Tips on Raising Reliable Local Perforator Flaps

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Summary: From early on in the development of plastic surgery, it was quickly realized that utilizing locally adjacent tissue, or "matching like with like," yielded superior aesthetic reconstructions to those in which the tissue was derived from a distant location. In many cases, the use of a local perforator flap is a simpler procedure with less patient morbidity and a quicker recovery from surgery. The difficulty with local perforator flaps has been locating the supplying perforators, ensuring that the flap has a robust and reliable blood supply, and that sufficient tissue is able to be transferred. The recent reappraisal of our understanding of the blood supply of the integument has allowed, for the first time, the capacity to accurately and inexpensively, without the need for "high tech equipment," locate perforators, as they emerge from the deep fascia into the overlying integument, and through a better understanding of the interconnecting anastomotic vessels between perforators reliably predict how much tissue can be safely raised on a single perforator, before surgery. Further, through the use of strategic "delay," it is possible to manipulate the interconnecting vessels between the selected perforator and its surrounding neighbors to design a flap of tissue of any dimension, composed of whatever tissue we require, and safely transfer that tissue locally, or if required, distantly, as a free flap. This article will highlight these advances, explain their relevance in raising reliable local perforator flaps, and will, where possible, call attention to any pearls and pitfalls, and how to avoid complications. *(Plast Reconstr Surg Glob Open 2021;9:e3673; doi: 10.1097/GOX.0000000000003673; Published online 28 July 2021.)*

Give me six hours to chop down a tree and I will spend the first four sharpening the axe.
——Abraham Lincoln, former US President

It is often said that the hallmark of a master reconstructive surgeon is a beautiful cosmetic result. From early on in the development of plastic surgery, it was quickly realized that utilizing locally adjacent tissue, or "matching like with like," [1,2] yielded superior aesthetic reconstructions to those in which the tissue was derived from a distant location.

This is particularly clear in reconstruction of the face—where local rotation, or local advancement flaps, consistently yields superior cosmetic results to those achieved with micro-vascular free tissue transfer of distant tissue. All too frequently, skin derived from other parts of the body is paler, of different texture, and results in a different colored patch on the face, rather than resulting in a homogenous blending of skin color and feel.

The recent reappraisal of the blood supply of the integument has provided, for the first time, the capacity to accurately and inexpensively, without the need for "high tech equipment," locate the perforators as they emerge from the deep fascia into the overlying integument, and, through a better understanding of the interconnecting anastomotic vessels between perforators, reliably predict how much tissue can be safely raised on a single perforator, before surgery.

Further, through the use of strategic "delay," it is possible to manipulate the interconnecting vessels between the selected perforator and its surrounding neighbors, to design a flap of tissue of any dimension, composed of whatever tissue we require, and safely transfer that tissue locally, or if required, distantly, as a free flap.

This article will highlight these advances, explain their relevance in raising reliable local perforator flaps, and will, where possible, call attention to any pearls and pitfalls, and how to avoid complications.
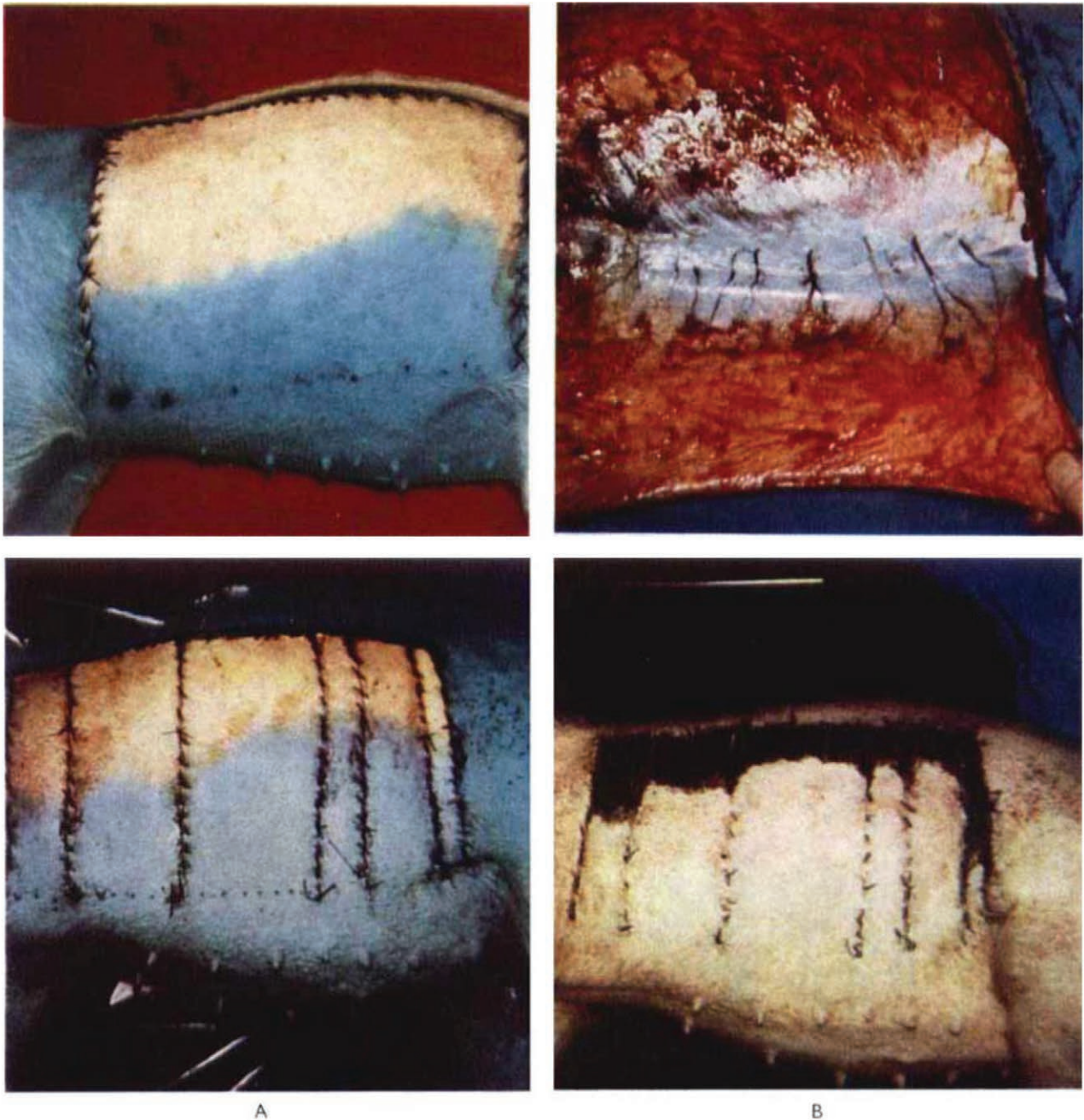
Fig. 1. The distance of perfusion of disulphine blue in Figures 3 and 5 above is the same and is not related to the width of the individual flaps. This distance corresponds to the eventual line of tissue necrosis and the length of flap survival. The length of tissue survival is not dependent on the width of the flap, but rather is determined by its internal vascular anatomy. Reprinted with permission from *Br J Surg.* 1970;57(7):502–508.[3]

INTRODUCTION

In 1970,[3] Milton comprehensively showed that the length of tissue that could be raised safely on an individual blood vessel was not related to the width of the flap (the so-called length versus width ratio), but is instead determined by its internal vascular anatomy (Fig. 1). Taylor and Pan[4] showed that this vascular anatomy is laid down very early in the development of the embryo and is permanent (Fig. 2).

The arterial and venous systems of the body develop differently.[5] In the limbs, tissue growing out from the body is initially supplied by a central artery and a peripheral, superficial, plexus of draining veins (Fig. 3). This "primary" vascular system leads to the development of the cephalic and basilic veins in the forearm, and the saphenous and sural veins in the leg. Subsequently, an additional (or "secondary") system of veins develop within limbs. These new veins are closely aligned with the central arteries and go on to form the venae commitantes.

