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Atlas of Perforator Flap and Wound Healing

Microsurgical Reconstruction and Cases

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Part I

Overview of Perforator Flap

Development History of Flap

1

Before the 1950s, due to the lack of in-depth studies carried on the cutaneous vasculature, the pedicled random pattern flap was the mainstream in flap surgery; during 1950s–1960s, studies on flap vessels resulted in the advent of muscle flap and axial pattern flap; in 1970s, the free flap, musculocutaneous flap and musculoskeletal flap involving with vascular anastomosis were applied in clinical practice along with the development of the organ transplants using the microsugical technique; since 1980s, the flourishing and development of microdissection greatly promoted the development of flap surgery, and many achievements were gained in flap surgery, not only in theoretical field, but in the clinical application of relevant technologies. A variety of new types of flaps were developed and employed in surgeries, such as flap with main artery, reverse-flow island flap, fasciocutaneous flap, flap with intermuscular septal vascules, distally pedicled flap, venous flap, subcutaneous vascular plexus flap, veno-neurocutaneous vascular flap and perforator flap. With continuous increase of flap donor sites, the transposition of flap with a vascular pedicle was widely applied in clinical practice.

1.1 Random Pattern Flap

Random pattern flap, also known as random flap, contains no axial vessels and is nourished by dermal vascular network, subdermal vascular network or subcutaneous vascular network (Fig. 1.1). Due to absence of axial vessel, the flap shall be cut with a length: width ratio of 1.5:1. As the flap is prepared on supreficial layer of deep fascia, the incision should be performed on the same surgery plane with particular caution to ensure the homogeneity of the flap in thickness and depth without any injury to the continuity of vascular network. Based on the distance between flap donor site and recipient site, random flap can be categorized into local flap, regional flap and distant flap.

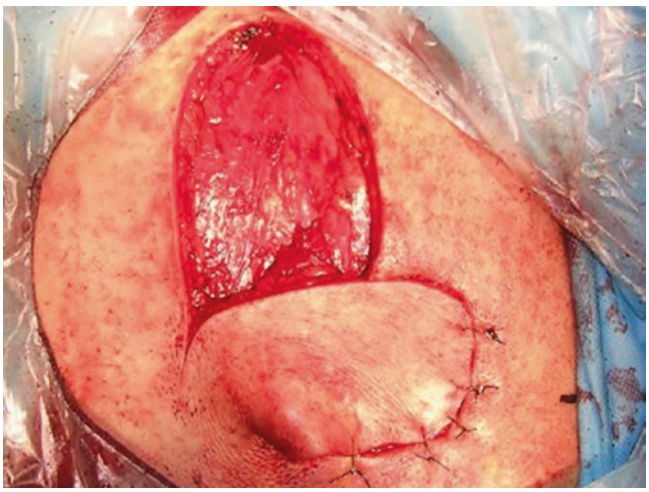

Fig. 1.1 Random pattern flap (provided by Xu Yongqing)

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1.2 Tubed Flap

The tubed flap is also defined as tubed pedicled flap. Being completely or partially sutured into a tubed structure, the flap has an increased flexibility and harvesting area in flap transposition, and thus can be used for flap delay operation or protecting important vascular pedicle (Fig. 1.2). The concept of tubed flap was firstly put forward by Russian scholar Filatov in 1917, and England scholar Gillies for the first time performed tubed flap transplantation in 1920. With the rapid development of flap surgery, tubed flap has a tendency to phase out from clinical practice due to the need for a higher number of operations and a longer course for recovery.

Fig. 1.2 Tubed flap (Provided by Zhang Xinying)

1.3 Axial Pattern Flap

The axial pattern flap refers to the flap that contains axial vein and axial artery parallel to flap vertical axis in flap supply area (Fig. 1.3). A complete set of regional blood circulation system is established with the blood supply by axial artery and blood return to axial vein, and works as a guarantee for nutrition supply to the flap. The concept of axial pattern flap was firstly put forward by American doctors McGregor and Morgan in 1973.

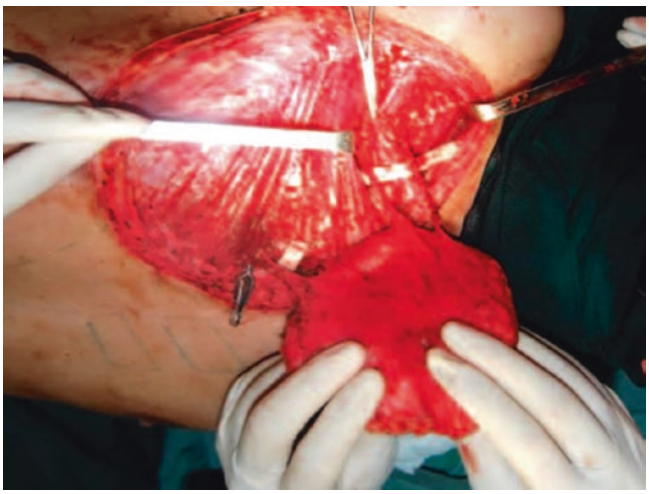

Fig. 1.3 Groin flap (Provided by Zhang Yixin)

1.4 Free Flap

The free flap refers to the tissue flap with a newly established blood supply system obtained by anastomosing the flap nutritious vessel and vessel of recipient site using microvascular anastomosis techniques, by which the goal of repairing soft tissue defects can usually be achieved (Fig. 1.4). In 1973, Australian Daniel and Chinese Yang Dongyue respectively reported a successful free transplantation of the groin flap with a blood supply directly by the cutaneous artery, which are the first reports of free flap with vascular anastomosis and also with the blood supply directly by cutaneous artery. These groundbreaking cases pioneer the procedures of free flap transplantation and set off a wave of research on applied anatomy of flap donor sites.

In 1981, Yang Guo firstly reported the forearm flap with radial artery as the vessel pedicle (Fig. 1.5), which was the first case of flap with main artery ever reported in the world, and was honoured as "China Flap". The emerge of radial artery flap promoted the research on artery trunk reticulation flap (intermuscular septal branches of the main artery), leading to the development of the peroneal artery flap (reported by Gu Yudong in 1998), posterior tibial artery flap (Zhang Shancai et al. 1984), ulnar artery flap (Li Zhutian et al. 1985) and posterior interosseous artery flap (Lu Laijin et al. 1987).

