

He-Ping Zheng
Jian Lin
Yong-Qing Xu
De-Qing Hu

Atlas of Perforator Flap and Wound Healing

Microsurgical Reconstruction and Cases



PEOPLE'S MEDICAL PUBLISHING HOUSE

 Springer

The Springer logo consists of a white chess knight (horse) facing left, positioned above a white horizontal line. To the right of this graphic, the word 'Springer' is written in a white, serif font.

Atlas of Perforator Flap and Wound Healing

He-Ping Zheng • Jian Lin
Yong-Qing Xu • De-Qing Hu

Atlas of Perforator Flap and Wound Healing

Microsurgical Reconstruction and Cases



PEOPLE'S MEDICAL PUBLISHING HOUSE



Springer

He-Ping Zheng
The 900th Hospital of PLA
Clinical Anatomic Center
Fuzhou
China

Jian Lin
Shanghai JiaoTong University
Xin-hua Hospital (ChongMing)
Shanghai
China

Yong-Qing Xu
Orthopaedic Department
Kunming General Hospital of PLA
Kunming
China

De-Qing Hu
Orthopaedic Department
The First Affiliated Hospital of Fujian Medical
University
Fuzhou
China

ISBN 978-981-13-1552-7 ISBN 978-981-13-1553-4 (eBook)
<https://doi.org/10.1007/978-981-13-1553-4>

Library of Congress Control Number: 2018955490

© Springer Nature Singapore Pte Ltd. and People's Medical Publishing House 2019

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors, and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Contents

Part I Overview of Perforator Flap

1	Development History of Flap	3
1.1	Random Pattern Flap	3
1.2	Tubed Flap	4
1.3	Axial Pattern Flap	4
1.4	Free Flap	5
1.5	Pedicled Cutaneous Flap	6
1.6	Reverse-Flow Island Flap	6
1.7	Musculocutaneous Flap	7
1.8	Fasciocutaneous Flap	7
1.9	Subcutaneous Vascular Plexus Flap	8
1.10	Nonphysiologic Flap	8
1.11	Neurocutaneous Flap	9
1.12	Perforator Flap	9
	References	10
2	Concept of Perforator Flap	11
2.1	Concept	11
2.1.1	Pedicled Perforator Flap	13
2.1.2	Free Perforator Flap	14
2.2	Perforator Vessel	15
2.3	Angiosome Area	16
2.4	Perforator Vessel Anastomosis	18
2.5	Flap Donor Site	19
2.6	Special Types of Perforator Flap	19
2.6.1	Propeller Perforator Flap	20
2.6.2	Mintype Perforator Flap	21
2.6.3	Cutaneous Neurovascular Perforator Flap	22
2.6.4	Flow-Through Perforator Flap	23
2.6.5	Micro-Dissected Thin Perforator Flap	24
2.6.6	“Kiss” Combined Perforator Flap	25
2.6.7	Chimeric Perforator Flap	26
	References	26
3	Principles for Perforator Flap Selection	27
3.1	Flap Selection by Transplantation Principles	27
3.2	Flap Selection by Transplantation Methods	27
3.3	Flap Selection by the Condition of Donor Site	27
3.4	Flap Selection by the Nature of Wound Surface	27
3.5	Flap Selection by the Scope of Recipient Site	28

4	Procedures for Perforator Flap	29
4.1	Preparation of Recipient Site	29
4.2	Design of the Flap	30
4.2.1	“Point”, “Line”, “Plane” and “Arc” in Perforator Flap Design	30
4.2.2	Flap Design Method	30
4.3	Flap Incision	31
4.4	Pedicled Perforator Flap Transfer	32
4.5	Free Perforator Flap Transplantation with Vascular Anastomosis	32
5	Complications of Perforator Flap and the Management	33
5.1	Blood Supply Disorder	33
5.1.1	Causes	33
5.1.2	Precautions	33
5.1.3	Management	33
5.2	Hematoma	34
5.2.1	Causes	34
5.2.2	Precautions	34
5.2.3	Management	34
5.3	Infection	34
5.3.1	Causes	34
5.3.2	Precautions	34
5.3.3	Management	34
 Part II Perforator Flap from the Trunk		
6	Internal Mammary Artery Perforator Flap	37
6.1	Applied Anatomy	37
6.2	Surgical Techniques	38
6.3	Typical Cases	38
	Reference	42
7	The Perforator Flap Pedicled with the Cervical Cutaneous Branch of Transverse Cervical Artery	43
7.1	Applied Anatomy	43
7.2	Surgical Techniques	44
7.3	Typical Cases	44
	Reference	44
8	The Thoracoacromial Artery Perforator Flap, TAAP	47
8.1	Applied Anatomy	47
8.2	Surgical Techniques	48
8.3	Typical Cases	48
	Reference	51
9	Lateral Thorax Perforator Flap	53
9.1	Applied Anatomy	53
9.2	Surgical Techniques	55
9.3	Typical Cases	55
	Reference	56
10	Deep Inferior Epigastric Perforator Flap, DIEP	57
10.1	Applied Anatomy	57
10.2	Surgical Techniques	58
10.3	Typical Cases	59
	References	68