Fig. 2. The angiosomes of the head and neck study of a 20-week-old fetus, a 28-week-old fetus, and an adult. The vascular pattern of the vessels of the scalp is constant and the blueprint is established very early on in fetal development. In particular, note that the superficial temporal artery is unchanged from the 28-week fetus to the adult. Reprinted with permission from Taylor GI, Pan WR, *The Angiosome Concept and Tissue Transfer.* Volume 2:656–657.[4] Chapter 4, Figures 4.31 and 4.32.

The developmental interconnection between the primary and secondary venous system within the integument explains why it is possible to raise a radial forearm perforator flap either on the radial artery's venae commitantes or on the cephalic vein. This pattern of venous drainage is replicated all over the body. The facial vein, the SIEV, and the SCIV are all examples of remnants of the primary venous system.

The Anatomy of the Integument, and How This Determines Perforator Location

At its most basic, the integument is composed of five layers (Fig. 4).

Layer 1 is the skin and sub dermis. Layer 5 is the deep fascia or periosteum. In between are layers 2, 3, and 4. These layers are always present, but vary in their composition depending on the region of the body. As an example, layer 3 is the SMAS in the face, Scarpa's fascia in the abdomen, and the dartos muscle in the scrotum.

Layers 1, 2, and 3 are bound tightly together.

Layer 4, interconnects the superficial fascia (layer 3) with the deep fascia (layer 5). It may fix the two layers of fascia together tightly, as it does in the sole of the foot, and therefore is composed of strong ligaments. Alternatively, it may allow gliding or movement of layer 3 over layer 5—as it does in the face, and is composed of loose areolar tissue, or a "space" as first described by Mendelson.[6–8] This "space" or loose areolar tissue allows movement of the muscle in layer 3 to move over layer 5 (Fig. 5). At the space's periphery, layers 1, 2, and 3 are rigidly fixed to the deep fascia (layer 5) by strong ligaments.

Therefore, it is the function of a particular area, or region, that determines the composition of layer 4.

Arteries, veins, nerves, and lymphatics supplying the integument run in constant and predictable locations within the integument's layers (Fig. 6). (As an example, collecting lymphatic vessels run from the sub dermal plexus (the interface between layers 1 and 2) to a constant plane deep in layer 2, just above layer 3 (called layer 2c).[9–12]

Taylor[13] confirmed the work of Manchot[14,15] that perforating blood vessels characteristically emerge from the deep fascia at points of fixation, and he further showed that nerves "hitchhike" with these vessels[16] (particularly in the limbs). This is also true in the integument, superficial to the deep fascia. Because layers 1, 2, and 3 are rigidly fixed together, and because layer 5 is the deep fascia or periosteum, the only variable is layer 4.

And so, vessels emerging from the deep fascia (layer 5) to supply the superficial layers (1, 2, and 3) do so in constant and predictable ways directly related to the composition and nature of layer 4. (Fig. 7). Hence, a knowledge of the nature of layer 4 in a particular area can predict the anatomy of the arteries, veins, nerves, and lymphatics in that region.

Let us look at two different scenarios to explain this point. First, the sole of the foot, where all five layers of the integument are tightly bound together. Here, layer 4 is composed of multiple strong ligaments binding layers 3 and 5 firmly together because of the function required. Vessels emerge from the deep fascia to pass directly, and vertically, into layers 1, 2, and 3 in association with the multiple vertical ligaments. It means vessels are frequent, closely located together, and because there are multiple vessels supplying a small volume of tissue, their individual caliber is correspondingly small.[17]

In contrast, in an area of the body where the layers 1, 2, and 3 must glide over the deep fascia, as in the face, layer 4 is composed of loose areolar tissue to facilitate this movement. Vessels must pass from the deep fascia to supply layers 1, 2, and 3 around the periphery of this loose areolar tissue and utilize the ligaments at the boundaries of these "mobile spaces" (Fig. 8). In the face, these points of fixation are the line of mandibular and maxillary ligaments
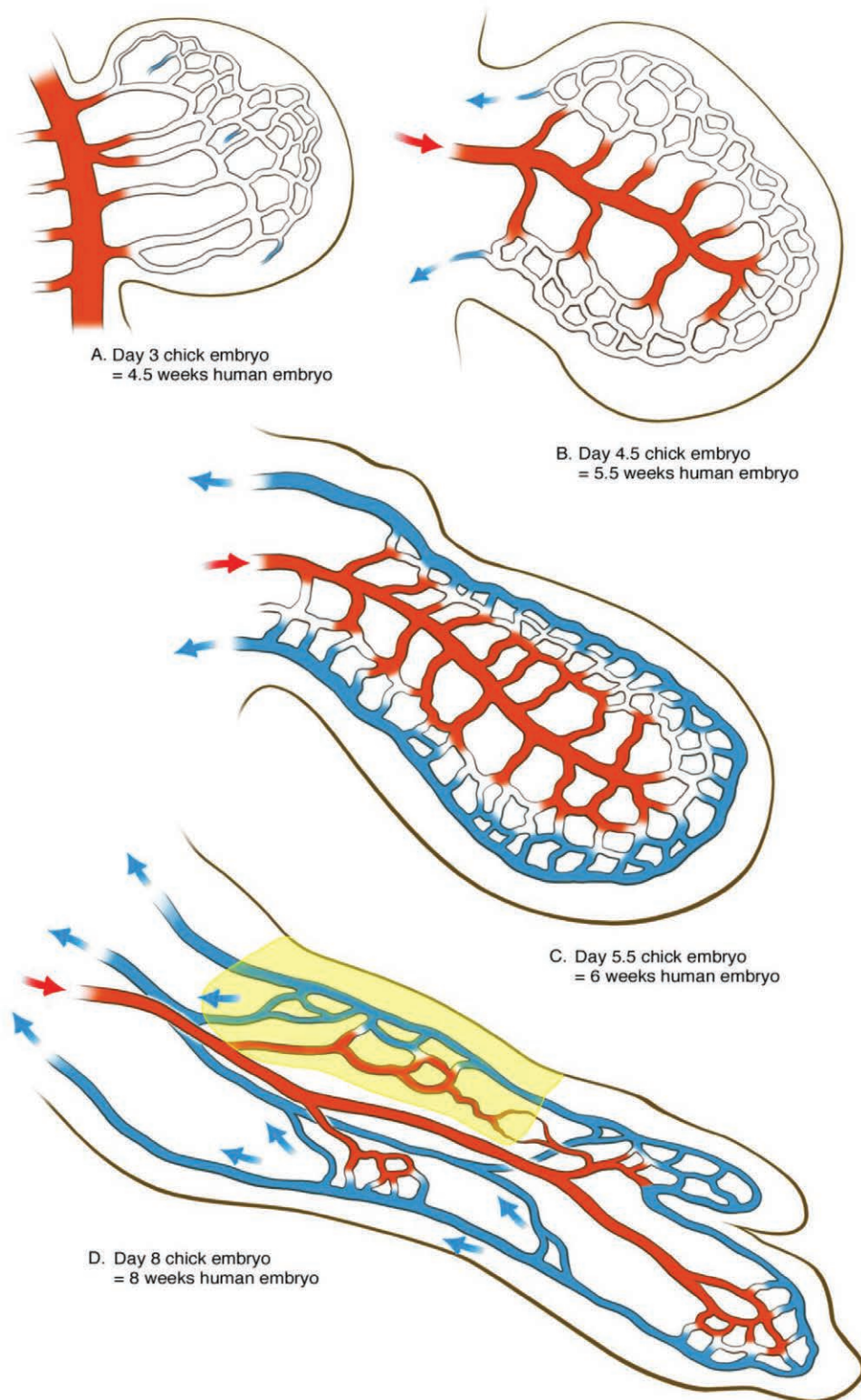
Fig. 3. Stages of vascular development of the ventral limb bud of a quail. Reprinted with permission from Taylor GI and Pan WR, *The Angiosome Concept*. Volume 1:183.[4] Chapter 2, Figures 2–5.
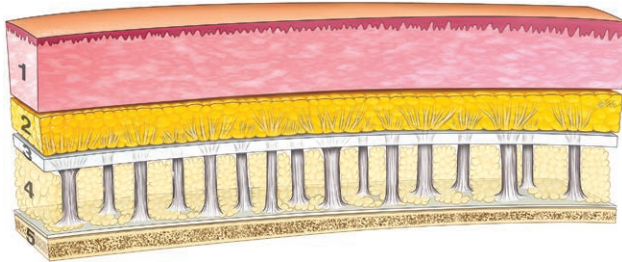
Fig. 4. Layers 1, 2, and 3 are rigidly fixed together. They are attached to the underlying deep fascia or periosteum by ligaments binding them to the deep fascia below (Layer 5). These ligaments comprise layer 4.
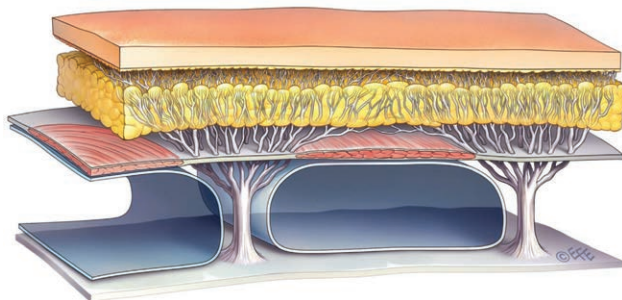