Fig. 1.4 Groin flap (Provided by Lin Jian)

Fig. 1.5 Radial artery flap (Provided by Wei Zairong)

1.5 Pedicled Cutaneous Flap

Pedicled cutaneous flap refers to the microsurgery technique for repairing adjacent tissue defects with nutritious vessel of flap because of the using of a local transposition procedure (Fig. 1.6). More options on flap donor site, especially on new types of flaps, make it possible to repair the tissue defect at any site of our body by using pedicled cutaneous flap and local transposition technique. This method has been widely applied in clinical practice due to the safety and high success rate while in no need of vascular anastomosis. The first academic work in China associated with pedicled flap, *Transpositon Technique for Vascular Pedicled Cutaneous Flap and musculocutaneous Flap* was published in 1988 (Sun Hong, Hou Chunlin), followed by *Transposition technique for Vascular Pedicled Tissue* (Yang Zhiming 1988).

1.6 Reverse-Flow Island Flap

Reverse-flow island flap, also know as reverse blood flow island flap, is a special type of distally pedicled flap characterized by a reverse blood flow in both of the artery for blood supply and the vein for blood return (Fig. 1.7). Such flaps can be harvested only at sites with at least two parallel main arteries that are accurately anastomosed at the distal end. Such flaps are characterized by a good blood perfusion and less satisfied blood return, and usually have a high survival rate despite of the post-surgical swelling observed in many cases. In 1982, Wang Wei and Lu Kaihua firstly reported their experiences in hand wound repairing utilizing radial artery reverse-flow island flap, which boosted the research on the artery blood supply and vein blood return of reverse-flow island flap as well as the subsequent clinical application of peroneal artery reverse-flow island flap, posterior tibial artery reverse-flow island flap and ulnar artery reverse-flow island flap.

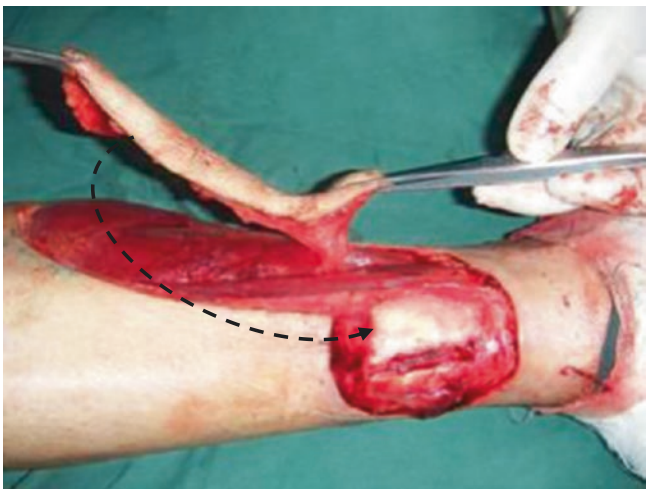

Fig. 1.6 Pedicled cutaneous flap (Supplied by Xu Yongqing)

Fig. 1.7 Ulnar artery flap (Provided by Wei Zairong)

1.7 Musculocutaneous Flap

Musculocutaneous flap refers to the composite tissue blocks containing skin, superficial fascia, deep fascia and muscular tissues (Fig. 1.8). It has a complete vascular system of arteries and veins. As the survival of the skin on the surface of muscle is dependent on the muscle, the flap shall be collected included with the deep-layer muscle. Musculocutaneous flap can be used for filling the defects of deeper tissues due to the larger size, and for repairing osteomyelitis-induced wounds owing to the rich blood supply and strong ability of anti-infection. Those with innervation can also be used for reconstruction of motor function. Since 1970s, gracilis myocutaneous flap (Orticochea 1972), gastrocnemius myocutaneous flap (McCraw 1980), trapezius myocutaneous flap (Demergasso and Piazza 1979), rectus abdominis myocutaneous flap (Tai and Hasegawa 1974), latissimus dorsi myocutaneous flap (Olirari 1976), gluteal musculocutaneous flap (Minami et al. 1977a), tensor fascia lata myocutanous flap (Hill et al. 1978), and pectoralis major myocutaneous flap (Ariyan 1979) were successively applied in clinical practice.

1.8 Fasciocutaneous Flap

Fasciocutaneous flap refers to the flap that contains skin, subcutaneous fat tissues and deep fascia (Fig. 1.9). In 1981, the Sweden Pontén collected the attached deep fascia when preparing for a random pattern flap from posterior superior calf, making a flap with a length-to-width-ratio of 2.5:1. Tolhurst from Dutch and Barclay and Haertsch from England all made great contribution to early development of fasciocutaneous flap. Relevant books published include *The Arterial Anatomy of Skin Flaps* (Cormack 1986), Facsiocutaneous Flaps (Hallock 1992) and *Fasciocutaneous Flap and Fascia-pedicled Tissue Flaps* (Chunlin and Shimin 2000).

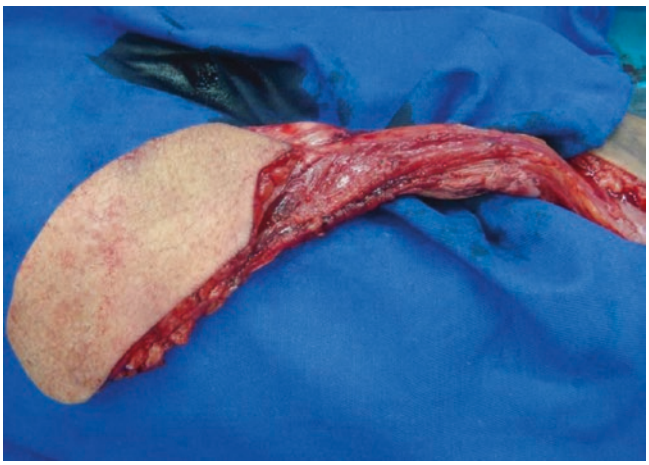

Fig. 1.8 Musculocutaneous flap (Provided by Wei Zairong)

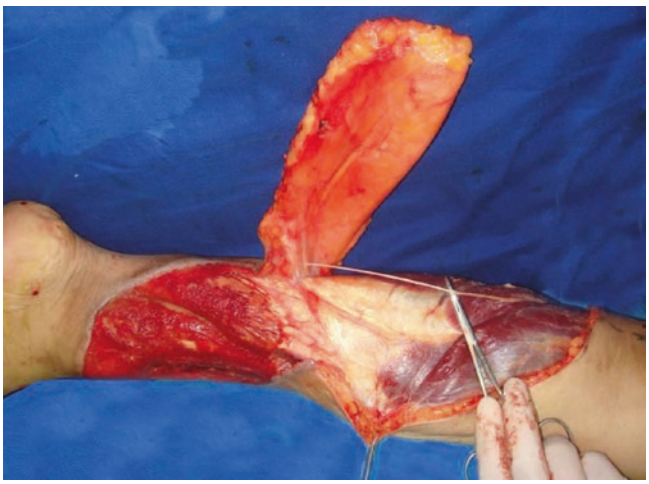

Fig. 1.9 Fasciocutaneous flap (Provided by Wei Zairong)

1.9 Subcutaneous Vascular Plexus Flap

Subcutaneous vascular plexus flap, also known as "Ultrathin Flap", is a thin flap obtained by modifying free pattern flap or axial flap, to be specific, by cutting off most of the subcutaneous fat tissues with only a thin layer of fat tissue left under the subdermal vascular plexus (Fig. 1.10). It derives from subdermal vascular plexus skin graft and was firstly introduced by Si Tutu in 1986.