11	Circumflex Scapular Artery Perforator Flap	69
11.1	Applied Anatomy	69
11.2	Surgical Techniques	71
11.3	Typical Cases	71
	References	73
12	Thoracodorsal Artery Perforator Flap	75
12.1	Applied Anatomy	75
12.2	Surgical Techniques	77
12.3	Typical Cases	78
13	Superior and Inferior Gluteal Artery Perforator Flap	101
13.1	Applied Anatomy	101
13.2	Surgical Techniques	103
13.3	Typical Cases	104
	References	110
14	Deep Circumflex Iliac Artery Perforator Flap	111
14.1	Applied Anatomy	111
14.2	Surgical Techniques	112
14.3	Typical Cases	113
	References	117

Part III Perforator Flap from Upper Limbs

15	Medial Arm Perforator Flap	121
15.1	Applied Anatomy	121
15.2	Surgical Techniques	123
15.3	Typical Cases	123
	References	128
16	Lateral Arm Perforating Flap	129
16.1	Applied Anatomy	129
16.2	Surgical Techniques	130
16.3	Typical Cases	131
	References	134
17	Radial Forearm Perforator Flap	135
17.1	Section 1: Proximal Radial Artery Perforator Flap	135
17.1.1	Applied Anatomy	136
17.1.2	Surgical Techniques	137
17.1.3	Typical Cases	138
17.2	Section 2: Postero-Lateral Mid-Forearm Perforator Flap	140
17.2.1	Applied Anatomy	140
17.2.2	Surgical Techniques	142
17.2.3	Typical Cases	143
17.3	Section 3: Distal Radial Artery Perforator Flap	148
17.3.1	Applied Anatomy	148
17.3.2	Surgical Techniques	149
17.3.3	Typical Cases	149
17.4	Section 4: Snuffbox Radial Perforator Flap	154
17.4.1	Applied Anatomy	154
17.4.2	Surgical Techniques	155
17.4.3	Typical Cases	155
	References	160

18	Antebrachial Ulnar Perforator Flap	161
18.1	Section 1: Proximal and Middle Ulnar Perforator Flap	161
18.1.1	Applied Anatomy	162
18.1.2	Surgical Techniques	163
18.1.3	Typical Cases	164
18.2	Section 2: Distal Ulnar Perforator Flap	169
18.2.1	Applied Anatomy	169
18.2.2	Surgical Techniques	170
18.2.3	Typical Cases	171
	References	186
19	Dorsal Antebrachial Perforator Flap	187
19.1	Section 1: Posterior Interosseous Perforator Flap	187
19.1.1	Applied Anatomy	187
19.1.2	Surgical Techniques	189
19.1.3	Typical Cases	190
19.2	Section 2: Anterior Interosseous Dorsal Perforator Flap	195
19.2.1	Applied Anatomy	195
19.2.2	Surgical Techniques	196
19.2.3	Typical Cases	196
	References	200
20	Perforator Flap at Dorsal Hand	201
20.1	Section 1: Dorsal Metacarpal Artery Perforator Flap	201
20.1.1	Applied Anatomy	202
20.1.2	Surgical Techniques	204
20.1.3	Typical Cases	204
20.2	Section 2: Little Finger Perforator Flap Pedicled with Ulnar Palmar Artery	217
20.2.1	Applied Anatomy	217
20.2.2	Surgical Techniques	218
20.2.3	Typical Cases	219
	References	224
21	Digital Dorsal Perforator Flap	225
21.1	Section 1: Thumb Radialis/Ulnar Palmar Artery Perforator Flap	225
21.1.1	Applied Anatomy	225
21.1.2	Surgical Techniques	227
21.1.3	Typical Cases	227
	Reference	240

Part IV Perforator Flap from Lower Limbs

22	Anterolateral Thigh Perforator Flap	243
22.1	Section 1: Tensor Fascia Lata Myocutaneous Perforator Flap	243
22.1.1	Applied Anatomy	243
22.1.2	Surgical Techniques	245
22.1.3	Typical Cases	246
22.2	Section 2: Anterolateral Thigh Perforator Flap	248
22.2.1	Applied Anatomy	248
22.2.2	Surgical Techniques	250
22.2.3	Typical Cases	250
	References	266

