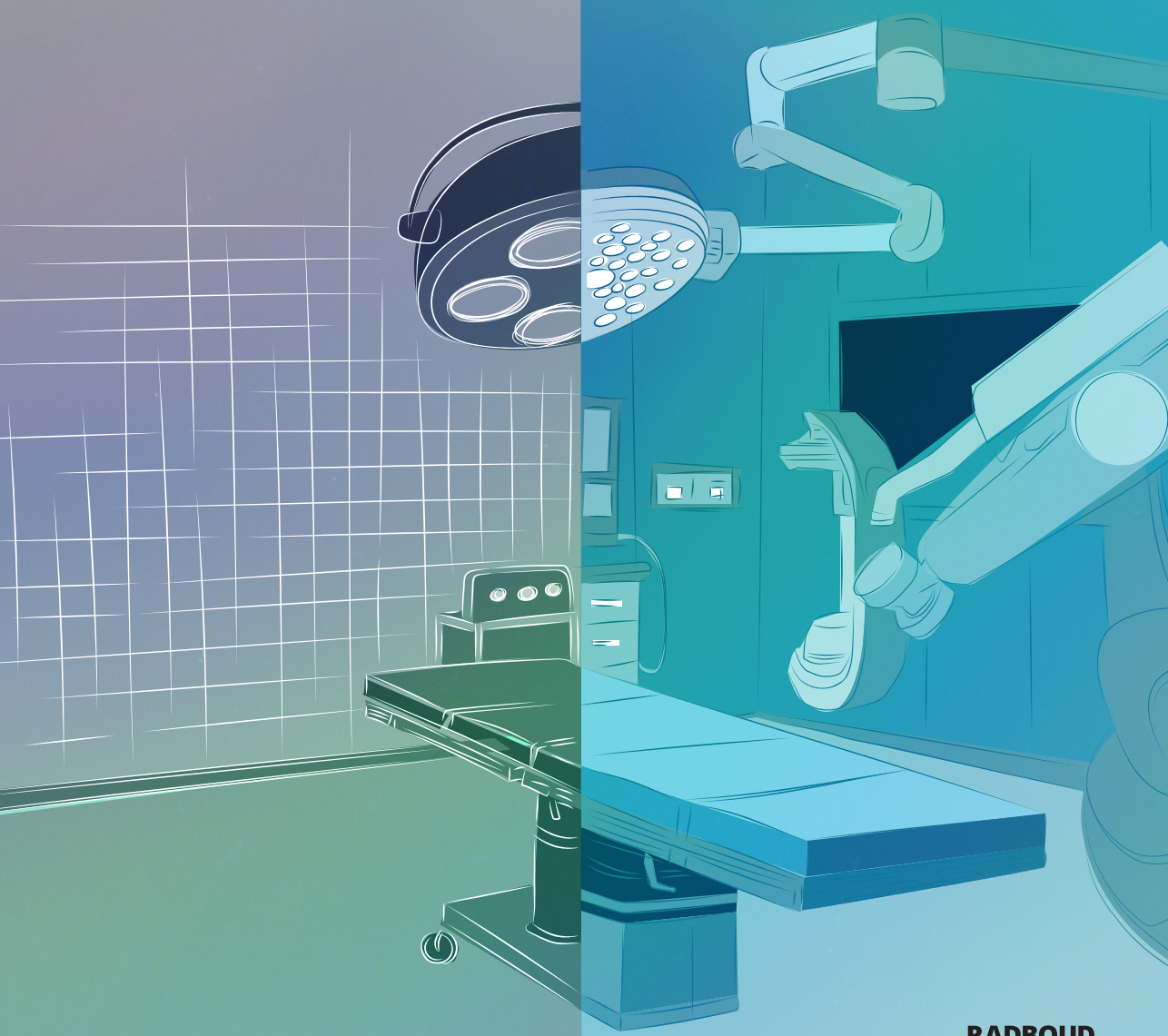
OLD CONCEPTS REVISED AND NEW SOLUTIONS DERIVED IN PLASTIC SURGERY

Perforator Flap Innovations for Upper and Lower Limb Salvage: A Translational Approach from Anatomy to Clinical Practice



TILL WOLFRAM WAGNER

RADBOUD UNIVERSITY PRESS

Radboud Dissertation Series

OLD CONCEPTS REVISED AND NEW SOLUTIONS DERIVED IN PLASTIC SURGERY

Perforator Flap Innovations for Upper and Lower Limb Salvage: A Translational Approach from Anatomy to Clinical Practice

Till Wolfram Wagner

OLD CONCEPTS REVISED AND NEW SOLUTIONS DERIVED IN PLASTIC SURGERY
Perforator Flap Innovations for Upper and Lower Limb Salvage: A Translational Approach from Anatomy to Clinical Practice
Till Wagner

Radboud Dissertation Series
ISSN: 2950-2772 (Online); 2950-2780 (Print)

Published by RADBOUD UNIVERSITY PRESS
Postbus 9100, 6500 HA Nijmegen, The Netherlands
www.radbouduniversitypress.nl

Design: Proefschrift AIO | Annelies Lips
Cover: Proefschrift AIO | Guntra Laivacuma
Printing: DPN Rikken/Pumbo
ISBN: 9789465152387
DOI: 10.54195/9789465152387
Free download at: https://doi.org/10.54195/9789465152387

RADBOUD UNIVERSITY PRESS

OLD CONCEPTS REVISED AND NEW SOLUTIONS DERIVED IN PLASTIC SURGERY

Perforator Flap Innovations for Upper and Lower Limb Salvage: A Translational Approach from Anatomy to Clinical Practice

Proefschrift

ter verkrijging van de graad van doctor

aan de Radboud Universiteit Nijmegen

op gezag van de rector magnificus prof. dr. J.M. Sanders,

volgens besluit van het college voor promoties

in het openbaar te verdedigen op

dinsdag 9 juni 2026

om 10.30 uur precies

door

Till Wolfram Wagner

geboren op 16 april 1972

te Nürnberg (Duitsland)

Promotoren:
Prof. dr. D.J.O. Ulrich
Prof. dr. E.P.A.van der Heijden

Copromotor:
Dr. S.L.M. Hummelink

Manuscriptcommissie:
Prof. dr. I.C.M. van der Geest (voorzitter)
Prof. dr. T.J.J. Maal
Prof. dr. A.A. Piatkowki de Grzymala (Maastricht UMC+)

Paranimfen:
Drs. Hanneke Tielemans
Dr. Franz Pronk

Voor mijn hele gezin

and most of all for myself

Contents

Chapter 1 General introduction and outline 9

Part I: Upper extremity

Chapter 2 Extended distally based DMCA flap in combination with autologous amputate skin transplantation as a salvage procedure for ring avulsion injury. 21

Chapter 3 The anatomic relationship of dorsal arterial perforators of the distal forearm, wrist, and dorsum of the hand with conclusions for the clinic. 29

Chapter 4 Anatomy, evolution, and clinical aspects of the superextended-intercompartmental supraretinacular artery perforator flap (SISAP-flap): A proof of concept. 43

Part II: Lower extremity

Chapter 5 The proximally based long peroneal muscle turnover flap: A novel salvage flap for small to medium-sized defects of the knee. 65

Chapter 6 The myocutaneous long peroneal flap: An anatomical study and its clinical application. A letter to the editor. 77

Chapter 7 General discussion 83

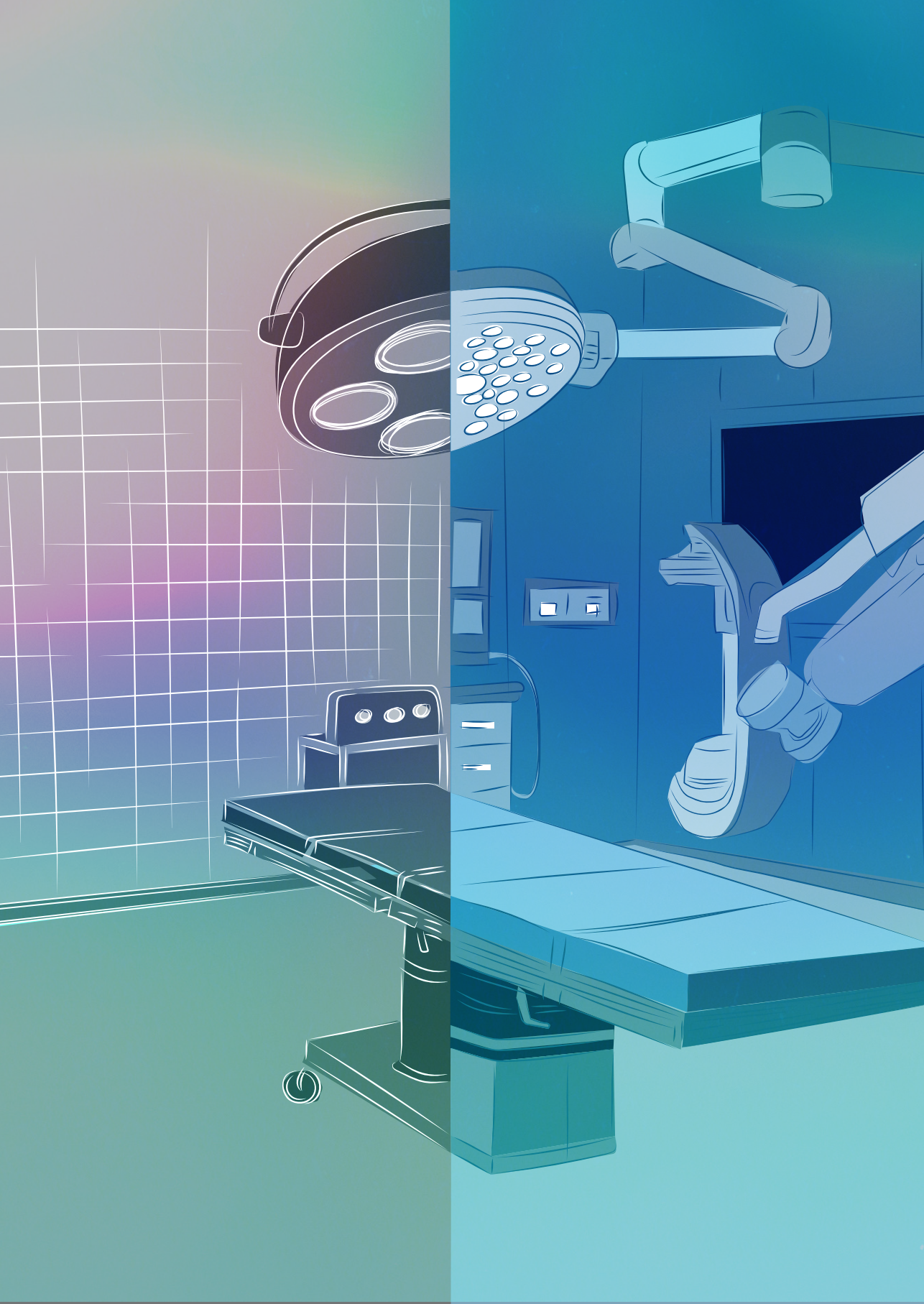
Chapter 8 English summary 93

Chapter 9 Dutch summary 99

Appendices Research data management 106
PhD Portfolio 107
List of publications 110
Acknowledgements/dankwoord 112
About the author 115

The Answer to the Ultimate Question of Life, the Universe, and Everything is…42.

The Hitchhiker's Guide to the Galaxy by Douglas Adams 1979



Chapter 1

General Introduction

Progress in plastic and reconstructive surgery has historically advanced through a cycle of clinical need, anatomical discovery, and technical innovation. From the pedicled groin and deltopectoral flaps of the 1970s to today's perforator-based free-style concepts, each generation of surgeons has revisited classical principles while pushing the boundaries of feasibility (1). This dynamic is particularly evident in the reconstruction of extremities, where functional and aesthetic requirements should be combined. Based on my clinical work over the past decade, I have seen patients with soft tissue defects who, due to their specific clinical setting, could not be adequately helped using standard procedures. This ultimately prompted me to start this PhD-project with the development of potential additional treatment options. Due to my specific field of activity as a hand surgeon and consultant in plastic surgery for orthopaedics, I focused my research on the distal upper extremity and the knee area, which, due to prosthetic implantation surgery, carries an increased risk of wound complications with soft tissue loss.

Part 1 Upper extremity

Hand surgery is a main part of this challenge. The hand is simultaneously an organ of fine motor function, a primary sensory interface, and an important tool for non-verbal communication. Severe soft-tissue loss- particularly the circumferential loss produced by degloving injuries- therefore carries disproportionate physical and psychosocial morbidity (2, 3). Degloving, defined as avulsion of skin and subcutaneous tissue from the underlying fascia, is uncommon yet devastating, accounting for up to 4 % of major hand trauma in large series (4, 5). High-energy mechanisms such as industrial rollers or conveyor belts produce longitudinal shearing forces that strip neurovascular structures from their soft-tissue envelope (6). Because the amputated tissue is frequently macerated or extensively crushed, replantation or revascularization is successful in fewer than one-half of cases (5, 7, 8). Standard salvage options- further amputation (5), ray resection, or shortening with local advancement- often fail to meet younger patients' expectations and may cause long-term psychosocial sequelae (3). Therefore, the treatment of degloving injuries remains challenging. Of the two main reconstructive surgical treatment options- free flap versus local flap-, each has its advantages and disadvantages. Microsurgical free flaps provide sufficient amount of tissue with suitable quality, but ask often for two-team approach, and advanced postoperative monitoring infrastructure that may be unavailable outside tertiary centers (9). In contrast, local pedicled flaps can be harvested under loupe magnification and have shorter learning curves, reduced theatre times, and fewer anesthetic demands. Within the group of local flaps in hand surgery, nothing has

been described to date, regarding the surgical treatment of degloving injuries in finger trauma. Within this area, the distally based dorsal metacarpal artery (DMCA) perforator flap has emerged as a robust solution for dorsal and more proximal digital defects, offering thin, pliable coverage with excellent color match (10) (11). Although the DMCA flap was first described in the 1990s (12), there is no description within this concept for deglovement injuries or other extensive skin loss at the fingers. Modern refinements- including pre-operative Doppler mapping, skeletonised pedicle dissection, and intra-operative fluorescence perfusion assessment- could potentially expanded its indication spectrum to include total digital degloving injuries, combined with spare-part epidermal skin grafts, if necessary. When developing new skin flaps, it is most important to elucidate the vascular basis of potential new candidates. This fact also prompted renewed interest in the vascular anatomy of the dorsal hand and distal forearms, when avulsion extends beyond the proximal interphalangeal joint (13). Therefore I started - after a clinical case with a finger deglovement injury as a primer- to reevaluate the known anatomy with cadaver dissection to enlighten the precise spatial distribution of the arterial perforators and vessels of the lower dorsal upper extremity. Without any proof of existence of a consistent arterial interconnecting network, lengthening of the known local axial flap would be literally impossible and therefore the chance to cover extended soft tissue defects with local sufficient pliable tissue is virtually zero. With growing insights, I started to develop an superextended axial perforator flap- capable to cover most parts of an denudated finger with sufficient soft tissue as a lower demanding local flap compared with free tissue transfer in situations where the amputate is not further available or technically completely lost by a crush injury. Even when deglovement injuries are much less common compared with transverse amputations of digits, they have a much higher risk to fail caused by more extensive crush trauma. Therefore a new option to cover should have well additional value in the armamentarium of reconstructive surgeons.

Part 2 Lower extremity

As in the beginning outlined, the area around the knee is also prone to soft tissue defects. In contrary to the upper extremity- which suffers more trauma by the regular use of both hands, the lower extremity -especially the area around the knee, is more vulnerable to soft tissue defect caused by the increasing number of elective total knee prosthesis replacement surgery, based on the growing number of elderlies. With an raising number of implant surgery there is also an increased risk of complications and ultimately loss of surrounding soft tissue. Even in high volume clinics with expert experience, the risk of postoperative complications with secondary loss of tissue is

still existent. Although further improvements in aseptic technique, biomaterials, and peri-operative antibiotic stewardship have reduced the overall incidence of exposed prostheses after total knee arthroplasty (TKA), the absolute number of cases continues to rise in line with population ageing and the global expansion of arthroplasty programs (14, 15, 16). In most cases of periprosthetic soft tissue loss, the medial or lateral head of the gastrocnemius muscle- first popularised by McCraw (17) and colleagues in 1978- remains the workhorse flap for small to moderate periprosthetic defects (18, 19, 20). Despite a historical success rate exceeding 90 %, gastrocnemius transfer can be precluded by prior harvest, inadvertent pedicle injury during revision arthroplasty, or tightening- particularly of the lateral head in valgus knees (21). Free-tissue transfer remains an option but is vulnerable to the same infrastructural constraints described for the hand and is further complicated by restricted recipient vessels in scarred popliteal zones (22-24). Vacuum-assisted closure (VAC) may help bridge to definitive coverage, yet fails to eradicate biofilm and cannot provide the durable, vascularized soft tissue required for long-term prosthesis retention (25).

With this issue in mind, I also was interested in developing a fail back option for reconstructive knee surgery in a peripheral operating setting without any options for microsurgical equipment. The basic and mandatory conditions for a putative flap candidate were a save vascular pedicle which is independent of arteria prone to intraoperative orthopedic injuries and with a constant spatial distribution which makes them easy te find during surgery without additional guiding equipment. Taking these prerequisites into account, I came across the peroneus longus muscle flap as one of a potential candidate for this purpose. The peroneus longus muscle self has not yet been described as an alternative in soft tissue coverage in reconstructive knee surgery. Situated within the lateral compartment, it possesses a dominant vascular pedicle arising from the peroneal artery approximately 4-6cm distal to the fibular head. Crucially, this pedicle is independent of the original genicular arterial network and is therefore preserved even in extensive posterior scarring. Biomechanical studies demonstrate minimal gait disturbance following harvest, owing to functional redundancy with the peroneus brevis and synergistic tibialis posterior (26). By tunnelling the muscle subcutaneously across the inter-muscular septum or converting it into an islanded myocutaneous unit, small to medium sized defects around the anterior tibial tubercle or patellar ligament could potentially covered also without microsurgical anastomosis.

Beyond the hand and knee, the broader objective of this work is to reinforce the enduring relevance of classical surgical research in an era increasingly dominated by tissue engineering, alloplastic substitutes, and robotic automation. While these technologies hold transformative promise, their universal adoption remains limited

by cost, regulatory barriers, and steep learning curves. In contrast, creativity based on detailed anatomy leverages resources already present in most operating theatres—scalpels, loupes, and human creativity. The two novel flap solutions presented herein exemplify how meticulous anatomical investigation can yield immediately translatable advances that improve outcomes, expand indications, and reduce reliance on resource-intensive microsurgery.

Aim of the Thesis

The central hypothesis underlying this dissertation is that rare but in certain circumstances otherwise resulting mutilating defects can be solved through an out of the box reuse of regional vascular anatomy. Specifically, I posit that:

1. Previously under-recognized perforators of the dorsum of the hand and distal forearm can support reliable, super-extended, distally based flaps capable of addressing circumferential digital defects larger than those treatable with existing designs.

2. The peroneus longus muscle, when raised on its proximal vascular pedicle, can provide sufficient coverage for composite soft-tissue losses around the knee- particularly in revision TKA- while maintaining acceptable donor-site function.

Outline of the Thesis

Chapter 2 presents a "primer" case report in which length-preserving reconstruction of a nearly circumferential index-finger avulsion was achieved by combining a distally based DMCA flap with autologous epidermal grafts harvested from the amputate.

Chapter 3 explores the vascular anatomy of dorsal arterial perforators in the distal forearm, wrist, and hand based on cadaveric studies, and proposed harvest guidelines with direct clinical implications.

Chapter 4 translates these findings into clinical practice through a proof-of-concept flap derived from the anatomical findings.

Chapter 5 introduces the proximally based peroneus longus muscle flap, including anatomical validation, surgical technique, and early clinical experience in patients with complex periprosthetic knee defects.

Chapter 6 expands this concept to a myocutaneous variant, thereby obviating the need for split-thickness grafting and facultatively reducing overall operative time, as summarized in a letter to the editor.

Chapter 7 synthesises the data, discusses limitations, and outlines putative options for future research, including perfusion imaging, sensate flap design, and potential applications in diabetic limb salvage.

Chapters 8 and 9 summarize the thesis in English and Dutch, respectively.

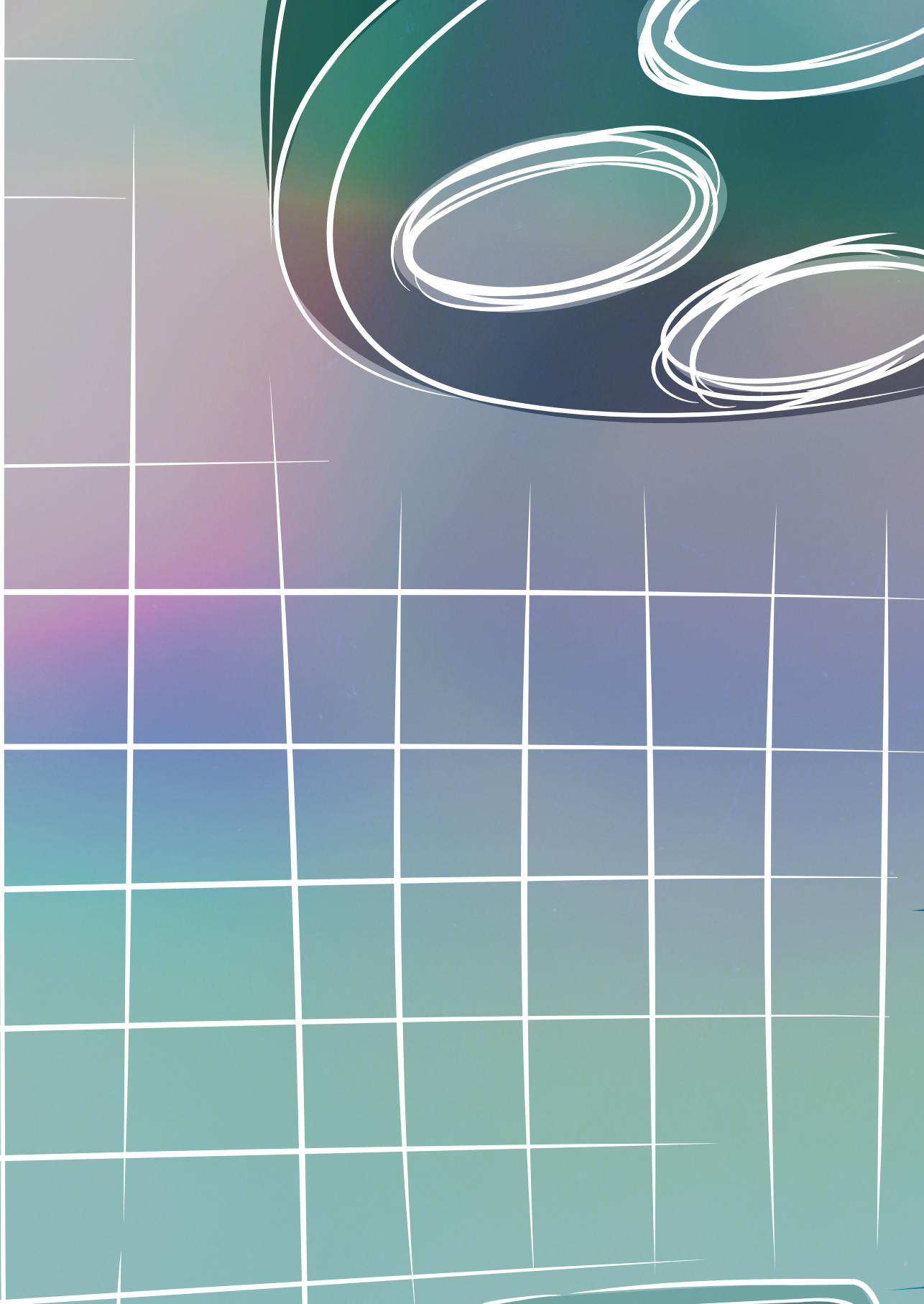
The research was conducted at the Department of Plastic and Reconstructive Surgery, Radboudumc.