Fig. 1.10 Ultrathin flap (Provided by Mu Guangtai)

1.10 Nonphysiologic Flap

Nonphysiologic flap refers to the flaps with no normal arterial and venous blood circulation (Fig. 1.11), such as venous flap and reverse-flow island flap. It has a blood circulation in nonphysiologic pattern. Nakayama et al. firstly put forward the concept of arterialized venous flap in 1981. Thereafter, the venous flaps attracted more attention from an increasing number of studies and were developed in a variety of types, including: (1) arterial blood nourished venous flap or arterialized venous flap; (2) venous blood nourished venous flap; (3) purely venous flap or venous pedicled island flap. However, nonphysiologic flap also has limitations, such as unstable survival rate, high randomness, and lack of theoretical guidance for quantification.

Fig. 1.11 Venous flap (Provided by Lin Jian)

1.11 Neurocutaneous Flap

The neurocutaneous flap is a flap with a blood supply on the basis of the internal vessel chain and that peripheral to the cutaneous nerve (Fig. 1.12). It was reported by Bertelli (1993) from Brazil and Masquelet (1992) from France, and the flaps from the lower leg and the hand were respectively introduced by Zhang Shiminm and Song Jianliang (China) in 1994. Its naming was controversial in early years and eventually defined as "Neurocutaneous Flap" by Shizhen et al. (1999) based on the anatomy research and the vasular structure for the survival of the flap. The first version of *Neurocutaneous Flap* (Zheng Heping and Yongqing.) in China was published in 2006.

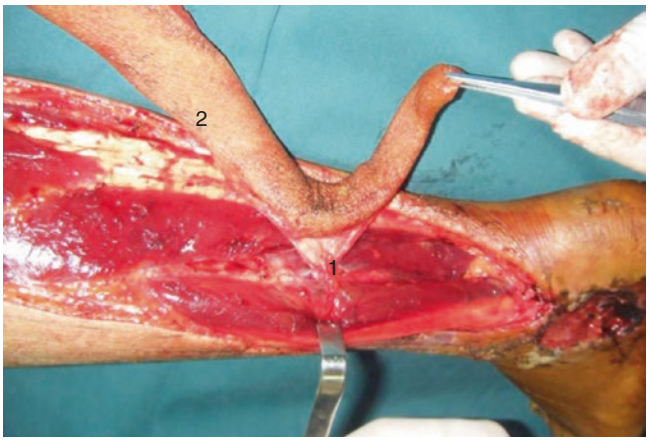

Fig. 1.12 Neurocutaneous flap (Provided by Xu Yongqing). *1* Pedicle (perforator pedicle), *2* flap

1.12 Perforator Flap

The perforator flap is an island pattern flap with the blood supply from thin skin perforator vessels (diameter ≥0.5 mm after perforating deep fascia) (Fig. 1.13). It is within the concept of axial pattern flap, and in the narrow sense, only refers to the thin subcutaneous flap that has no deep fascia and is nourished by myocutaneous artery perforator. Currently, the concept has been expanded to a broader sense which includes all the island pattern flaps nourished by blood vessels perforating deep fascia. This concept was firstly put forward by Koshima and Soeda (1989).

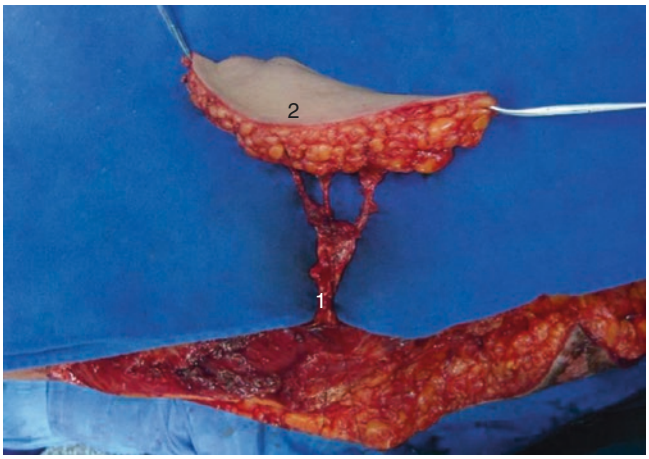

Fig. 1.13 Perforator flap (Provided by Wei Zairong). *1* Perforator pedicle, *2* flap

References

Ariyan S. The pectoralis major myocutaneous flap a versatile flap for reconstruction in the head and neck. Plast Reconstr Surg. 1979;63(1):73–81.

Bertelli JA. Neurocutaneous axial island flaps in the forearm**:** anatomical, experimental and preliminary clinical results. Br J Plast Surg. 1993;46(6):489–96.

Bolkovitinova LA, Ivanova NP, Byelyayeva AA. Filatov's tubed flap—one more contribution. Acta Chir Plast. 1989;31(3):172.

Chunlin H, Shimin Z. Fasciocutaneous flap and fascia pedicled tissue flap. Shanghai: Shanghai Scientific and Technical Publishers; 2000.

Cormack GC. The arterial anatomy of skin flaps. Edinburgh: Churchill Livingstone; 1986. p. 12–20.

Daniel RK, Taylor GI. Distant transfer of an island flap by microvascular anastomoses. A clinical technique. Plast Reconstr Surg. 1973;52(2):111–7.

Demergasso F, Piazza MV. Trapezius myocutaneous flap in reconstructive surgery for head and neck cancer**:** an original technique. Am J Surg. 1979;138(4):533–6.

Gillies HD, Fry WK. Injuries in the region of the eyes, including burns of the face. Plastic surgery of the face: based on selected cases of war injuries of the face, including burns. London: H. Frowde; 1920.

Hallock GG. Fasciocutaneous flaps. Boston: Blackwell Scientific Publications; 1992.

Heping Z, Yongqing X. Zhang Shimin neurocutaneous flap. Tianjin: Tianjin Science and Technology Publishing House; 2006. p. 10–25.