23	Medial Thigh Perforator Flap	267
23.1	Section 1: Vastus Medialis Perforator Flap	267
23.1.1	Applied Anatomy	267
23.1.2	Surgical Techniques	269
23.1.3	Typical Cases	270
23.2	Section 2: Descending Genicular Artery Perforator Flap	273
23.2.1	Applied Anatomy	273
23.2.2	Surgical Techniques	275
23.2.3	Typical Cases	276
23.3	Section 3: Saphenous Artery Perforator Flap	282
23.3.1	Applied Anatomy	282
23.3.2	Surgical Techniques	284
23.3.3	Typical Cases	284
	Reference	288
24	Posterolateral Thigh Perforator Flap	289
24.1	Section 1: Posterolateral Proximal-Middle Thigh Perforator Flap	289
24.1.1	Applied Anatomy	289
24.1.2	Surgical Techniques	291
24.1.3	Typical Cases	291
24.2	Section 2: Posterolateral Distal Thigh Perforator Flap (Superolateral Genicular Artery Perforator Flap)	293
24.2.1	Applied Anatomy	293
24.2.2	Surgical Techniques	294
24.2.3	Typical Cases	294
	References	298
25	Posterior Thigh Perforator Flap	299
25.1	Section 1: Posterior Femoral-Inferior Gluteal Perforator Flap	299
25.1.1	Applied Anatomy	299
25.1.2	Surgical Techniques	301
25.1.3	Typical Cases	301
25.2	Section 2: Posterior Femoral Popliteal Perforator Flap	303
25.2.1	Applied Anatomy	303
25.2.2	Surgical Techniques	304
25.2.3	Typical Cases	304
26	Lateral Crural Perforator Flap	307
26.1	Section 1: Proximal-Middle Peroneal Artery Perforator Flap	307
26.1.1	Applied Anatomy	307
26.1.2	Surgical Techniques	310
26.1.3	Typical Cases	311
26.2	Section 2: Superior (Anterior) Lateral Malleolus Perforator Flap	316
26.2.1	Applied Anatomy	317
26.2.2	Surgical Techniques	318
26.2.3	Typical Cases	319
26.3	Section 3: Posterosuperior Lateral Malleolar Perforator Flap	325
26.3.1	Applied Anatomy	326
26.3.2	Surgical Techniques	327
26.3.3	Typical Cases	327
26.4	Section 4: Lateral Retromalleolar Perforator Flap	337
26.4.1	Applied Anatomy	337
26.4.2	Surgical Techniques	339
26.4.3	Typical Cases	340
	References	343

27	Anterolateral Crus Perforator Flap	345
27.1	Section 1: The Flap Based on the Proximal-Middle Segments of the Anterior Tibial Artery Perforator	345
27.1.1	Applied Anatomy	345
27.1.2	Surgical Techniques	348
27.1.3	Typical Cases	349
27.2	Section 2: The Flap Based on the Distal Segment of the Anterior Tibial Artery Perforator (The Anterosuperior Malleolar Perforator Flap)	352
27.2.1	Applied Anatomy	353
27.2.2	Surgical Techniques	354
27.2.3	Typical Cases	354
	References	359
28	Medial Crus Perforator Flap	361
28.1	Applied Anatomy	361
28.2	Surgical Techniques	362
28.3	Typical Cases	363
29	Dorsal Pedis Perforator Flap	391
29.1	Section 1: Dorsal Pedal Artery Perforator Flap	391
29.1.1	Applied Anatomy	392
29.1.2	Surgical Techniques	393
29.1.3	Typical Cases	393
29.2	Section 2: Dorsal Metatarsal Artery Perforator Flap	398
29.2.1	Applied Anatomy	398
29.2.2	Surgical Techniques	399
29.2.3	Typical Cases	399
30	Medial Pedis Perforator Flap	405
30.1	Applied Anatomy	405
30.2	Surgical Techniques	407
30.2.1	Design of Flap	407
30.2.2	Resection of Flap	407
30.3	Typical Cases	408
31	Toe Cutaneous (Perforator) Flap	415
31.1	Section 1: The Great Toe Flap	415
31.1.1	Applied Anatomy	416
31.1.2	Surgical Techniques	417
31.1.3	Typical Cases	417
31.2	Section 2: The Second Toe Flap	425
31.2.1	Applied Anatomy	425
31.2.2	Surgical Techniques	426
31.2.3	Typical Cases	426
	References	430

Editors and Contributors

Editors

He-Ping Zheng Department of Comparative Medicine, The 900th Hospital of PLA, Fuzhou, P. R. China

Jian Lin Department of Orthopedics, Xinhua Hospital (Chongming) of Shanghai Jiao Tong University, Shanghai, P. R. China

Yong-Ying Xu Institute of Orthopedic Surgery, Kunming General Hospital of Chengdu Military Region, Kunming, P. R. China

De-Qing Hu Department of Orthopaedics, The First Affiliated Hospital of Fujian Medical University, Fuzhou, P. R. China

Contributors

Hui Chen Institute for Orthopaedics, Fuzhou General Hospital of Nanjing Military Area Command, Fuzhou, P. R. China

Xue-Song Chen Department of Microsurgery and Trauma, No. 59 Military Hospital, Trauma Microsurgery Centre of Chengdu Military Region, Kaiyuan, Yunnan, P. R. China

Dong Du Department of Microsurgery and Hand Surgery, Shenzhen People's Hospital, Shenzhen, P. R. China

Shun-Hong Gao Department of Hand Surgery, The Second Hospital of Tangshan, Tangshan, Hebei, P. R. China

Yan Han Department of Plastic and Reconstruction, Chinese PLA General Hospital, Beijing, P. R. China

Li Huang Department of Oral and Maxillofacial Surgery, The First Affiliated Hospital of Fujian Medical University, Fuzhou, P. R. China

You-Hua Huang Department of Orthopaedics, Haikou People's Hospital, Haikou, Hainan, P. R. China

Qing-Lin Kang Department of Orthopaedics, Sixth People's Hospital Affiliated to Shanghai Jiao Tong University, Shanghai, P. R. China

Yan-Wen Lei Department of Microsurgery, Shunde Heping Surgery Hospital, Shunde, Guangdong, P. R. China

