) in the PAFS layer.

of the MC perforator was imaged in the back and buttocks, which are representative of 2-layer and 1-layer regions of the trunk, and the characteristic morphology of the twig in each tissue layer and the vascular network by the twig were revealed.

Arborization of the perforators, particularly in relation to adjacent perforators, has been reported in previous studies.[14,28–30] We have also discussed this in our own publications.[19,31] These studies focused on the concept of the peripheral vascular network at the branch level. However, with the advancement of techniques allowing us to identify finer peripheral structures, we now propose assigning specific names to each vessel. Furthermore, because the term "vessel" does not account for variations in thickness, we suggest that the terms "branch" and "twig" be used instead, as these vessels arborize and become progressively thinner. On the basis of the vascular architecture, we propose that the skin and subcutaneous tissues contain the following 3 types of vascular plexuses from a clinical viewpoint of flap elevation (Fig. 9).

Dermal Plexus

Most vessels in the dermis consisted of dermal twigs and finer arborizing vessels from the twigs, and horizontal vascular continuity was observed approximately at the middle of the dermis. We named this vascular network the dermal plexus. Although the subpapillary plexus at

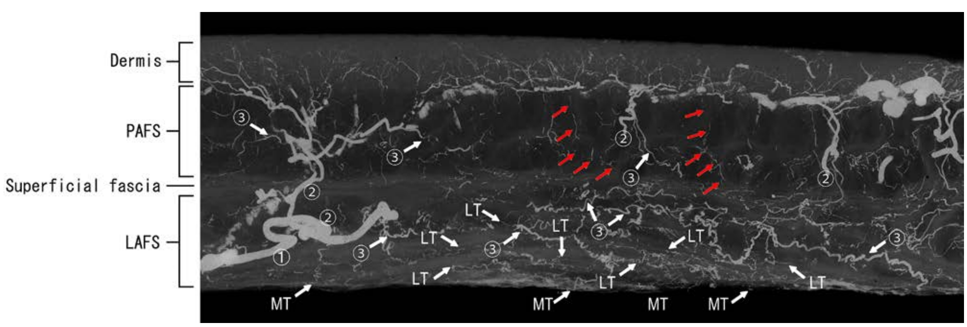

Fig. 5. Cross-sectional angiogram of a perforator on the latissimus dorsi muscle, where the subcutaneous tissue consists of the PAFS and LAFS layers. The arborization of the perforator was basically the same as that in Figure 2. Note that the fine blood vessels run horizontally in the LAFS layer. 1, The main trunk of the perforator; 2, adipocutaneous branches; and 3, adipofascial branches. LT, linear twig; MT, musculofascial twig; SF, superficial fascia. The red arrows indicate linking twigs.

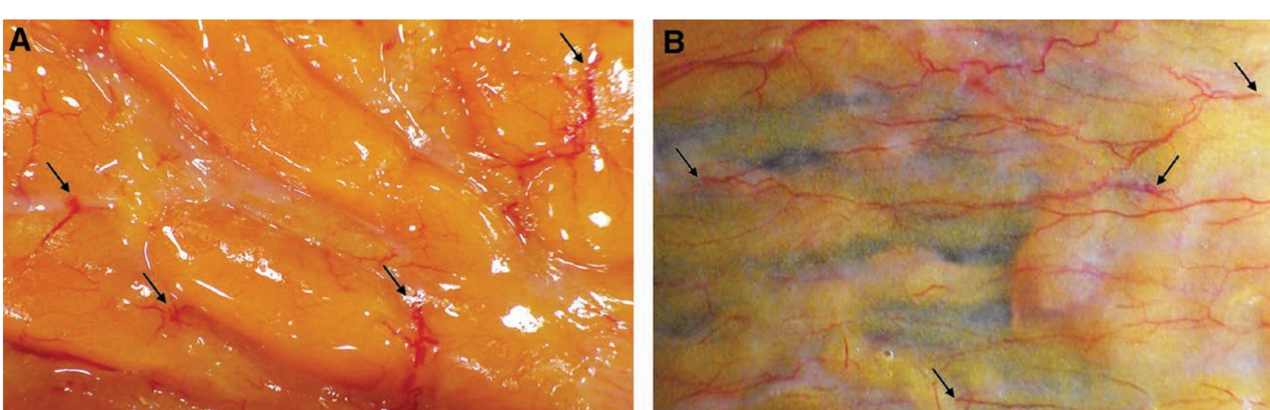

Fig. 6. Gross anatomy of the vascular continuity in the PAFS and LAFS layers. A, Poor vascular continuity in the PAFS layer. The black arrows indicate the surrounding twigs. B, Good vascular continuity in the LAFS layer. The black arrows indicate the linear twigs.