Fig. 5. Where layers 1, 2, and 3 must move over the deep fascia, layer 4 becomes a space. Original concept and diagram: Mr BC Mendelson, FRACS, FACS. Slide used in his lecture series 2008. With permission from Mr. Bryan Mendelson, MD, MBBS, FRCS, FRACS, FACS. For more information, see Melbourne Advanced Facial Anatomy Course.
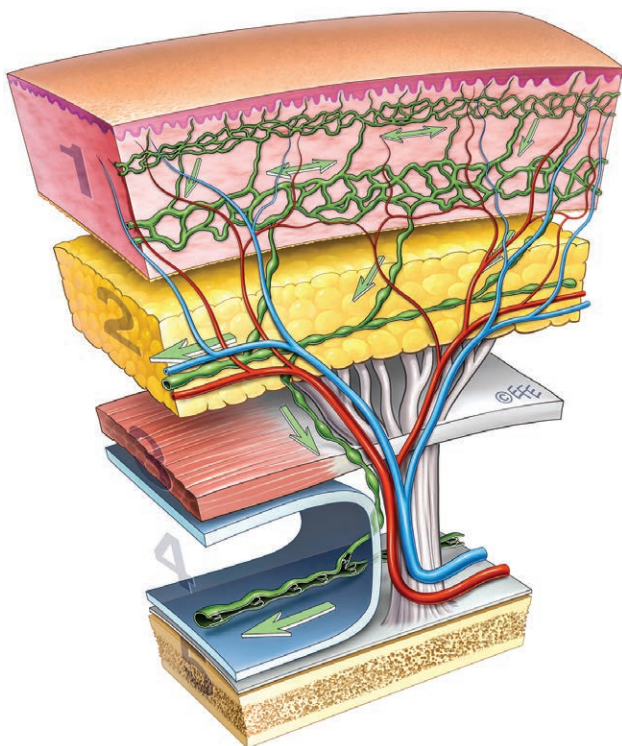

Fig. 6. Blood vessels, nerves, and lymphatics all use the ligaments of layer 4 to cross between the deep fascia and the superficial integument.

laterally at the edge of the premaxillary and premandibular spaces that allow movement of the cheek, mouth, and jowl, and superiorly, the orbicularis retaining ligament and its medial extension, the naso-jugal ligament. We said before that nerves hitchhike with vessels, and hence these ligaments will also be the site at which the branches of the facial nerve, and blood vessels, will emerge from under the deep fascia to cross layer 4 and supply the overlying SMAS in layer three. It follows then that the facial nerve will cross layer 4 in close association with the line of maxillary and mandibular ligaments[6,7,18] and the angular artery and vein in association with the naso-jugal ligament.[19,20] This is predictable and constant (Fig. 9).

In summary, there are, therefore, two different patterns of perforators emerging from the deep fascia, and these are determined by the function of the integument in that area. Where the skin is fixed, the perforators are closely packed together and are multiple and small. Where the skin is mobile, the perforators are more widely spaced apart, and because each vessel is supplying a much greater volume of tissue, their caliber is larger.

The first key tip therefore is that perforators, in areas of the body where there is loose skin, will be bigger, and will emerge at the boundaries of that loose skin, where it is "fixed" to the underlying deep fascia. Underneath the loose skin—there will be an avascular plane (layer 4)—that allows for movement of the overlying layers 1, 2, and 3. This avascular plane can be used to facilitate rapid, bloodless dissection (a scalp flap is an example).

The Interconnections between Perforators

Early work by Taylor[21] showed that the tissue between two perforators can be raised safely anywhere on the body. If the distance between perforators is long, then a correspondingly long flap can be safely raised on a single perforator without fear of tissue necrosis (Fig. 10). How much tissue beyond that second perforator can be raised safely depends upon the interconnections between that second perforator and its neighboring perforators.[22]

Perforators are joined,[23–25] or interconnect with each other by two very different anastomotic vessels. Taylor and Palmer in their original work[26,27] called these vessels "true" and "choke" anastomoses. True anastomoses are what the term implies; they truly interconnect the two perforators as if they were one. There is no change in caliber of the vessel, and most importantly, no restriction in flow between perforators.

Choke vessels, on the other hand are very different. They are characterized by a reduction in vessel caliber, and most importantly, control the blood flow between the perforators (Fig. 11).

Unfortunately, and confusingly, later work has named these very same vessels by other terms. As an example, Saint Cyr et al[28] have called true anastomoses "direct linking" vessels, and choke anastomoses "indirect linking" vessels.

Irrespective of the names used, the key point remains. True anastomoses interconnect two perforators as if they were one, and choke vessels restrict flow (Fig. 12). The two vessels function differently, and choke vessels in particular, directly influence how much tissue beyond the second perforator a surgeon can transfer.[29,30]
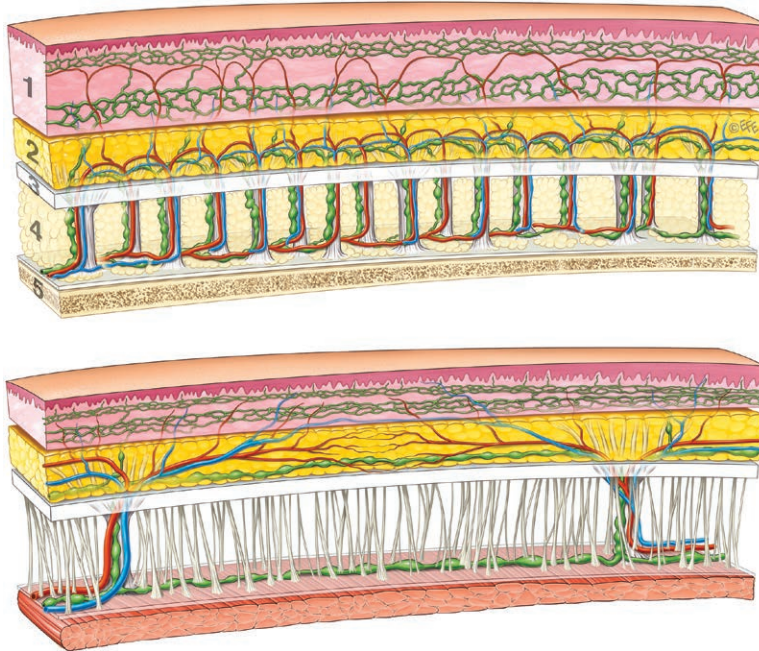
Fig. 7. The illustration above shows two different patterns of attachment of the superficial integument to the deep fascia. In the top diagram, the superficial integument (layers 1, 2, and 3) is rigidly fixed to the deep fascia by multiple ligaments in layer 4. In the bottom illustration, the layers 1, 2, and 3 must glide over the deep fascia and hence, layer 4 is composed of loose areolar tissue and the ligaments are spaced widely apart. Because the blood vessels use the ligaments to cross layer 4, the orientation of the ligaments predicts the geography of the perforating blood vessels.
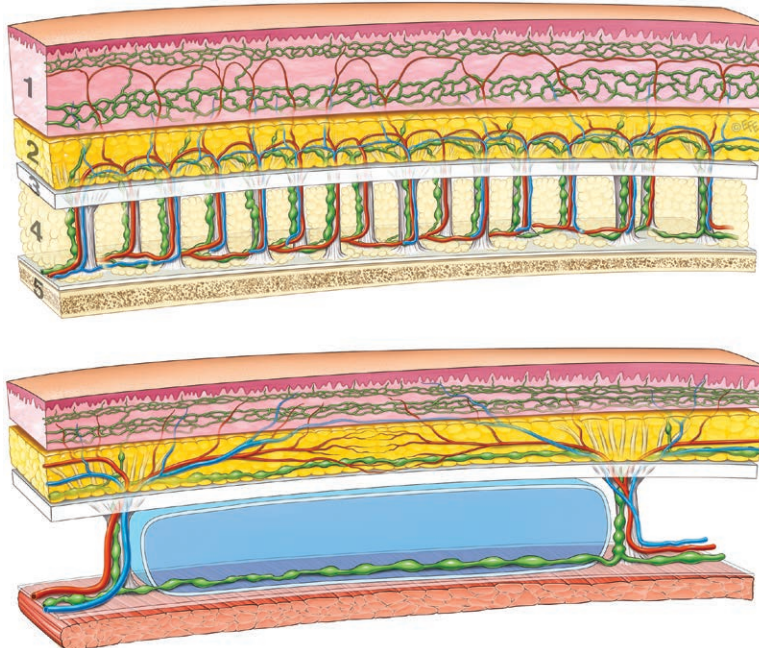