Hill HL, Nahai F, Vasconez LO. The tensor fascia lata myocutaneous free flap. Plast Reconstr Surg. 1978;61(4):517–22.

Hou CL. Application of vascular pedicled skin flap and myocutaneous flap in reparative and reconstructive surgery. J Repar Reconst Surg. 1988.

Koshima I, Soeda S. Inferior epigastric artery skin flaps without rectus abdominis muscle. Br J Plast Surg. 1989;42(6):645–8.

Laijin L, Shoufu W, Jun Y, et al. Interosseous dorsal forearm artery reverse-flow Island flap. Chin J Hand Surg. 1987;3:141–2.

Lu KH, Zhong DC, Chen B. Forearm radial artery reverse-flow Island flap and its clinical application. Chin J Surg. 1982;20(2):695.

Masquelet AC, Romana MC, Wolf G. Skin island flaps supplied by the vascular axis of the sensitive superficial nerves: anatomic study and clinical experience in the leg. Plast Reconstr Surg. 1992;89(6):1115–21.

McCraw JB. The recent history of myocutaneous flaps. Clin Plast Surg. 1980;7(1):3–7.

McGregor IA, Morgan G. Axial and random pattern flaps. Br J Plast Surg. 1973;26(3):202–13.

Minami RT, Mills R, Pardoe R. Gluteus maximus myocutaneous flaps for repair of pressure sores. Plast Reconstr Surg. 1977;60(2):242–9.

Nakayama Y, Soeda S, Kasai Y. Flaps nourished by arterial inflow through the venous system an experimental investigation. Plast Reconstr Surg. 1981;67(3):328–34.

Olivari N. The latissimus flap. Br J Plast Surg. 1976;29(2):126–8.

Orticochea M. A new method of total reconstruction of the penis. Plast Surg. 1972;25(4):347–66.

Pontén B. The fasciocutaneous flap:its use in soft tissue defects of the lower leg. Br J Plast Surg. 1981;34(2):215–20.

Shancai Z, Jinming L, Kexun S. Clinical application of reverse-flow Island flap of posterior Tibial artery. Chin J Surg. 1984;22(11):685–7.

Shizhen Z, Yongqing X, Changman Z, et al. Anatomical basis and naming of neurocutaneous flap. Chin J Microsurg. 1999;1:37–9.

Si TP, Chen J, Chen JH, et al. Subdermal vascular plexus pedicle flap. Acad J First Military Medical Univ. 1986;6(1):60–1.

Song JL, Li YC, Fan XL, et al. Reverse neurocutaneous island flaps in the hand. Chin J Hand Surg. 1994;10(4):233–5.

Sun H. Clinical application of nasolabial fold dermal tissue flap in lower facial paralysis. J Repar Reconstr Surg. 1988.

Tai Y, Hasegawa H. A transverse abdominal flap for reconstruction after radical operations for recurrent breast cancer. Plast Reconstr Surg. 1974;53(1):52–4.

Wang W, Huang YW, Zhang DS, et al. Island forearm flap for the repair of scar contraction of the hand. Asia Acad Med Second Shanghai 1982;31–3.

Wang CQ, Wang JL, Zhang JL, et al. Review and prospect of flap transplantation. Chin J Microsurg. 2000;23(1):12–4.

Yang GF, Chen BJ, Gao YZ, et al. Forearm flap free transplantation. Chin Med J (Engl). 1981;61(12):139–41.

Yang ZM, Luo YX, Chen BL, et al. Treatment of tibia defect. J Repar Reconst Surg. 1988.

Yudong G. Microsurgical repair of limbs. Shanghai: Shanghai Medical University Press; 1998. p. 61–2.

Zhang SM, Zhang LS, Liu DX. Crural fascia tissue flap with neurocutaneous vascular plexus. Chin J Microsurg. 1991;17(4):284–5.

Zhutian L, Yude C, Dongbai K. Ulnar artery reverse-flow Island flap and its application in hand soft tissue defects. J Norman Bethune University Med Sci. 1985;11(2):179.

Concept of Perforator Flap

2

2.1 Concept

The concept of perforator flap was first put forward in the late 1980s. It is an axial pattern flap of skin and subcutaneous tissue with small-diameter skin perforator vessel (perforator artery and perforator vein) as the pedicles (Fig. 2.1a). Perforator flap is a development in microsurgery and has advantages as flexible design, small wounds at donor site, convenient transfer and good appearance of recipient site etc. At the beginning, perforator flap developed slowly and failed to attract much attention. Then two milestone meetings in Ghent, Belgium (2001) and Yinchuan, China (2005) promoted the research and development of perforator flap. A large number of basic researches and clinical application of perforator flap were reported since. Series of symposia and forums focused as well as collections and works published on perforator flap have laid an important theoretical basis for the development of perforator flap and raised a great enthusiasm in its research. With the increase of new donor sites and wide clinical application, dispute over the concept and nomenclature of perforator flap emerged. At the third Summit of Chinese Microsurgical Perforator Flap held in Ningbo in September 2013, following a principle of "seeking consensus on major issues while reserving dissensus on minor issues", some domestic experts in flap surgery made profound discussions about current concept of perforator flap in China and reached a consensus on issues as whether to carry deep fascia and superior source artery.

The perforator flap, according to clinical demand, can be designed into pedicled (Fig. 2.2b) or free perforator flap (Fig. 2.2c).