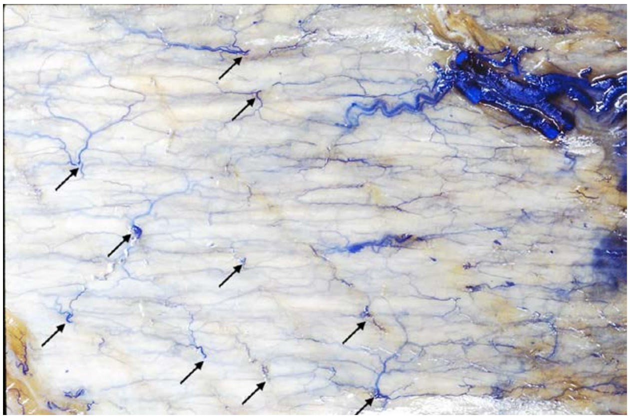

Fig. 7. Gross anatomy of the undersurface of the LAFS layer on the latissimus dorsi muscle. Numerous musculofascial twigs (arrows) from the latissimus dorsi muscle were observed. Both arteries and veins are filled with Microfil.

the junction of the reticular and papillary dermis was impossible to delineate on our angiograms, its existence is well known.[32] This vascular network was considered to be formed just below the epidermis by the most peripheral portions of the dermal twigs. The subpapillary plexus was considered to be included in the dermal plexus. Various thin flaps have been developed, and Narushima et al[9] recently reported a pure skin perforator flap with the same thickness as a full-thickness skin graft. They skeletonized a perforator until it reached the dermis. The dermal plexus identified in this study is an important vascular plexus that serves as a hemodynamic concept, and the vasculature of the pure skin perforator flap is thought to consist of adipocutaneous branches, the subdermal plexus discussed later, and the dermal plexus. Apart from their clinical usefulness, these anatomical results suggest that a skin flap with the same thickness as a split-thickness skin graft, which Narushima et al[9] described, is also possible.