Fig. 8. Where the superficial integument must glide over the deep fascia, layer 4 becomes a space. Ligaments attaching the two components are located at the boundaries of the space. Nerves and blood vessels use the ligaments to cross layer 4 and are therefore also located at the boundaries of the space. The spaces are avascular.
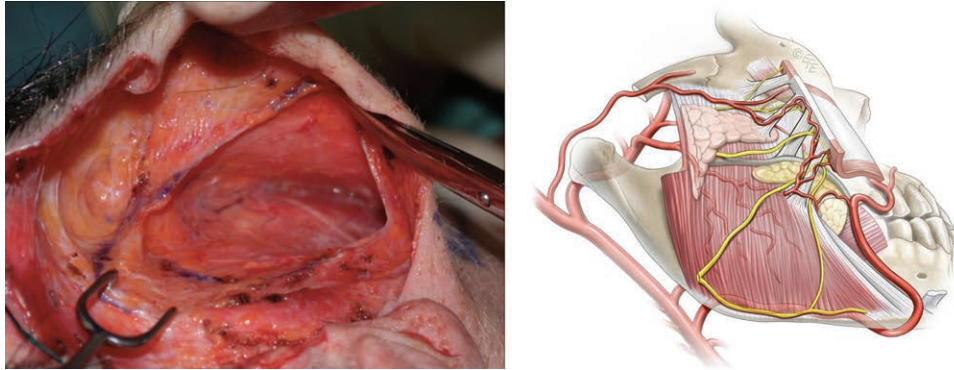
Fig. 9. The top photograph shows the premasseter space viewed from just in front of the ear, looking forward toward the mouth and nose. The facial nerve can be seen coursing over the masseter in the floor of the space. The ligaments fixing the superficial fascia to the deep fascia are at the periphery of the space have been marked with blue ink. The branches of the facial nerve pass directly on top of the masseter muscle below the deep fascia, and use the massenteric ligaments to enter the platysma and other muscles of the SMAS. Because the Platysma in layer 3 must move over the masseteric deep fascia in layer 5, there is a space in layer 4. This space (the lower premasseter) is avascular, and contains no branches of the facial nerve. This knowledge provides for safe and rapid dissection of the middle lower face. Concept and original drawing: Mr BC Mendelson, MD, MBBS, FRCS, FRACS, FACS. Arterial overlay by the author. Image Courtesy: Mr BC Mendelson, MD, MBBS, FRCS, FRACS, FACS.

What Is an Angiosome, and Why Is it Important?