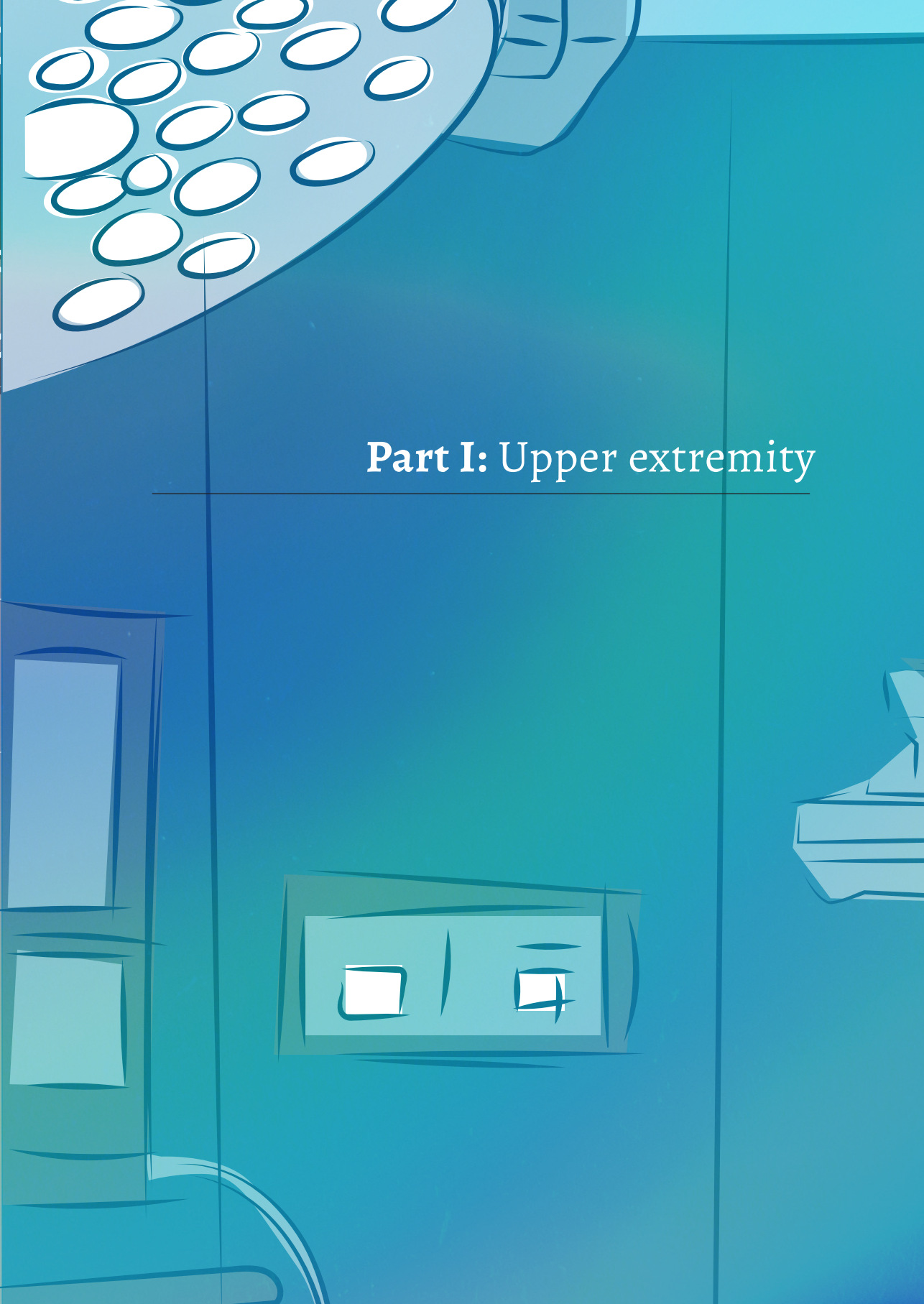
References

1. Wei FC, Mardini S. Free-style free flaps. Plast Reconstr Surg. 2004;114(4):910-6.
2. Pomares G, Coudane H, Dap F, Dautel G. Psychological effects of traumatic upper-limb amputations. Orthop Traumatol Surg Res. 2020;106(2):297-300.
3. Jo SH, Kang SH, Seo WS, Koo BH, Kim HG, Yun SH. Psychiatric understanding and treatment of patients with amputations. Yeungnam Univ J Med. 2021;38(3):194-201.
4. Krishnamoorthy R, Karthikeyan G. Degloving injuries of the hand. Indian J Plast Surg. 2011;44(2):227-36.
5. Adani R, Castagnetti C, Landi A. Degloving injuries of the hand and fingers. Clin Orthop Relat Res. 1995(314):19-25.
6. Zhang G, Ju J, Jin G, Tang L, Fu Y, Hou R. Replantation or revascularization for the treatment of hand degloving injuries. J Plast Reconstr Aesthet Surg. 2016;69(12):1669-75.
7. Kerschhagl M, Larcher L, Mattiassich G, Prantl L. Replantation of a circumferentially degloved thumb in an occupational crush injury - A case report and review of the literature. Clin Hemorheol Microcirc. 2019;71(4):403-14.
8. Ju J, Li J, Hou R. Microsurgery in 46 cases with total hand degloving injury. Asian J Surg. 2015;38(4):205-9.
9. Ono S, Chung KC. Efficiency in Digital and Hand Replantation. Clin Plast Surg. 2019;46(3):359-70.
10. Besmens IS, Guidi M, Frueh FS, Uyulmaz S, Lindenblatt N, Reissner L, et al. Finger reconstruction with dorsal metacarpal artery perforator flaps and dorsal finger perforator flaps based on the dorsal branches of the palmar digital arteries - 40 consecutive cases. J Plast Surg Hand Surg. 2020;54(4):248-54.
11. Shimbo K, Kawamoto H, Koshima I. Finger Reconstruction With Distally Based Dorsal Metacarpal Flaps: A Systematic Review. Ann Plast Surg. 2022;89(5):573-80.
12. Gregory H, Heitmann C, Germann G. The evolution and refinements of the distally based dorsal metacarpal artery (DMCA) flaps. J Plast Reconstr Aesthet Surg. 2007;60(7):731-9.
13. Sebastin SJ, Mendoza RT, Chong AKS, Peng YP, Ono S, Chung KC, et al. Application of the dorsal metacarpal artery perforator flap for resurfacing soft-tissue defects proximal to the fingertip. Plast Reconstr Surg. 2011;128(3):166e-78e.
14. Roman MD, Russu O, Mohor C, Necula R, Boicean A, Todor A, et al. Outcomes in revision total knee arthroplasty (Review). Exp Ther Med. 2022;23(1):29.
15. Parvizi J, Adeli B, Zmistowski B, Restrepo C, Greenwald AS. Management of periprosthetic joint infection: the current knowledge: AAOS exhibit selection. J Bone Joint Surg Am. 2012;94(14):e104.
16. Parvizi J, Zmistowski B, Adeli B. Periprosthetic joint infection: treatment options. Orthopedics. 2010;33(9):659.
17. McCraw JB, Fishman JH, Sharzer LA. The versatile gastrocnemius myocutaneous flap. Plast Reconstr Surg. 1978;62(1):15-23.
18. Salibian AH, Anzel SH. Salvage of an infected total knee prosthesis with medial and lateral gastrocnemius muscle flaps. A case report. J Bone Joint Surg Am. 1983;65(5):681-4.
19. Greenberg B, LaRossa D, Lotke PA, Murphy JB, Noone RB. Salvage of jeopardized total-knee prosthesis: the role of the gastrocnemius muscle flap. Plast Reconstr Surg. 1989;83(1):85-9, 97-9.
20. Osei DA, Rebehn KA, Boyer MI. Soft-tissue Defects After Total Knee Arthroplasty: Management and Reconstruction. J Am Acad Orthop Surg. 2016;24(11):769-79.

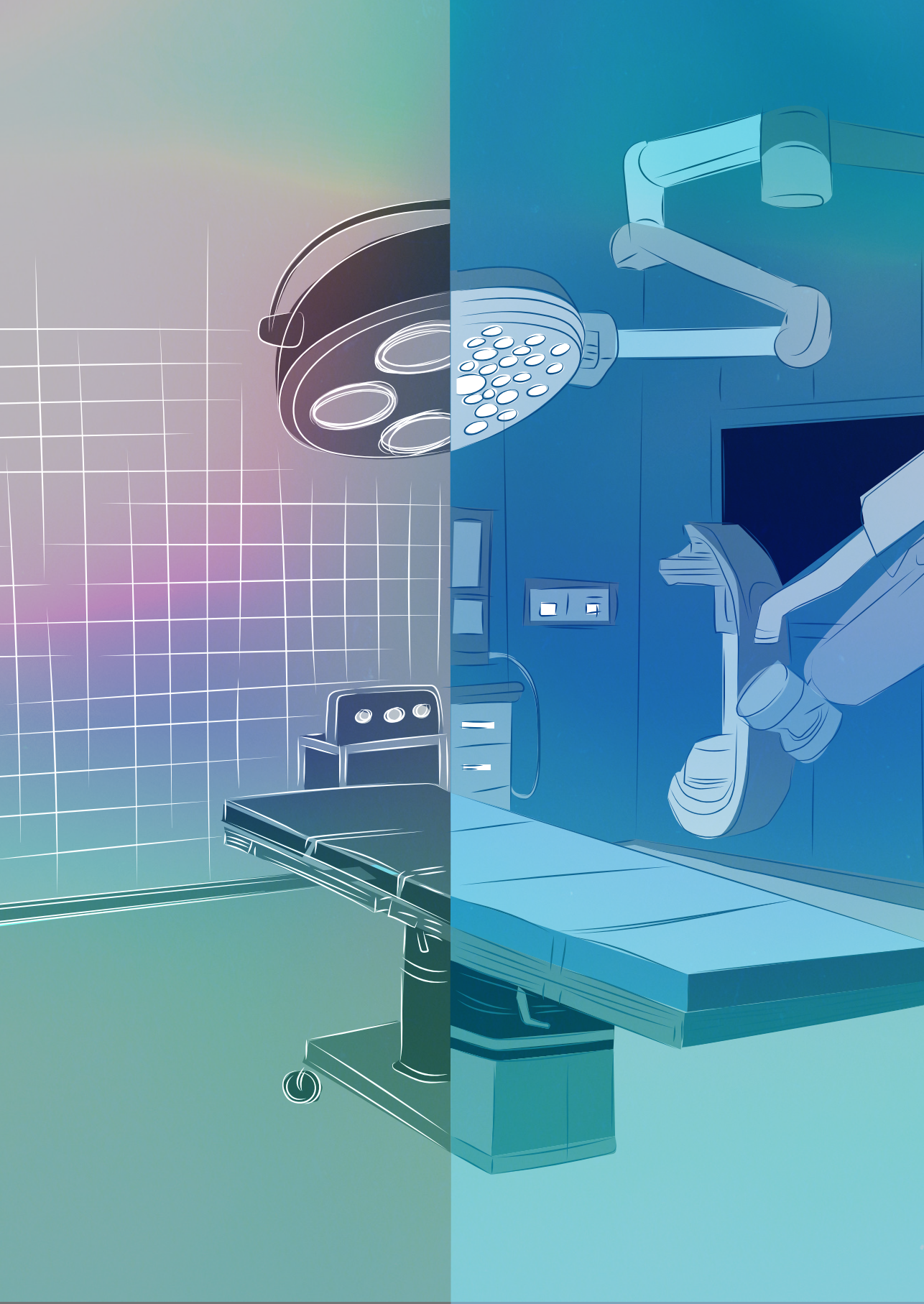
21. Rossi R, Rosso F, Cottino U, Dettoni F, Bonasia DE, Bruzzone M. Total knee arthroplasty in the valgus knee. Int Orthop. 2014;38(2):273-83.
22. Cetrulo CL, Jr., Shiba T, Friel MT, Davis B, Buntic RF, Buncke GM, et al. Management of exposed total knee prostheses with microvascular tissue transfer. Microsurgery. 2008;28(8):617-22.
23. Gravvanis A, Kyriakopoulos A, Kateros K, Tsoutsos D. Flap reconstruction of the knee: A review of current concepts and a proposed algorithm. World J Orthop. 2014;5(5):603-13.
24. Jeong S-H, Baik S-H, Namgoong S, Dhong E-S, Han S-K. An algorithmic approach to soft-tissue reconstruction around the knee using anterolateral thigh perforator flap in patients with post-traumatic knee osteomyelitis. Frontiers in Surgery. 2023;Volume 10 - 2023.
25. Lehner B, Fleischmann W, Becker R, Jukema GN. First experiences with negative pressure wound therapy and instillation in the treatment of infected orthopaedic implants: a clinical observational study. Int Orthop. 2011;35(9):1415-20.
26. Cohen JC, de Freitas Cabral E. Peroneus longus transfer for drop foot in Hansen disease. Foot Ankle Clin. 2012;17(3):425-36, vi.

1





Part I: Upper extremity



Chapter 2

Extended distally based DMCA flap in combination with autologous amputate skin transplantation as a salvage procedure for ring avulsion injury

Till Wagner, Nicholas Slater, Dietmar Ulrich

European Journal of Plastic Surgery 39, 69–72 (2016)

Abstract

A 23-year-old male student presented to our clinic with a traumatic complex ring avulsion of his right dominant index finger. Clinical evaluation revealed

a complete distal amputation of the DIP joint with a laceration of the soft tissue at the middle phalanx and a rupture of the FDP-2-tendon far proximally. We here- by present the patient's clinical outcome after reconstruction with a distally based extended DMCA-II flap. To our own knowledge, this is the first report of an extended distally based DMCA flap for coverage of a class IVd ring avulsion injury in combination with autologous amputate skin transplantation.

Introduction

Ring avulsion injuries are difficult to treat despite more and more upcoming indications for microsurgical replantations. When amputates are either missing or in poor condition there are usually two options: First, further amputation or ray resection or second, free transplantation. In cases in which the patient isn't suitable for both, the options are limited. Since its first

description, the distally based DMCA flap and its modifications have a broad spectrum of indications. To our knowledge, this is the first described case of a DMCA wraparound modification for finger amputations. In selected cases, this procedure may be a helpful additional reconstructive option.

Case report

On arrival at the emergency department, we saw an adolescent male student with a complete ring avulsion of his right dominant index finger as a result of an unfortunate climb and jump over a bar fence under the influence of energy drink and alcohol. At first, the patient did not recognize his trauma and continued walking after passing the fence, only to return after a short time when he became aware of the situation and collected his amputate and called the ambulance that took him to our hospital (Fig. 1).

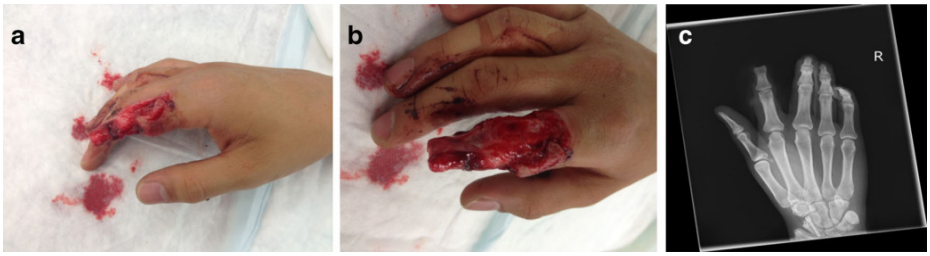


Figure 1 a and b Preoperative views, c Preoperative X-ray of the right hand

During transport, the amputate was directly packed in Ringer's lactate for over 1 h which caused maceration and edema of the soft tissue especially of the vessels. Therefore, replantation was not possible and the patient demanded a local option to keep as much length as possible with a good cosmetic and functional result. Intraoperatively, after exploration and debridement of the amputate, we decided to close the defect with an extended DMCA-II-flap. After drawing the flap design with the support of a template of the defect, we decided to take a slightly different approach with primarily closeable skin at the donor site of the flap and using "spare part" full-thickness skin grafts from the amputate for transplantation (Fig. 2). A volar

splint was applied postoperatively for immobilization. The drain was removed after 2 days, and after 3 days, a slight superficial epitheliolysis was observed and treated conservatively. Physiotherapy was started 2 weeks postoperatively. The further clinical course was uneventful. The student returned to his normal life about 3 weeks after the trauma. At his check-up appointment 6 months later, the patient was satisfied with the achieved result. The range of motion in the metacarpophalangeal (MCP) and proximal interphalangeal (PIP) joints were 0-0-90 and 0-0-90, respectively. The active range of motion in his right wrist was not impaired. Blood perfusion had returned to the normal level. Even sensibility was up to the PIP level rated as normal, whereas a more distal two-point discrimination was around 8 mm (Fig. 3).

Figure 2 Immediate postoperative result

Discussion

Since the first description of the DMCA flap in 1990 (1) and his modification, the flap quickly became part of the plastic surgeon's armamentarium for the coverage of soft tissue defects of the hand (2). Despite its easy use, the flap has not gained its position in amputation and deglovement injuries.

Today, with the ongoing discussion regarding indications for replantation after ring avulsions (3), there is still a lack of surgical options due to absent amputates or amputates in a poor condition. Even in recent studies (4) which have shown more satisfying results in replantation after complete ring avulsion, these issues are not addressed. Most authors agree that amputations distal of the FDS insertion with intact PIP joint are potential candidates for replantation (5). When the injured amputate is not available or replantable, ray resection is estimated to be the best option except in patients with manual jobs where preserving the MCP joint is said to be favorable (6). In the current case, we show that a well-known locoregional flap such

as the DMCA flap may well serve as a solution where the amputate was not suitable for replantation and the patient negotiates further amputation. The advantage of this procedure is the relatively short operating time with less need for extensive vascular debridement and a short recovery time to normal life. To our knowledge, this is the first description of a case report of a DMCA flap in combination with an autograft from the amputate for a soft-tissue coverage. The patient achieved a good functional and cosmetic outcome and was satisfied with the daily usability of the finger.

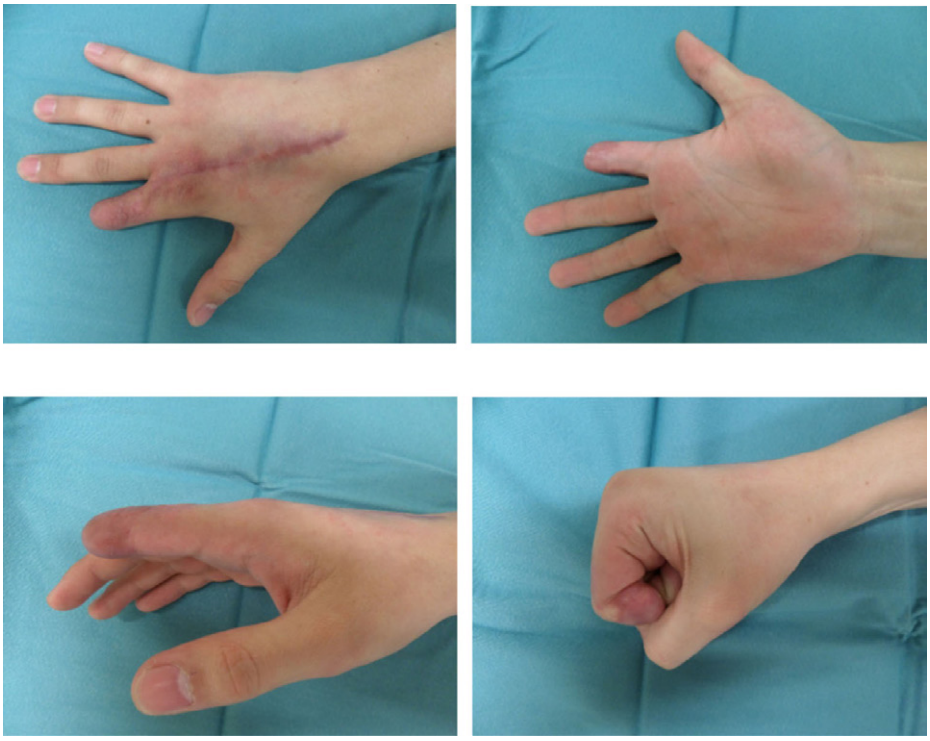
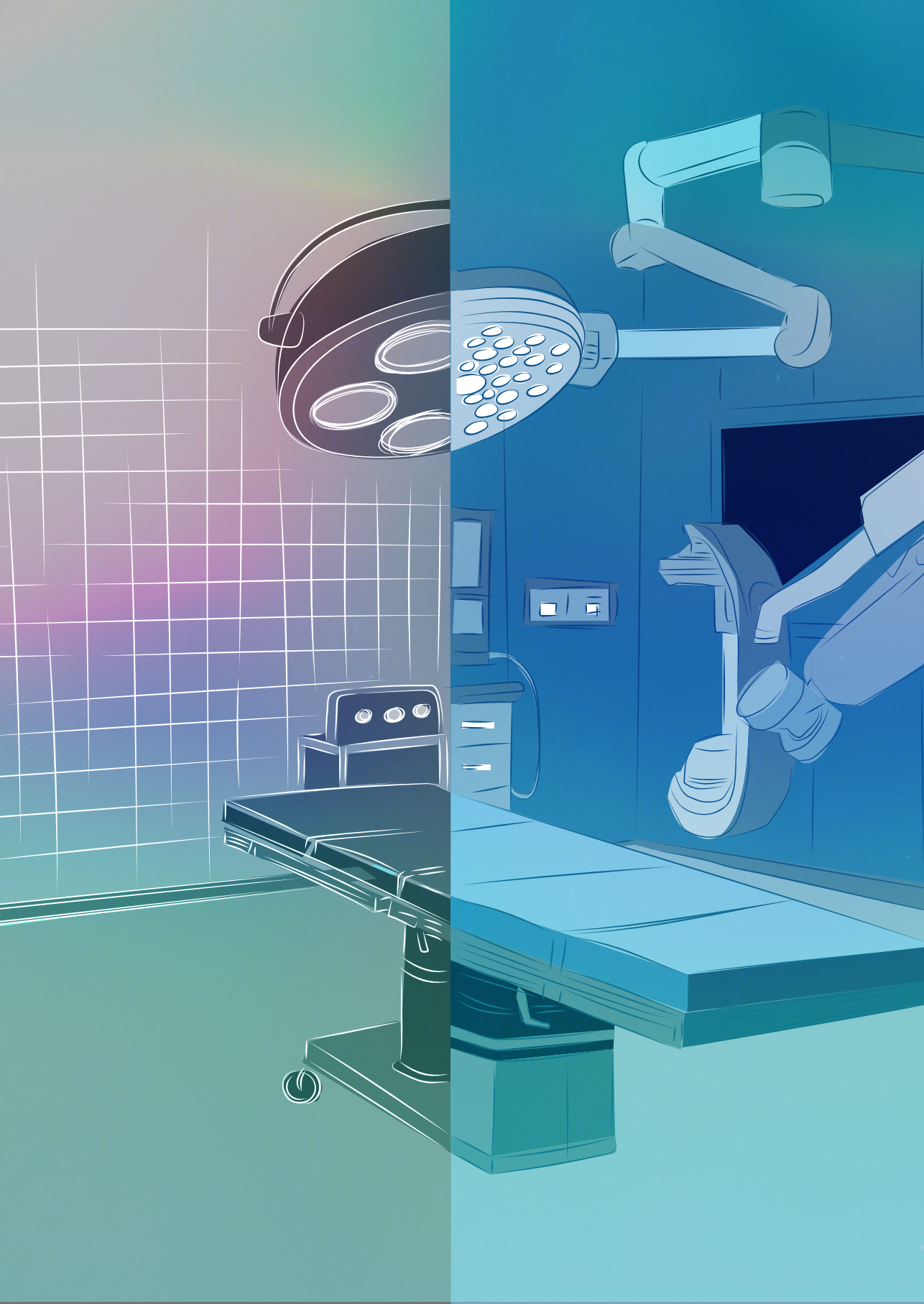


Figure 3 Postoperative view at 6 months with good functional results

References

1. Maruyama Y (1990) The reverse dorsal metacarpal flap. Br J Plast Surg 43(1):24–27
2. Gregory H, Heitmann C, Germann G (2007) The evolution and refinements of the distally based dorsal metacarpal artery (DMCA) flaps. J Plast Reconstr Aesthet Surg 60(7):731–739
3. Rawles RB, Deal DN (2013) Treatment of the complete ring avulsion injury. J Hand Surg 38(9):1800–1802
4. Ozaksar K, Toros T, Sugun TS, Kayalar M, Kaplan I, Ada S (2012) Finger replantations after ring avulsion amputations. J Hand Surg, Europe 37(4):329–335
5. Adani R, Marcoccio I, Castagnetti C, Tarallo L (2003) Long-term results of replantation for complete ring avulsion amputations. Ann Plast Surg 51(6):564–568
6. Brooks D, Buntic RF, Kind GM, Schott K, Buncke GM, Buncke HJ (2007) Ring avulsion: injury pattern, treatment, and outcome. Clin Plast Surg 34(2):187–195

2



Chapter 3

The anatomic relationship of dorsal arterial perforators of the distal forearm, wrist, and dorsum of the hand with conclusions for the clinic

Till Wagner, Stefan Hummelink , Femke Mathot, Dietmar Ulrich

Journal of Plastic, Reconstructive & Aesthetic Surgery 83 (2023) 141–147

Summary

Background: Extended soft tissue defects of the fingers are often challenging to treat, and therefore, we performed cadaver dissections to elucidate the anatomic relationship between dorsal arterial perforators of the distal upper extremities to support the development of new local flaps.

Methods: Ten fixated cadaveric distal dorsal lower forearms were dissected to their arterial perforators down to 0.1 mm diameter in size with identification of their relationship.

Results: Dorsal distal fascia piercing perforators of the lower forearm come in two distinct rows, radial and ulnar, of the fourth extensor compartment. These were interconnected by subfascial axial arteries in line. The most proximal perforator is usually located 8–10 cm from the dorsal wrist, the most distal about 1–2 cm, and on average, only three subcutaneous bridging vessels connect both axial systems. The number of less reliable subcutaneous arterial connecting vessels between the dorsal wrist and forearm is also fairly limited to only one or two. More constant bridging arteries interconnect at the level of the dorsal retinaculum between the axial systems of the hand and lower forearm. At the level of the dorsum of the hand perforators reaching the skin, they interconnect in an arcuate fashion. This unique distribution pattern could be used for freestyle perforator propellor flaps of the hand, as we demonstrated in a case directly derived from our recent research.

Conclusion: In our opinion, a super-extended perforator flap should be possible with the inclusion of the bridging arteries in flap design at the level of the dorsal retinaculum.

The human hand is, due to its daily common use, most often involved in upper extremity injuries and, therefore, prone to soft tissue defects. Especially, posttraumatic defects distal of the metacarpophalangeal joints of the fingers or the interphalangeal joint of the thumb are common. These wounds are challenging to treat because they lack a surplus of surrounding soft tissue suitable for local or distant flaps. Several local flaps are well known to address this issue, but most of them fail to address defects distally of the proximal interphalangeal joint or especially those with degloving injuries. Covering denudated functional structures like tendons, bones, and joints with sufficient pliable tissue is vital for functional outcomes and esthetic aspects. At present, proximal soft tissue defects of fingers are often closed by local perforator flaps based on the arterial system of the dorsal metacarpals artery, but they fail in distal finger defects or in extensive loss of covering tissue. The purpose of this study was to elucidate the relationship of dorsal arterial perforators of the distal

upper extremity/hand and to identify new possible options to treat distally extensive soft tissue defects, addressing the lack of suitable flaps.

Figure 1: Schema of skin markings and coordinate system.