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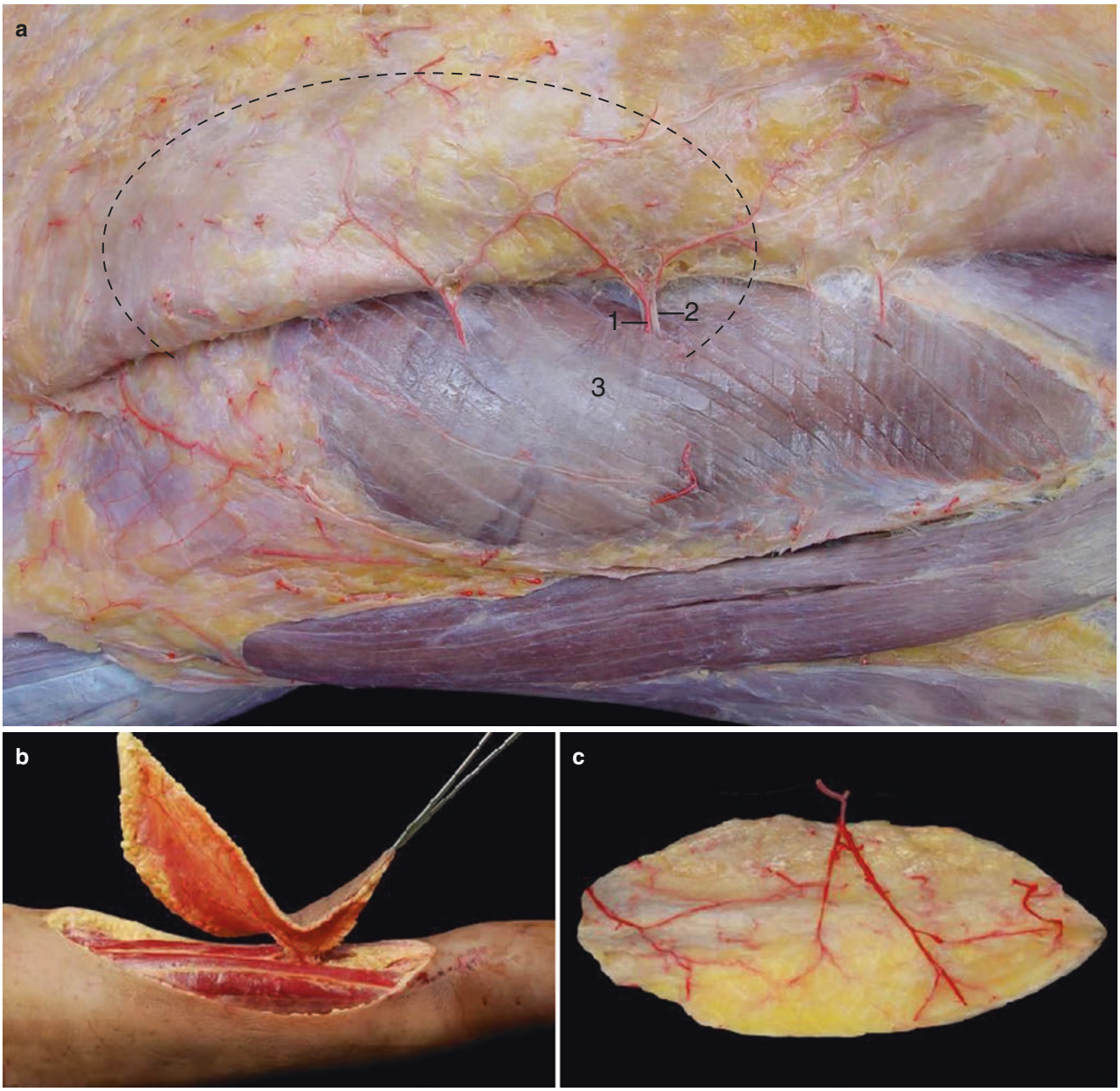

Fig. 2.1 Perforator flap. (**a**) Perforator vessel, *1* artery, *2* vein, *3* muscle; (**b**) pedicled perforator flap; (**c**) free perforator flap

2.1.1 Pedicled Perforator Flap

Pedicled perforator flap refers to the perforator flap with a pedicle designed and harvested peripheral to the wound of recipient site for local transposition (Fig. 2.2). It has an advantage of no need for microsurgical vascular anastomosis. The perforator vessel pedicled propeller flap with an eccentric design is most frequently used in clinical practice, and can rotate to cover the wound in 180° to the donor site.

Fig. 2.2 Transposition of first plantar metatarsal artery perforator flap for repairing zaozi001 distal toe defects (provided by Lin Jian). (**a**) Tissue defects before the surgery; (**b**) design of the flap; (**c**) resection of the flap; (**d**) flap transposition for wound coverage and skin grafting in the donor site; (**e**) flap and donor site 9 months after the surgery

2.1.2 Free Perforator Flap

Free perforator flap refers to the perforator flap that is designed and dissected at any site meeting the requirement for vessel anastomosis, and used for free vessel transplantation (Fig. 2.3).

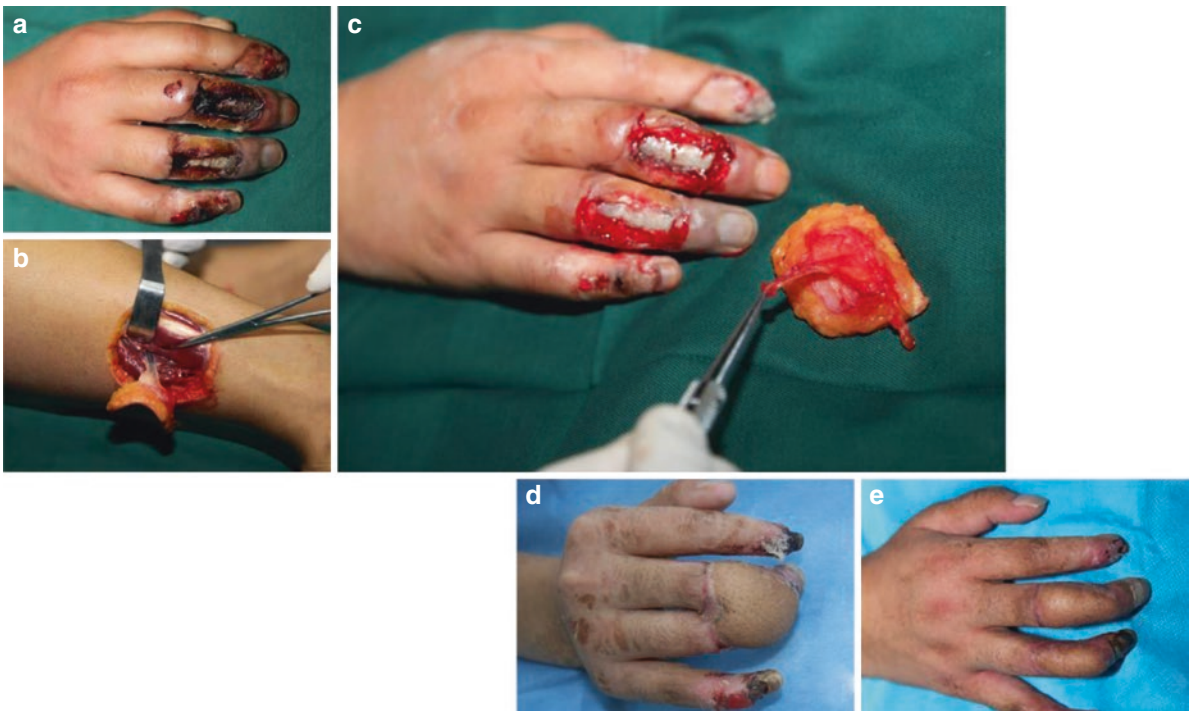

Fig. 2.3 Free transplantation of proximal and middle peroneal artery flap for repairing the defects of dorsal skin in middle finger and ring finger (Provided by Xu Yongqing). (**a**) Necrotic and unhealed wounds in dorsal skin of middle finger and ring finger; (**b**) flap dissection and vessel pedicle exposure; (**c**) flap dissociation; (**d**) 3 weeks after flap transplantation for wound covering; (**e**) appearance of the flap 60 days after finger separation

2.2 Perforator Vessel

Perforator vessel refers to the nutrient vessels that can supply blood for subcutaneous tissues and skin after originating from the source artery (not including the source artery), passing through the deep fascia and exiting from the superficial layer of the fascia, including indirect perforator and direct perforator.