An angiosome[26,27] is the volume of tissue that is supplied by an individual artery and vein. It is constant, and, as stated earlier, determined very early in life. This three-dimensional block of tissue may be composed of skin, fat, tendon, bone, or any combination of the above. It is defined by an artery, its draining vein, and the surrounding tissue enclosed within a perimeter of anastomostic
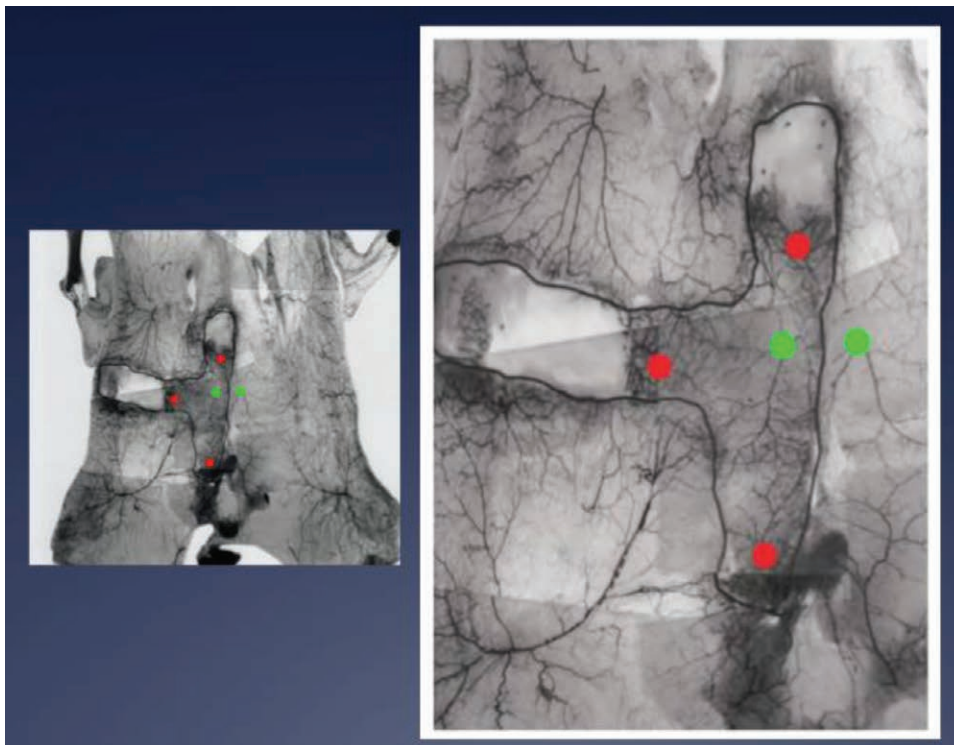
Fig. 10. Seminal study by Taylor. In a T-shaped flap on the abdomen of a dog, three flaps of equal width are raised based on the central green perforator. The geographic location of the surrounding red perforators determines the length of the flap survival. In the inferior flap, the red perforator is located at the flap's tip, and the entire flap survives. Reprinted with permission from *Plast Reconst Surg.* 2017;140(4):721–733.[22] Figure 5.
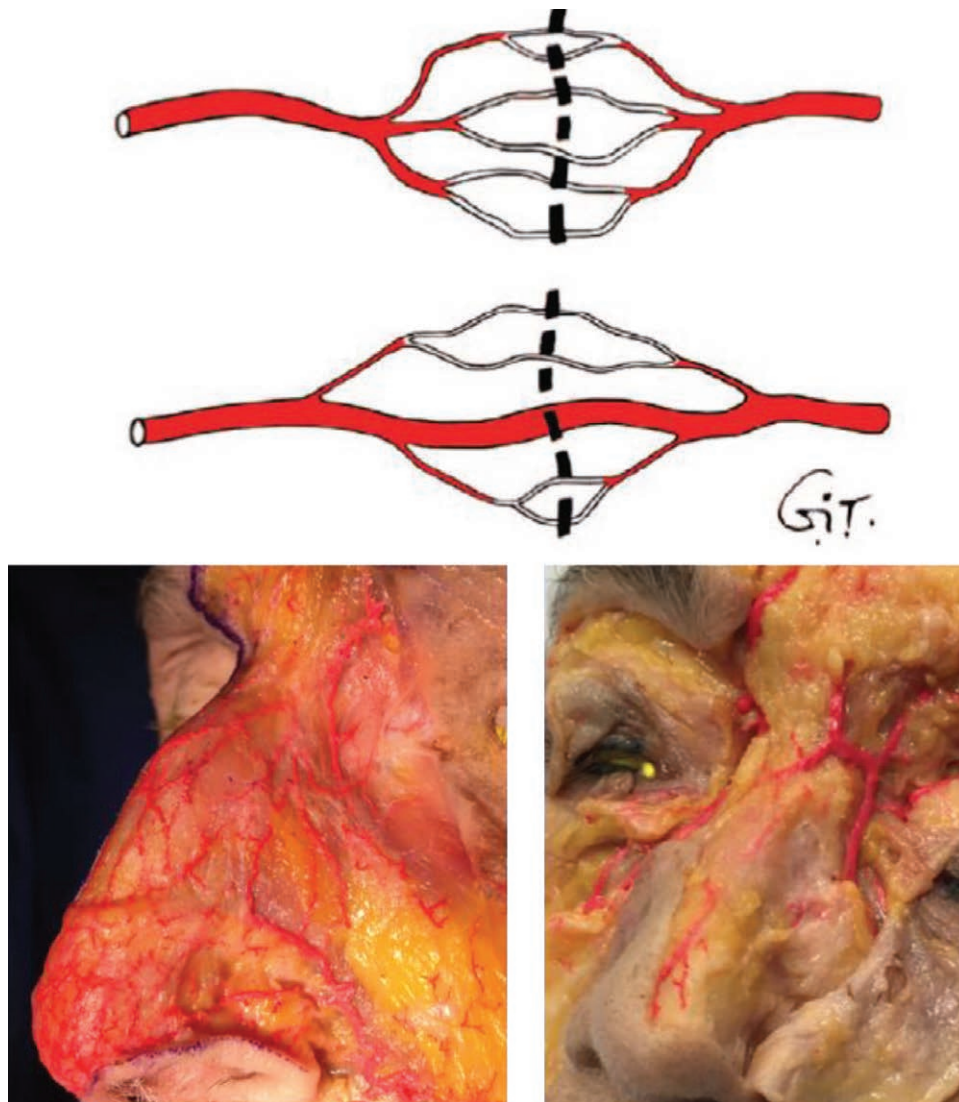
Fig. 11. Perforators are interconnected by either choke or true anastomoses. Choke anastomoses, as their name suggests, restrict flow between perforators, whilst true anastomoses allow unrestricted flow between perforators effectively joining them together as one. The top diagram shows choke anastomoses above, and a true anastomosis below. The bottom photographs of the side of the nose show pink perspex filled anastomoses between the dorsal nasal branches of the facial artery and supra-trochlear and supra-orbital branches of the ophthalmic artery. In the left photograph these are choke anastomoses. In the right these same anastomoses are true anastomoses. Reprinted with permission from *Plast Reconst Surg*. 2013;132(6):1447–1456. Figure 1.[32]

vessels connecting the artery and vein with neighboring blood vessels.

In the integument, superficial to the deep fascia, we labeled these corresponding blocks of tissue by their supplying perforating artery and vein, and called them "perforator angiosomes."[31] Others have named the same tissue blocks "perforasomes."[28]

The important message is that the concept is the same.

A perforator will supply a constant volume of tissue that is determined by the geographical location of the perforator (and therefore the composition of layer 4), extending to the anastomotic vessels of that perforator with its neighboring perforators.

Where the perforators are widely spaced apart, the dimensions of tissue supplied by that perforator will be correspondingly large. Where the perforators are closely packed together—as in the sole of the foot, the volume of tissue, or perforator angiosome, will be correspondingly small.

Where individual perforators are interconnected by choke anastomoses, only the tissue between the perforators may be safely and reliably captured. It may be possible to capture tissue that is immediately adjacent to the second perforator—on the other side of that perforator—but the extent of this tissue capture is unreliable and not predictable. In contrast, where individual perforators are interconnected by true anastomoses, there is no restriction in flow and the two "perforator angiosomes" act as if they were one, and all of the second angiosome may be safely captured on the initial single perforator.
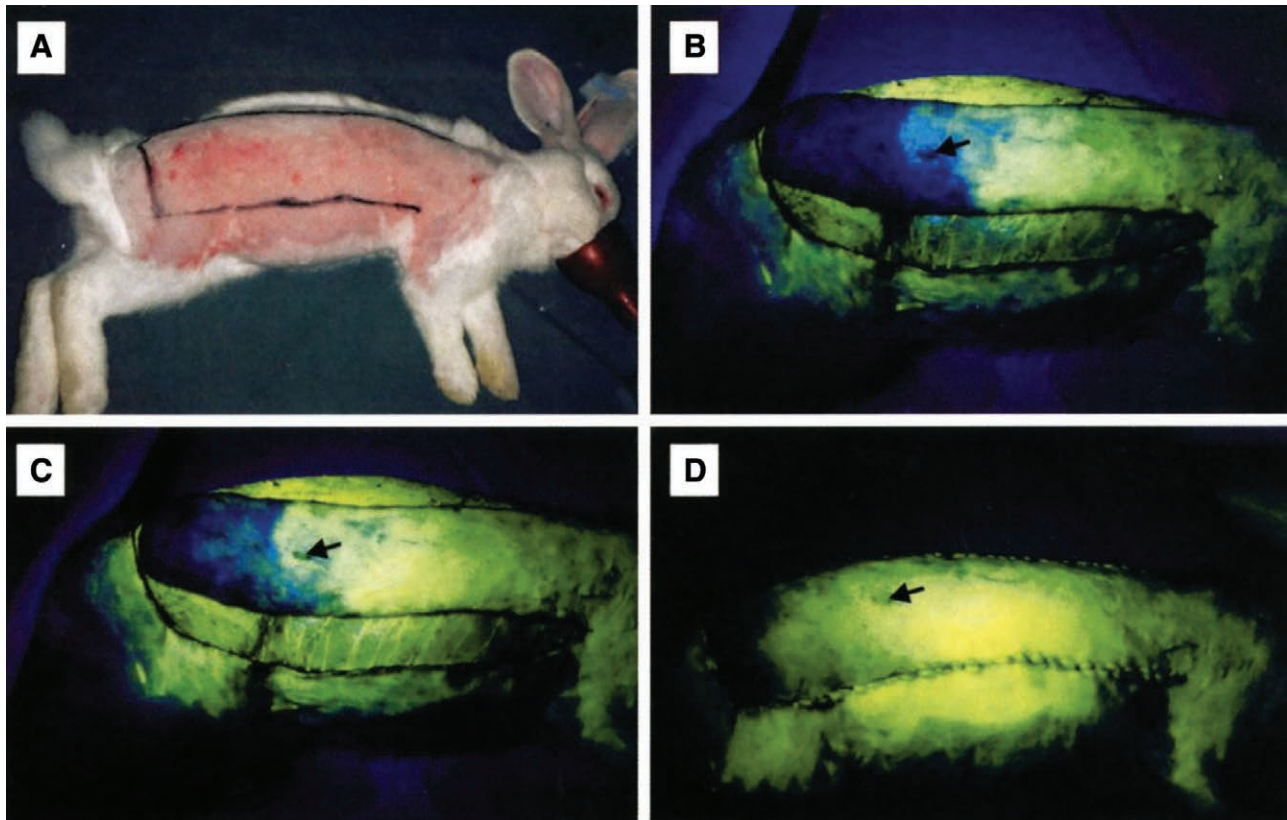
Fig. 12. This seminal study from Taylor and Dahr[29] shows the functional influence of choke anastomoses between perforators—in this case the thoracodorsal and the deep circumflex iliac arteries of a rabbit. When the deep circumflex artery is ligated, fluorescein traveling from the thoracodorsal perforator is held up at the choke anastomoses (arrows), and restricted from entering the distal territory, before eventually being able to enter the deep circumflex artery angiosome at 30 minutes. Reprinted with permission from *Plast Reconstr Surg* 1999;104:2079–2091.[29] Note: Descriptors of the part labels A-D were not included in the original publication.