Ye-Qing Lin Department of Orthopaedics, Fuzhou General Hospital of Nanjing Military Area Command, Fuzhou, P. R. China

Yong-Sui Lin Shanghai Public Health Clinical Center, Fudan University, Shanghai, P. R. China

Yong Liu Department of Orthopedics, Ningxia General Hospital of Chinese Armed Police Force, Yinchuan, Ningxia, P. R. China

Li-Qiang Ma Department of Orthopaedics, Fuzhou General Hospital of Nanjing Military Area Command, Fuzhou, P. R. China

Fan-Tan Meng Department of Orthopaedics, Quanzhou Wanhe Hospital, Quanzhou, P. R. China

Guang-Tai Mu Department of Orthopedics, Ningxia General Hospital of Chinese Armed Police Force, Yinchuan, Ningxia, P. R. China

Da-Liang Tang The Third People's Hospital of Chizhou, Anhui, P. R. China

Mao-Lin Tang Department of Anatomy, Wenzhou Medical University, Zhejiang, P. R. China

Ai-Wu Wang Department of Bums and Plastic Surgery, Hanzhong Central Hospital, Hanzhong, Shanxi, P. R. China

Tian-Quan Wang The Fifth Hospital of Xiamen, Xiamen, P. R. China

Xian-Cheng Wang Department of Burn and Plastic Surgery, Second Xiangya Hospital of Central South University, Changsha, P. R. China

Zai-Rong Wei Department of Burn and Plastic Surgery, Affiliated Hospital of Zunyi Medical University, Zunyi, P. R. China

Fu-Li Wen Department of Comparative Medicine, Fuzhou General Hospital of Nanjing Military Area Command, Fuzhou, P. R. China

Li-Zhi Wu Department of Orthopedics, Taizhou Hospital of Zhejiang Province, Linhai, P. R. China

Ze-Dong Wu Department of Orthopedics, Suizhou Hospital Affiliated to Hubei Medical University, Suizhou, Hubei, P. R. China

Zeng-Bing Xia Department of Orthopedics, Huzhou First People's Hospital of Zhejiang Province, Huzhou, P. R. China

Yun Xie Department of Orthopaedics, The First Affiliated Hospital of Fujian Medical University, Fuzhou, P. R. China

Yang-Bin Xu Division of Plastic and Reconstructive Surgery, The First Affiliated Hospital, Sun Yat-sen University, Guangzhou, P. R. China

Zhan-Wu Xu Department of Orthopedics, The 211th Hospital of PLA, Harbin, P. R. China

Xiao-Dong Yang Department of Orthopedics, Sir Run Shaw Hospital Affiliated to Zhejiang University Medical College, Hangzhou, Zhejiang, P. R. China

Lin Yan Division of Plastic and Reconstructive Surgery, The Third Affiliated Hospital, Sun Yat-sen University, Guangzhou, P. R. China

Bin Zhang Department of Head and Neck Surgery, Cancer Hospital, Chinese Academy of Medical Sciences, Beijing, P. R. China

Jing-Liang Zhang Department of Microsurgery, Shunde Heping Surgery Hospital, Shunde, Guangdong, P. R. China

Sheng-Hang Zhang Department of Orthopaedics, Fuzhou General Hospital of Nanjing Military Area Command, Fuzhou, P. R. China

Wen-Ming Zhang Department of Orthopaedics, The First Affiliated Hospital of Fujian Medical University, Fuzhou, P. R. China

Yi-Xin Zhang Department of Plastic and Reconstructive Surgery, Ninth People's Hospital Affiliated to Shanghai Jiaotong University, Shanghai, P. R. China

Hong-Yila Zheng Overseas Education College, Fujian Medical University, Fuzhou, P. R. China

Xiao-Hui Zheng Department of Orthopaedics, Hospital of Fujian Provincial Corps, Chinese People's Armed Police Force, Fuzhou, P. R. China

Xiao Zhou Department of Orthopaedics, The Ninth People's Hospital of Wuxi, Wuxi, P. R. China

Yue-Hong Zhuang Department of Anatomy, Fujian Medical University, Fuzhou, P. R. China

Yue-Liang Zhu Department of Orthopedics, Kunming General Hospital of Chengdu Military Region, Kunming, P. R. China

Part I

Overview of Perforator Flap

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 microsurgical 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 vasculae, 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.

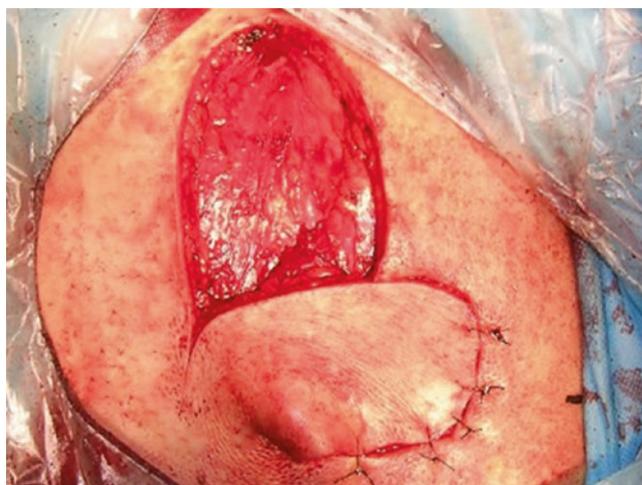


Fig. 1.1 Random pattern flap (provided by Xu Yongqing)

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.