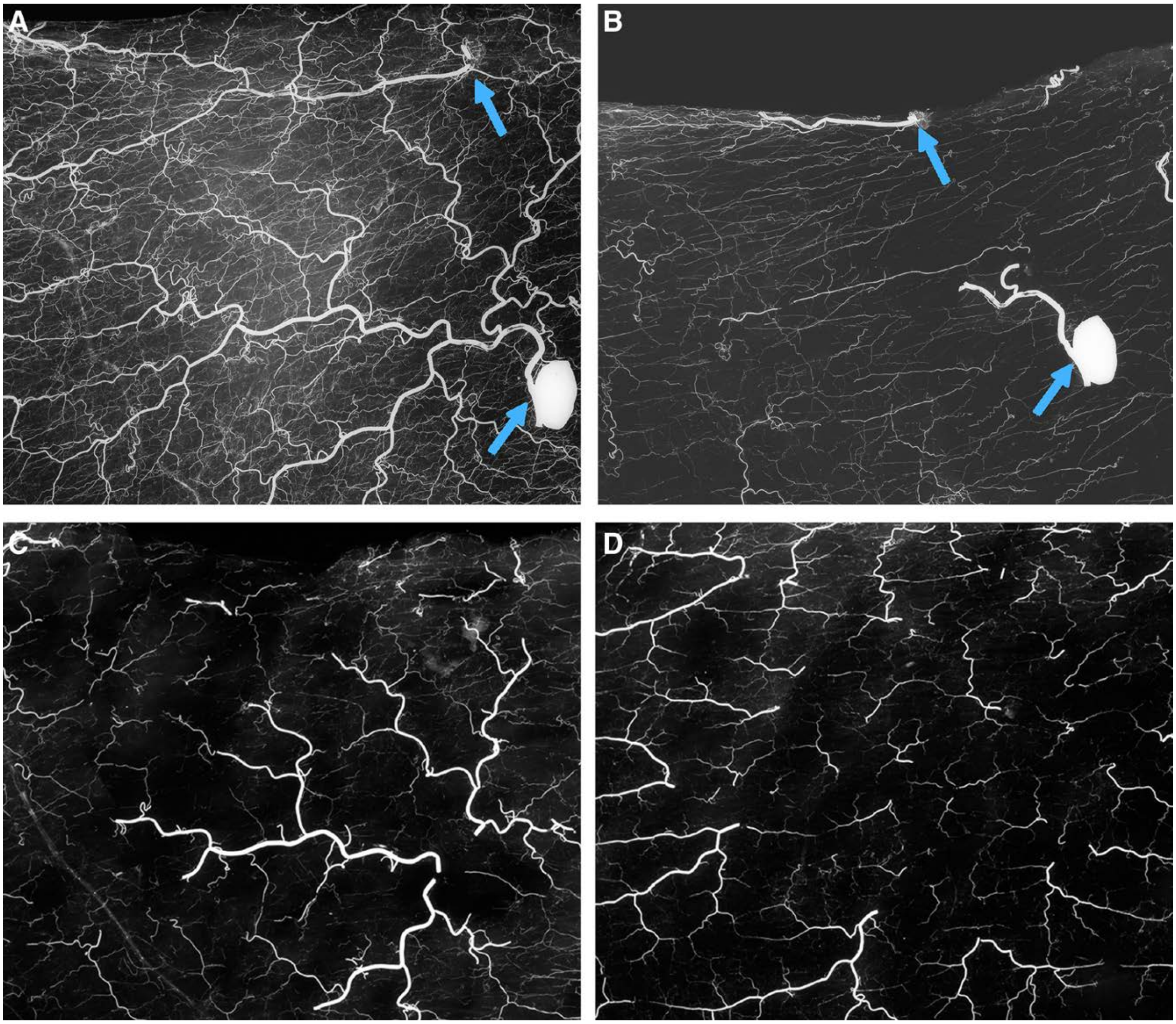

Fig. 8. Horizontal sectional angiogram of MC perforators (light blue arrow) on the latissimus dorsi muscle. A, Full thickness of skin. B, LAFS. C, PAFS. D, Epidermis and dermis. Note that the vascular network of the LAFS is dense, although the vessels are very fine.