1. Indirect perforator usually runs through deep muscle and deep fascia to subcutaneous tissues and skin, and mostly exists in flat and broad muscles, such as trunk and proximal limbs (Fig. 2.4a, b). Longer and thicker vessel pedicles can be obtained by tracing the anatomical structure of the deep muscles after cutting open the deep fascia.
2. Direct perforator usually runs through lacuna musculorum/intermuscular space/intermuscular septum (Fig. 2.4c–e), and then through deep fascia to subcutaneous tissues and skin. It mostly existed in thin intermuscular space/lacuna musculorum, or between the muscles with same functions or in intermuscular septum (between muscle groups). By separating the intermuscular septum (intermuscular space), we can see that the perforator vessel orginates from the deep main artery.

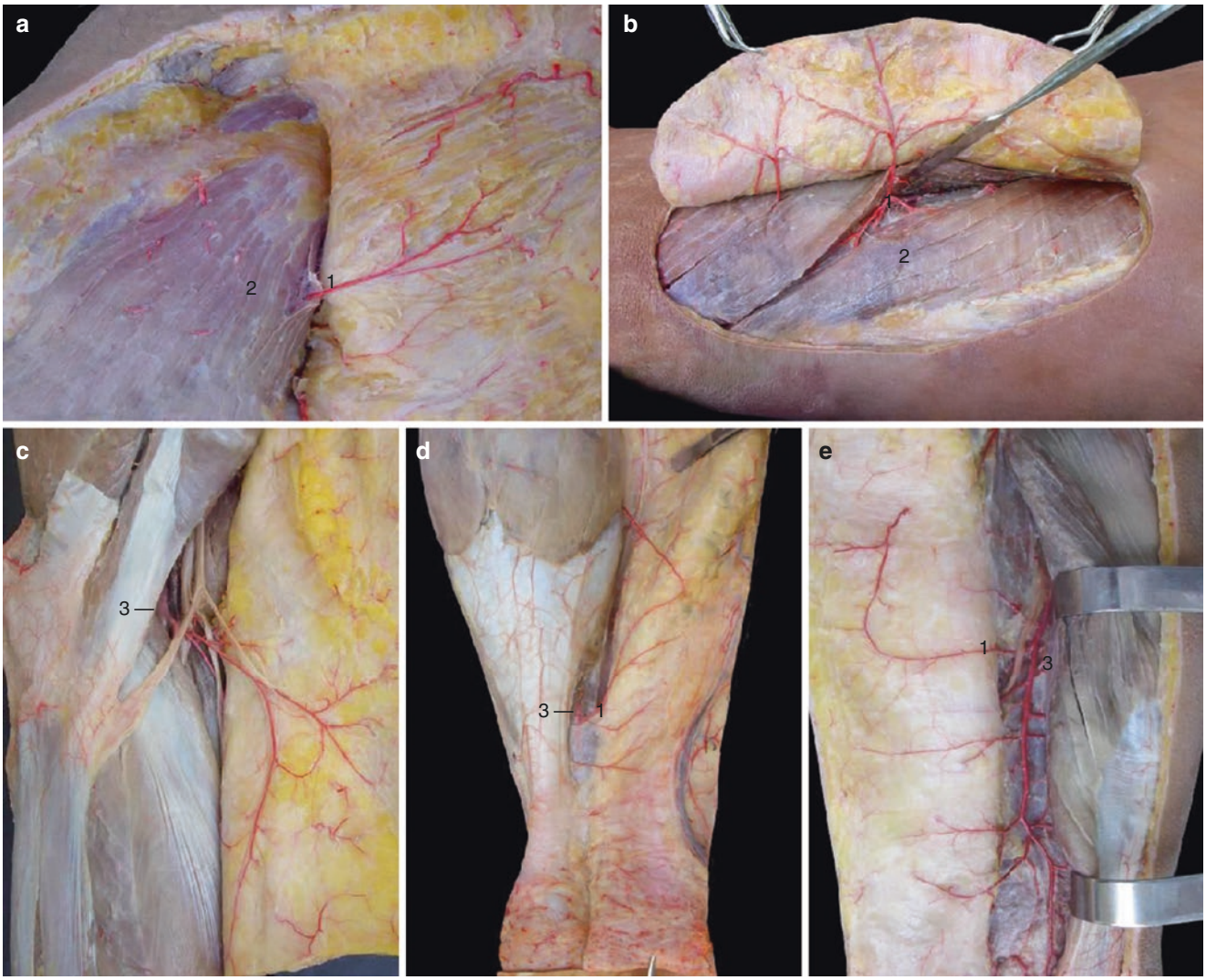

Fig. 2.4 Perforator vessel. (**a**) Indirect perforator in the trunk; (**b**) indirect perforator in proximal limbs; (**c**) lacuna musculorum perforator; (**d**) intermuscular space perforator; (**e**) intermuscular septum perforator, *1* perforator, *2* muscle, *3* superior main vessel

2.3 Angiosome Area

Angiosome is a three-dimensional complex with the same blood supply and consists of skin and deep tissues (muscles, tendons, bones). It originates from the big deep vessel and runs along connective tissue, and radiates to movable parts from the fixed parts (Fig. 2.5). The concept of flap vessel was put forward by Australian Doctor Taylor and Palmer in 1987.

Tang Maolin et al. in 2002 successfully modified the angiography and combined it with the modern computer imaging technology, by which the origins, runnings and distribution of perforators (diameter ≥0.5 mm) in the skin and subcutaneous tissues were thoroughly observed, and the distribution map of human skin perforators was plotted (Fig. 2.6). The map revealed that a total of 61 skin-originated vessels in our body gave out 442 perforators (diameter ≥0.5 mm) to nourish the skin. The ratio of intramuscular perforator to intermuscular space perforator was 3:2, the average diameter of perforator vessels was 0.7 mm, and the running distance in superficial fascia was measured as 3.3 cm. Meanwhile, the number of perforators from each of the source arteries and their distribution area were calculated.