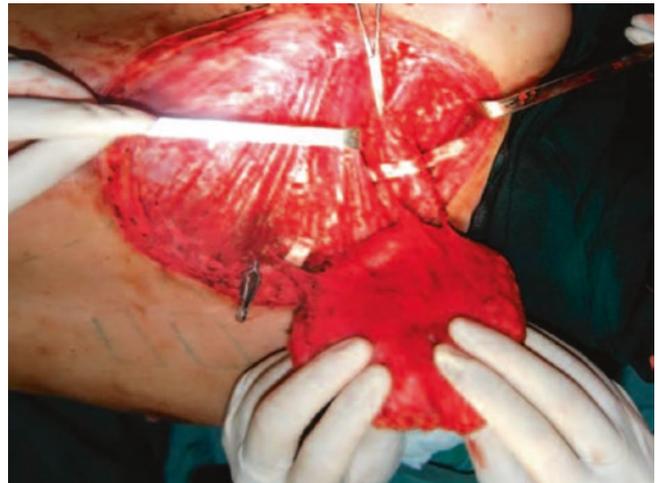


Fig. 1.3 Groin flap (Provided by Zhang Yixin)

1.4 Free Flap

The free flap refers to the tissue flap with a newly established blood supply system obtained by anastomosing the flap nutritive 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



Fig. 1.4 Groin flap (Provided by Lin Jian)

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. 1.5 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, *Transposition 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).



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

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. 1.7 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 (Ollirari 1976), gluteal musculocutaneous flap (Minami et al. 1977a), tensor fascia lata myocutaneous flap (Hill et al. 1978), and pectoralis major myocutaneous flap (Ariyan 1979) were successively applied in clinical practice.



Fig. 1.8 Musculocutaneous flap (Provided by Wei Zairong)

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), *Fasciocutaneous Flaps* (Hallock 1992) and *Fasciocutaneous Flap and Fascia-pedicled Tissue Flaps* (Chunlin and Shimin 2000).

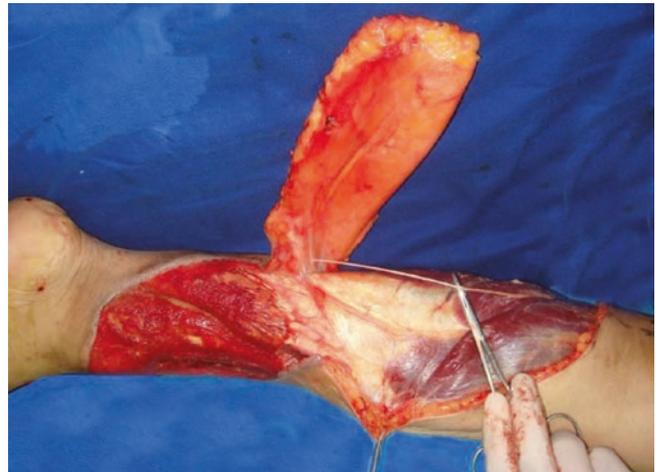


Fig. 1.9 Fasciocutaneous flap (Provided by Wei Zairong)

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 Shimin 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.

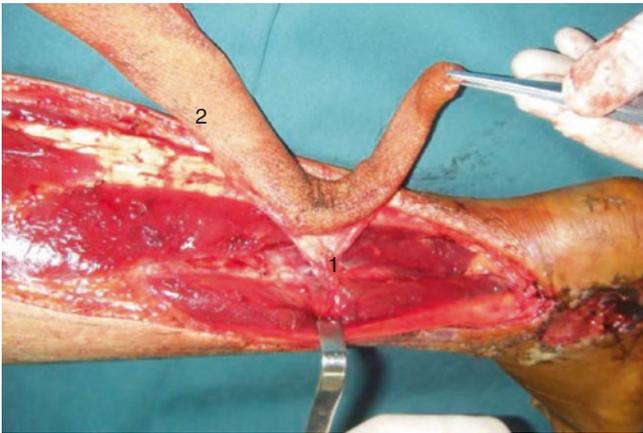


Fig. 1.12 Neurocutaneous flap (Provided by Xu Yongqing). 1 Pedicle (perforator pedicle), 2 flap

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).

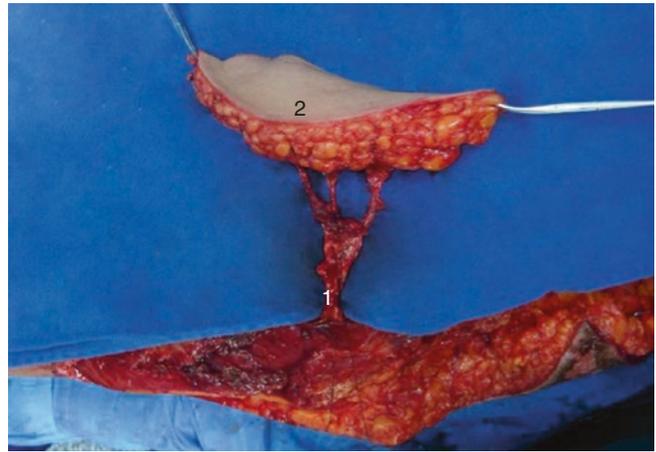


Fig. 1.13 Perforator flap (Provided by Wei Zairong). 1 Perforator pedicle, 2 flap

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.