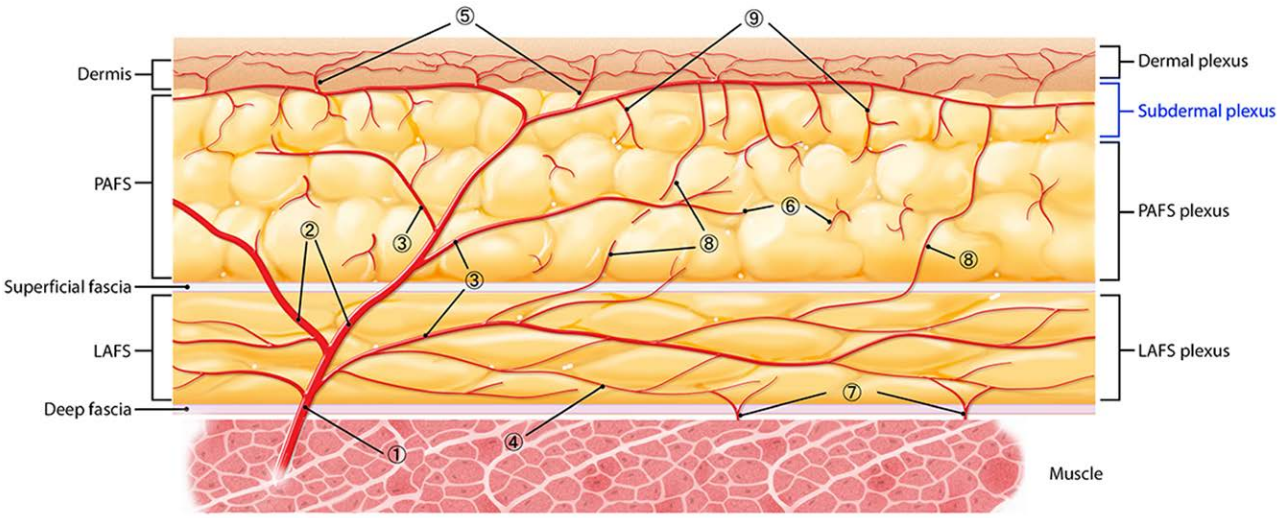

Fig. 9. Schematic view of arborization of the perforator and vascular plexuses in the skin with the PAFS and LAFS 2-layer structure. 1, The main trunk of a perforator; 2, adipocutaneous branch; 3, adipofascial branch; 4, linear twig; 5, dermal twig; 6, surrounding twig; 7, MC twig; 8, linking twig; and 9, descending twig.

Subdermal Plexus

The concept of the subdermal plexus seems to be somewhat ambiguous. As we have previously reported, we considered that the so-called subdermal plexus was composed of vessels in both the subdermal and deep dermal layers.[33] The subdermal plexus was considered to be formed by the adipocutaneous branches that reached the dermis and ran in parallel. Anatomical dissection revealed that the subdermal plexus gave off descending twigs into the shallow portion of the PAFS layer. From the viewpoint of thin-flap hemodynamics, our study led to the conclusion that the descending twigs should be included in the subdermal plexus. Therefore, the subdermal plexus is the vascular network in the deep dermis, just below the dermis, and in the shallow portion of the PAFS layer (Fig. 9).

Fasciocutaneous Plexus

The fasciocutaneous plexus has been considered a single vascular network, with or without the inclusion of the deep fascia. However, in most areas of the body, the subcutaneous tissue consists of 2 layers, the PAFS and LAFS, and the vascular architecture of each layer shows clear differences. Therefore, we thought that the fasciocutaneous plexus should be divided into the PAFS and LAFS plexuses. However, because the descending twigs in the shallow PAFS layer were included in the category of the subdermal plexus, the PAFS plexus indicates the vascular network present in the PAFS layer, excluding the adipofascial tissue just below the dermis. The PAFS plexus is composed mostly of adipofascial branches and their surrounding twigs, with the participation of the main trunk, adipocutaneous branches, and linking twigs. We believe that one of the arborizing adipocutaneous branches corresponds to the communicating branch referred to by Saint-Cyr et al.[14]

Because of the poor anastomosis between the surrounding twigs, the PAFS plexus has poor horizontal vascular continuity. Therefore, if an adipofascial flap that depends only on the PAFS plexus is considered, blood circulation is likely to be poor. Although the PAFS plexus is important in terms of blood supply to the round fat lobules through the surrounding twigs, we believe that the more important role of the PAFS plexus is to connect the LAFS and deeper PAFS plexuses to the subdermal plexus through the linking twigs. The main vertical blood supply to the dermis is provided by the adipocutaneous branches but is compensated by the linking twigs in the PAFS plexus. Although the present study did not focus on anastomosis with the adjacent perforator, we believe that the direct anastomosis of the adipofascial branches from adjacent perforators was the same as the direct linking vessel referred to by Saint-Cyr et al[14] and the true anastomosis referred to by Taylor et al.[29]

The LAFS plexus is a vascular network in the LAFS layer that consists mostly of adipofascial branches, linear twigs, and musculofascial twigs, with the participation of the main trunk and adipocutaneous branches. The LAFS plexus is a dense network located within a highly mobile adipofascial structure. We considered the LAFS plexus to be equivalent to the suprafascial plexus, which is considered the hemodynamic basis for the fasciocutaneous flap.[34] The good horizontal vascular continuity of the LAFS plexus contributes to the survival of fasciocutaneous flaps. Reconstructive surgery with the perifascial areolar tissue has been performed on the donor site where blood circulation is poor.[35–37] The perifacial areolar tissue is the LAFS itself, which is used as a flexible tissue with rich blood circulation.