If three, or even four, individual perforators are interconnected by true anastomoses—then all three, or even four, angiosomes may be safely captured on a single perforator (Fig. 13). We called this concept the "functional angiosome"[22] and it is particularly relevant in the lower leg.[32]

In essence, therefore—and this is the second key tip—if a perforator is connected to its neighboring perforators by true anastomoses, those adjacent additional angiosomes may be captured on the selected perforator, and safely transferred without risk of necrosis. As stated above, the dimensions of tissue and the components that can be transferred are dependent on the components of the individual perforator angiosomes that make up the flap.

And hence, if an adjacent perforator angiosome is composed of tendon, or fat, or a nerve, and if the two perforators supplying the desired tissue are interconnected by true anastomoses, it is possible to transfer the two angiosomes, and therefore the desired tendon, fat, or nerve, in a single operation safely.
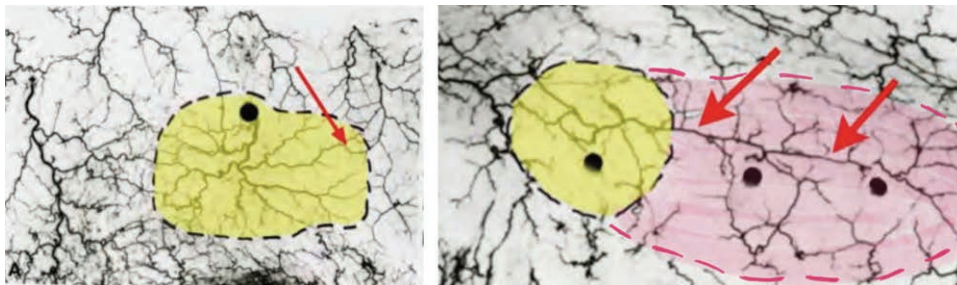
Fig. 13. The dimensions of tissue that can be safely captured on a perforator are not just dependent upon the distance between perforators, but also upon the interconnection between those perforators. In the two images above, the perforator on the left is surrounded by choke anastomoses (red arrow) and, hence, only the area in yellow can be reliably captured. In the image on the right, the three perforators are interconnected by true anastomoses and, hence, they will act as one, and the additional pink area can also be captured, on the same chosen perforator, without the risk of necrosis. (The two true anastomoses are identified with the two red arrows in the diagram on the right.)

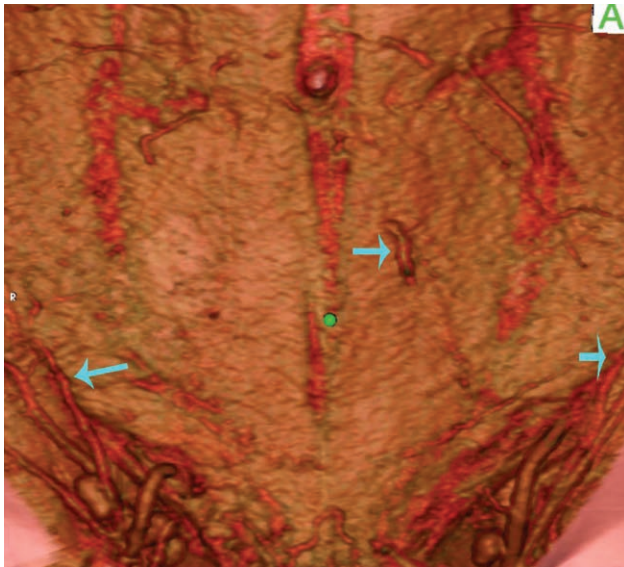Fig. 14. CT angiogram of the abdomen. This technology allows clear identification of perforators as they emerge through the deep fascia. In this CT angiogram a large perforator (central blue arrow) can be seen emerging through the left rectus muscle. This CTA also shows the "law of equilibrium;" that is, where a perforator is unusually large, the contralateral or adjacent perforators will be correspondingly small. In this case there are no large perforators on the right hemiabdomen, and the right SIEA (left blue arrow above) is dominant. On the patient's left, the perforator (central blue arrow) is the main blood supply to the abdomen, and the left SIEA (right blue arrow above) is small. Concept introduced in Rozen WM, Grinsell D, Koshima I, et al. Dominance between angiosome and perforator territories: a new anatomical model for the design of perforator flaps. *J Reconstr Micro.* 2010 ;26:539-45.[47]
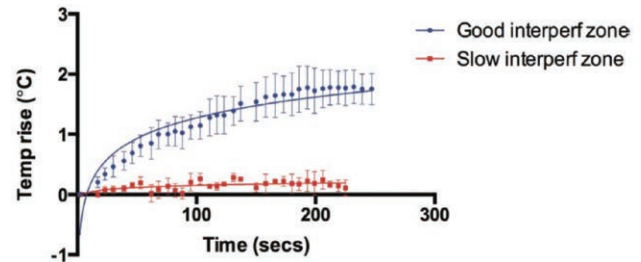

Fig. 15. This figure shows the rate of rewarming of tissue between perforators. There is a statistical difference in the rate at which true and choke anastomoses re-heat tissue after that tissue has been cooled. This difference can be used clinically to identify the interconnections between perforators and whether they are true or choke anastomoses. Reprinted with permission from *Plastic Reconst Surg.* 2013;132(6):1457–1464.[38]

We can identify them clinically by monitoring the rate, and pattern, by which tissue that has been deliberately cooled before-hand reheats itself[38] (Fig. 15). Warm blood, at core body temperature, will emerge from beneath the deep fascia, via the perforators, to supply the cooled integument, and will show up as "hot spots." Where the perforators are interconnected by true anastomoses, warm blood will flow out into the integument without resistance, and the temperature of the cooled integument will rapidly increase as the warm blood flows unimpeded through the tissue.

In contrast, where perforators are interconnected by choke anastomoses, warm blood will flow into the perforator, and its angiosome, but will then stop, as the choke anastomosis prevents flow of the blood into surrounding perforator angiosomes.

In the past, monitoring of tissue temperature was difficult, and expensive, and required infra-red cameras costing tens of thousands of dollars. The recent advances in digital thermography have meant that this information is now available through a number of budget priced thermal cameras that simply plug into a smart phone.[39,40]

In the same way as expensive infra-red cameras, these cameras also allow identification of the perforators as they emerge from the deep fascia, and then by monitoring the rate of rewarming of tissue between perforators, it is possible to ascertain if that interconnection is through a true or choke anastomosis. (Figs. 16, 17).

Delay

Where two perforators are connected by choke anastomoses, and extra additional tissue is required beyond the adjacent perforator, it is possible to convert that interconnection into a true anastomosis through the process of "delay."[41–44] This is a separate small operation performed before the definitive flap transfer, and was historically the basis for tubed pedicle flap transfer (Figs. 18–20).

In a separate, first stage, the blood supply to the selected tissue is carefully isolated so that the only blood entering the planned flap is from the selected perforator, and to the tip of the flap beyond the adjacent

Clearly then, a capacity to identify the interconnections of a selected perforator with its neighboring perforators is critical, as the type of interconnection directly influences the amount of tissue that can be safely transferred. Ideally, we would like to know the characteristics of the interconnections before we raise a flap.