Material and methods

Anatomic study

Ten upper extremities of adult cadavers (six left / four right) without signs of trauma were obtained from the willed donor program of Radboud Medical University (Nijmegen, the Netherlands). Age, nationality, and sex were unknown. All specimens were, before dissection, injected with blue-green latex via the brachial artery and then fresh frozen. In all ten specimens, the length of the forearm was measured from the ulnar styloid to the far most proximal edge of the olecranon and divided by two. This gave the proximal border of the dissection area of the forearm. The width of the wrist was measured with a caliper at the level of the wrist joint and the proximal border of the dissection area and also divided by two. Connecting these two points resulted in zero/origin coordinates of the cartesian coordinate system at the level of the wrist joint. Drawing the line further distal to the middle of the MCP-3 knuckle resulted in the midline of the dissection area at the level of the hand. Extending the lines to radial

and ulnar at the level of the distal web space and proceeding back to the wrist gave the missing dissection borders. Further markings were done at the far most lateral edge of the radial and ulnar sides of the distal part of the forearm to complete the field of dissection (Figure 1). Following the drawing, careful incisions were made with a 15-blade scalpel along the drawings under loupe magnification (2x) from proximal to distal and from medial to lateral, and thus, in total, four skin flaps were created and elevated. Next, meticulous identification and dissection of all perforators within these borders took place. Spatial anatomic positions were notated to the cartesian coordinate system. Next, the relationship between perforators was investigated at the level of the subcutaneous skin, dorsal retinaculum, and subfascial plane.

Results

Anatomic findings

On the dorsal side of the distal lower forearm, two rows of cutaneous perforators regularly arise laterally of the 4th extensor compartment (Figure 2). The most distal perforator of the two rows pierces the lower forearm fascia at 13 mm radially (range 5-26 mm) and 10 mm ulnarly (range 3-17 mm) proximal to the wrist crease. In most specimens, they were neighbored in line with more proximal perforators at a distance of 10-15 mm until the far most proximal perforator was reached around a distance of 80-100 mm on average. Both rows are (Figure 1 Schema of skin markings and coordinate system.) interconnected with arterial branches arising from the posterior interosseus artery (Table 1).

At the subcutaneous level, only a few numbers of connecting vessels between the radial and ulnar sides exist (usually 2-3, on average 2.8) and commonly interconnect the 3rd and 5th perforator laterals of the common extensor digital muscle (Figure 3). Between the dorsal skin of the hand/wrist and the lower forearm, only a small number of subcutaneous arterial vessels are present (usually 1-2, on average 1.3). However, at the level of the dorsal retinaculum, we found two bridging arterial vessels lateral of the 4th extensor compartment: first, radially, the 2,3 intercompartimental-supraretinacular artery (ICSA) (100% of the cases), and second, on the ulnar side, the 4,5 intercompartimental-supraretinacular artery (50% of the cases), see Figure 4. These two connect most constantly to the first fascia piercing perforator ulnar and radial of the fourth extensor compartment. The known 1,2 ICSR artery, as often described for pedicled bone grafts from the radius, was absent in all of our specimens.

Table 1 Position of the lower forearm perforators in relation to the wrist line in mm

Distance perforator forearm from wrist line	**Cases**										**Average**
	#1	**#2**	**#3**	**#4**	**#5**	**#6**	**#7**	**#8**	**#9**	**#10**	
Most distal perforator: Radial side (mm)	5	10	5	26	7	18	17	10	13	22	13,30
Most distal perforator: Ulnar side (mm)	17	7	13	14	7	15	13	10	5	3	10,4
Most proximal perforator: Radial side (mm)	121	108	100	68	115	85	34	51	63	60	80,5
Most proximal perforator: Ulnar side (mm)	77	125	101	116	106	110	97	93	113	120	105,8
Number of interconnecting vessels subcutanously forearm radially/ulnarly	3	2	4	2	2	3	2	3	3	4	2,8
Number of interconnecting vessels subcutanous wrist/forearm	2	1	2	1	1	1	1	1	1	2	1,3
Presence 2,3ICSA	+	+	+	+	+	+	+	+	+	+	100%
Presence 4,5ICSA	-	-	+	-	-	-	+	+	+	+	50%

Figure 2: The ulnar row of skin perforators with underlying subfascial axial artery.

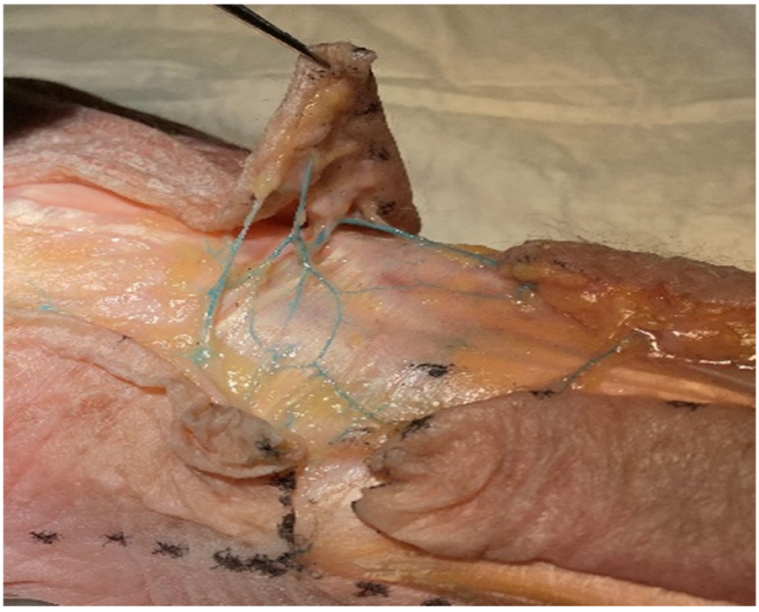


Figure 3: Subcutaneous interconnecting bridging vessels between radial, ulnar, and wrist.

Figure 4: Supraretinacular-intercompartemental arteries connecting dorsal wrist/hand perforators with lower forearm perforators.

Figure 5: Example skin perforators arising from the second dorsal metacarpal arteries of the hand.

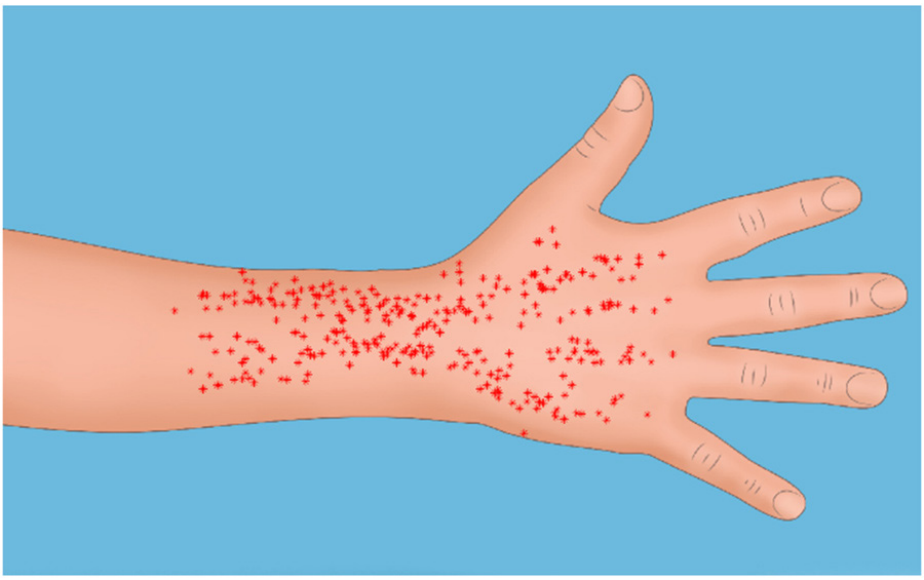


Figure 6: Matched normative relative position of all skin perforators of the dorsal forearm and hand of ten dissected specimens.

As known from previous anatomic studies, the dorsal skin of the hand gets its blood supply almost constantly from the distal perforators at the level of the metacarpophalangeal (MCP) joints, which arise from the dorsal metacarpal arteries (DMCA) at the first to fourth web space (Figure 5). They interconnect with each other just proximal to the joint knuckles by small and thin arcading vessels. The very center of the dorsal skin has almost no underlying feeding perforator and is dominantly nourished by the intra- and subcutaneous small arteries. Interestingly, we constantly found a common arterial source of DMCA 3 and 4, which divided distally of the distal carpal row into its two branches at the more ulnar side and one more radial, which fed DMCA 2. To elucidate further distribution patterns, we notated the positions of all perforators related to a standard lower forearm/hand based on an average arm (Figure 6). Furthermore, we found in common the dorsal skin perforators of the hand in a line drawn between the middle of the knuckles and our center of the coordinate system and spread over the distal part of the different DMCAs (more details see Table 2).

Table 2 Number of perforators of the hand and position in relation to 0/) in mm.

Matrix center at 0/0 with postive values (mm) proximal/radial																						
Specimen number	1		2		3		4		5		6		7		8		9		10			
Length of distal part of forearm (50% of total length) mm	135		131		115		138		133		118		116		116		144		134			
Width of forarm distal/prox	52	65	52	52	58	60	56	61	66	82	58	65	50	62	50	62	62	65	58	60		
0/0 center at wrist line, diameter mm	26		26		29		28		33		29		25		25		31		29			
Gender of specimen male/female	f		f		f		f		f		f		f		f		m		f			
Total number of perforators:																					Average	
Dorsum of the hand	13		11		15		13		12		16		9		14		19		16		13,8	
DMCA1	1		2		3		4		3		2		3		3		2		4		2,7	
DMCA2	3		1		3		4		2		4		1		3		3		2		2,6	
DMCA3	2		2		4		1		1		1		1		3		2		3		3,0	
DMCA4	2		2		4		3		2		1		2		4		5		3		2,8	
Dorsum of the forearm	12		13		13		15		17		14		13		17		14		12		14,0	
Total length hand with 50% forearm mm	230		231		217		245		243		224		209		205		268		246			
Abscence of DMCA	none		none		none		none		3		3 + 4		none		none		none		none			
Side of the arm left/right	l		r		l		r		r		l		r		l		l		l			
Average skin perforator posstion in relation to 0/0 in mm	x	y	x	y	x	y	x	y	x	y	x	y	x	y	x	y	x	y	x	y	Average x	Average y
most distal postion of skin perforator at 1st webspace DMCA1	-75	45	-95	35	-95	40	-87	34	-86	38	-60	35	-78	30	-73	25	-95	38	-89	35	-83	37
most distal postion of skin perforator at 2nd webspace DMCA2	-97	8	-80	10	-90	10	-105	15	-98	12	-90	15	-76	15	-78	4	-111	10	-95	12	-92	11
most distal postion of skin perforator at 3rd webspace DMCA3	-109	-12	-90	-15	-98	-12	-84	-13	-100	-10	-95	-14	-65	-11	-80	-10	-109	-15	-87	-15	-92	-13
most distal postion of skin perforator at 4th webspace DMCA4	-98	-30	-90	-35	-89	-35	-90	-27	-85	-12	-70	-26	-63	-25	-67	-25	-106	-36	-73	-30	-83	-28
most proximal postion of skin perforator of DMCA1	none	none	-51	42	-35	30	-47	32	-30	25	-51	30	-28	30	-30	24	-55	39	-37	35	-40	33
most proximal postion of skin perforator of DMCA2	-30	21	none	none	-24	28	-35	17	-73	12	-65	13	none	none	-41	12	-90	9	-80	10	-55	15
most proximal postion of skin perforator of DMCA3	-50	-10	-50	-15	-50	-10	none	none	none	none	none	none	none	none	-48	-4	-85	-13	-22	-14	-51	-11
most proximal postion of skin perforator of DMCA4	-25	-8	-50	-32	-58	-45	-28	-24	-85	-12	none	none	-26	-16	-33	-25	-51	-29	-55	-22	-46	-24

Clinical application

In November 2022, we could- by chance- perform a distally based freestyle perforator propeller flap of the first dorsal metacarpal artery (FDMA) for a thumb defect in one patient, which was- by design- directly derived from our previous cadaver dissection earlier in 2022. In opposition to a common Quaba flap, which is based on the dorsal skin perforators of the second to fourth DMCA at the level of the web space, we were intraoperatively searching with a Doppler probe for a distal FDMA skin perforator, which was found- according to our research- approximately 2 cm proximally and about 2 cm radially to the MCP2 knuckle at the distal border of the first web space (Figure 7).

Case report and clinical outcome

A 56-year-old woman was referred to our department with a PCC on her right dominant thumb proximal to the interphalangeal joint. She was a heavy smoker, smoking 25 cigarettes per day for more than 35 years. She also had a history of double renal transplantation in 1991 and 2006 with consecutive immunosuppression and multiple operations for skin cancer (more than 30 all over her integument). After complete resection with 1 cm margins, a soft tissue defect was visible in the first place, which was temporarily covered with artificial skin. One week later, she came back for the intended defect closure with skin grafting. During preparation, a denudated extensor pollicis longus tendon was visible, and the question arose of how to cover it because of multiple surrounding scaring from previous incisions. We decided to use a distally based first dorsal metacarpal artery (FDMA) perforator propellor flap to cover the defect based on our anatomic research. After marking a suitable skin perforator with a Doppler probe distally of the first web space and ensuring not to dissect the radial artery, we drew incision lines along existing scars at the level of the first and second metacarpal bones. Preparation started proximally with the inclusion of the fascia of the first dorsal interosseus muscle. Dissection turned then toward the marked skin perforator beside the radial aspect of the second metacarpophalangeal joint. After preparation of the pedicle, checking refill, and venous congestion, we completely dissected the distal remnant skin bridge to enlarge the arc of rotation of this island perforator propeller flap. After the inset of the flap, a small soft tissue defect was still visible, but without functional structures, full-thickness skin grafting was sufficient, and the donor site was closed primarily. The further clinical course was, even with continued heavy smoking, uneventful under splinting. The flap survived completely even in a worst-case scenario of immunosuppression with "poor skin" quality. Skin sutures were removed three weeks postoperatively, and the patient regained good function and esthetics after six weeks of follow-up time and was satisfied. The donor site healed successfully as well. Furthermore, we could demonstrate with this patient- to our best knowledge- the first reported case of a distally based FDMA propeller island flap for thumb reconstruction.

Figure 7: Preoperative, intraoperative after removing temporary wound dressing with complete denudated EPL-tendon in staged reconstruction after R0 resection, and postoperative photos (at 8 weeks) of clinical case with a distally based first dorsal metacarpal artery propellor perforator flap. An asterisk shows the position of the FDMA skin perforator.

Discussion

Most anatomic publications about dorsal perforators based on skin flaps of the hand are focusing on the perforators around the metacarpophalangeal (MCP) joints and branches of the dorsal metacarpal arteries as published by Quaba (1) and Maruyama (2) with different pedicles and other modifications. Only a paucity of publications exists on the dorsal arterial skin perforators of the wrist and distal dorsal forearm (3–5) and their relationship with each other. Most perforator flaps of the dorsal wrist, which are described in the literature, are based on a perforating branch of the anterior interosseous artery or the posterior interosseous artery. Neither of them describes the relationship with skin perforators more proximally and distally nor the special distribution pattern. According to Quaba et al., skin perforators arise approximately one cm proximal to the metacarpal head (1). Further proximal, the number of arterial skin perforators is inconsistent, and less is described. As we found in our cadaveric study, the central skin of the dorsum of the hand is an area of less vascularity because of a minor number of nourishing perforator vessels based on the partial subtendineous course of the DMCA vessels. More proximally, at the level of the distal carpal row at the conjunction of the 2nd,3rd metacarpal bone and 4th, 5th metacarpal bone, there is a relatively constant interconnection between the dorsal and palmar artery networks of the hand. Also, the arterial dorsal network of the carpal bones interconnects with the DMCAs and the most distal perforators along the intercompartimental-supraretinacular arteries. In contradiction to the publications of Waitayawinyu (6) and Varma (7), the 1,2 intercompartemental-supraretinacular artery (ICSA) seems to be more of a 2,3 ICSA in our study. We found in our own

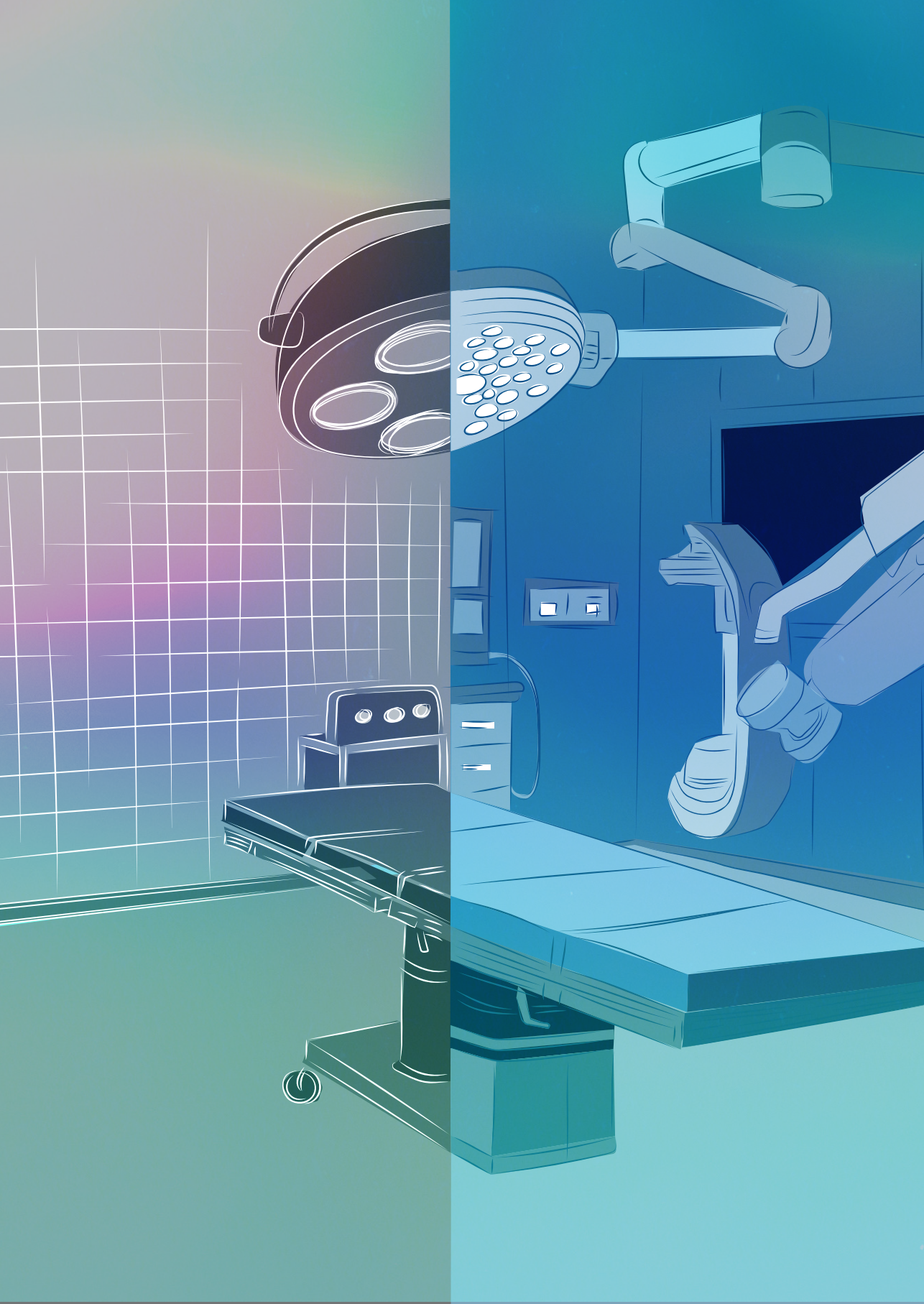
cadaver dissections a small artery that most often started distally at the level of the 1,2 ICSA, ran distally of the extensor retinaculum toward the ulnar side of the wrist, and ultimately crossed the extensor retinaculum more at the level of the 2,3 ICSA. Another explanation for our missing 1,2 ICSA is the more volar course of this artery, and therefore, it is outside of our dissection area. The variability of the distal origin 1,2 ICSA and the numbers of osseous perforators has also been seen in the above-mentioned publications and gives rise to the question of how reliable anatomic dissections are. Even more contrary to the publication of Omokawa (8), we found a consistent palmar connection at the level of the metacarpal head or somewhat more distally at the level of the web of the second to fourth web space. Furthermore, in 50% of our dissected specimens, the dorsal branch of the radial artery serves as the first dorsal metacarpal artery, which gives off cutaneous branches, contrary to the publication of Tan (9). Also, the presence of the dorsal metacarpal arch is inconsistent in our survey. Therefore, the skin paddles of super-extended flaps depend on ultrathin intracutaneous blood vessels and less on DMCA, as we could demonstrate.

Conclusions

Assessing the dorsal anatomy of the distal upper extremity skin perforators, the development of new perforator flaps seems possible. By including the supraretinacular arteries of the wrist as interconnecting bridging vessels, the super-extension of the well-known flaps like DMCA flap should be an option for wounds further distally than proximal interphalangeal joints or more extensive defects, but more clinical research has to be done.

References

1. Quaba AA, Davison PM. The distally-based dorsal hand flap. Br JPlast Surg 1990;43(1):28–39.
2. Maruyama Y. The reverse dorsal metacarpal flap. Br J Plast Surg 1990;43(1):24–7.
3. Shibata M, Ogishyo N. Free flaps based on the anterior inter-osseous artery. Plast Reconstr Surg 1996;97(4):746–55.
4. Panse NS, et al. The anterior interosseus artery perforator flap: anatomical dissections and clinical study. World J Plast Surg 2017;6(2):152–8.
5. Hu D, et al. Anatomical basis and clinical application of the dorsal perforator flap based on the palmar artery in the first web. Surg Radiol Anat 2020;42(3):269–76.
6. Waitayawinyu T, et al. The detailed anatomy of the 1,2 inter-compartmental supraretinacular artery for vascularized bone grafting of scaphoid nonunions. J Hand Surg Am 2008;33(2): 168–74.
7. Varma V, et al. Study of anatomical variations of 1,2 intercompartmental supraretinacular artery-based vascularized bone graft in cadavers. Indian J Orthop 2020;54(5): 565–9.
8. Omokawa S, et al. The anatomical basis for reverse first to fifth dorsal metacarpal arterial flaps. J Hand Surg Br 2005;30(1): 40–4.
9. Tan RES, Lahiri A. Vascular anatomy of the hand in relation to flaps. Hand Clin 2020;36(1):1–8.



Chapter 4

Anatomy, evolution, and clinical aspects of the super extended-intercompartmental- supraretinacular artery perforator flap (SISAP-flap): A proof of concept

Till Wagner, Dietmar Ulrich

Journal of Plastic, Reconstructive & Aesthetic Surgery 93 (2024) 215–221

Abstract

Background: Extended soft tissue defects of the fingers- irrespective of their origin- are challenging to treat. In cases of missing amputates or crush injuries, the options are often limited to further amputation, ray resection, or free tissue transplantation. The SISAP-flap was developed to add an extra option to treat finger avulsion injuries or otherwise extended soft tissue finger defects.

Methods: Cadaveric SISAP-flaps were individually dissected, tested for arterial perfusion using red ink and radiopaque dye, and transposed into artificially created same-size defects. After introducing this flap in the clinic, which was partially successful in the first patient, we modified the flap to its definite design.

Results: Average cadaver flap size ranges between 11 cm and 22 cm in length, allowing dorsal wrapping of the flap over the fingertip and way back to the palmar metacarpophalangeal-joint. The flap is based on the distal web space perforator, which is commonly used by a dorsal metacarpal artery flap and supercharged using an intercompartmental, supraretinacular artery. Donor sites were closed primarily with little tension. Application of the flap in the clinic resulted in satisfactory functional and esthetic outcomes. Conclusion: The SISAP-flap is a new option for the reconstruction of extended finger defects and should be added to the reconstructive surgeon's armamentarium of pedicled flaps, providing relatively short operating times and promising clinical outcomes.

Introduction

Finger avulsion injuries or other extended soft tissue defects are a well-known hassle for the patients and a challenge for the surgeon. Both are difficult to treat, because of the frequent lack of sufficient soft tissue to cover the defects, independently of the eventual indications for micro-surgical replantation. Thus, two options are generally available when amputates are either missing or in poor condition and therefore not suitable for replantation: further amputation, ray resection, or free tissue transplantation. In cases where the patient is not suitable or willing, the options become limited. Since the first description of the distally based dorsal metacarpal artery (DMCA) flap as a wrap-around flap for such injuries, there has been an ongoing search for similar options to treat complete deglovement injuries or other extended defects of the fingers using local flaps (10). Our primary idea was to extend a common DMCA flap as long as possible toward the lower forearm with direct closure of the donor site- for esthetic reason- and to use the length to compensate for the width (Figure 1).

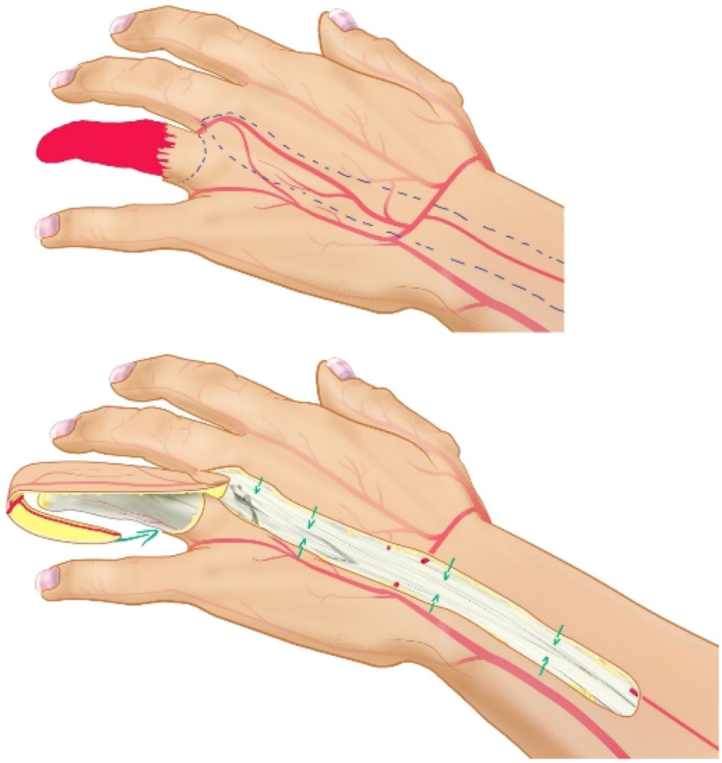


Figure 1: Schematic illustration of the SISAP-flap for extended soft tissue defects or deglovement injuries of a finger.