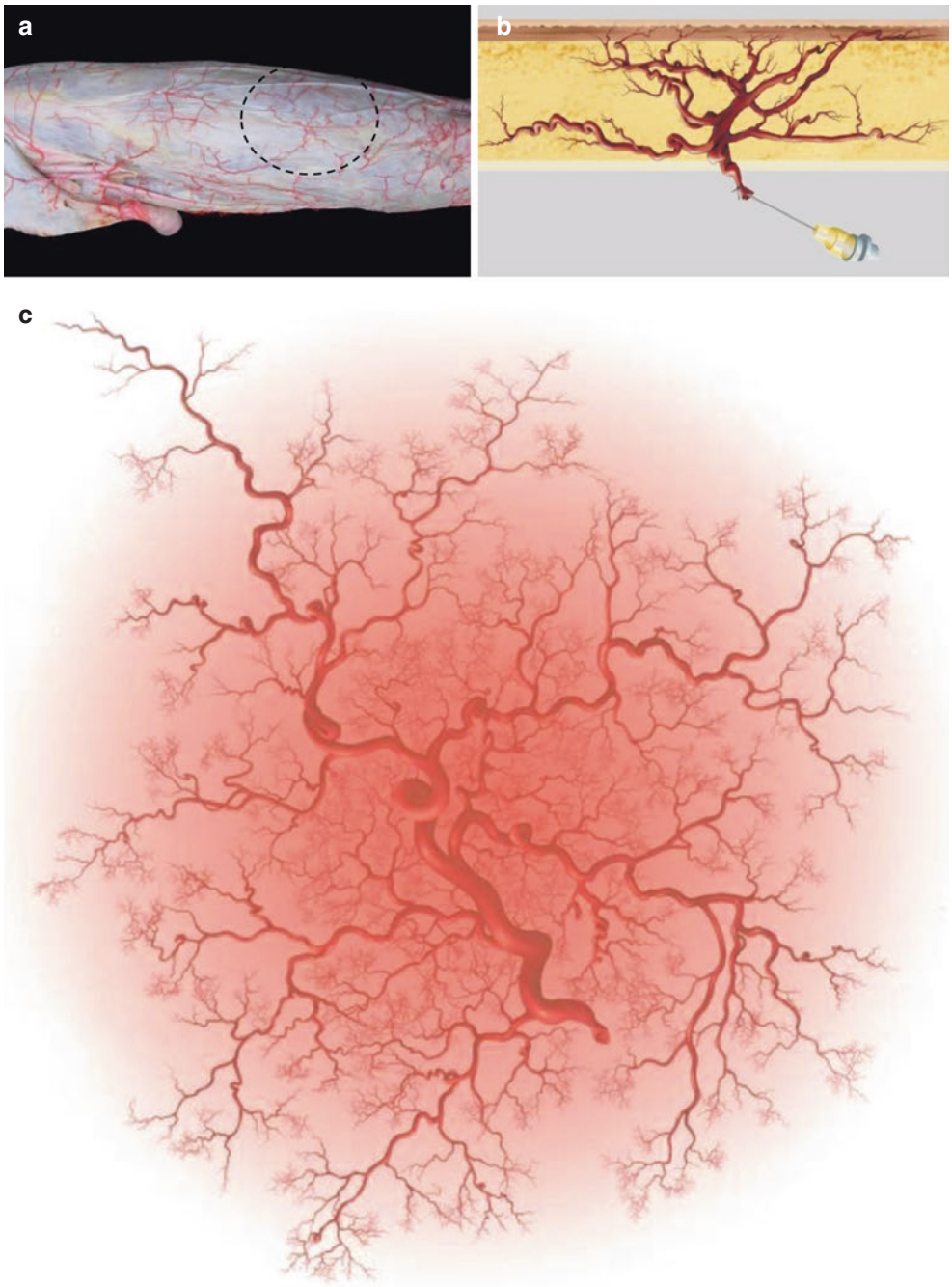

Fig. 2.5 Pattern diagram of perforator angiosome area. (**a**) View of the free surface; (**b**) side view; (**c**) basal surface view