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).

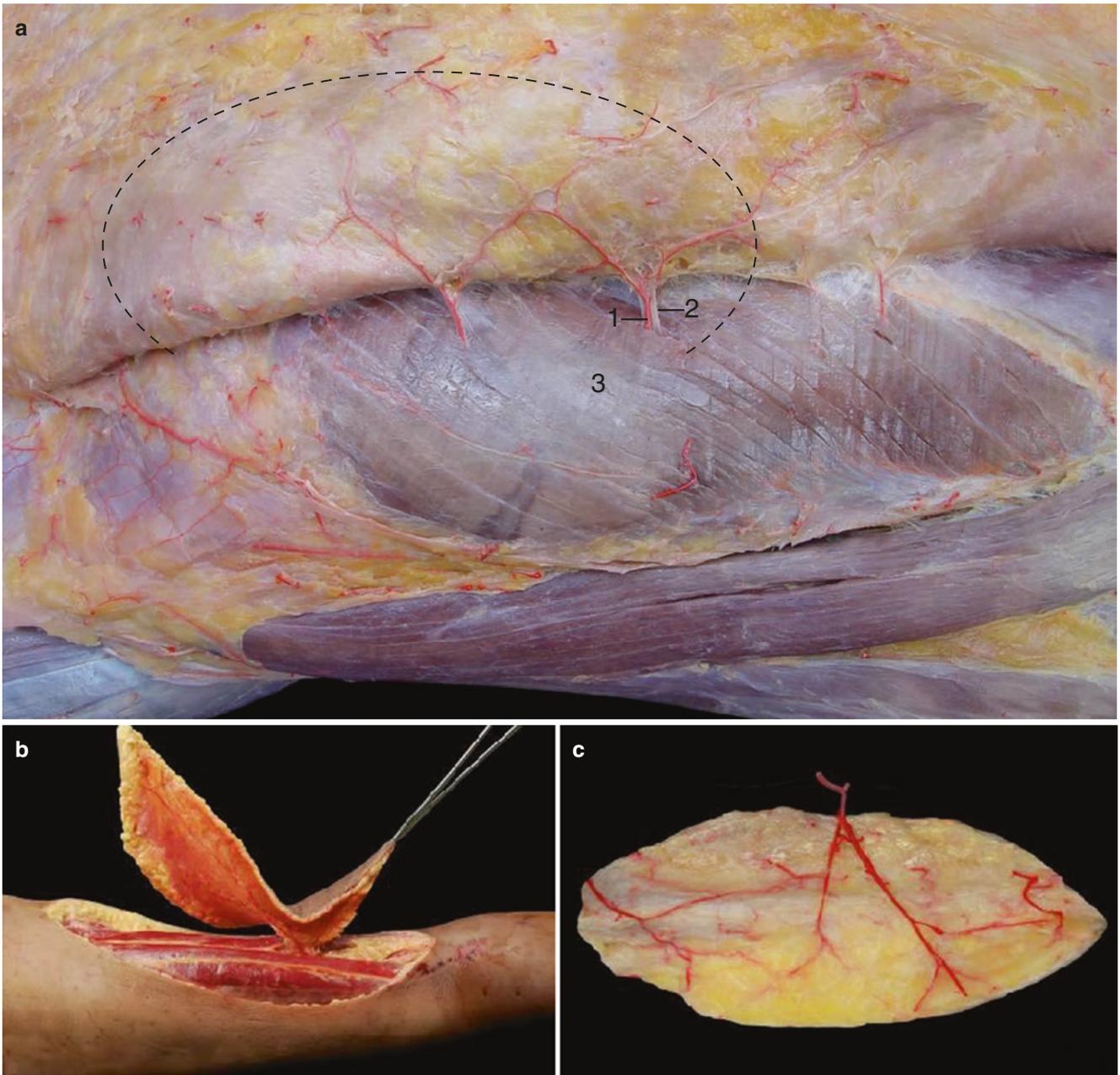


Fig. 2.1 Perforator flap. (a) Perforator vessel, 1 artery, 2 vein, 3 muscle; (b) pedicled perforator flap; (c) free perforator flap

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).