Identifying Perforators and Their Interconnections

The advances in CT angiography have meant that it is now possible to precisely, and preoperativey, identify the location of perforators, as they emerge through the deep fascia, their caliber, and the spatial orientation to other perforators[33–37] (Fig. 14).

We said above that the tissue between perforators can be safely captured when the connecting anastomoses are choke anastomoses, but that if perforators are connected by true anastomoses, the two perforators will act as one, and far greater volumes of tissue can be safely transferred. In fact, all tissue connected by true anastomoses can be captured on a single perforator.

What is required is a method that allows identification of the true anastomoses before surgery. This is not possible with CT angiography.

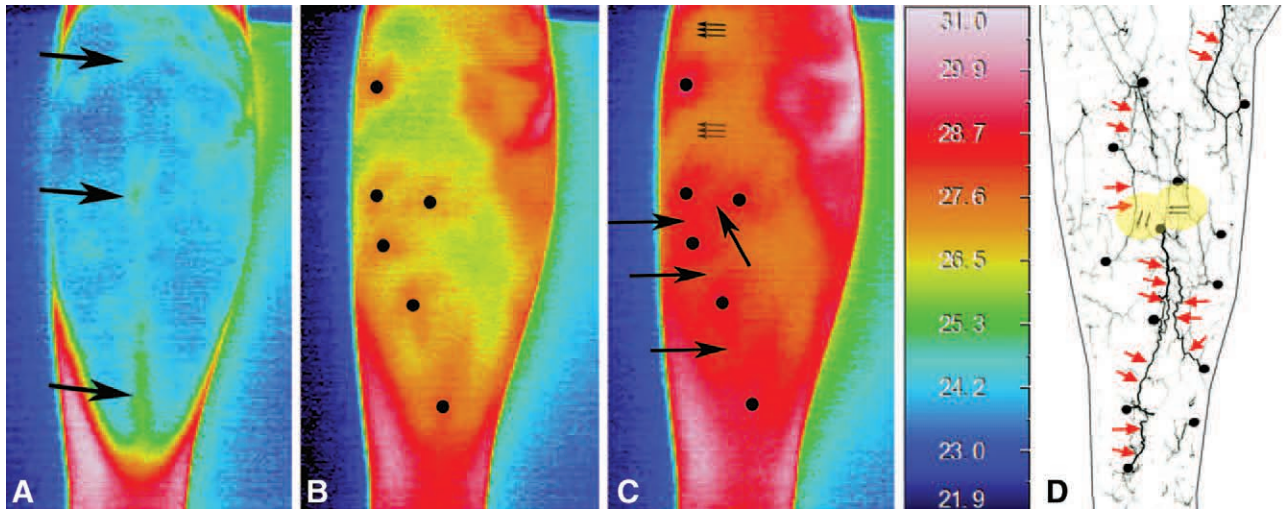As stated above true and choke anastomoses are functionally different.

Fig. 16. The above sequence shows the posterior aspect of the left calf that has initially been precooled with an icepack to 20 degrees (A). (The arrows show the uniform blue/green color). Upon removal of the icepack, warm blood below the deep fascia emerges through perforators, to heat the cooled integument and highlights their position; seen as orange spots in (B). As the tissue is warmed, the color of the perforator location changes from orange to red. Critically, image C also identifies the nature of the interconnections between perforators; the lower most perforators are connected by true anastomoses in red (identified with arrows), whilst the top perforator is connected with the others by a choke anastomosis. This corresponds with the angiogram in image D. The clinical significance of this study is that, counterintuitively, this flap is more reliable when raised on the distal (rather than on the proximal) perforator. Reprinted with permission from *Plast Reconstr Surgery*. 2013; 132(6):1457-1464.[38]
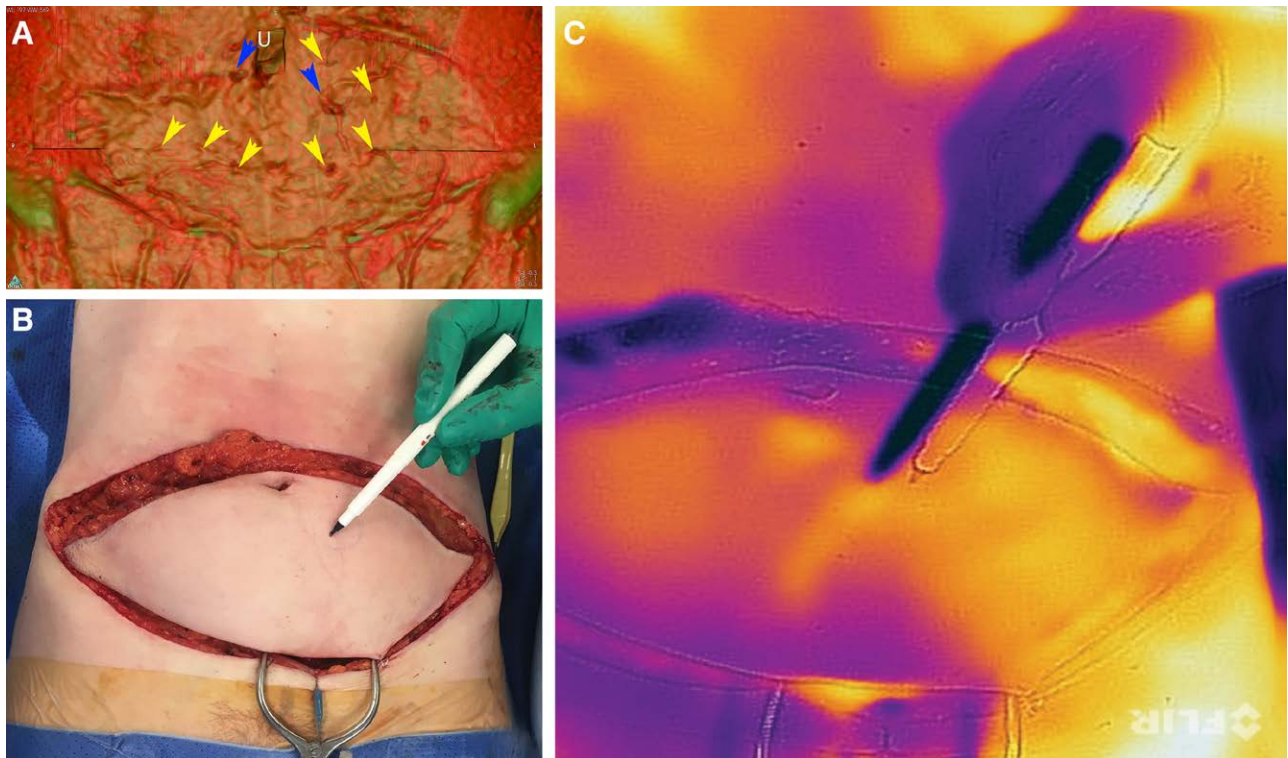
Fig. 17. CT angiography and Thermal imaging of the same abdomen. A, The CT Angiogram provides detail on the exact location of the perforators as they emerge through the deep fascia, and their caliber. The largest perforator is seen emerging through the left rectus muscle (blue arrows). This perforator has been identified with thermography and confirmed with Doppler Ultrasound. B, A pen marks the location in the middle diagram. C, Importantly, in addition to being able to locate the perforators (in yellow), the thermography also shows the interconnections between perforators—the true anastomoses are also yellow.

Pearls

Harvesting a flap in mobile tissue preselects for a bigger perforator, with a larger angiosome, and therefore a more reliable flap. And the donor defect can invariably be closed directly.

This flap orientation tends to be longitudinal in the limbs and circumferentially in the torso.

Knowledge of whether a proposed flap contains true or choke anastomoses predicts the dimensions of tissue that can be safely transferred.

The exact location and type of interconnection between perforators can be determined, inexpensively, *before* surgery, through digital thermography smart phone attachments.

The identification of choke anastomoses within a proposed flap allows the strategic manipulation of those anastomoses into true anastomoses before surgery, by surgical delay of the flap; thereby ensuring complete flap survival, when transferred.

Pitfalls

Assuming that a wider flap is safer and more reliable is wrong.