In 1986, we reported the classification of skin flaps and the nutrient vessels of the fasciocutaneous flap, but at that time, the understanding of the vascular plexus in the skin and subcutaneous tissue was conceptual.[38] We believe that these details regarding the vascular architecture of perforators will further improve the classification of skin flaps and clarify the confusion in recent reports of perforator flaps.

CONCLUSIONS

In this study, we clarified the fine arborization of perforators in the skin, subcutaneous tissue, and PAFS and

LAFS plexuses. We believe that knowledge of perforator arborization will enable clinicians to shift from empirical serendipitous perforator flap–making to evidence-based flap-making that enables an anatomically and hemodynamically stable design. This shift will ultimately lead to a more precise definition of perforator flaps and the classification of skin flaps.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

REFERENCES

1. Kroll SS, Rosenfield L, Kroll SJ. Perforator-based flaps for low posterior midline defects. *Plast Reconstr Surg*. 1988;81:561–566.
2. Koshima I, Soeda S. Inferior epigastric artery skin flaps without rectus abdominis muscle. *Br J Plast Surg*. 1989;42:645–648.
3. Koshima I, Moriguchi T, Soeda S, et al. Free thin paraumbilical perforator-based flaps. *Ann Plast Surg*. 1992;29:12–17.
4. Kim JT, Koo BS, Kim SK. The thin latissimus dorsi perforator-based free flap for resurfacing. *Plast Reconstr Surg*. 2001;107:374–382.
5. Kimura N. A microdissected thin tensor fasciae late perforator flap. *Plast Reconstr Surg*. 2002;109:69–77; discussion 78.
6. Koshima I, Nanba Y, Tsutsui T, et al. Superficial circumflex iliac artery perforator flap for reconstruction of limb defects. *Plast Reconstr Surg*. 2004;113:233–240.
7. Oki K, Hyakusoku H, Murakami M, et al. Dorsal intercostal perforator (DICP) augmented scapular "super-thin flaps" for the reconstruction of extensive scar contractures in the axilla and anterior chest: a case report. *Burns*. 2005;31:105–107.
8. Hong JP, Choi DH, Suh H, et al. A new plane of elevation: the superficial fascial plane for perforator flap elevation. *J Reconstr Microsurg*. 2014;30:491–496.
9. Narushima M, Yamasoba T, Iida T, et al. Pure skin perforator flaps: the anatomical vascularity of the super thin flap. *Plast Reconstr Surg*. 2018;142:351e–360e.
10. Li B, Chang SM, Du SC, et al. Distally based sural adipofascial turnover flap for coverage of complicated wound in the foot and ankle region. *Ann Plast Surg*. 2020;84:580–587.
11. Facchin F, Sonda R, Faccio D, et al. Multi-dorsal metacarpal artery perforator adipofascial turnover flap for index to little finger reconstruction: anatomical study and clinical application. *Hand Surg Rehabil*. 2021;40:177–182.
12. Alonso-Burgos A, García-Tutor E, Bastarrika G, et al. Preoperative planning of deep inferior epigastric artery perforator flap reconstruction with multislice-CT angiography: imaging findings and initial experience. *J Plast Reconstr Aesthet Surg*. 2006;59:585–593.
13. Masia J, Clavero JA, Larrañaga JR, et al. Multidetector-row computed tomography in the planning of abdominal perforator flaps. *J Plast Reconstr Aesthet Surg*. 2006;59:594–599.
14. Saint-Cyr M, Schaverien M, Arbique G, et al. Three- and four-dimensional computed tomographic angiography and venography for the investigation of the vascular anatomy and perfusion of perforator flaps. *Plast Reconstr Surg*. 2008;121:772–780.
15. Wong C, Saint-Cyr M, Rasko Y, et al. Three- and four-dimensional arterial and venous perforasomes of the internal mammary artery perforator flap. *Plast Reconstr Surg*. 2009;124:1759–1769.
16. Zou Z, Lee HK, Levine JL, et al. Gadofosveset trisodium-enhanced abdominal perforator MRA. *J Magn Reson Imaging*. 2012;35:711–716.