The result of our research is the super-extended, intercompartmental, supraretinacular artery perforator flap (SISAP)-flap, which we estimated as a candidate for further evaluation. Notably, the SISAP-flap has never been described elsewhere. We performed cadaver dissection to develop a step-by-step operating procedure of the SISAP-flap with secondary modification based on clinical experience and additional research. The flap was used in three patients- first in its original form and twice, in a modified form, to reconstruct extended soft tissue defects of the third and fourth finger of a hand.

Methods and patients

Cadaver dissection

A total of four cadaver dissections were included in the first line of the current study, and the cadavers were provided by the Willed Body Program. The cadavers were fresh-frozen and defrosted just before dissection. The limbs showed no evidence of peripheral vascular disease or other trauma on the macroscopic level, but the exact past medical history of the specimen was unknown. First, we marked the expected incision lines at the dorsum of the hand/forearm centered over the wrist (Figure 2 of the Supplementary File).

Figure 2: Pre-dissection drawings of the four different SISAP-flaps from web space 1 to 4

The flap design focused on direct closure of the donor-site defect- for esthetic reasons-which was tested by the pinch test followed by dissection of the most distal part of the flap along the fascia with identification of the supraretinacular perforators dorsally. The next step was to include the DMCA artery with all its branching skin perforators, overlying venous skin vessels, and adjacent subcutaneous fat into the flap, followed by further dissection until the most distally piercing perforator of the DMCA was identified (Figure 3 of the Supplementary File).

Figure 3: Position of the dorsal hand- and forearm perforators in a cadaver specimen marked with black ink

Finally, after careful preparation of the flap from the lower forearm to the dorsum of the hand, we dissected the palmar metacarpal artery, and injected 1.5 cc of red dye for the perfusion study of the SISAP-flap. Later, we rotated the SISAP-flap around the piercing DMCA perforator into a previously created matched same-size defect of the finger as a propeller flap. The donor site was then closed primarily with little tension (Figure 4).

Additionally, we carried out an extra radiopaque dye cadaver study to evaluate the perfusion pattern within the flap (4 specimens; Figure 5 of the Supplementary File). Thus, we could visualize flow using the radiopaque dye up to the uttermost distal part of the flap. Statistical analysis was not done due to the limited sample size.

Figure 4: Staining of the vessels of the SISAP-flap after injection of red dye into the palmar metacarpal artery.

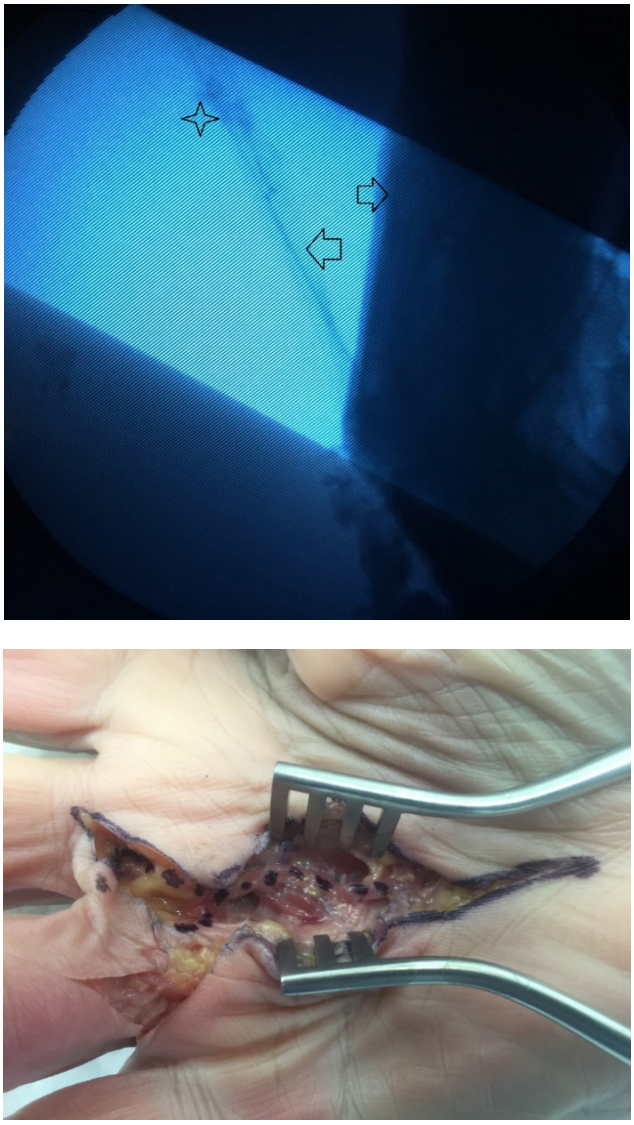


Figure 5: Radio opaque perfusion study showing dye distribution of the cadaveric flap with IOMERON 400 dye 1,5 cc with an elevated flap in lateral view on an image magnifier after dissection of a common metacarpal palmar artery at the level of the MCP joints. The asterisk shows the perfusion pattern of the flap at the level of the dorsal wrist crease. The arrow to the left demonstrates the perfusion of the DMCA in the flap and the arrow to the right shows the metacarpal bone. Below is the corresponding palmar common metacarpal artery marked with black.

Operative technique

Preoperative planning- according to our modified protocol- is strongly recommended with Doppler assisted perforator mapping of the distal DMCA perforators along the expected longitudinal axis of the flap. The operation itself should be performed during the early steps of preparation using a blood tourniquet without exsanguination for better visualization of the small arterial perforators. First debridement and inspection of the defect are to be performed with an adequate assertion of the amputate's skin for further use as a source of full-thickness grafts in deglovement injuries. Depending on the location and size of the finger defect that has to be covered, the flap design should be centered at the level of the dorsal wrist crease above the ¾ extensor compartment for defects of the digits 1/2/3 or 4/5 extensor compartment for defects of the digits 3/4/5 and not centered exactly at the midline of the wrist according to our extra separate research (2), followed by drawing of two axial lines parallel to the dorsum of the wrist connecting to a standard DMCA flap incision line with pinch testing. The length of the incision lines depends on the soft tissue defect and length of the mutilated finger. This is followed by dissection from proximal to distal end under the fascia of the lower forearm with the inclusion of the fascia to prevent shear forces. Meticulous hemostasis is advised. Superficial skin veins will be spared and all of them will be included for an extra emergency vein anastomosis, if necessary. After reaching the supraretinacular artery, intercompartmental bridging vessels with their interconnecting branches that have to be included in the flap for sufficient distal flap perfusion, preparation follows the common procedure for harvesting a DMCA flap (Figure 6).

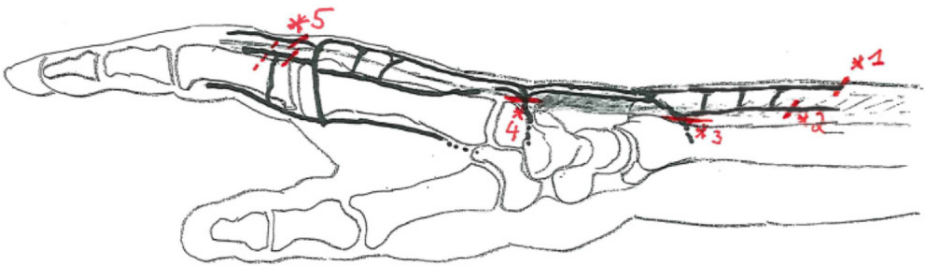


Figure 6: Modified schematic dissection protocol with the inclusion of the intercompartmental, supraretinacular arteries.

After reaching the base of the designated SISAP-flap at the undamaged web space, the tourniquet has to be opened to control flap perfusion and meticulous hemostasis. The interconnecting vessels between the dorsal hand, wrist, and forearm are sensitive and need at least 5–10 minutes to adapt to the new perfusion pattern (3). Additional padding with warm gauzes in combination with papaverine or lidocaine solution without adrenaline is advised. Meanwhile, closure of the donor site is possible. After

fully mobilizing the SISAP-flap, perfusion will be controlled once again, followed by flap rotation into the finger defect. Attention has to be paid to the distal end of the flap and avoiding tension during fixation. Suturing of the flap using interrupted suture without tension, if possible, is advised. Small drains should be placed under the flap with soft gauze for dressing. The donor site can be closed primarily. Postoperative brace therapy without compromising the vascular pedicle of the flap should be performed for 2 weeks with the finger and wrist in intrinsic plus position if possible to lower the skin tension at the level of the dorsal wrist crease.

Results

Cadaver study

The range of the flap size was between 11 cm to 22 cm in length and 1.5 cm to 2.0 cm in width depending on the finger that had to be covered. These dimensions allowed us to wrap the flap around the top of the artificially degloved finger, reaching the dorsal and palmar sides. The cadaver dissection yielded a consistent bouquet of 2 to 3 small perforators superficial to the dorsal retinaculum (Table 1).

Table 1 Characteristics of the SISAP-flaps

	Cadaver 1	Cadaver 2	Cadaver 3	Cadaver 4
Web space based on	DMCA 1	DMCA 2	DMCA 3	DMCA 4
Flap length (cm)	11	21	22	15
Flap width (cm)	1,5	2;0	2	1,3
Perforator distance in cm from the most distal end of the flap	4,5/8,5	1/3,5/6/10/11/19	3.5/6/7/10,5/13/ 15,5/19,5	1,5/5/5,5/7,5/ 8,5/10
Sufficient for	Thumb	Index/middle finger	Ring finger	Small finger

DMCA, dorsal metacarpal artery

These perforators link—in combination with the intercompartmental arteries-the superficial subcutaneous arterial system of the lower forearm with the dorsal metacarpal arteries, dorsal carpal arch, and dorsal interosseus artery of the lower forearm. The distance of the supraretinacular perforator from the most distal DMCA perforator was between 8 cm to 13 cm, depending on the web space on which the flap was based. The mean diameter of the dorsal perforating arterial branches was in all specimens less than 1 mm. We have recently published more detailed information on the distribution patterns at the level of the dorsal wrist or lower forearm.

Clinical application

Case 1

An 18-year-old man was admitted to our department with an extended complex chainsaw trauma of his right dominant middle finger and second web space with 50% loss of soft tissue cover of the finger (Figure 7A of the Supplementary File).

Figure 7A: Preoperative and one day after postoperative X-rays of the mutilated finger of the first case

The young patient emphasized on retaining as much of his mutilated finger as possible. Therefore, we decided to perform a SISAP flap to retain as much length as possible of his right middle finger (Figure 7B).

Figure 7 B: Pre- and intraoperative picture of the SISAP-flap in combination with a small full-thickness skin graft.

To facilitate a primary wound closure of the flap's donor site, we used the skin of the amputate to cover part of the base of the SISAP-flaps. After direct intraoperative immobilization with a palmar cast, a slight superficial epitheliolysis of the distal part of the SISAP-flap was observed 3 days later, which was treated conservatively in the first instance. Later, with some progression of the superficial skin necrosis, we covered the resulting defect with an extra split skin transplantation after 4 weeks (Figure 8B of the Supplementary File).

Figure 8B: 11 weeks postoperatively after distally partial superficial flap-skin necrosis and extra split skin grafting with an x-ray of the incomplete arthrodesis of the DIP-joint of the 3rd finger

Ten months later, we performed a scar tissue release with a z- plasty palmary and dorsal resection of excessive flap tissue (Figure 9 of the Supplementary File).

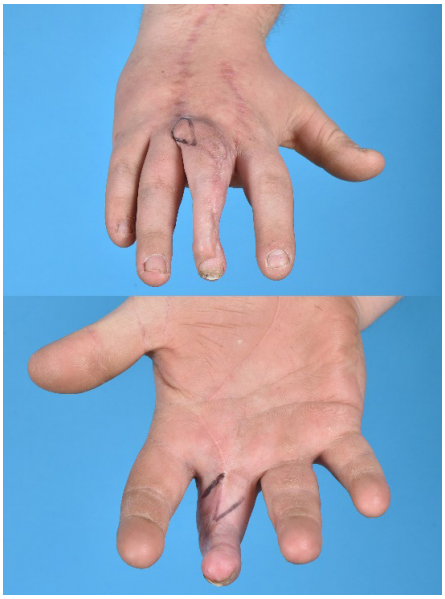


Figure 9: Result seven months after trauma with some excessive skin dorsally and light scar contracture palmarly at the level of the first phalanx

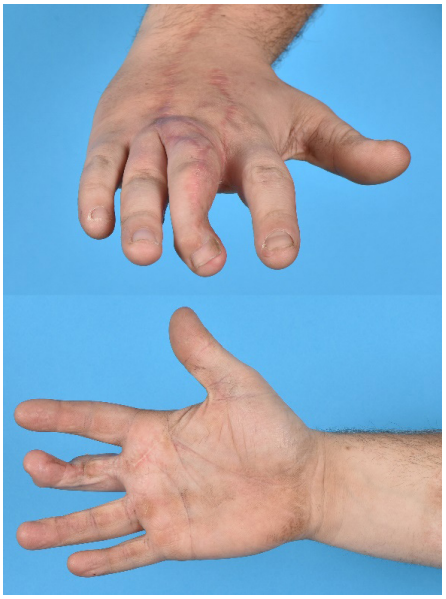


Figure 10: 15 months after first operation and 10 months after 3rd operation with dorsal skin refinement and palmar z-plasty for scar lengthening with beginning radial deviation of the distal phalanx

At 15 months after the initial trauma, the patient presented with a progressive deviation of his middle finger and opted for an amputation of the distal part of the finger at the level of the distal interphalangeal joint (Figure 10 of the Supplementary File).

Case 2

A 22-year-old woman with a venous-lymphatic vessel malformation of her right hand, wrist, and trunk with hand dysplasia- most probably based on a Klippel- Trenaunay spectrum syndrome- with naevus flammeus of her fingertips (digits 3/4/5). She was referred to our department after incomplete resection and a local recurrence of a retiform/composite hemangioendothelioma (a local aggressive vessel tumor) on her third finger for further surgical therapy (Figure 11 of the Supplementary File).

Figure 11: Tumor preoperatively and intraoperative defect with SISAP-flap for cover.

After histologically confirming complete resection, we closed the defect using our SISAP-flap successfully (Figures 12 and 13 of the Supplementary File).

Figure 12: First day after operation with complete flap perfusion

Figure 13: 12 weeks postoperative result

Case 3

A 24-year-old man with a ring avulsion lesion at the level of his left proximal interphalangeal joint of his 4th finger was referred to our unit. On arrival, we observed an amputate on ice with an extra fracture of the distal phalanx, a rupture of the distal extensor tendon at the level of the insertion (Figure 14), and a massive elongation of both neurovascular bundles over the hole amputation site.

Figure 14: Pre- and postoperative X-rays of the third case with palmar luxation of the basis of the distal phalanx and k-wire refixation.

On the explicit wish of the patient, we closed the central defect of his nondominant hand using our SISAP-flap as a wrap-around flap and the lateral defects with the full-thickness skin from the palmar part of the amputation. Five days later- after removing the intraoperative dressing- we found a vital flap but almost no take of the skin graft, mainly because of its rigidity and not using a tie-over. With further conservative regime, the rest of the defects healed well but the finger contracted because of a re-rupture of the extensor tendon. Therefore, we did a repositioning of the flap with a temporary K-wire fixation of the proximal interphalangeal joint after removing the small rest of the distal phalanx. Further wound healing was uneventful and the patient was satisfied with the overall aspect of his finger (Figure 15).

Figure 15: Pre- and intraoperative defect with closure using a SISAP-flap and K-wire fixation and postoperative result.

Discussion

Most typical deglovement injuries or other extended soft tissue defects leave a denudate finger behind, which is hard to cover using thin pliable soft tissue. In most cases, treatment option is limited. Despite free tissue transfer or replantation, local options are few, including further proximal amputation, ray resection, or local pedicled flaps. We recently described one of these replantations. With further cadaver studies, we derived our novel flap from the well-known DMCA flap. Since the first description of the DMCA flap in 1990 (4,5) and its modification, the flap quickly became a part of the plastic armamentarium for coverage of soft tissue defects of the hand. (6,7) Despite its easy use, the flap is not suitable for deglovement injuries or injuries with extended loss of soft tissue because of its insufficient length to cover the dorsal and palmar sides. Currently, the ongoing discussion over free tissue transfer- for example, free wrap-around toes (8) or others digits (9)- in extended soft tissue defects of fingers (10) there is still a lack of local surgical options by absent microsurgical expertise or equipment. Furthermore, recent studies (11) that have shown satisfying results in replantation after complete ring avulsion still do not address this issue. Thus, giving rise to the quest for alternative options. Most authors agree that even extended soft tissue defects in finger injuries are worth reconstructing (12). We have shown in these selected cases that this newly-developed flap well may serve as a possible solution. The advantage of this procedure is a short operating time with a lower requirement for extensive vascular debridement and a limited recovery time to normal life. A disadvantage of our local flap compared to the flap of di Summa (13) is the missing sensory potential, because of the length of our flap, which crosses the wrist crease dorsally. To the best of our knowledge, this is the first description of the SISAP-flap to cover extended soft tissue of the fingers. All three patients achieved sufficient functional and cosmetic outcomes and were satisfied with daily usability of their digits.

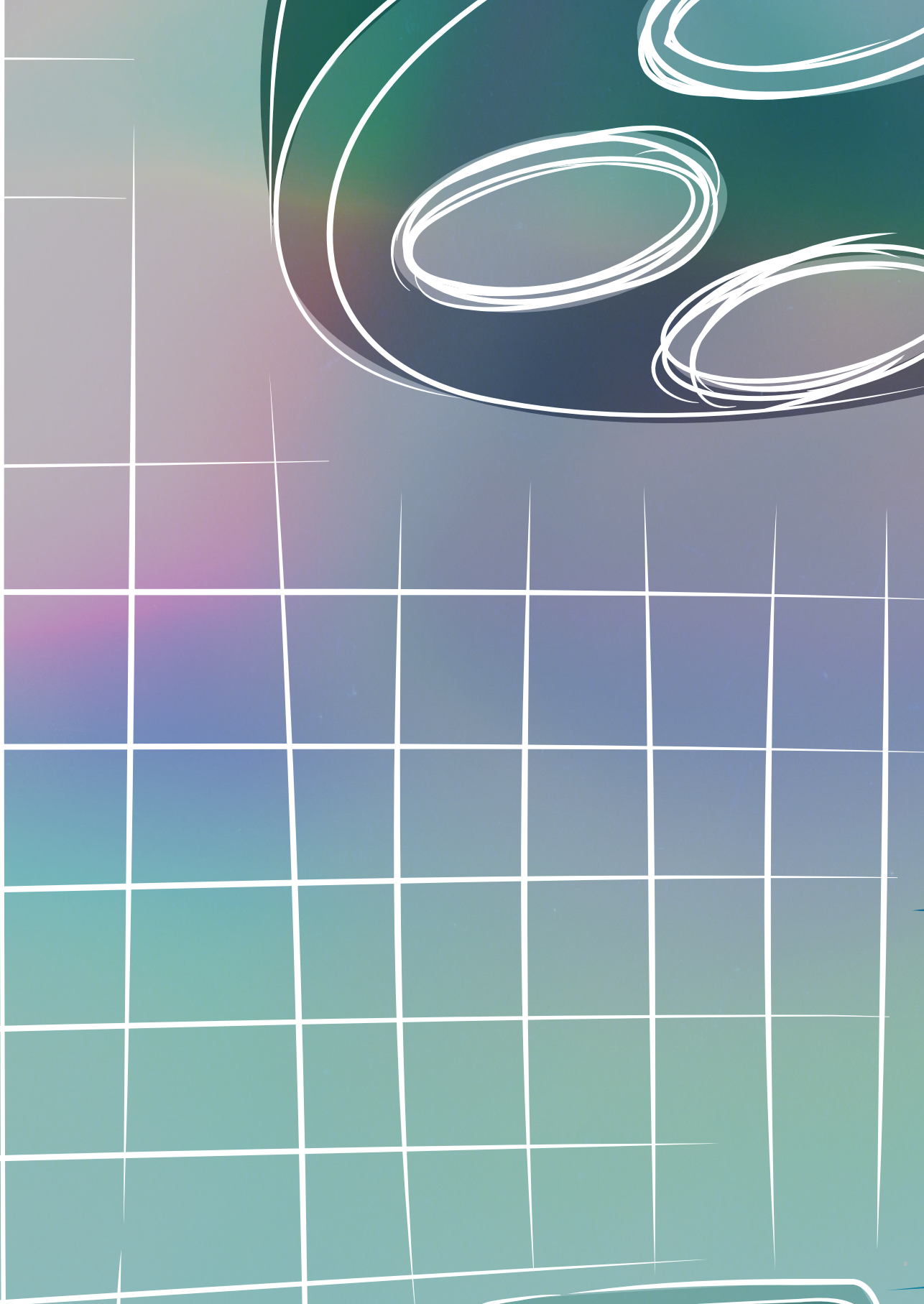
Conclusions

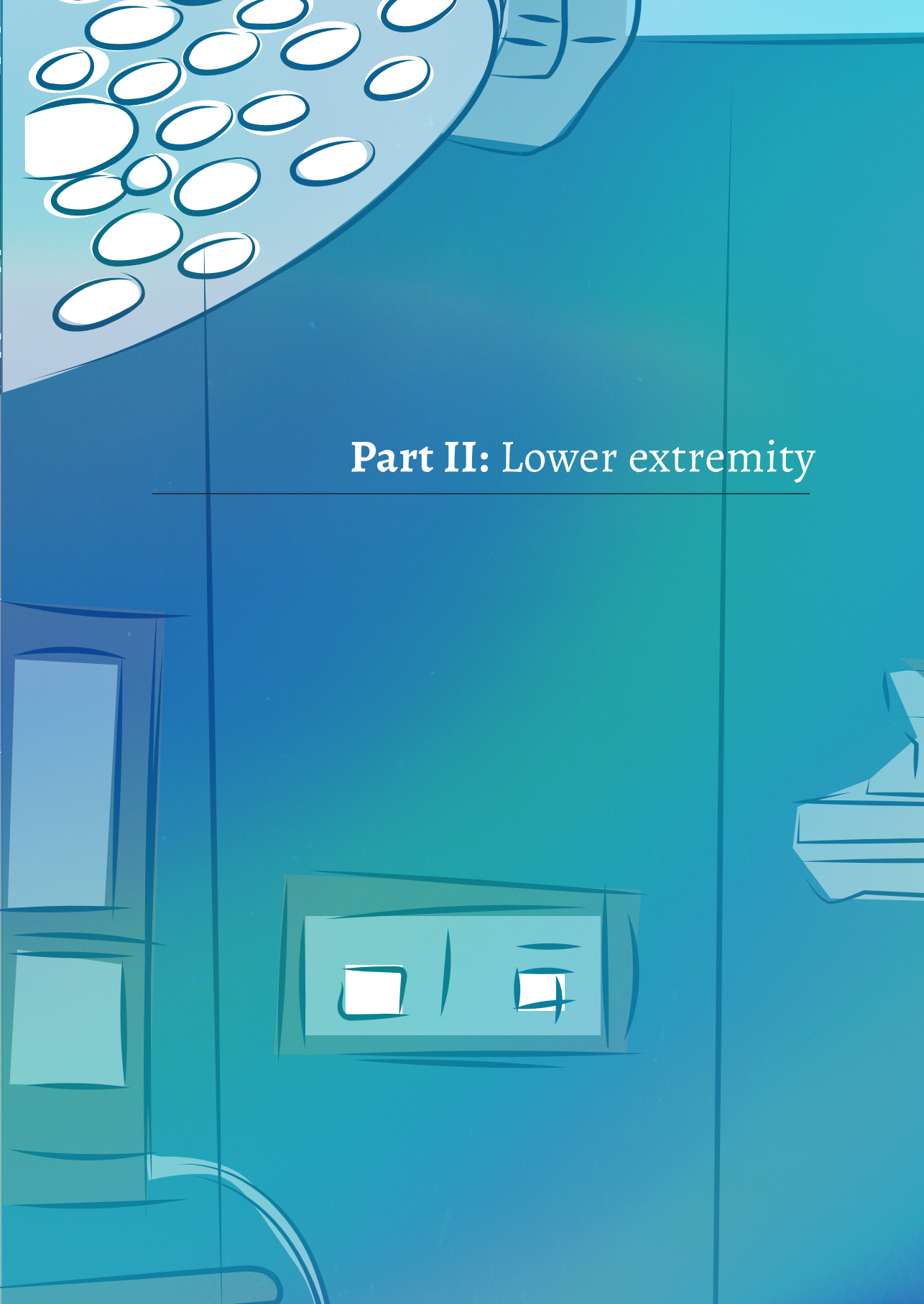
The novel SISAP-flap is an easier procedure for extended-sized soft tissue defects of the hand compared to free tissue transfer or replantation. With support from our cadaver study, where we demonstrated the anatomical base of the SISAP-flap, we presented three cases before and after modification and their clinical outcomes using this new technique. With a relatively short operating time for harvesting and in setting, this procedure is straightforward and shows promising results after modification of the dissection protocol. Loss of function and donor-site morbidity

is low combined with a short recovery time. We advise this method primarily for patients who are not suitable or willing for free tissue transfer or replantation or absence of amputates. In selected cases, this type of flap is a helpful option and should be added to the reconstructive armamentarium. Larger series are necessary to further delineate the advantages, disadvantages, and other indications of the SISAP flap. To the best of our knowledge, this is the first description of the SISAP flap in literature.