The supplying perforator is usually not in the centre of the tissue to be transferred and is often at the edge of the mobile tissue.

Transferring a flap that is composed of two or more (undelayed) choke anastomoses will invariably result in the death of the flap at the second choke zone.

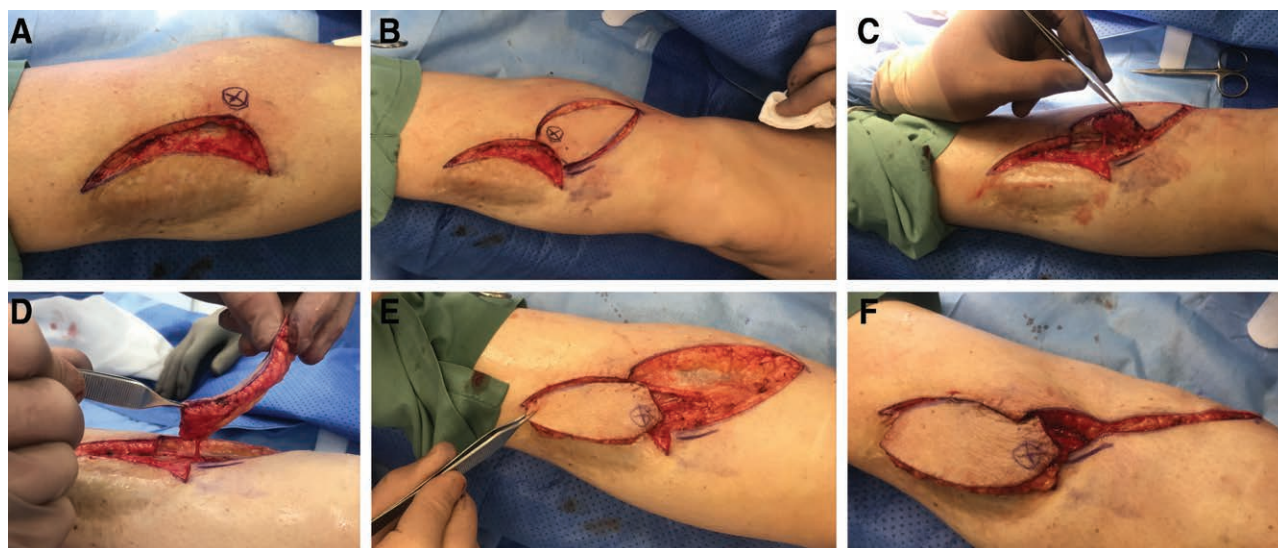**Fig. 18.** A summary of key points to be learned from this article.

Fig. 19. A series of photographs to show the method used by the author to transfer a local perforator flap. This patient had a sarcoma excised from the shin of her left leg. The defect was initially closed with a skin graft to allow monitoring for recurrence. After 2 years, she requested replacement with more robust tissue. A, A local perforator is identified preoperatively using either CTA, Doppler, or thermography. Before any skin is removed, an exploratory incision is made at the edge of the scar to confirm the perforator is adequate. This is done by carefully dissecting beneath the deep fascia. B, A flap is marked and then incised. The direction of the flap is based upon skin laxity to preselect for longer vessels and to allow direct closure of the secondary defect. C, The flap is raised, protecting the perforator, and preserving the underlying saphenous nerve. D, Until it is completely islanded on the perforator. E, The flap is then rotated 180 degrees to sit upon the proposed defect. F, Once confirmed that the flap is adequate, the skin graft is excised, and the donor defect approximated.
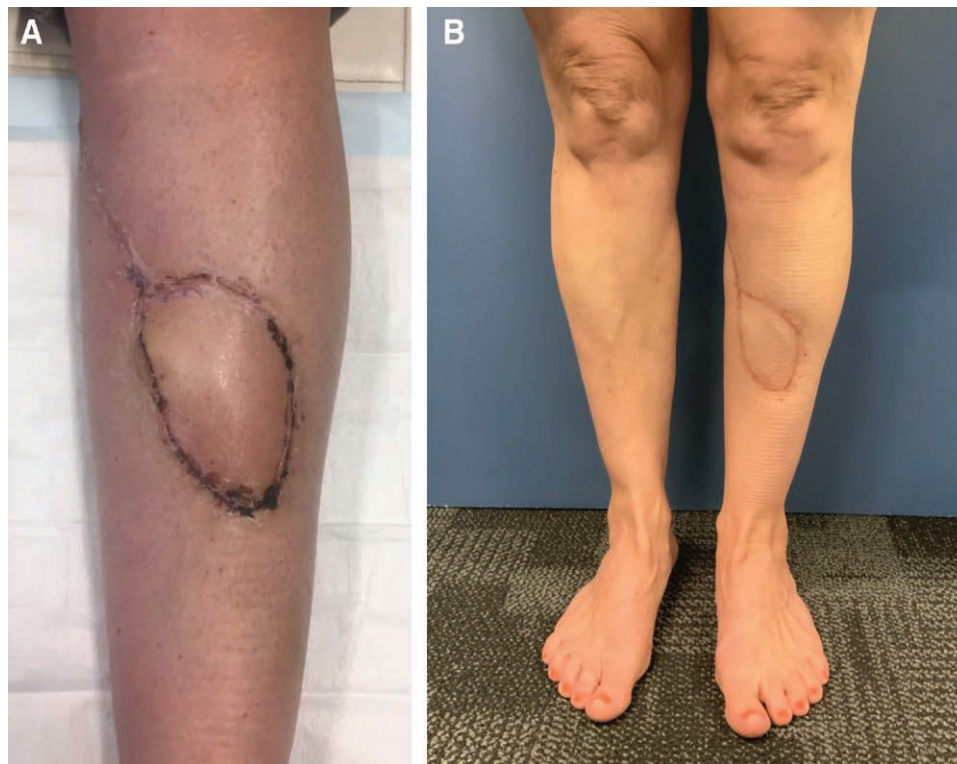
Fig. 20. Postoperative results. The final healed result at 2 weeks (A) and at 3 months postoperative (B).

perforator. The intervening, adjacent, perforator is ligated, and all other vascular connections to the flap are divided. At a minimum of 72 hours[45] later, the tip of the flap can be detached, and the entire flap then safely transferred on the chosen perforator without risk of necrosis.

In planning the initial delay, it is important not to be too aggressive and attempt to alter more than two adjacent choke zones in any one stage.

If this is required, it is essential an additional intermediate stage is added. This is called the "bridge delay" technique.[46]

This three-stage technique can dramatically increase the length of a flap. The first stage involves leaving a skin bridge or a perforator intact, within the center of the flap. This perforator is left alone for 72 hours before it is also divided; to render the flap once again nourished by its perforator and its tip. After an additional 72 hours, the tip of the flap can be divided, as before, and the flap transferred as a third stage.

Each transformation from choke anastomosis to true anastomosis takes 72 hours, and once undertaken, is permanent.

Through analysis of the location of true and choke anastomoses within the proposed flap, the surgeon is able to individually target key choke vessels, and through a series of staged operations, convert all the choke anastomoses within the proposed flap to true anastomoses ahead of the definitive flap transfer. This delay of the choke vessels can be performed weeks or months ahead. Once delayed, and the

choke vessels interconnecting perforators within the flap are converted into true anastomoses, the entire flap can be safely and reliably transferred on the chosen perforator.

CONCLUSIONS

In summary, the dimensions of a flap that can be safely raised are determined by its internal vascular anatomy, and not by a length versus width ratio. The location of perforators is determined by the function of the integument. Where the integument is loose and mobile, perforators will be located around the periphery of the mobile layer 4 and will emerge at points of fixation. Perforators adjacent to mobile tissue tend to be of larger caliber and have larger perforator angiosomes.

Perforators interconnected by true anastomoses will effectively "act as one," and hence much larger volumes of tissue can be safely transferred. The identification of these "true anastomoses" between perforators can be made before surgery. Choke vessels interconnecting perforators can be converted into true anastomoses by delay.

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