17. Lam DL, Mitsumori LM, Neligan PC, et al. Pre-operative CT angiography and three-dimensional image post processing for deep inferior epigastric perforator flap breast reconstructive surgery. *Br J Radiol*. 2012;85:e1293–e1297.
18. Tsuge I, Saito S, Yamamoto G, et al. Preoperative vascular mapping for anterolateral thigh flap surgeries: a clinical trial of photoacoustic tomography imaging. *Microsurgery*. 2020;40:324–330.
19. Nakajima H, Minabe T, Imanishi N. Three-dimensional analysis and classification of arteries in the skin and subcutaneous adipofascial tissue by computer graphics imaging. *Plast Reconstr Surg*. 1998;102:748–760.
20. Gray H. Anatomy of the human body. In: Clement CD, ed. *Fasciae and Muscles of the Trunk*. 30th ed. Williams & Wilkins; 1984:483.
21. Markman B, Barton FE, Jr. Anatomy of the subcutaneous tissue of the trunk and lower extremity. *Plast Reconstr Surg*. 1987;80:248–254.
22. Lockwood TE. Superficial fascial system (SFS) of the trunk and extremities: a new concept. *Plast Reconstr Surg*. 1991;87:1009–1018.
23. Illouz YG. History and current concepts of lipoplasty. *Clin Plast Surg*. 1996;23:721–730.
24. Lancerotto L, Stecco C, Macchi V, et al. Layers of the abdominal wall: anatomical investigation of subcutaneous tissue and superficial fascia. *Surg Radiol Anat*. 2011;33:835–842.
25. Nakajima H, Imanishi N, Minabe T, et al. Anatomical study of subcutaneous adipofascial tissue: a concept of the protective adipofascial system (PAFS) and lubricant adipofascial system (LAFS). *Scand J Plast Reconstr Surg Hand Surg*. 2004;38:261–266.
26. Ashton MW. Tips on raising reliable local perforator flaps. *Plast Reconstr Surg Glob Open*. 2021;9:e3673.
27. Goh TLH, Park SW, Cho JY, et al. The search for the ideal thin skin flap: superficial circumflex iliac artery perforator flap—a review of 210 cases. *Plast Reconstr Surg*. 2015;135:592–601.
28. Taylor GI, Corlett RJ, Dhar SC, et al. The anatomical (angiosome) and clinical territories of cutaneous perforating arteries: development of the concept and designing safe flaps. *Plast Reconstr Surg*. 2011;127:1447–1459.
29. Taylor GI, Chubb DP, Ashton MW. True and "choke" anastomoses between perforator angiosomes: part I. Anatomical location. *Plast Reconstr Surg*. 2013;132:1447–1456.
30. Taylor GI, Corlett RJ, Ashton MW. The functional angiosome: clinical implications of the anatomical concept. *Plast Reconstr Surg*. 2017;140:721–733.
31. Nakajima H, Imanishi N, Minabe T. The arterial anatomy of the temporal region and the vascular basis of various temporal flaps. *Br J Plast Surg*. 1995;48:439–450.
32. Williams PL. Gray's anatomy. In: Bannister LM, ed. *Integumental System*. 38th ed. Churchill Livingstone; 1995:398.
33. Imanishi N, Nakajima H, Minabe T, et al. Angiographic study of the subdermal plexus: a preliminary report. *Scand J Plast Reconstr Surg Hand Surg*. 2000;34:113–116.
34. Tolhurst DE, Haeseker B. Fasciocutaneous flaps in the axillary region. *Br J Plast Surg*. 1982;35:430–435.
35. Kouraba S, Takeuchi A, Honda K, et al. Perifascial areolar tissue graft: novel autologous graft material and its clinical application for coverage of exposed bone and tendon. *Aust N Z J Surg*. 2003;73:260.
36. Koizumi T, Nakagawa M, Nagamatsu S, et al. Perifascial areolar tissue graft as a nonvascularized alternative to flaps. *Plast Reconstr Surg*. 2010;126:182e–183e.
37. Ito T, Akazawa S, Ichikawa Y, et al. Exposed artificial plate covered with perifascial areolar tissue as a nonvascularized graft. *Plast Reconstr Surg Glob Open*. 2019;7:e2109.
38. Nakajima H, Fujino T, Adachi S. A new concept of vascular supply to the skin and classification of skin flaps according to their vascularization. *Ann Plast Surg*. 1986;16:1–19.