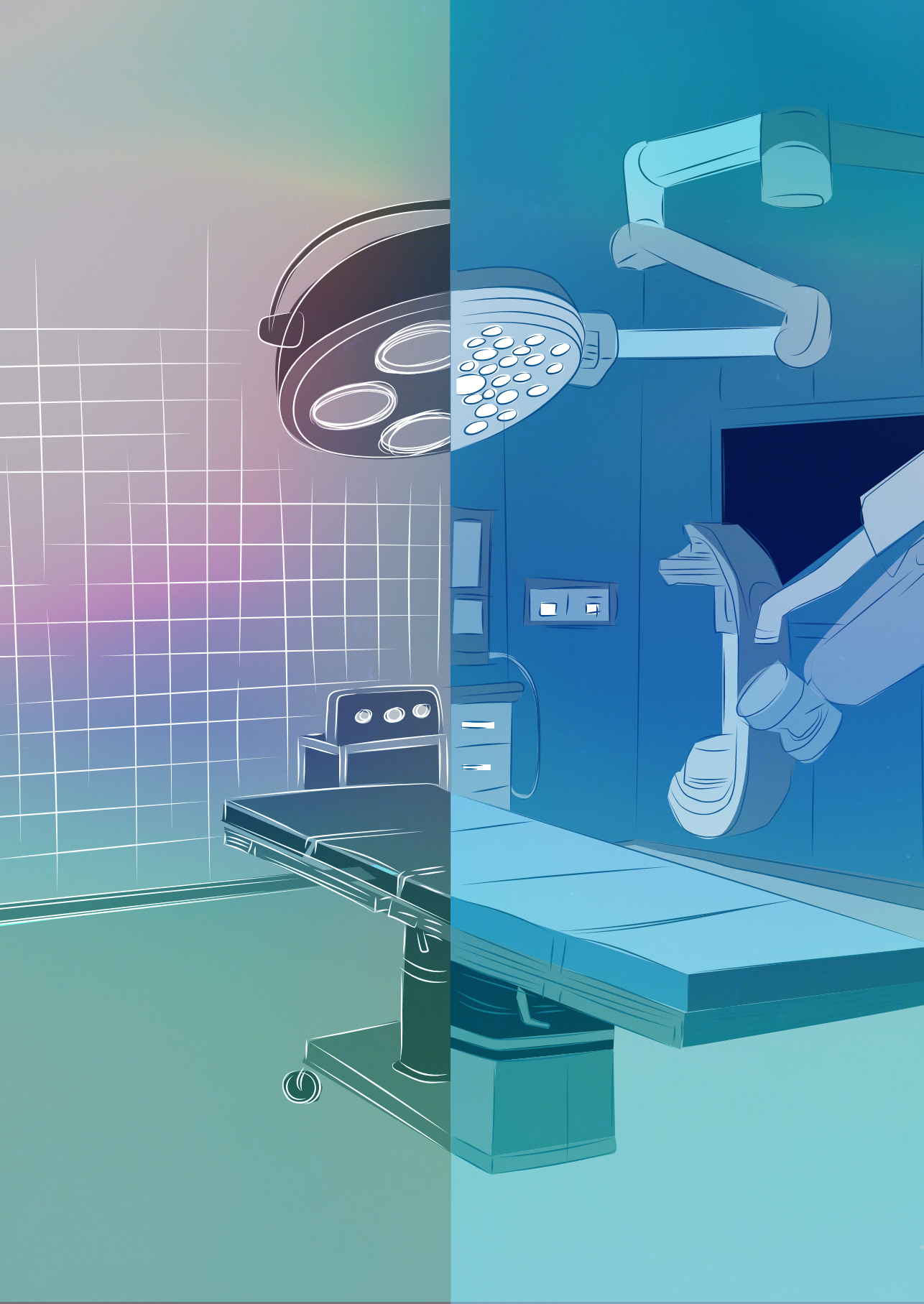
References

1. Wagner T, Slater N, Ulrich D. Extended distally based DMCA flap in combination with autologous amputate skin transplantation as a salvage procedure for ring avulsion injury. Eur J Plast Surg 2016;39:69–72.
2. Wagner T, Hummelink S, Mathot F, Ulrich D. The anatomic relationship of dorsal arterial perforators of the distal forearm, wrist, and dorsum of the hand with conclusions for the clinic. J Plast Reconstr Aesthet Surg 2023;83:141–7.
3. Herold C, Vogt P, Strub D, Spies M. Delayed DMCA-flap in a case of infection in the finger. Handchir Mikrochir Plast Chir 2008;40(2):138–42.
4. Quaba AA, Davison PM. The distally-based dorsal hand flap. Br J Plast Surg 1990;43(1):28–39.
5. Maruyama Y. The reverse dorsal metacarpal flap. Br J Plast Surg 1990;43(1):24–7.
6. Gregory H, Heitmann C, Germann G. The evolution and refinements of the distally based dorsal metacarpal artery (DMCA) flaps. J Plast Reconstr Aesthet Surg 2007;60(7):731–9.
7. Webster N, Saint-Cyr M. Flaps based on the dorsal metacarpal artery. Hand Clin 2020;36(1):75–83.
8. Tang L, Zhou X, Huang Y, et al. Application of wrap-around great toe flap combined with medial plantar artery perforator flap for completely degloved fingers. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi 2022;36(4):456–60.
9. Rawles RB, Deal DN. Treatment of the complete ring avulsion injury. J Hand Surg Am 2013;38(9):1800–2.
10. Chi Z, Yang P, Song D, et al. Reconstruction of totally degloved fingers: a novel application of the bilobed spiraled innervated radial artery superficial palmar branch perforator flap design provides for primary donor-site closure. Surg Radio Anat 2017;39(5):547–57.
11. Ozaksar K, Toros T, Sugun TS, Kayalar M, Kaplan I, Ada S. Finger replantations after ring avulsion amputations. J Hand Surg Eur Vol 2012;37(4):329–35.
12. Adani R, Marcoccio I, Castagnetti C, Tarallo L. Long-term results of replantation for complete ring avulsion amputations. Ann Plast Surg 2003;51(6):564–8.
13. di Summa PG, Davies K, Hart A. The first dorsal metacarpal propeller perforator (FDMP) flap for finger reconstruction. Case Rep Plast Surg Hand Surg 2020;7(1):94–7.





Part II: Lower extremity



Chapter 5

The proximally based long peroneal muscle turnover flap: novel salvage flap for small to medium-sized defects of the knee

Till Wagner, Pieter Hupkens, Nicholas J. Slater, Dietmar J.O. Ulrich

Journal of Plastic, Reconstructive & Aesthetic Surgery (2016) 69, 533-537

Summary

Background and aim: Coverage of soft-tissue defects of the knee due to multiple operations, trauma, and infection remains a surgical challenge. Often, these defects are repaired using free tissue transfer. The aim of this study was to find an easy and reliable local method of repair for small to medium-sized defects. The authors describe a new surgical option for tissue coverage using a proximally based long peroneal muscle turnover flap (LPTF) with split thickness skin graft.

Methods: Proximally based LPTFs were harvested and transposed into same size created defects in five cadavers. After optimizing this technique, it was clinically used in two patients with defects secondary to total knee replacement revisions.

Results: Average cadaver flap size was 4.7 x 15.8 cm allowing reach of all knee joint areas and was based consistently on a sufficient (2-mm-diameter average) proximal arterial branch of the anterior tibial artery. Donor sites were closed without tension. Subsequent application of the flap on two patients resulted in good functional outcome.

Conclusion: The proximally based LPTF is a new option available in the reconstruction of knee defects and should be added to the reconstructive surgeon's armamentarium of pedicled flaps,providing short operating time and promising clinical outcome.

Introduction

The area around the knee is well known for its paucity of soft-tissue coverage with higher risk of defects after trauma or infection. Several reconstructive options, including pedicled and free flaps, are well described. Nevertheless, reconstructive surgery of this area often remains a challenge. Therefore, we developed a simple, fast, and reliable method for closing small to medium sized defects of this area. In our opinion, the long peroneal muscle is a candidate for further evaluation (1,2). The long peroneal muscle is rarely described as a donor site for muscle flap coverage (3). We performed cadaver dissection to develop a step-by-step operating procedure of the proximally based long peroneal muscle turnover flap (LPTF). Subsequently, the flap was used in two patients to reconstruct medium-sized defects of the knee region.

Methods and patients

Cadaver dissection

This study included five cadaver dissections that were provided by the Willed Body Program. The cadavers were fresh frozen and defrosted just before preparation/ dissection. The limbs showed no evidence of peripheralvascular disease or other trauma. First, we marked theanatomical landmarks of the fibula. The incision line was centered over the fibula (Figure 1). After identification of the peroneal compartment, the compartment was opened and the distal portion of the long peroneal muscle wasidentified at the site of the peroneal tendon. After careful dissection of the muscle from distal to proximal, the peroneal nerve and its two branches were identified. Following the nerve from distal to proximal, we consistently found a small cranial perforating artery about 4 cm distal from the most cranial tip of the fibula (Figure 1).

Figure 1: Cadaver dissections. a. The range of motion of the LPTF and the size of defects closable without tension (excised skin) are demonstrated. b. The most cranial position of the flap is illustrated. c. The most proximal sufficient perforator is demonstrated.

The diameter of this vessel was between 1.5 and 2.3 mm. After detaching the distal portions of the long peroneal muscle, the size and arc of rotation of the muscle were measured. An adjacent area of skin matching the flap size was then resected to mimic the maximal defect size, and the flap was sutured in place using Prolene 4/0 (Figure 1). The donor site was primarily closed with Vicryl 3/0 running sutures at the level of the fascia, subcutaneously with Vicryl 3/0 interrupted sutures, and intracutaneously with Prolene 4/0 running sutures. Statistical analysis was performed using SPSS version 16.0 (SPSS, Chicago, IL, USA), without performing a formal test for differences due to limited sample size.

Operative technique

No preoperative planning with perforator mapping is required, except inspection and assurance of undamaged soft tissue in the area around the fibular head. With the patient in supine position, the operation is performed without blood tourniquet. First, debridement of the necrotic wound is performed followed by drawing a vertical line from the proximal to mid-fibula along the outer lateral rim of the fibula. This is followed by dissection of the fascia of the lower leg and identification of the distal portion of the peroneus longus muscle (Figure 2a).

Figure 2: Operative technique of LPTF.

Further cranial dissection with identification of the conjunction between peroneus brevis en longus muscles is performed, followed by preparation of the peroneal nerve until the most proximal perforating vessel branch is visualized (Figure 2b).

After fully mobilizing the muscular flap, dissection focuses on leaving the intercalating soft tissue for a tension-free fixation of the LPTF. A full open approach to the defect site is emphasized. Fixation of the flap with Vicryl 3/0 interrupted sutures is followed by split-thickness skin graft. The donor site is closed primarily without tension. Postoperative brace therapy with knee in extension or slight flexion at 10 degree is performed for 6 weeks.

Results

Cadaver study

The cadaver dissection yielded a consistent proximal vascular pedicle within a mean distance of 4.4 cm (range: 3.5-5 cm) distal of the cranial rim of the fibular head. The mean diameter of the perforating arterial branches was 2 mm (range: 1.5-2.3 mm). The pedicle penetrated the anterior intermuscular septum just above the ventral edge of the fibula. The average flap size was 7 (range: 4.0-5.5) x 15.8 (range 13-18) cm. This allowed for reaching of almost all portions of the knee joint. The pedicle length was 4.5 cm (range: 3.5-5.0 cm) Table 1.

Table 1 Characteristics of the proximally-based peroneal muscle turn-over flap

	Cadaver 1	Cadaver 2	Cadaver 3	Cadaver 4	Cadaver 5	Mean
Flap length (cm)	13	15	15.5	17.5	18	15.8
Flap width (cm)	4.5	4.5	5.5	5	4	4.7
Perforator location* (cm)	3.5	4.5	5	5	4	4.4
Perforator diameter (mm)	1.5	2.0	2.3	1.8	2.1	2.0

* distal distance from the cranial rim of the fibular head

Clinical cases

Patient 1

An 85-year-old female patient presented at our unit with an infection after total knee joint replacement. Prosthesis removal had been performed by the orthopedic surgeon and medial soft-tissue coverage had been attempted in the referring hospital using a medial gastrocnemius muscle flap with split thickness skin transplantation. Tertiary reconstruction was performed with a new prosthetic knee system. This was complicated by lateral soft-tissue necrosis encompassing the extra-long lateral incision. On the first consultation, a partial necrosis of the muscle flap was visible with partial exposure of the knee prosthesis (Figure 3a). Using the LPTF as a salvage procedure, a radical debridement was performed with direct reconstruction. The flap was harvested as described in the cadaver model. A perforating artery and vein could be found about 3 cm distal from the caput of the fibula. Vessel diameter was 1.8 mm. Flap size was 4.5 x 14 cm. Preparation time with split-thickness skin graft was 40 min. The clinical course was uneventful without functional impairment (Figure 3b). One year after surgery, follow-up was not possible due to multiple transient ischemic attacks and consecutive death.

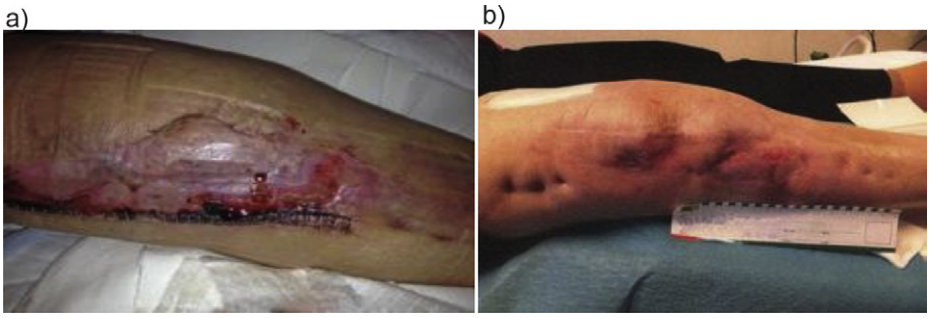


Figure 3: a. An 85-year-old female patient with total knee joint replacement and wound healing problems after gastrocnemius muscle flap. b. Result 3 months after using the proximally based long peroneal muscle turnover flap.

Patient 2

A 70-year-old female patient presented with wound-healingproblems between two parallel knee incisions for revisional knee surgery. Full-thickness necrosis of the skin and underlying soft tissue with no coverage of the patella was visible. The tibia plateau was covered with granulation tissue (Figure 4 a). After radical debridement, the lateral defect with exposed prosthesis was closed with an LPTF, whereas the medial bony defect was closed using a medially based gastrocnemius muscle flap with overlying split-thickness skin graft (Figure 4b). The LPTF size was 4 x 16 cm, operation time 50 min. The postoperative course was uneventful, and the wound healed primarily. Both patients were operated under single-sided spinal cord anesthesia because of poor physical conditions.

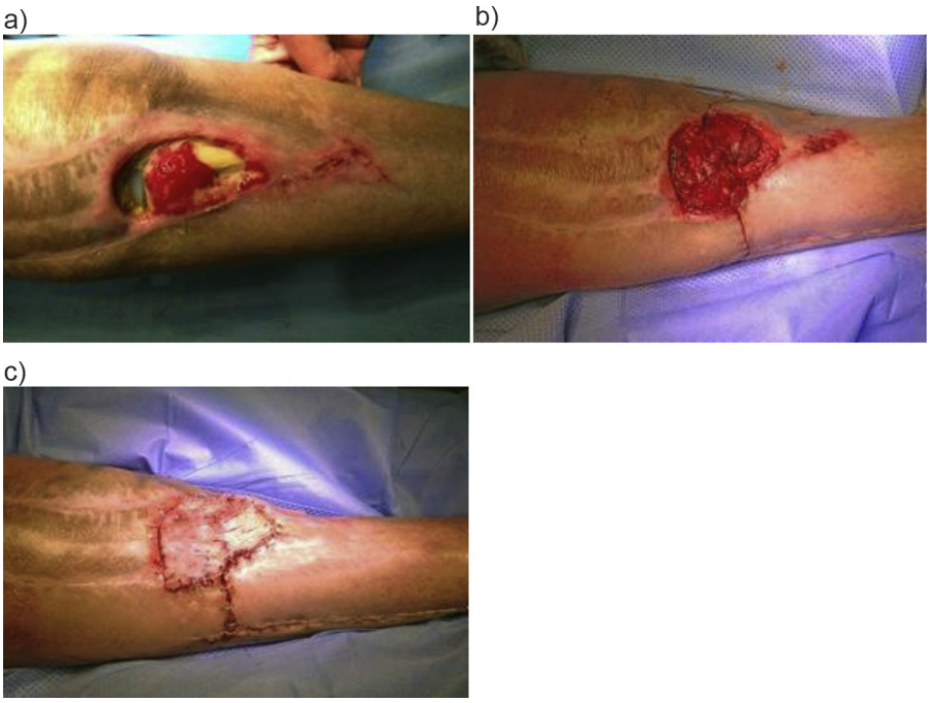


Figure 4: a. A 70-year old female patient with wound-healing problems due to revisional knee surgery. b. Closure of the craniolateral defect with exposed prosthesis with an LPTF. c. Split-thickness skin graft.

Discussion

Soft-tissue defects of the knee are well known after traumatic injuries or revision orthopedic surgery. Most patients requiring surgery for coverage will undergo one of the common reconstructive procedures. Several options have been described, including gastrocnemius muscle flap, distally based anterior lateral thigh flap, other locoregional pedicled flaps, or even free flaps for full soft-tissue coverage (4). However, many of these flaps have often already been used or have been rendered useless during revision surgery or due to the initial trauma. Flaps for covering knee defects in patients with poor physical conditions are limited and rarely described. These patients would be better served by reducing operating times and minimizing recovery time (5), with low donor-site morbidity and no loss of function. In patients with secondary of tertiary revision surgery, options are limited. Due to multiple incisions propeller of free-style perforator flaps are at significant risk to fail (6). To overcome these problems, we have modified the peroneus longus muscle flap originally described by Pers et al (3). The authors used the flap to fill cavities in the upper lateral part of the tibia. In the literature, the flap is not well established and mentioned. We have modified the flap into a turnover flap with greater arc of rotation. First, in a cadaveric model we showed that the proximally based LPTF is suitable for transposition into small to medium-sized defects around the knee joint, providing an average flap size of 4.7 x 15.8 cm. After this, we successfully applied the LPTF as a salvage flap in two patients with full-thickness soft-tissue defects after orthopedic revision surgery, resulting in good functional outcome. Advantages of the proximally based LPTF are its consistent pedicle characteristics, great range of motion, short and relatively simple operative procedure, and low donor-site morbidity. The LPTF offers good muscle coverage with a thin and pliable layer best suited for its reconstructive demands. The peroneal muscle is a type IV muscle following Mathes en Nahai's reclassification of Taylor and Pan's flap classification (7), with a dense web of intramuscular vascular connections between the branches of anterior tibial and peroneal arteries. Therefore, by using only one vascular pedicle, the risk of partial necrosis is low. The muscle flap itself might have a theoretical advantage in treating osteomyelitis or covering hardware (8). The donor site does not need split-thickness skin grafting, and the graft needed to cover LPTF flap can be easily harvested from a cosmetically acceptable donor site. We emphasize the utility of the flap for small to medium-sized defects of all areas of the knee. In combination with a medial gastrocnemius muscle flap, LPTF is a possible option for lager defects in physically limited patients. Its drawback might be the unpredictable flap size preoperatively, allowing doubt regarding easy coverage of greater defects. However, this might be resolved with preoperative imaging using ultrasound, computed tomography,

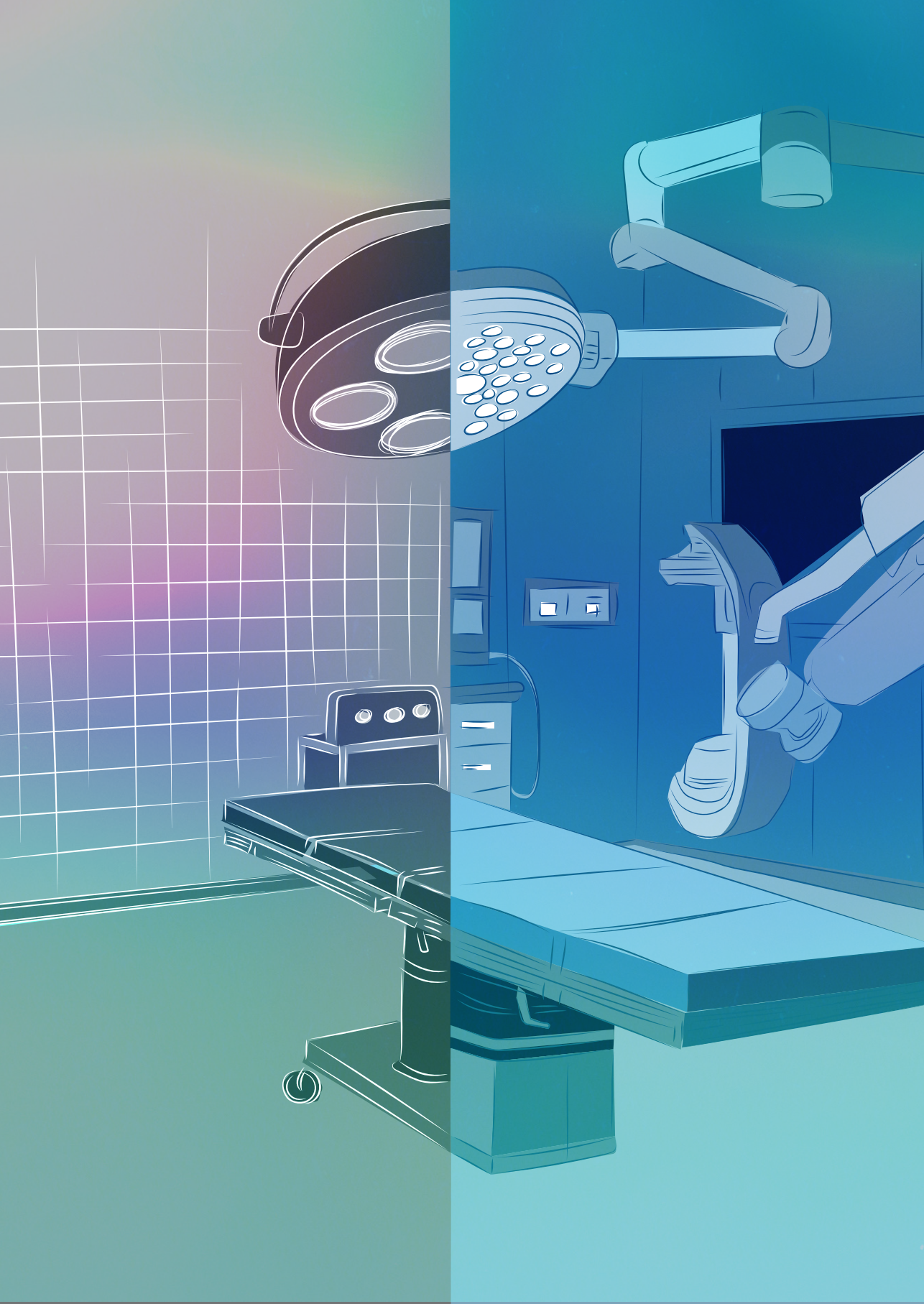
or magnetic resonance imaging (9). Further study is warranted to verify this. In addition, the flap seems to be a candidate for further study as a myocutaneous flap with a skin paddle or even as an osteomyocutaneous flap with fibular parts for the reconstruction of cranial tibial bony defects. In a cadaveric anatomical study of the lower leg, Hupkens et al. found adirect musculocutaneous perforator that pierced the peroneus longus muscle in 11.3% of legs (10). Provided preoperative ultrasound-based perforator mapping can be obtained, the LPTF is therefore a candidate for myocutaneous flap harvesting.

Conclusions

The novel proximally based LPTF with split-thickness skin coverage seems to be a valid and safe procedure for small to medium-sized defects of the lateral to medial aspect of the knee. With a short operating time of around 45 min for harvesting and inset, this procedure is reliable, fast, and shows promising results. Loss of function is minimal with low donor-site morbidity and a short recovery time. We advise this method primarily for older patients in poor physical condition with limited options of reconstructive procedures. Larger series are warranted to further delineate advantages, disadvantages, and indications of the LPTF.

References

1. Cho BC, Kim SY, Park JW, Baik BS. Blood supply to osteocutaneous free fibula flap and peroneus longus muscle: prospective anatomic study and clinical applications. Plast Reconstr Surg 2001;108:1963-71.
2. Villarreal PM, Monje F, Ganan Y, Junquera LM, Morillo AJ. Vascularization of the peroneal muscles. Critical evaluation in fibular free flap harvesting. Int J Oral Maxillofac Surg 2004;33: 792-7.
3. Pers M, Medgyesi S, Kirkby B. Peroneus longus muscle flap. In: Strauch B, Vasconez LO, Hall-Findlay EJ, editors. Grabb's encyclopedia of flaps. 2nd ed. Philadelphia: Lippincott-Raven; 1998. p. 1779-80.
4. Pu LLQ, Levine JP, Wei F. Reconstructive surgery of the lower extremity. St. Louis: Quality Medical Publishing; 2013. p.303-68.
5. Mitsala G, Varey AH, O'Neill JK, Chapman TW, Khan U. The distally pedicled gracilis flap for salvage of complex knee wounds. Injury 2014;45:1776-81.
6. Georgescu AV. Propeller perforator flaps in distal lower leg: evolution and clinical applications. Arch Plast Surg 2012;39: 94-105.
7. Tylor GI, Pan WR. Angiosoms of the leg: anatomic study and clinical implications. Plast Reconstr Surg 1998;102:599-616.
8. Pallua N, Ulrich D. Expression of basic fibroblast growth factor and transforming growth factor-Beta 1 in patients with fasciocutaneous and muscle flaps. Plast Reconstr Surg 2003 Jan; 111(1):79-82. discussion 83-4.
9. Pratt GF, Rozen WM, Chubb D, Ashton MW, Alonso-Burgos A, Whitaker IS. Preoperative imaging of perforator flaps in reconstructive surgery: a systematic review of the evidence for current techniques: reply. Ann Plast Surg 2013;71:246.
10. Hupkens P, Schijns W, Van Abeelen M, Kooloos JG, Slater NJ, Ulrich DJ. Lateral lower leg perforator flaps: an anatomical study to localize and classify lateral lower leg perforators. Microsurgery 2015 Feb;35(2):140-7.