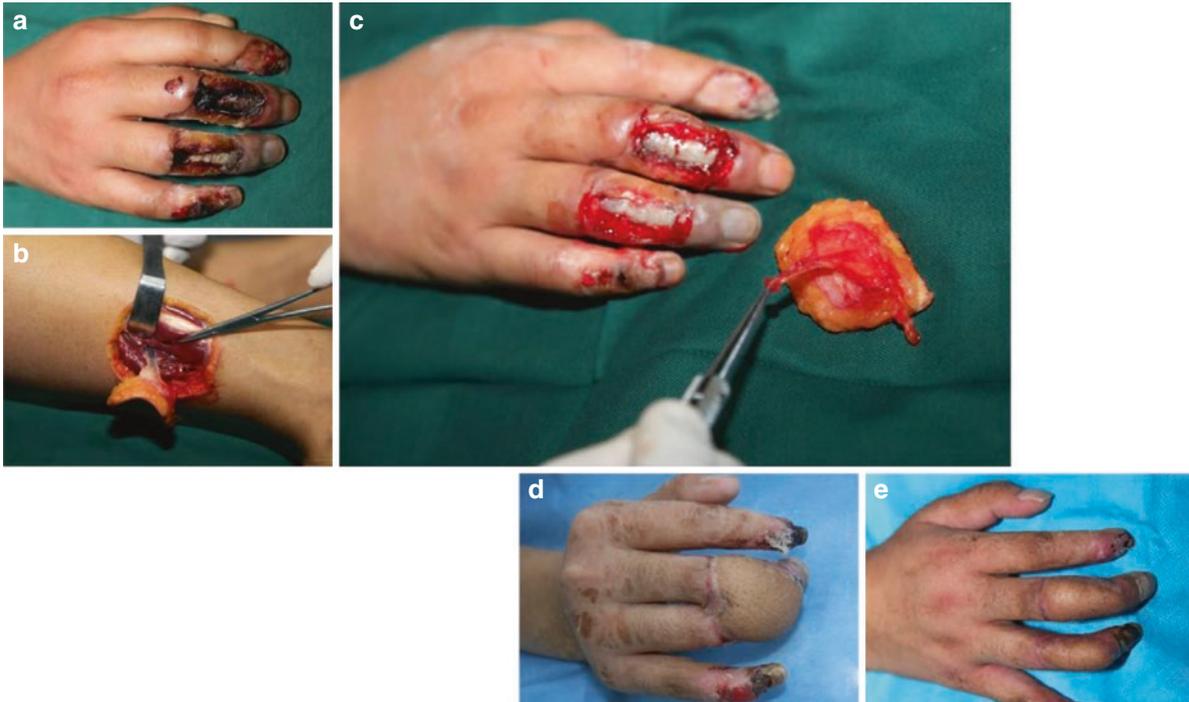


Fig. 2.3 Free transplantation of proximal and middle peroneal artery flap for repairing the defects of dorsal skin in middle finger and ring finger (Provided by Xu Yongqing). (a) Necrotic and unhealed wounds in dorsal skin of middle finger and ring finger; (b) flap dissection and

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 proxi-

mal 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 originates 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