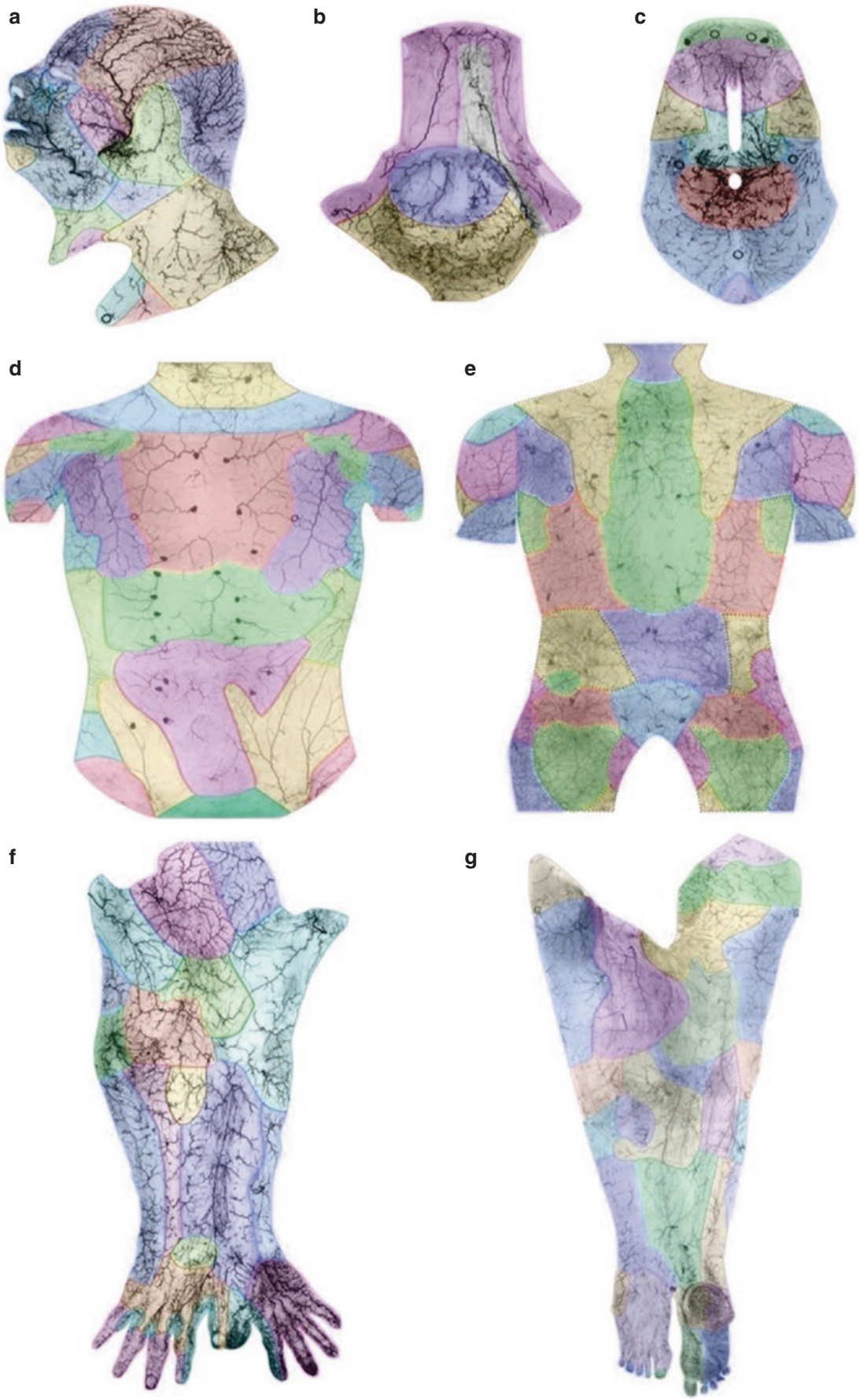

Fig. 2.6 Perforator vascular body of human skin and perforator distribution (Provided by Tang Maolin). (**a**) Head and face; (**b**) male perineum; (**c**) female perineum; (**d**) front view of the trunk; (**e**) rear view of the trunk; (**f**) upper limb; (**g**) lower limb

2.4 Perforator Vessel Anastomosis

The adjacent perforator vessels are connected by their branches (Fig. 2.7) including three types of anastomosis: (1) True anastomosis (diameter not reduced) with the vessels running on the fascia or in fat layer; (2) obstructive anastomosis (diameter gradually reduced) with the vessels existed in dermis. The tiny ramus communicans are also formed between true anastomosis vessels and obstructive anastomosis vessels to maintain the blood flow perfusion; (3) potential anastomosis usually does not work under normal conditions.

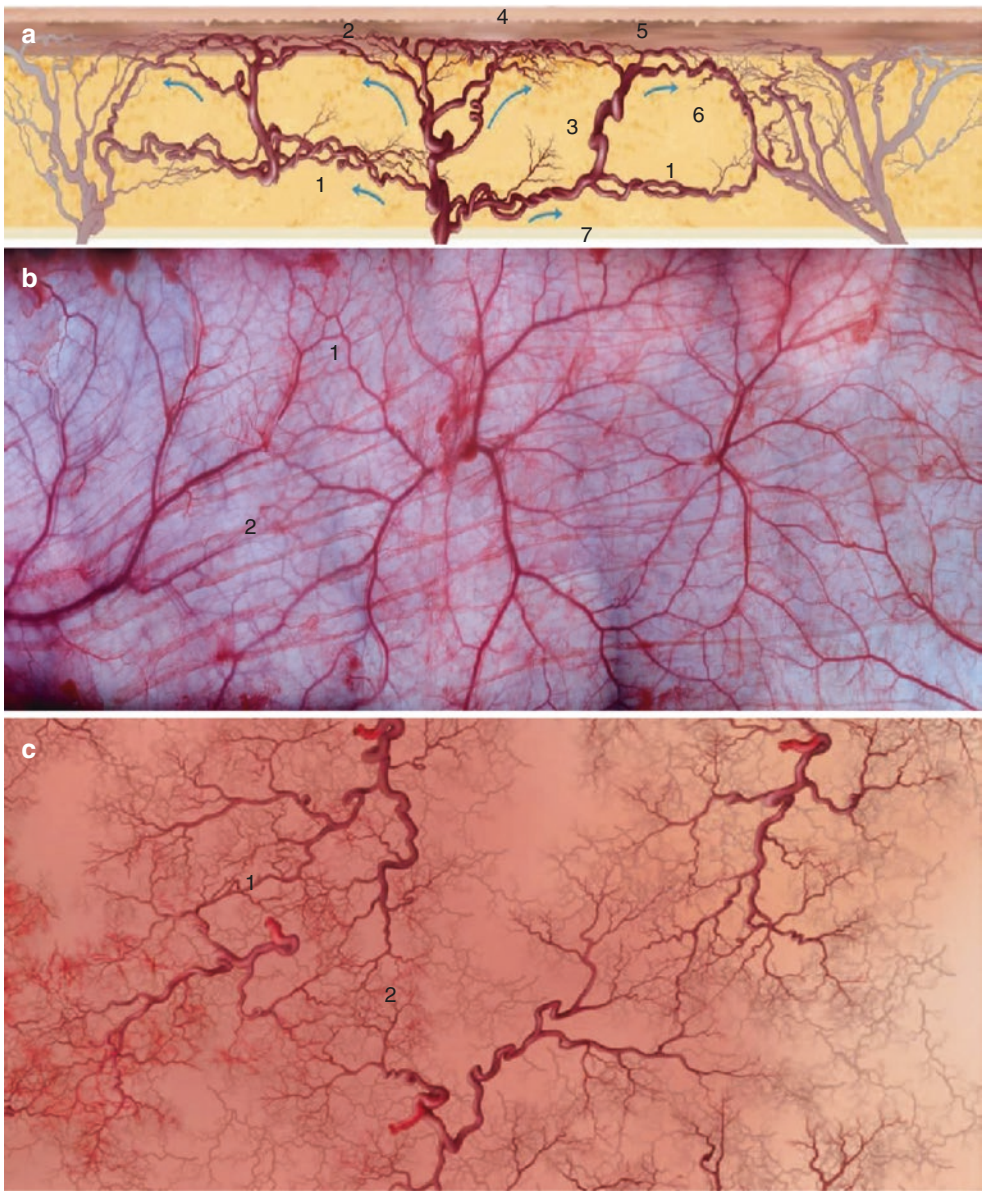

Fig. 2.7 Pattern diagram of perforator vessel anastomosis. (**a**) Side view; (**b**) basal surface view (Picture of real vessels); (**c**) basal surface view (sketch map), *1* true anastomosis, *2* obstructive anastomosis, *3* ramus communicans, *4* skin, *5* dermis, *6* subcutaneous fat, *7* deep fascia