Chapter 6

The myocutaneous long peroneal flap: An anatomical study and its clinical application

Till Wagner, Joris Franken, Marijn Hameeteman, Dietmar J.O. Ulrich

Journal of Plastic Reconstructive Aesthetic Surgery. 2021 Mar;74(3):648-650

Dear Sir,

The knee joint and its surrounding are prone to complications after trauma or elective surgery because of its paucity of pliable soft tissue with higher risk of defects or infections. Despite the well-known different techniques (1) as first line treatment in reconstructive surgery, this area nevertheless remains a challenge. The aim of this study was to develop a solution to close small to medium defects of this area with minimal use of extra needed split skin grafts especially those after failed knee surgery where the gastrocnemius muscle has to be spared for revision endoprosthesis implantation in a setting without microscope or in elderly in poor physical state with already used gastrocnemius muscle flap. We performed primarily cadaver dissections to clarify vascularity and size of the skin island of the mcLPF and secondary to develop a standard operation protocol. First, we marked the anatomical landmarks of the fibula and centered the planned skin island over its proximal half and checked the primary closure with a pinch test. After incision of the skin island, the peroneal compartment was opened distally, identifying the lower part of the long peroneal muscle at the site of the peroneal tendon junction. After carefully dissection of the muscle from distal to proximal the peroneal nerve and its two branches were identified in combination with its most proximal vascular muscle pedicle. This vascular pedicle acts as the pivot point of the whole flap. We then dissected the skin island from lateral to central towards the skin perforators which were almost constantly located on a vertical line in the middle of the muscle. The length of the five cadaveric skin paddles was 19–24 cm (mean 21,2 cm), width was 3,5–4,5 cm (mean 4,1 cm) and the number of skin perforators 3–5 (mean 3,8 cm) (Figure 1).

Figure 1 Cadaver dissection which shows overall design with its anatomic landmarks, position of the pedicle (in average 4 cm distal of the fibular head), skin perforators and the possible range of motion of the flap (flap size 20 × 4 cm).

A – 72 year old diabetic female patient was presented to our unit by the orthopedic department with a chronic knee infection after failed patella tendon reconstruction one year ago. After orthopedic debridement with cartilage resection and cement spacer implantation a lateral patellar defect remained which we covered in the same operation with our mcLPF (Figure 2).

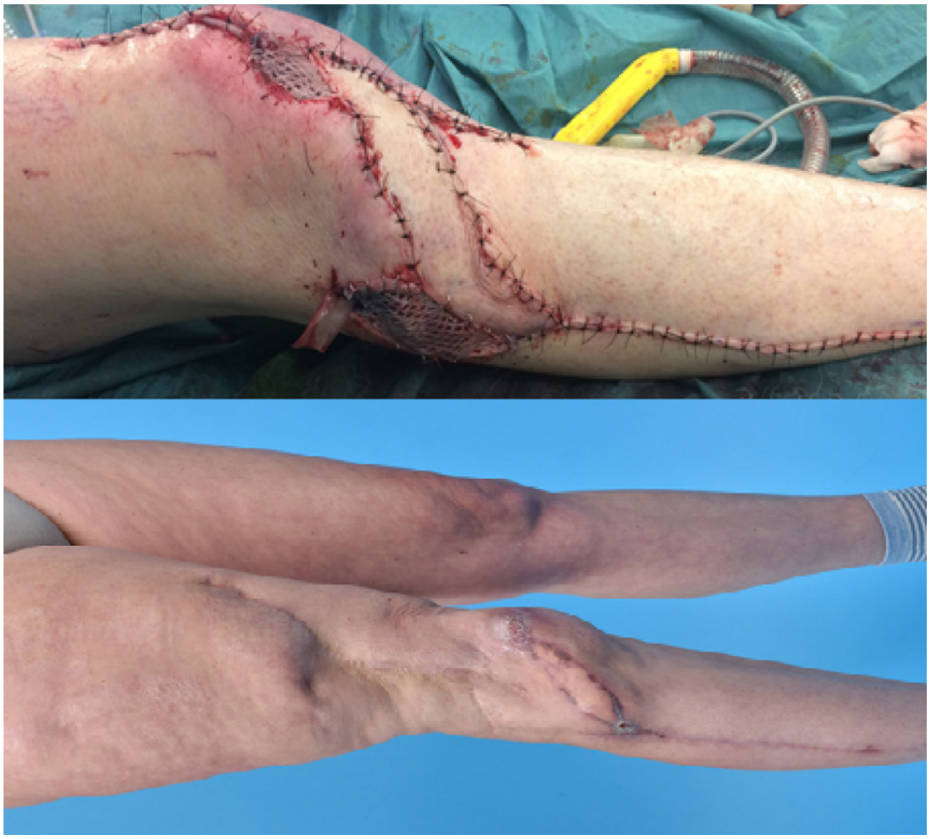


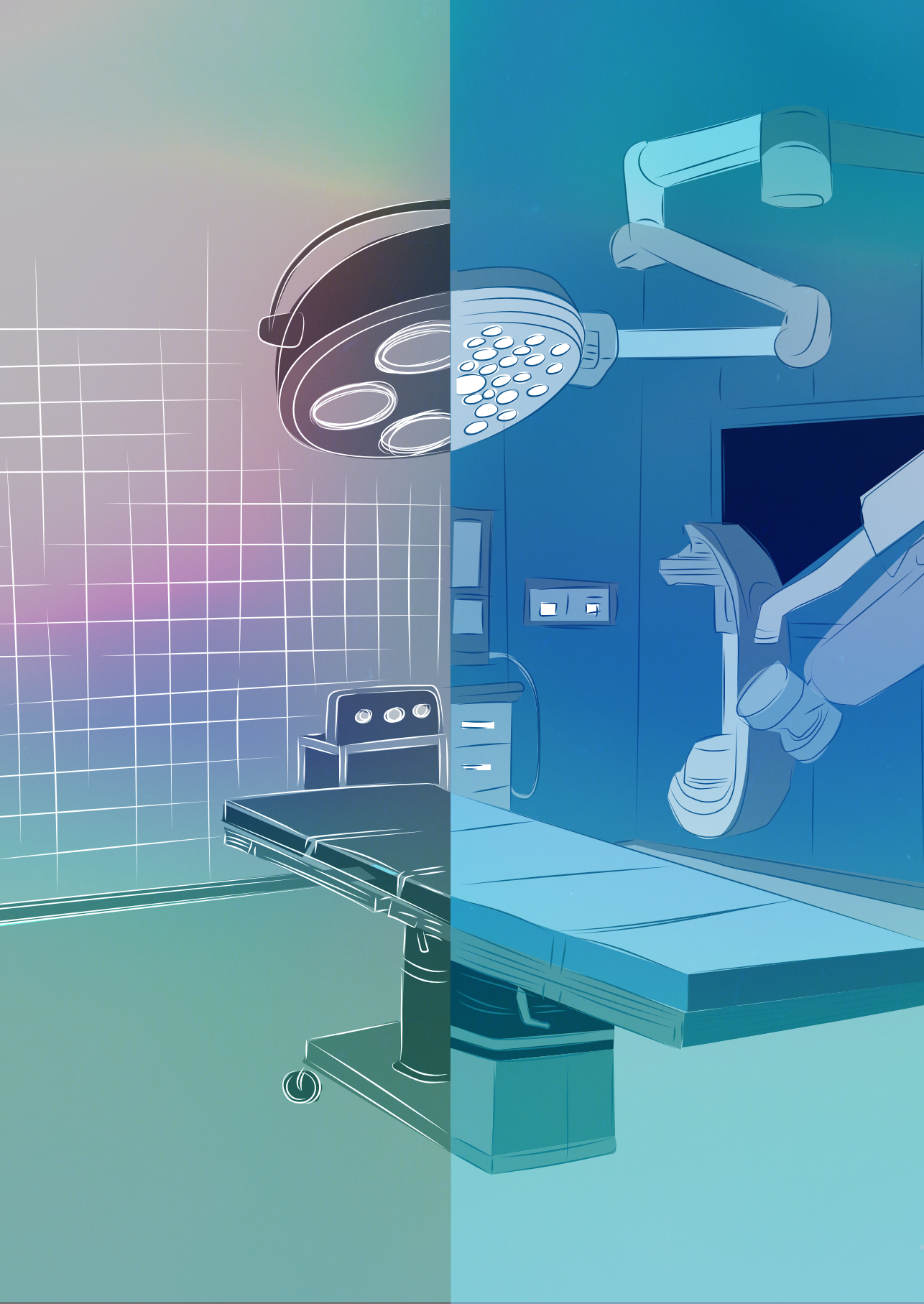
Figure 2 Immediate postop. result in a patient and long term result after 4 months in another patient.

We chose the mcLPF as our first choice sparing the gastrocnemius muscle flap for later reconstruction in combination with a revision knee prosthesis. Dissection time was 51 min. Inset of the flap was followed by a small split-thickness skin graft on the muscular pedicle to reduce skin tension at the level of the fibular head. Two days after the intervention the knee became septic again and after orthopedic revision with radical debridement we did an extra lateral gastrocnemius muscle flap for coverage. By persistent infection under iv antibiotics the patient opted for orthopedic knee amputation 3 weeks later. The area around the knee is prone to defects after

traumatic injuries or revision orthopedic surgery due to its paucity of pliable soft tissue. Flaps for covering knee defects in patients in poor physical conditions are limited and rarely described (2). In patients with multiple revisions surgical options are even more often limited. Because of multiple preexisting incisions free-style perforator propeller flaps have a higher risk to fail (3) in revision surgery. To address this issue, we modified the recently described peroneus longus muscle turn over flap originally described by Wagner (4) into a myocutaneous rotational flap to reduce needed amount of split skin graft and to enhance cosmetic outcome. The advantage of the flap is its deep and therefore save anatomical position of its cranial pedicle which serves as the pivot point. Little has been described about the anatomic blood supply of the skin directly adjacent to the long peroneal muscle (5). We could identify a relative constant line of small myocutaneous perforators in the middle of the long axis piercing the fascia directly overlaying the long peroneal muscle and nourishing the skin. Preparation of these skin island perforators could give an even larger range of rotation. In combination with a medial gastrocnemius muscle flap, mcLPF is a possible option for larger defects in physically limited patients or in settings without microsurgical expertise. This new myocutaneous muscle flap appears to be a relatively simple procedure to close small to medium-sized defects around the knee without or with minimal split skin grafts. With a short dissection time for harvesting and inset, this procedure is fast forward. Loss of function is minimal with low donor-site morbidity, good cosmetically result (Figure 2) and overall a short recovery time. We recommend this method primarily for patients of advanced age, in poor physical condition where the gastrocnemius flap has already been used, or in situations where the gastrocnemius muscle flap should be spared for delayed revision prosthesis reconstruction. Larger series are necessary to further delineate advantages, disadvantages and other indications of the mcLPF.

References

1. Rao AJ, et al. Soft tissue reconstruction and flap coverage for revision total knee arthroplasty. J Arthroplasty 2016; 31 (7):1529–38 .
2. Mitsala G, et al. The distally pedicled gracilis flap for salvage of complex knee wounds. Injury 2014; 45 (11):1776–81 .
3. Georgescu AV. Propeller perforator flaps in distal lower leg: evolution and clinical applications. Arch Plast Surg 2012; 39 (2):94–105 .
4. Wagner T, et al. The proximally based long peroneal muscle turnover flap: a novel salvage flap for small to medium-sized defects of the knee. J Plast Reconstr Aesthet Surg 2016; 69 (4):533–7 .
5. Ozalp T, Masquelet AC, Begue TC. Septocutaneous perforators of the peroneal artery relative to the fibula: anatomical basis of the use of pedicled fasciocutaneous flap. Surg Radiol Anat 2006; 28 (1):54–8.



Chapter 7

General discussion

Extremity reconstruction continues to evolve along a translational axis that links anatomical discoveries with surgical innovations. The research findings presented in this thesis address two areas where current solutions still have gaps in certain specific uncommon situations: the digits and the area around the peri-patellar knee area. By re-examining regional angiosomes and focusing on pedicled, loupe-based techniques instead of resource-intensive or unavailable microsurgery, research could potentially also expand access to functional limb preservation options for a broader patient population (1) in less developed countries.

In Part I of this thesis, based on an unusual case report of a degloving/amputation injury, the dorsal vascular architecture of the distal forearm, wrist, and hand was analyzed first to gain a more detailed insight into the specific arterial distribution pattern of the dorsal wrist. Systematic latex and radiographic injection studies confirmed two longitudinal axial rows of perforators adjacent to the fourth extensor compartment, consistently bridged by the 2-3 and, to varying degrees, the 4-5 intercompartmental supra-retinacular arteries (ICSAs). Based on these findings three clinical applications were explored and appeared feasible:

- An extended, distally based dorsal metacarpal artery perforator flap (DMCA) can cover circular ring avulsion injuries of class IVd without digital shortening (2, 3) with additional skin grafts;

- The super-extended intercompartmental supra-retinaculum artery perforator flap (SISAP), a circumferential design that combines distally based DMCA perforators with dorsal wrist bridging vessels to cover degloving defects well beyond the proximal interphalangeal joint (4);

- A distally based first DMCA propeller variant for thumb reconstruction that extends the Quaba concept to the radial side of the hand (5).

A total of five patients were treated with a 100% flap survival rate and without split skin grafting from the donor site, resulting in superior aesthetic outcomes. The SISAP flap itself is a potentially valuable option when the soft tissue envelope of a degloved finger is completely crushed or absent. The disadvantage of this design is that it is only available for a single finger, for example in a typical ring avulsion injury, and not for multiple finger avulsions on one hand, which are more common in occupational accidents. In addition, it can also be used for the reconstruction of oncological skin defects. A positive side effect of the flap is the limited scarring on the distal dorsal forearm and the fact that no additional flap need to be harvested causing additional

scarring. The most significant disadvantage of this flap is the small number of patients, which makes it difficult to assess the actual clinical value of these flaps in terms of their everyday usability. Another limitation during the investigation is that the perfusion pressure in cadaveric injections may not adequately reflect in vivo hemodynamics. Therefore, there is a risk of overestimating the usable flap length when using SISAP flaps. Another limitation is the heterogeneity of the injuries (traumatic vs. oncological), which may bias the results of the functional endpoints. Also confounded by the low number of patients, formal statistical analysis is not possible in either part of this study. Therefore, the published studies do not make this type of flap more reliable than case reports, and long-term results are also not yet available. The main reason for this is the relatively rare type of the injury, which occurs much less frequently than other soft tissue injuries of the hand, and in some cases, microsurgical reconstruction is likely to be the better treatment option.

Part II addressed small to medium-sized full-thickness composite defects in the knee area—particularly those appearing after repeated arthroplasty. Cadaver studies showed that the peroneus longus muscle is supplied proximally by a robust 1.5–2.3 mm thick branch of the anterior tibial artery, located approximately 4 cm distal to the fibular head (6). This pivot point allowed for either a turn-over muscle flap (LPTF) (7) or a myocutaneous variant (mcLPF) with reliable reach to the patella. Two frail patients with soft tissue shortening or prosthesis exposure were successfully treated with these procedures without complications. An additional advantage of all pedicled flaps in contrast with free flaps is- according to a cost comparison- a 31% reduction in direct operating room expenses compared to reconstruction with free flaps, which is mainly due to the use of a single team and the elimination of microvascular anastomosis sets (1), making them more suitable for less developed countries. Viewed critically, these cases also describe more or less case reports as a kind of proof of concept. In most cases, a gastrocnemius muscle flap is the flap of choice with reliable results in soft tissue defects with bone or implant exposure. Part II of this dissertation therefore describes only an alternative, convenient option for closing recurrent defects when the gastrocnemius muscle flap is no longer available and microsurgery is not possible or the patient is not suitable for it. On the downside, despite the relatively simple harvesting, the area to be covered is actually smaller than with a pedicled gastrocnemius muscle flap.

Microsurgical free flaps remain the gold standard for extensive soft tissue loss, but requires longer operating times, often a two-team approach, and intensive monitoring (8). Meta-analyses estimate complication rates of 15–25% in centers with lower volumes (9). In contrast, pedicled perforator-based approaches offer shorter theater times, reduced costs, and a flatter learning curve (1, 10).

Both parts of this thesis reinforce expanding the indications for local flaps rather than replacing them with free tissue transfers. Both approaches have their own side effects. Recent ultrasound-based mapping studies by Chim et al. localized consistent dorsal wrist perforators, but clinical use was limited to small transposition flaps (11). Our anatomical data confirm these observations and transfer them to a significantly expanded axial flap design used as a propeller flap. Similarly, the peroneus longus flap has been described sporadically, but not promoted as a proximally- based pedicled workhorse in the knee area (6). The turnover concept therefore offers an unusual option for closing a persistent reconstruction gap around the knee (7).

The clinical implication of this thesis concerning hand reconstruction means an alternative flap when the amputation status, the time to replantation, or the microsurgical resources preclude revascularization. The SISAP technique offers a potentially digit-saving alternative. With an operative time compared to digital replantation free flaps, making it attractive in low resource settings. The same applies for the new flaps of this thesis for the lower extremity reconstruction in the knee region: The LPTF and mcLPF circumvent the dilemma of the gastrocnemius as a "last resort." Both preserve muscle function synergistically with the peroneus brevis, and gait analyses revealed no significant weakness of eversion. Since the donor sites are primarily closed, aesthetic concerns should be minimal.

In summary, based on a clinical case the vascularity of the dorsum hand and lower arm were explored by fundamental anatomical research, which ultimately led to the further development of a new dorsal distally pedicled flap of the hand that can be used to cover more extensive soft tissue injuries of a single finger without microsurgical equipment or expertise.

The same concept was applied to the lower extremities to develop a fail-back option for periarticular knee surgery in cases of soft tissue defects, which also led to two additional, previously unpublished flap options: firstly, as a pedicled muscle flap with split-skin grafting for coverage, and secondly, as a myocutaneous flap with a more aesthetically pleasing long-term result.

The new flaps described in this thesis are only a beginning and may serve as a basis for further exploration and refinement of existing flaps so that their fields of application can be expanded, and may provide an impetus for the development of new flaps for defects for which no good solutions currently exist. Unanswered questions and future perspective:

1. Can dynamic fluorescence imaging quantify the perfusion contribution of ICSAs and thereby refine the design of the flap intraoperatively (12, 13)?

2. Is it possible to achieve sensory coaptation of the digital nerves within the SISAP flap design without compromising pedicle length?

3. Could the peroneal pedicle support vertical muscle-type chimeric constructs with a fibular osteosegment for complex periprosthetic defects?

Furthermore, prospective multicenter registries and randomized comparisons with free flaps are essential for all types of recently developed pedicled flaps to investigate durability, restoration of sensation, and patient-reported outcomes. Clinically, these innovations have potential implications for healthcare equity and sustainability. While precision imaging and robotic-assisted tools are capital intensive, they may ultimately reduce costs associated with complications and enable the shift of complex reconstructions to district-level hospitals. Their adoption could therefore extend advanced reconstructive care to regions where microsurgical programs are in their infancy or nonexistent, ultimately reducing disparities in limb preservation outcomes. Equally important, the anatomical methods used—dye injection, angiography, and quantitative pedicle morphometry—could provide a framework for future researchers interested in investigating other, less-studied angiosomes. For low- and middle-income countries, the modular nature of pedicled-plus technology solutions—basic flap surgery today, additional fluorescence imaging tomorrow—offers a scalable path to adoption.

From an ethical perspective, more comprehensive limb preservation options will reshape shared decision-making and shift discussions away from binary choices between "amputation or preservation" toward differentiated assessments of function, sensation, and psychosocial value. From an environmental perspective, shorter operating times and the elimination of disposable microsurgical items are consistent with the increasingly urgent demands for "green" surgery. Finally, the convergence of digital registries, wearable rehabilitation sensors, and patient-reported outcome platforms will lead to longitudinal data streams that enable continuous, evidence-based refinement of these techniques long after their introduction. Next-generation limb reconstruction is likely to be shaped by synergistic advances in intraoperative imaging, computer-aided planning, and regenerative biotechnologies. Combined fluorescence-based perfusion studies with LASER analysis is already evolving from qualitative "yes-no" signals to pixel-level quantification of perfusion and could be algorithmically coupled with augmented reality overlays that guide flap harvesting

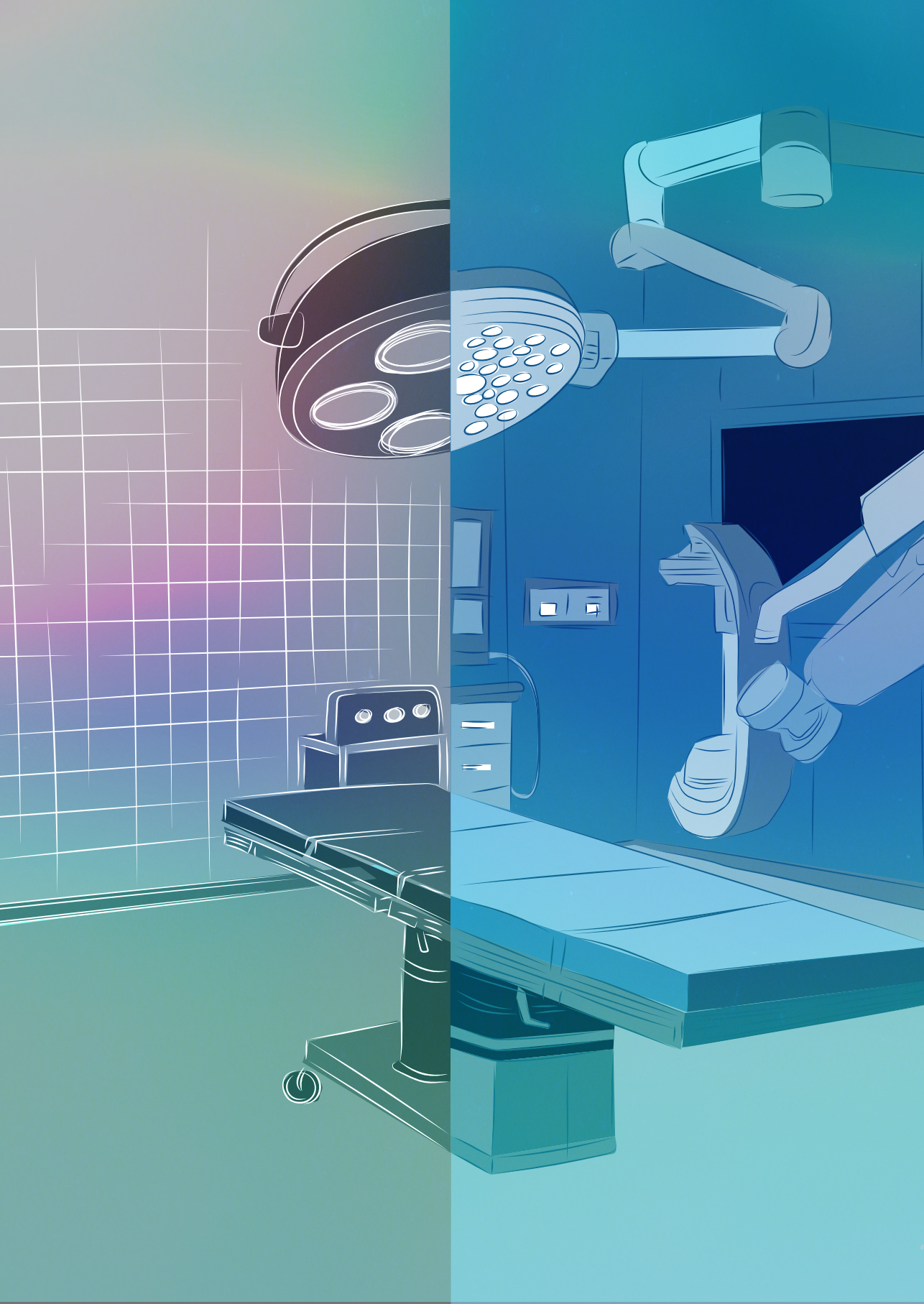
in real time (14). Customized, 3D-printed bony or tendinous scaffolds seeded with autologous mesenchymal cells promise to transform pedicled flaps into vascularized bioreactors, thereby accelerating osteo-integration and tendon regeneration (15, 16, 17). In the field of instrumentation, robot-assisted supermicrosurgical platforms—currently validated for 0.35 mm anastomoses—may soon popularize ultra-distal replantation and vascular supercharging of pedicled constructs (18). Parallel advances in single-cell transcriptomics are beginning to map the molecular choreography of ischemia-reperfusion injury (19), opening up therapeutic opportunities for perioperative gene editing or targeted biologics that could extend the safe ischemia time of flaps far beyond the current dogma. Finally, machine learning models trained on multicenter registries will refine patient-specific risk prediction and enable adaptive, data-driven surgical algorithms (20).

Finally, I would like to emphasize once again that, even in the coming 21st century, new surgical techniques can be developed cost-effectively in plastic surgery using simple and proven examination methods, as this work has shown. At the same time, however, the likelihood of a significant increase in costs is also growing, as the further development of these techniques appears to be possible only with the increasing use of expensive high-tech materials. Whether these financial investments provide additional added value is then a matter for public debate.