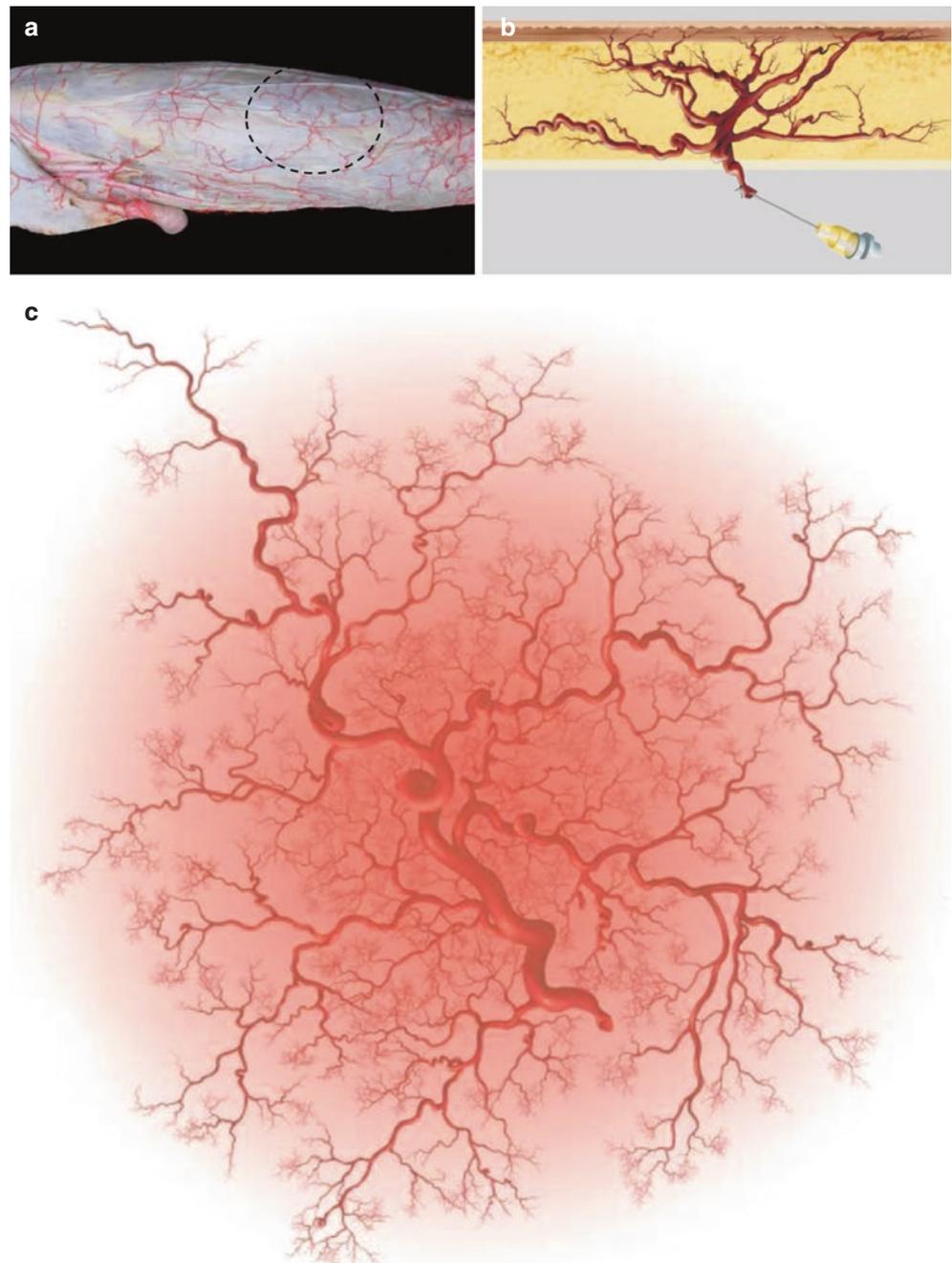
2.3 Angiosome Area

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



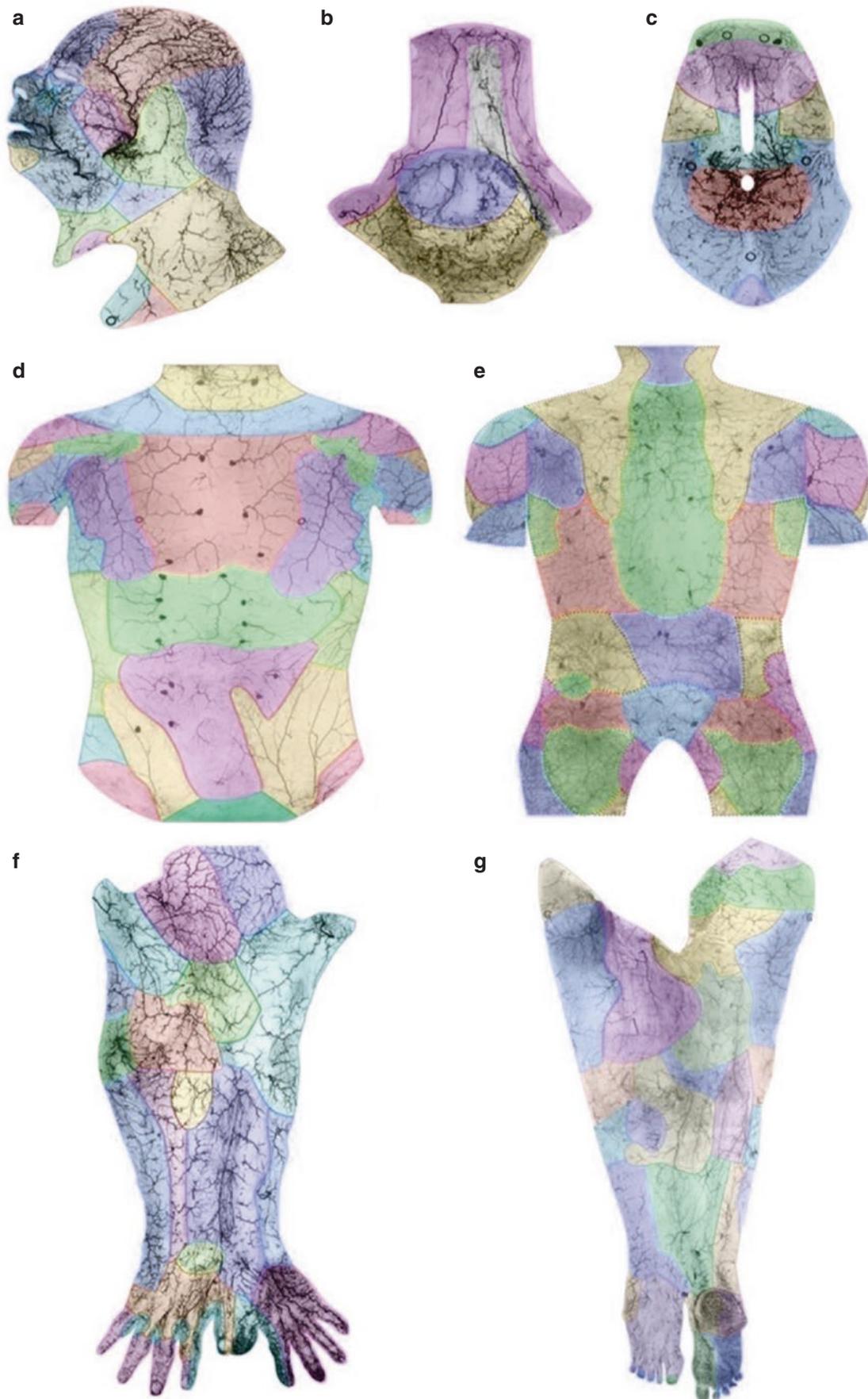


Fig. 2.6 Perforator vascular body of human skin and perforator distribution (Provided by Tang Maolin). (a) Head and face; (b) male perineum; (c) female perineum; (d) front view of the trunk; (e) rear view of the trunk; (f) upper limb; (g) lower limb

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