References

1. Innocenti M, Dell'Acqua I, Famiglietti M, Vignini L, Menichini G, Ghezzi S. Free perforator flaps vs propeller flaps in lower limb reconstruction: A cost/effectiveness analysis on a series of 179 cases. Injury. 2019;50 Suppl 5:S11-s6.
2. Quaba AA, Davison PM. The distally-based dorsal hand flap. Br J Plast Surg. 1990;43(1):28-39.
3. Maruyama Y. The reverse dorsal metacarpal flap. Br J Plast Surg. 1990;43(1):24-7.
4. Wagner T, Ulrich D. Anatomy, evolution, and clinical aspects of the superextended-intercompartmental-supraretinacular artery perforator flap (SISAP-flap): A proof of concept. J Plast Reconstr Aesthet Surg. 2024;93:215-21.
5. Wagner T, Hummelink S, Mathot F, Ulrich D. The anatomic relationship of dorsal arterial perforators of the distal forearm, wrist, and dorsum of the hand with conclusions for the clinic. |J Plast Reconstr Aesthet Surg. 2023;83:141-7.
6. Wagner T, Franken J, Hameeteman M, Ulrich DJO. The myocutaneous long peroneal flap: An anatomical study and its clinical application. J Plast Reconstr Aesthet Surg. 2021;74(3):644-710.
7. Wagner T, Hupkens P, Slater NJ, Ulrich DJ. The proximally based long peroneal muscle turnover flap: A novel salvage flap for small to medium-sized defects of the knee. J Plast Reconstr Aesthet Surg. 2016;69(4):533-7.
8. Yazar S, Lin CH, Wei FC. One-stage reconstruction of composite bone and soft-tissue defects in traumatic lower extremities. Plast Reconstr Surg. 2004;114(6):1457-66.
9. Eskander A, Merdad M, Irish JC, Hall SF, Groome PA, Freeman JL, et al. Volume-outcome associations in head and neck cancer treatment: a systematic review and meta-analysis. Head Neck. 2014;36(12):1820-34.
10. Alzahrani HA, Asiri MN, Humedi AM, Alammar J, Alrashed H, Hakami F. Free versus Pedicled Flaps for Hand Reconstruction: A Systematic Review and Meta-Analysis. JPRAS Open. 2025.
11. Chim H, Nichols DS, Chopan M. Ultrasound for Perforator Mapping and Flap Design in the Hand and Upper Extremity. J Hand Surg Am. 2023;48(6):595-601.
12. Shi C, Guo L, Song R, Xu H, Zhang Y. Prediction of pedicled flap survival preoperatively by operating indocyanine green angiography at 1,450 nm wavelength: an animal model study. Front Med (Lausanne). 2024;11:1389384.
13. Zötterman J, Tesselaar E, Elawa S, Elmasry M, Farnebo S. Perfusion Mapping of Flaps Using Indocyanine Green Fluorescence Angiography and Laser Speckle Contrast Imaging. Plast Reconstr Surg Glob Open. 2024;12(7):e5964.
14. Rook ARD, Chizari A, Knop T, Teunissen SEM, Wijbenga JG, Evers DJ, et al. Assessing DIEP flap perfusion using handheld wireless laser speckle contrast imaging: A proof of principle study. J Plast Reconstr Aesthet Surg. 2025;106:426-34.
15. Silva M, Gomes S, Correia C, Peixoto D, Vinhas A, Rodrigues MT, et al. Biocompatible 3D-Printed Tendon/Ligament Scaffolds Based on Polylactic Acid/Graphite Nanoplatelet Composites. Nanomaterials (Basel). 2023;13(18).
16. Warnke PH, Springer IN, Wiltfang J, Acil Y, Eufinger H, Wehmöller M, et al. Growth and transplantation of a custom vascularised bone graft in a man. Lancet. 2004;364(9436):766-70.
17. Bai Y, Wu N, Li X, Liu Z, Li K, Jiao T, et al. Recent progress of 3D printed responsive scaffolds for bone repair: A review. Materials Today Bio. 2025;35:102351.

18. Mihara M, Hara H, Wakana K, Owaki H, Mikami K, Miyamoto A, et al. The First Microsurgery-assisting Robot Equipped With an Automatic Instrument Exchange System and a Miniature Tool Kit. Plast Reconstr Surg Glob Open. 2025;13(9):e7072.
19. Zhang Z, Liu Y, Huang D, Huang Z. Single-Cell WGCNA Combined with Transcriptome Sequencing to Study the Molecular Mechanisms of Inflammation-Related Ferroptosis in Myocardial Ischemia-Reperfusion Injury. J Inflamm Res. 2024;17:6203-27.
20. Mansoor M, Ibrahim AF. The Transformative Role of Artificial Intelligence in Plastic and Reconstructive Surgery: Challenges and Opportunities. J Clin Med. 2025;14(8).



Chapter 8

Summary

Chapter 1: General Introduction

This opening chapter outlines the original motivations—based on individual clinical cases—that prompted me to initiate this project with its various research components. The results of these efforts ultimately culminated in this doctoral thesis.

Chapter 2: Distally Based DMCA Flap for Ring Avulsion Injury

This chapter describes the reconstruction of a severe ring avulsion injury using a distally based dorsal metacarpal artery flap (DMCA) in combination with an autologous skin graft from the amputation site. A 23-year-old male patient suffered a complex avulsion of the right index finger with complete amputation distal to the DIP joint and laceration of surrounding soft tissues. The amputated part was deemed unsuitable for replantation due to improper storage, as it was macerated. An extended DMCA-II flap was designed and harvested with the aim of maximizing finger length, preserving function, and achieving a cosmetically acceptable result. The defect was covered with this flap, and full-thickness skin grafts from the amputate were used to minimize donor site morbidity. Postoperative recovery was uneventful, with early hand physiotherapy and return to daily activities within three weeks. At six months, the patient demonstrates good range of motion in the MCP and PIP joints, intact perfusion, and acceptable sensory return.

This case illustrates the use of locoregional flaps when replantation is not possible. Despite advanced microsurgical techniques, the DMCA flap remains a valuable option due to its straightforward harvesting, short operating time, and reliable vascular supply. The result shows that even in complex finger injuries, careful flap planning and innovative use of available tissue can preserve finger length and function. To our knowledge, this is the first report describing the use of a distally based DMCA flap in combination with autologous amputation skin in such a case, adding a new option for reconstructive hand surgery.

Chapter 3: Dorsal Arterial Perforators of the Distal Forearm and Hand

This anatomical study investigates the vascular pattern of dorsal arterial perforators of the distal forearm, wrist, and dorsum of the hand. The aim was to improve the local flap design for challenging soft tissue defects of the hand and fingers, especially in cases unsuitable for free tissue transfer. Ten cadaver specimens were dissected to identify reliable perforators and their spatial distribution.

Two consistent rows of perforators were found: radial and ulnar to the fourth extensor compartment. These perforators were interconnected by subfascial axial arteries and supraretinacular intercompartmental arteries at the level of the dorsal wrist.

The findings suggest a unique distribution network capable of supporting a “super-extended” perforator flap. The clinical application of this concept was demonstrated in a 56-year-old woman with a soft tissue defect on her thumb. A distally based first dorsal metacarpal artery (FDMA) propeller flap was successfully designed and elevated, resulting in complete flap survival despite the patient's immunosuppressed status and history of heavy smoking.

This study provides practical anatomical insights for designing propellor flaps with extended reach, particularly for distal finger injuries. It highlights the potential of freestyle perforator flaps based on precise Doppler mapping, allowing surgeons to harvest tissue with minimized donor site morbidity. By elucidating the detailed anatomy of the dorsal perforators, the study lays the foundation for safer and more versatile reconstruction options in hand surgery. These findings not only expand anatomical knowledge, but can also be directly translated into clinically relevant applications, bridging the gap between cadaver research and patient care.

Chapter 4: SISAP-Flap- Super-Extended Arterial Perforator Flap for Finger Defects

The SISAP flap was developed to address a long-standing challenge in hand reconstruction: extensive soft tissue defects of the fingers, particularly in cases of avulsion or degloving injuries. Traditional options such as ray resection or free flaps often require extensive surgical time, microsurgical expertise, and prolonged recovery, making them unsuitable for certain patient populations.

Based on anatomical studies and cadaveric dissections, the SISAP flap incorporates a long pedicled flap from the distal forearm and dorsum of the hand, based on distal DMCA perforators and supercharged with intercompartmental supraretinacular arteries. The design allows for a flap length of up to 22 cm, sufficient to wrap around an entire finger and cover both dorsal and palmar aspects.

Clinically, the flap was used in three cases in young patients with complex finger trauma or tumor resections. In each case, the flap provided adequate soft tissue coverage and acceptable aesthetic and functional outcomes. Minor complications such as superficial necrosis were manageable. The main advantages of the SISAP flap are its locoregional harvesting, short operating time, and versatility, even in the absence of microsurgical equipment.

This flap expands the reconstructive options available for finger injuries, particularly in settings where free flaps are not feasible. The development of the SISAP flap

exemplifies translational research- moving from anatomical theory to clinical implementation. Although long-term studies and larger series are needed, early results indicate that this novel technique holds promise for treating complex hand injuries with less operative complexity and favorable patient outcomes.

Chapter 5: LPTF- Long Peroneal Muscle Turnover Flap for Knee Defects

Small to medium-sized knee defects are frequent after trauma, revision arthroplasty, or infection. In patients with multiple surgeries or comorbidities, conventional flaps such as the gastrocnemius may already be unavailable or unsuitable. The proximal-based long peroneal muscle-turnover flap (LPTF) was developed as a reliable alternative for these cases.

Cadaveric dissections confirmed a consistent vascular pedicle from the anterior tibial artery about 4.4 cm distal to the fibular head, with a mean vessel diameter of 2 mm. The flap demonstrated a broad arc of rotation and sufficient muscle bulk to fill soft tissue defects over the patella or joint capsule. Clinical application in two elderly patients with previous knee surgery and exposed prosthesis components showed that the LPTF could be harvested and inset in short time. Healing was uneventful, and donor site morbidity was minimal.

The LPTF provides an easy accessible, muscle-only flap that meets the needs of a subgroup of high-risk patients. It does not require microsurgery, shortens surgical time, and can be combined with split-thickness skin grafts. By repurposing the underutilized peroneus longus muscle, this flap offers a sustainable and reproducible technique for reconstructing lateral or anterior knee defects. Its simplicity and low risk profile make the LPTF an attractive choice, especially in resource-limited or urgent situations. The consistent anatomy of the flap and favorable outcomes in early cases support its inclusion in the armamentarium of reconstruction options for complex knee wounds.

Chapter 6: mcLPF – Myocutaneous Long Peroneal Flap for Knee Reconstruction

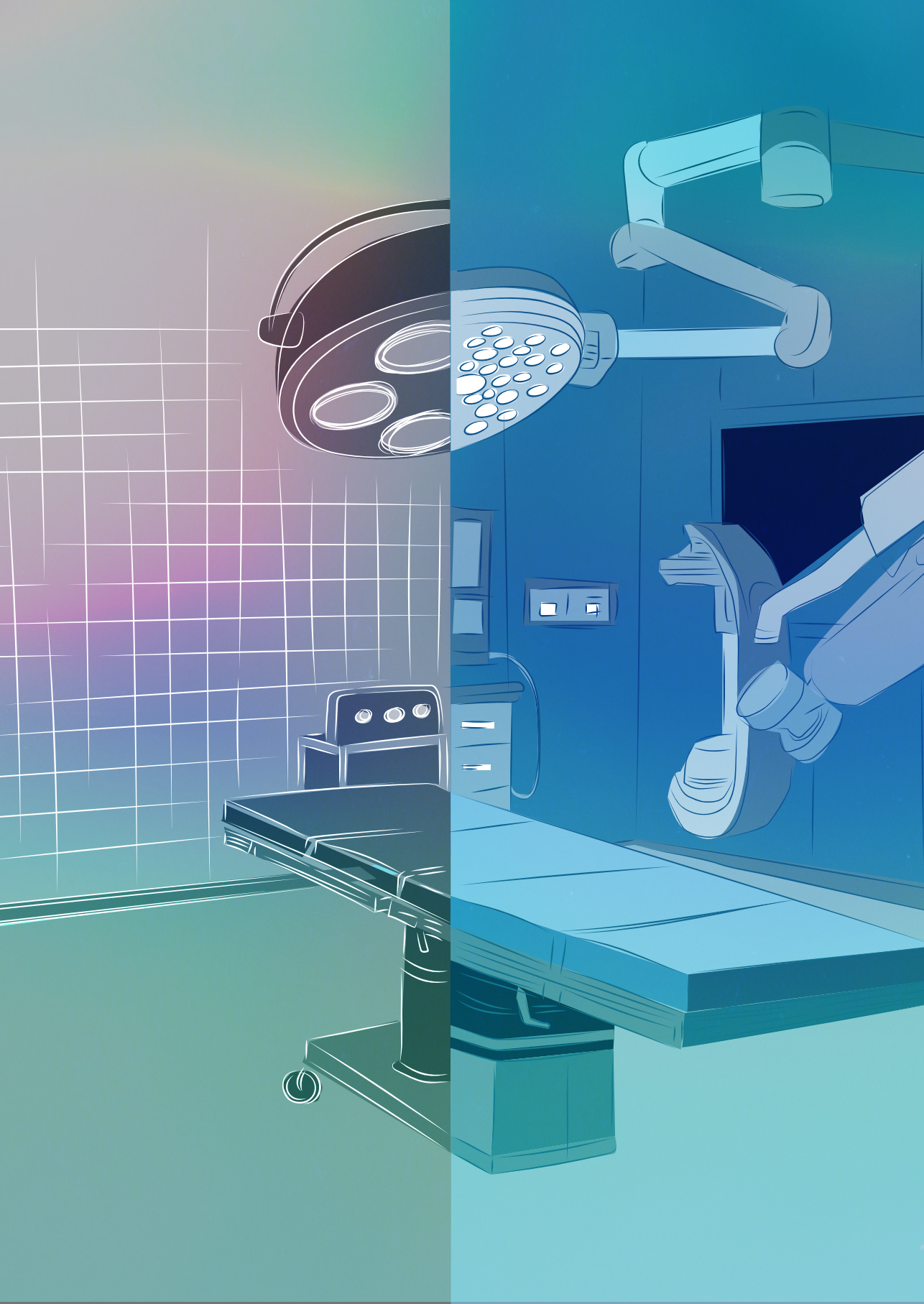
To further enhance the versatility of the LPTF, the myocutaneous long peroneal flap (mcLPF) integrates a skin paddle nourished by perforators directly overlying the long peroneal muscle. This addition allows defects to be covered with minimal to no need for split-thickness skin grafts, improving both aesthetics and healing.

Cadaver studies showed a consistent vertical line of 3–5 skin perforators located along the muscle's midline, allowing for a flap size of up to 24 × 4.5 cm. This design extends

the flap's reach and facilitates tension-free closure in anterolateral knee defects. A clinical case demonstrated its application in a 72-year-old diabetic woman with a chronic infected knee wound. Despite subsequent complications requiring additional intervention, the flap provided robust coverage and minimized secondary grafting.

The mcLPF is particularly useful in knee revision surgery, where previous use of gastrocnemius flaps and multiple incisions preclude other local options. It preserves the gastrocnemius for future procedures and minimizes donor site morbidity. In patients with limited mobility, the mcLPF rapid harvest and safe pedicle location make it an useful solution.

This evolution from muscle-only to myocutaneous flap reflects ongoing innovation in reconstructive surgery, offering tailored solutions for complex problems. While long-term data are still limited, the mcLPF demonstrates how anatomical insights can be transformed into helpful surgical advances with direct clinical benefit.



Chapter 9

Nederlandse samenvatting (Dutch summary)

Hoofdstuk 1: Algemene Inleiding

In het eerste hoofdstuk lichten wij de oorspronkelijke beweegredenen toe- gebaseerd op afzonderlijke klinische probleemgevallen- die mij ertoe brachten de verschillende onderzoeken, op te zetten. De daaruit voortgekomen bevindingen zijn gebundeld en hebben uiteindelijk geresulteerd in dit proefschrift.

Hoofdstuk 2: Distaal gebaseerde DMCA-lap voor een ringavulsie letsel

Dit hoofdstuk beschrijft de reconstructie van een ernstig ring avulsie letsel met behulp van een distaal gebaseerde dorsale metacarpaal arterie (DMCA) lap in combinatie met autologe huidtransplantatie van het geamputeerde deel. Een 23- jarige mannelijke patiënt had een complexe avulsie van de rechter wijsvinger, met volledige amputatie distaal van het DIP- gewricht en uitscheuren van het omliggende weefsel. Het geamputeerde deel, dat onjuist was opgeslagen, werd als niet-levensvatbaar beschouwd voor replantatie vanwege maceratie.

Een gewone, verlengde DMCA-II- lap werd toegepast met als doel het behoud van maximale vingerlengte, functiebehoud en een cosmetische acceptabel resultaat. Het defect werd bedekt met deze lap, en volledige dikte huidtransplantaten van het geamputeerde deel werden gebruikt om de morbiditeit van de donorplaats te minimaliseren. Het postoperatieve herstel verliep vlot; fysiotherapie werd vroeg opgestart en de patiënt hervatte zijn dagelijkse activiteiten binnen drie weken. Na zes maanden vertoonde hij een goede bewegingsuitslag van het MCP- en PIP- gewricht, een intacte doorbloeding en een aanvaardbaar niveau van sensibiliteit.

Deze casus illustreert het nut van locoregionale lappen wanneer replantatie niet mogelijk is. Ondanks de geavanceerde aard van microchirurgische technieken blijft de DMCA-lap een waardevolle optie vanwege zijn relatief eenvoudige uitvoering, korte operatie tijd en betrouwbare vascularisatie. De uitkomst toont aan dat, zelfs bij complexe vinger letsels, het behoud van vinger lengte en functie haalbaar is door zorgvuldige lappen planning en innovatief hergebruik van beschikbaar weefsel. Voor zover bekend is dit de eerste beschrijving van het gebruik van een distaal gebaseerde DMCA-lap in combinatie met autologe huid van het geamputeerde deel in deze context, dat een waardevolle uitbreiding vormt van het reconstructieve repertoire voor hand chirurgen.

Hoofdstuk 3: Dorsale arteriële perforatoren van de distale onderarm en hand

In deze anatomische studie is het vaat patroon van dorsale arteriële perforatoren van distale onderarm, pols en handrug onderzocht. Het doel was om het ontwerp

van lokale lappen te verbeteren voor uitdagende weke delen defecten van hand en vingers, met name in gevallen die ongeschikt zijn voor vrije weefsel transplantatie. Tien kadaver preparaten werden gedissecteerd om betrouwbare perforatoren en hun ruimtelijke verdeling in kaart te brengen.

Er werden twee rijen perforatoren gevonden: radiaal en ulnair van het vierde strekker compartiment. Deze perforatoren waren onderling verbonden door subfasciale axiale arteriën en supraretinaculaire intercompartimentele arteriën ter hoogte van de dorsale pols. De bevindingen suggereren een uniek distributie netwerk dat in staat is een "super-extended" perforator lap te ondersteunen. Klinische toepassing van dit concept is vervolgens aangetoond bij een 56- jarige vrouw met een weke delen -defect aan de duim. Een distaal gebaseerde propeller lap van de eerste dorsale metacarpaal arterie (FDMA) werd met succes ontworpen en geprepareerd, wat resulteerde in volledige lappen overleving ondanks de immunosuppressieve status van de patiënte en haar rookverleden. Deze studie levert klinisch toepasbare anatomische inzichten op voor het ontwerpen van propeller lappen met groter bereik, vooral voor distale vinger letsels. Het onderstreept het potentieel van vrije-stijl perforator lappen gebaseerd op nauwkeurige Doppler onderzoek, waardoor chirurgen weefsel kunnen oogsten met minimale donor plaats morbiditeit, Door de gedetailleerde anatomie van dorsale perforatoren te verduidelijken, legt deze studie de basis voor veiligere en veelzijdigere reconstructieve opties in de hand chirurgie. De bevingen verbeteren niet alleen de anatomische kennis, maar vertalen zich ook direct naar klinisch relevante toepassingen, waarmee de brug wordt geslagen tussen kadaver onderzoek en patiënten zorg.

Hoofdstuk 4: SISAP- lap – Super-extended Arteriële Perforator lap voor vinger defecten

De SISAP- lap is ontwikkeld om een al langer bestaande uitdaging bij hand reconstructie aan te pakken: uitgebreide weke delen defecten van de vingers, met name in gevallen van avulsie- of degloving-letsels. Traditionele opties zoals straal-resectie of vrije lappen vereisen vaak veel operatie tijd, microchirurgische expertise en een langdurig herstel, waardoor ze voor bepaalde patiënten populaties soms minder geschikt zijn.

Op basis van anatomische studies en dissecties van kadavers bleek het mogelijk de SISAP-lap een lange gesteelde lap van de distale onderarm en de rug van de hand te oogsten, gebaseerd op distale DMCA-perforatoren t met extra bloedvoorziening geleverd door de intercompartimentele supraretinaculaire slagaders. Het ontwerp maakt een laplengte tot 22 cm mogelijk, voldoende om een hele vinger te omwikkelen en zowel de dorsale als de palmaire zijde te bedekken.

Klinisch werd de lap gebruikt in drie gevallen bij jonge patiënten met complex vingertrauma of tumorresecties. In elk geval zorgde de flap voor voldoende bedekking van het zachte weefsel en aanvaardbare esthetische en functionele resultaten. Kleine complicaties zoals oppervlakkige necrose waren beheersbaar. De belangrijkste voordelen van de SISAP-lap zijn de lokale oogst, de korte operatietijd en de uitgebreide toepassingsmogelijkheden , zelfs zonder microchirurgische apparatuur.

Deze lap breidt de reconstructieve mogelijkheden voor vinger letsels uit, met name in situaties waarin vrije flappen niet haalbaar zijn. De ontwikkeling van de SISAP-flap is een voorbeeld van translationeel onderzoek: de overstap van anatomische theorie naar klinische toepassing. Hoewel lange termijnstudies en grotere series nodig zijn, wijzen de eerste resultaten erop dat deze nieuwe techniek veelbelovend is voor de behandeling van complexe handletsels met minder operatieve complexiteit en gunstige resultaten voor de patiënt.

Hoofdstuk 5: LPTF- Long Peroneal muscle Turn over Lap voor knie defecten

Kleine tot middelgrote knie defecten komen vaak voor na trauma, revisie- arthroplastiek of infectie. Bij patiënten met meerdere operaties of comorbiditeiten zijn conventionele lappen zoals de gastrocnemius mogelijk al uitgeput of ongeschikt. De proximaal gebaseerde lange peroneus spier omklap lap (LPTF) werd ontwikkeld als betrouwbaar alternatief in dergelijk gevallen.

Kadaver dissecties bevestigden een consistente vasculaire vaatsteel van de arteria tibialis anterior op ongeveer 4,4cm distaal van het fibula kopje, met een gemiddelde diameter van 2mm. De lap vertoonde een ruime rotatie boog en voldoende spier massa om weke delen- defecten boven de patella of gewrichtscapsule op te vullen.

Klinische toepassing bij twee oudere patiënten met eerdere knie operaties en blootliggende prothesen toonde aan dat de LPTF binnen korte operatie tijd kon worden geoogst en gehecht. Genezing verliep zonder complicatie en donor plaats morbiditeit was minimaal.

De LPTF is een gemakkelijke toegankelijke spier lap die voldoet aan de behoefte van een kwetsbare patiënten groep. De techniek vereist geen microchirurgie, verkort de operatie tijd en kan worden gecombineerd met partiele dikte huid transplantaten. Door gebruik te maken van de onderbenutte musculus peroneus longus biedt deze lap een duurzame en reproduceerbare methode voor reconstructies van laterale of anterieure knie defecten.

Vanwege de eenvoud en het lage risico profiel is de LPTF bijzonder geschikt in urgente situaties of situaties met weinig alternatieve bedekkingsmogelijkheden, De consistente anatomie en gunstige resultaten in de eerste toepassingen rechtvaardigen opname in het reconstructieve arsenaal voor complexe knie wonden.

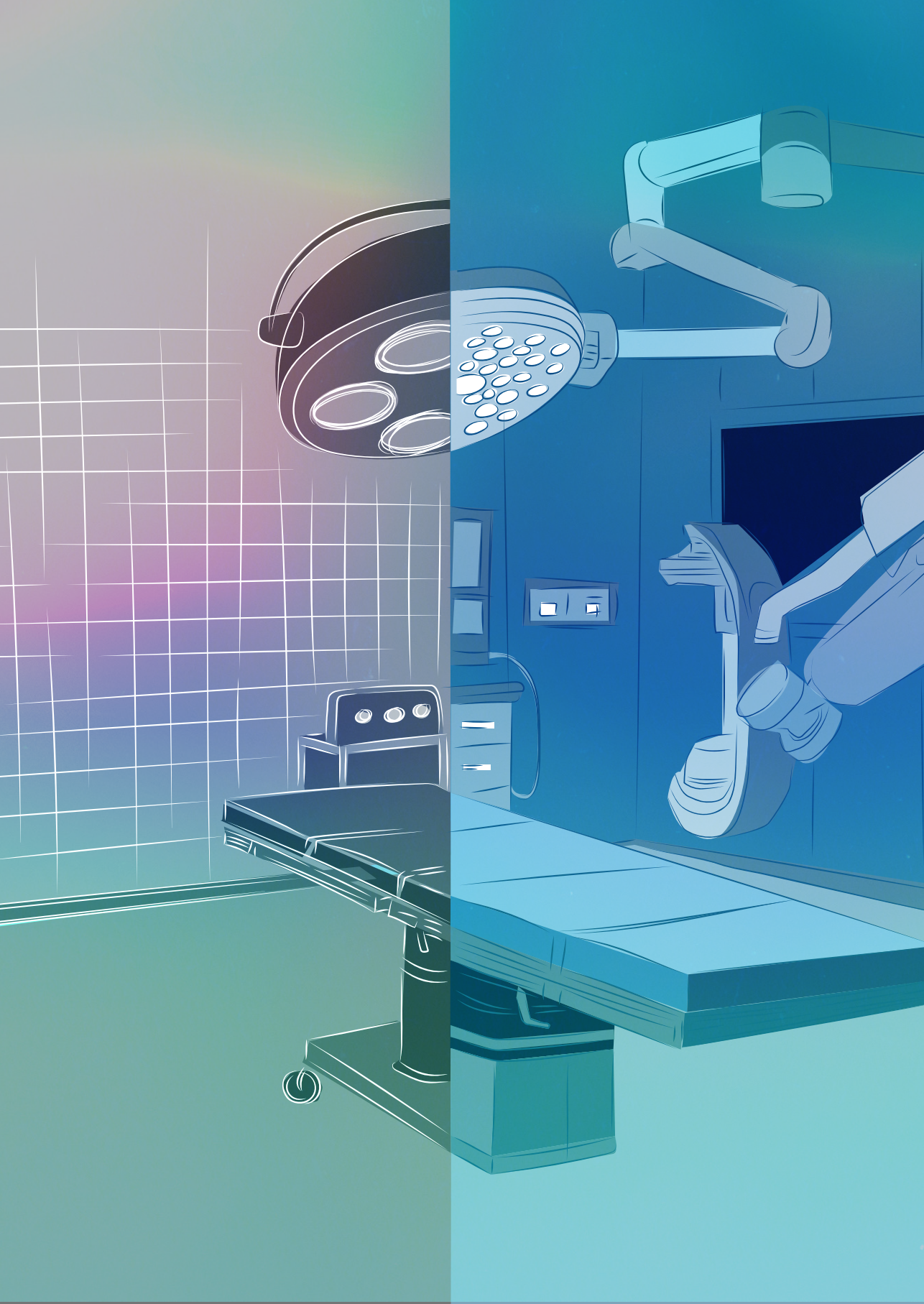
Hoofdstuk 6: mcLPF- Myocutaneous Long Peroneal Lap voor knie herstel

Om de veelzijdigheid van de LPTF verder te vergroten, integreert de myocutane lange peroneus lap (mcLPF) een huid component gevoed door perforatoren direct boven de musculus peroneus longus. Deze uitbreiding maakt het mogelijk defecten te bedekken met waarbij minimaal of geen aanvullende bedekking met huidtransplantaat nodig is dat zowel de esthetiek als de genezing bevordert.

Kadaver studies toonden een consistente verticale lijn van 3-5 huid perforatoren langs de middenlijn van de spier, waarmee lappen tot 24 x 4,5cm haalbaar zijn. Dit ontwerp vergroot het bereik van de lap en vergemakkelijkt spanningsvrije sluiting bij anterolaterale knie defecten. Klinische toepassing bij een 72-jarige diabetes patiënte met een chronisch geïnfecteerde knie wond toonde aan dat middels deze lap een robuuste bedekking kon worden verkregen met nog slechts een klein huidtransplantaat.

De mcLPF is met name nuttig bij revisie knie chirurgie, waarbij eerdere gastrocnemius lappen of meerdere incisies alternatieve opties uitsluiten. De lap behoudt de gastrocnemius voor toekomstige gebruik en minimaliseert morbiditeit op de donor plaats. Bij patiënten met beperkte mobiliteit maakt de snelle oogst en gunstige pedikel positie van de mcLPF het een geschikte oplossing.

Deze evolutie van spier naar myocutane lap weerspiegelt de voortdurende innovatie binnen de reconstructieve chirurgie die op maat gemaakte oplossing voor complexe klinische uitdagingen kan bieden. Hoewel lange termijnen gegevens nog beperkt zijn, toont de mcLPF aan hoe anatomisch inzicht kan worden vertaald naar betekenisvolle chirurgische vooruitgang met directe voordelen voor de patiënt.



Appendices

Research Data Management
PhD portfolio
List of publications
Dankwoord
About the author

Research data management

Ethics and privacy

Medical and ethical approval:
This thesis is based on the results of research involving human participants, which were conducted in accordance with relevant national and international legislation and regulations, guidelines, codes of conduct and Radboudumc policy.

Privacy measures:
According to Dutch legislation, data collection from electronic patient files was performed by personnel with a treatment relationship with the patient AND/OR by the researcher(s) upon consent by the study participant.

Informed consent:
Informed consent was obtained from participants to collect and process their data for this research project.

Data collection and storage

Data collection:
Data for chapter 3, 4 and 5 were obtained through laboratory experiments involving anonymous cadaveric materials.

Data storage:
Data from chapter 3, 4 and 5 were stored and analysed on the department server of the Department of Plastic Surgery and its local repositories and are only accessible by members working at the Radboudumc department of plastic surgery.

Data sharing according to the FAIR principles

All studies are published open access. The dataset from chapter 3, 4 and 5 are published with open access in Radboud Data Repository, DOI: DOI 10.34973/0hkv-m538 and are available for reuse. No chapters of this work were based on existing data.

PhD portfolio of Till Wolfram Wagner

Department: Plastic and Reconstructive Surgery Radboudumc Nijmegen
PhD period: 02/07/2025 – 31/03/2026
PhD Supervisor(s): Prof. dr. D.J.O Ulrich
PhD Co-supervisor(s): Dr S.L.M. Hummelink, Prof. dr. E.P.A. van der Heijden

Training activities	Hours
Courses	
• Radboudumc introduction day	6
• ALERT ™: Acute Life Threatening Events - Recognition and Treatment (2014)	6
• 2nd Radboud Aesthetic & Reconstructive Round: ' Aesthetic & Reconstructive Female Genital Surgery '. (2015)	8
• Open Tibia Fracture course (2015)	10
• 3rd Radboud Aesthetic & Reconstructive Round - Advances in Head & Neck Reconstruction (2016)	7
• Around the Nose Lecture: Reconstructive and Aesthetic Surgery of the Auricle (2016)	1
• European Course of Plastic Surgery (2016)	24
• 6th SOS Symposium ISAPS Course Cologne (2017)	17
• (P)-BLS-AED 2017 (2017)	2
• 4th Radboud Aesthetic & Reconstructive Round: Advances in head & neck reconstruction (2017)	2
• 5th Radboud Aesthetic & Reconstructive Round: Aesthetic Surgery of the Face	6
• 7th Radboud Aesthetic & Reconstructive Advances in Reconstructive Breast Surgery Round (2019)	5
• Verplichte Duitse refresher cursus straling beveiliging (2019)	8
• Acute Pediatric Burn Course (2019)	6
• (P)-BLS-AED 2019 (2019)	2
• Refresher training Vitaal bedreigde patiënt (2020)	4
• (P)-BLS-AED 2022 (2022)	2
• International Cleft Palate Master Course Amsterdam (2023)	8
• Refresher training Vitaal bedreigde patiënt (2023)	12
• Teach the Teacher: Opleiden van aiossen (2023)	6
• BLS-AED 2024 (2024)	2
• Teach the Teacher: Workshop Begeleiden en beoordelen van EPA's (2024)	4
• Refresher training Vitaal bedreigde patiënt (2024)	4
• 8th Radboud Aesthetic & Reconstructive Round: Challenges in Reconstructive & Aesthetic Breast Surgery (2025)	2
• Radboudumc - Scientific integrity (2025)	20
Seminars	
• The 12th International Netherlands Cancer Institute Head and Neck Symposium: Diagnosis and treatment of skin cancer of the head and neck (2015)	12
• 3rd International Breast Symposium Düsseldorf 17th-18th April (2015)	16
• All hands on deck - Farewell Symposium (2016)	6
• Avondsymposium brandwonden - Comfort Talk voor pijnlijke procedures (2019)	2
• Avondsymposium brandwonden - Hemodynamisch beleid bij kinderen met ernstige brandwonden (2019)	2
• Avondsymposium brandwonden - Ergotherapie en fysiotherapie bij kinderen met brandwonden (2019)	2
• Avondsymposium pediatric burns - Post burn contracture release, Co-intoxicatie meer dan alleen Co-Hb (2020)	2
• The Journal of Hand Surgery Journal Club Attendance Certificate (2021)	1
• International Confederation of Cleft Lip and Palate and Related Craniofacial Anomalies Certificate of Attendance (2021)	1

Seminars *(continued)*	
• Journal of Hand Surgery Journal Club Attendance Certificate (2021)	1
• Kindertrauma en Brandwonden (2021)	1
• The latest insights in vascularized composite allotransplantation and extracorporeal tissue preservation. (2021)	4
• International Breast Symposium Düsseldorf 2023 (2023)	18
• Periodieke Conferentie Kindergeneeskunde 2023-2024 (2024)	4
• The 12th International Netherlands Cancer Institute Head and Neck Symposium: Diagnosis and treatment of skin cancer of the head and neck (2025)	6
Conferences	
• NVPC Congres (2013)	10
• VDAEPC Kassel 2013 (2013)	20
• Kongress DGH (Deutsche Gesellschaft für Handchirurgie) (2013)	17
• DGPRAEC 2013 Münster (2013)	12
• NVPC Congres (2015)	20
• MMV Congres Samen leren, samen werken (2015)	6
• 16e Congres Wond genezing & Wond behandeling 2015 (2015)	11
• NVPC Congress (2016)	18
• Kongress DGPRAEC Kassel (2016)	18
• NVPC Congres (2016)	18
• NVPC Congres (2017)	16
• NVPC Congres (2018)	16
• The 24th Congress of ISAPS (2018)	21
• 49. Jahrestagung der DGPRÄC (50 Jahre DGPRAEC) 13.09.2018 - 15.09.2018 (2018)	18
• DAV 2019 (2019)	25
• NVPC-dagen mei 2019 (2019)	8
• 14th IFSSH Triennial Congress 2019 Combined FESSH Congress (2019)	24
• DGPRÄC Virtual Meeting (2020)	4
• NVPC-dagen december 2020 (2020)	10
• DGH congress (2020)	15
• 35e NVSCA najaarsvergadering (2020)	2
• NVPC-dagen mei (2021)	4
• NVPC-dagen november (2021)	16
• DGH congress Münster (2021)	15
• 3rd German Brazilian Aesthetic Meeting Berlin (2022)	15
• FESSH London 2022 (2022)	25
• NVPC-dagen november (2022)	8
• DGPRAEC Kongress Frankfurt (2022)	18
• NVPC-BAPRAS joint meeting June (2023)	16
• DGPRAEC Kongress Heidelberg 14.9.2023-16.9.2023 (2023)	18
• NVPC-dagen mei (2024)	16
• DGPRAEC Kongress Düsseldorf (2024)	12
• NVPC-dagen november 2024 (2024)	16
• DAV Kongress (Deutschsprachige Arbeitsgemeinschaft für Verbrennungsbehandlung) (2025)	15
• EURAPS Meeting 2025 (2025)	25

Other	
• Algemene ledenvergadering NVPC (2013)	2
• Crew Resource Management - Human Factors in de zorg (2013)	12
• EPIC-trainingen (2013)	18
• Lecture Surgical Approaches to the Paralyzed Face (2015)	1
• Algemene ledenvergadering NVPC mei (2016)	2
• NVPC - Kwaliteitsvisitatie Radboudumc (2016)	8
• AZO scholing Brandwondenzorg- snel, goed en op de juiste plek! (2017)	2
• Workshop EPA's (2020)	3
• Algemene ledenvergadering NVPC mei (2021)	2
• NVPC - Kwaliteitsvisitatie Radboudumc Nijmegen (2021)	8
• EAA Netwerkbijeenkomst (2024)	2
• Algemene ledenvergadering NVPC mei (2024)	2
• Algemene ledenvergadering NVPC november (2024)	2
• Algemene ledenvergadering NVPC (2025)	2
• NVPC - Kwaliteitsvisitatie Radboudumc (2025)	8
Teaching activities	
Lecturing	
• SEH artsen Basiscursus Operatieve Technieken, deel II (2020)	6
Supervision of internships / other	
• MedMink studenten cursus snijdend specialismen (2023)	16
• Medmink studenten cursus snijdend specialismen (2024)	16
• Medmink studenten cursus snijdende specialisme (2025)	13
Total	**905**

List of publications

Wagner, Till; Nienhuijs Marloes; Berge Stefaan; Ulrich Dietmar. Z-back-cut cheiloplasty: a cadaveric and clinical study on lip lengthening in unilateral cleft lip repair as a proof of concept (Jul 2025). *Maxillofacial Plastic and Reconstructive Surgery*. DOI: 10.1186/s40902-025-00470-z

Wagner, Till; Riesmeijer, Sophie; Ulrich, Dietmar (May 2025). Pediatric and Juvenile Lunatomalacia: To Treat Surgically or Not? A Systematic Review and Personal Experience. *Plastic and Reconstructive Surgery – Global Open*. DOI: 10.1097/GOX.0000000000006756

Peters, J. J.; van der Kooij, S. A.; van Gogh, C. D. L.; Coerts, M. J.; Don Griot, J. P. W.; Moues Vink, C. M.; **Wagner, T.**; Schols, R. M.; van Nimmen, B.; Pleumeekers, M. M.; Ruettermann, M.; Paes, E. C.; De Jong, T. R.; Breugem, C. C. (May 2025). Dutch Workflow for Diagnosis and Treatment of Velopharyngeal Insufficiency in Patients with Cleft Palate—A Survey Study. *Cleft Palate – Craniofacial Journal*. DOI: 10.1177/10556656251341757

Wagner, Till; Ulrich, Dietmar J. O. (Feb 2025). Using an acellular dermal matrix as a neuroprotective wrap-around for treating recurrent nerve entrapment syndromes: a proof of concept. *Cell and Tissue Banking*. DOI: 10.1007/s10561-025-10159-2

Crins-de Koning, Marjolein; Bruggink, Robin; Nienhuijs, Marloes; **Wagner, Till**; Bronkhorst, Ewald M.; Ongkosuwito, Edwin M. (Jan 2025). Three-dimensional analysis of facial morphology in nine-year-old children with different unilateral orofacial clefts compared to normative data. *PeerJ*. DOI: 10.7717/PEERJ.18739

Wagner, Till; Ulrich, Dietmar (Apr 2024). Anatomy, evolution, and clinical aspects of the superextended-intercompartmental-supraretinacular artery perforator flap (SISAP-flap): A proof of concept. *Journal of Plastic, Reconstructive & Aesthetic Surgery.* DOI: 10.1016/j.bjps.2024.04.053

Wagner, T.; Kruit, A. S.; Vehmeijer-Heeman, M.; Ulrich, D. (Mar 2024). Solar radiation can cause clinically relevant burns in breast reconstructed patients even after years- a rare case report. *Burns Open*. DOI: 10.1016/j.burnso.2024.03.006

Wagner, Till; Ulrich, Dietmar (Jan 2024). Increasing multidrug resistance in leech borne infections. Should we adjust antibiotic treatment regime in plastic surgery? A systematic review. *European Journal of Plastic Surgery.* DOI: 10.1007/s00238-023-02158-x

Wagner, T.; Hummelink, S.; Mathot, F.; Ulrich, D. (Apr 2023). The anatomic relationship of dorsal arterial perforators of the distal forearm, wrist, and dorsum of the hand with conclusions for the clinic. *Journal of Plastic, Reconstructive & Aesthetic Surgery.* DOI: 10.1016/J.BJPS.2023.04.040

Wagner, T.; Ulrich, D. (Sep 2022). Congenital nodular fasciitis: an extremely rare entity with review of literature. *Annals of Pediatric Surgery.* DOI: 10.1186/S43159-022-00204-0

Wagner, T.; Hummelink, S.; Ulrich, D. (Jul 2022). Past, present and future in plastic flap surgery: From surgeon to bioengineer driven progress. A personal view. *Journal of Tissue Viability.* DOI: 10.1016/J.JTV.2022.06.007

Braafhart, Marieke; de Laat, Henricus E. W.; **Wagner, Till**; van de Burgt, Emmy W. T.; Hummelink, Stefan; Ulrich, Dietmar J. O. (Aug 2020). Surgical reconstruction of pressure ulcers in spinal cord injury individuals: a single- or two-stage approach?. *Journal of Tissue Viability.* DOI: 10.1016/j.jtv.2020.08.004

Wagner, Till; Franken, Joris; Hameeteman, Marijn; Ulrich, Dietmar J. O. (Aug 2020). The myocutaneous long peroneal flap: An anatomical study and its clinical application. *Journal of Plastic, Reconstructive & Aesthetic Surgery, 74(3):644–710.* DOI: 10.1016/j.bjps.2020.08.020

Wagner, T.; Slater, Nicholas J.; Ulrich, Dietmar J. O. (Feb 2020). Treating a subtotal degloving ring avulsion with leeches: an unusual case report with review of the literature. *European Journal of Plastic Surgery, 43(1):103–106.* DOI: 10.1007/s00238-019-01580-4

Tian, Jia; **Wagner, Till**; Hoevenaren, Inge; Wesselius, Tycho; Verhulst, Arico; Ulrich, Dietmar (Jun 2018). Progress in surgical strategies for treatment of simple congenital syndactyly: A systematic review. *European Journal of Plastic Surgery, 41(3):259–268*. DOI: 10.1007/s00238-017-1386-8

Wagner, Till; Kloeters, Oliver; Ulrich, Dietmar (Apr 2018). The double-pedicled dorsal-metacarpal-artery (dpDMCA) flap of the hand: a novel DMCA-derived flap. *European Journal of Plastic Surgery.* DOI: 10.1007/s00238-017-1357-0

Hoevenaren, Inge A.; Vreeken, Rinaldo D. B.; Verhulst, Arico C.; Ulrich, Dietmar J. O.; Maal, Thomas J. J.; **Wagner, T.** (Mar 2018). Virtual Incision Pattern Planning using Three-Dimensional Images for Optimization of Syndactyly Surgery. *Plastic and Reconstructive Surgery - Global Open*. DOI: 10.1097/gox.0000000000001694

Wagner, Till (Jan 2017). Developing a new scissor for cleft surgery: The cleft palate dissection scissor. *Journal of Cleft Lip Palate and Craniofacial Anomalies.* DOI: 10.4103/jclpca.jclpca_25_17

Wagner, Till (Nov 2016). Subcutaneous Scar Retraction Release after Breast Reduction Using Percutaneous Needle Cordotomy. *Clinical Medical Image Library.* DOI: 10.23937/2474-3682/1510045

Wagner, Till; Slater, Nicholas J.; Ulrich, Dietmar (Feb 2016). Extended distally based DMCA flap in combination with autologous amputate skin transplantation as a salvage procedure for ring avulsion injury. *European Journal of Plastic Surgery.* DOI: 10.1007/s00238-015-1164-4

Wagner, Till; Hupkens, Pieter; Slater, Nicholas J.; Ulrich, Dietmar J. O. (Nov 2015). The proximally based long peroneal muscle turnover flap: A novel salvage flap for small to medium-sized defects of the knee. *Journal of Plastic, Reconstructive & Aesthetic Surgery.* DOI:10.1016/j.bjps.2015.11.012

de Jager, W. C. C.; Walbeehm, E. T.; **Wagner, T**. (Feb 2015). Marjolin ulcer; malignant degeneration in a chronic wound. *Nederlands Tijdschrift voor Geneeskunde, 159(7)*. PMID: 25654683.

Acknowledgement (Dankwoord)

Toen ik meer dan dertien jaar geleden als arts aan het Radboudumc begon, had ik nog helemaal geen plan om een tweede promotieonderzoek te starten – laat staan in het buitenland en in een taal die mij toen nog geheel onbekend was. Maar zoals het leven soms zijn verrassingen heeft, ontstonden er in de loop der jaren allerlei ideeën voor onderzoek die de moeite waard waren om verder uit te werken. Zo kwam het één tot het ander en begon de lijst met publicaties langzaam maar zeker te groeien.

Prof. dr. D. Ulrich. Beste Dietmar, heel hartelijk dank voor je steun bij het tot stand komen van dit promotieonderzoek. Ik kon in al die jaren altijd bij je terecht wanneer ik weer een idee had voor een artikel en kreeg daarbij alle ruimte om het uit te werken. Ik ben je ook bijzonder dankbaar dat ik, ondanks mijn klinische werkzaamheden, de tijd kreeg om mijn onderzoeksproject voort te zetten.

Dr. S. Hummelink. Beste Stefan, dankjewel dat je bereid was om als copromotor op te treden – ik waardeer je inzet zeer. Ik had ook nooit verwacht dat jij mijn copromotor zou zijn, maar ik ben erg blij mee.

Prof. dr. B. van der Heijden. Beste Brigitte, ook jou wil ik hartelijk bedanken voor het op je nemen van de promotor schap voor dit werk.

Mijn bijzondere dank gaat uit naar de leden van de manuscriptcommissie – Prof. dr. van der Geest, Prof. dr. Piatkowki de Grzymala en Prof. dr. Maal – voor het zorgvuldig lezen en beoordelen van mijn proefschrift. Eveneens wil ik de leden van de promotiecommissie bedanken voor hun deelname aan de commissie.

Lieve voormalige en huidige stafleden: Dalibor, Eric, Marie-Claire, Merel, Pieter, Oliver, Brigitte, Stefan, Mariëlle, Hanneke, Tim en Tim, Claire, Steven, Franz, Evelien en Anne Sophie – jullie allen bedankt voor de fijne en hartelijke samenwerking in de afgelopen meer dan een decennia. Jullie stonden altijd klaar voor een goed inhoudelijk gesprek, en ik heb er enorm van genoten om samen te mogen werken met zo'n bekwaam team.

Lieve voormalige en huidige assistenten en fellows: Willemieke, Marsha, Naomi, Robbert, Esther, Joris, Inge, Marjolijn, Marijn, Anne Sophie, Vera, Tycho, Nicholas, Elisa, Vivian, Laura, Harm, Yannick, Ali, Sophie, Bart, Saskia, Annewiek, Erol, Milly, Bo, Kaj, Ennie, Femke, Eva, Lennart, Muhammed, Masoud, Luc, Kim Phi en Francien – ik kon al die jaren op jullie rekenen als toegewijde collega's, en ik denk met

veel plezier terug aan de vele mooie en grappige momenten die we samen mochten beleven. Dank ook voor het vertrouwen in mij als supervisor binnen de kliniek – en prachtig om te zien hoe ieder van jullie zich heeft ontwikkeld.

Een speciaal woord van dank aan Francisca, Doortje, Annie, Daisy, Rozan, Ellen, Laura, Jose, Britt, Kim, Patty, Iris, Heidy, Sonja, Anouk, Dilay, Janne, Carolien, Adriana en Sophie van het secretariaat en de polikliniek, en aan de OK-assistenten Franzien, Ali, Helmi, Daphne, Kristine, Chantal, Heidy, Karin, Dorien, Nathalie en Corien – bedankt dat jullie mij al die jaren zo geduldig en professioneel ondersteund hebben op de polikliniek en in de operatiekamer. Zonder jullie hulp – vooral in mijn beginjaren aan het Radboudumc – had ik hier nooit mijn plek kunnen vinden.

Bijzondere dank gaat uit naar het schisis- en CoHNijn-team van het Radboudumc: Marloes, Titiaan, Stefaan, Godelieve, Arthur, Niels, Edwin, Mette, Eveline, Jeanne, Zdenka, Jessie, Renate, Iris, Marjan, Gera, Anne Sophie, Steven, Andrea en Christine – dankzij onze fantastische en vertrouwde samenwerking tijdens de interdisciplinaire spreekuren leer ik nog steeds elke week bij, zelfs na dertien jaar.

Extra dank gaat ook naar alle secretaresses en “poli dames”, die mij in allen jaren begeleid en naar het juiste plek hebben gestuurd.

Ook het RUWEC-team wil ik danken: Eric, Wilma, Alma, Harriëtte en Jolanda– zonder jullie inzet en intensieve samenwerking was de complexe zorg voor decubituspatiënten in de afgelopen jaren niet mogelijk geweest.

Dank ook aan Stephan, als afdelingsfotograaf, voor je hulp bij de beeldbewerking voor publicaties.

Dank aan het hele team van het preparatorium van de anatomie, dat altijd bereid was te helpen en de preparaten vakkundig ter beschikking stelde.

Tot slot wil ik mijn diepste respect en dank uitspreken aan allen die hun lichaam postuum ter beschikking hebben gesteld aan de anatomie voor onderzoek – zonder hun bijdrage was dit werk niet mogelijk geweest.

Bijna als laatste – maar zeker niet minder belangrijk – wil ik iedereen bedanken die ik hier niet bij naam heb genoemd. In meer dan veertien jaar Radboudumc heb ik met zoveel warme en betrokken mensen mogen samenwerken dat het onmogelijk is om iedereen persoonlijk te noemen. Mocht ik iemand vergeten zijn, weet dan dat dit

zeker niet met opzet was – voel je alsjeblieft toch aangesproken. Daarom nogmaals aan alle genoemde én niet-genoemde collega's (oud én nieuw): DANK JE WEL.

Lieve mama en papa, na vele jaren heb ik eindelijk de moed gevonden om uit de verschillende publicaties een tweede proefschrift samen te stellen. Ik ben blij dat ik het jullie nu toch nog kan presenteren. Bedankt dat jullie altijd in mij hebben geloofd.

Lieve Janina – zonder jouw eindeloze steun gedurende al die jaren die ik aan het Radboudumc werk, was dit alles niet mogelijk geweest. Jij hebt zoveel op je genomen om mij de ruimte te geven voor dit werk en voor ons gezamenlijke leven. Daar ben ik je meer dan dankbaar voor.

About the author

Till Wolfram Wagner was born on 16 April 1972 in Neurenberg (Nürnberg), Germany. He received his primary education at Wendelstein Primary School (1978–1982), followed by secondary education at Neues Gymnasium Nürnberg, where he obtained the German Abitur (higher education entrance qualification) in 1991.

In 1991–1992, he completed vocational training as a nursing assistant at the Rummelsberg Hospital School of Nursing, graduating with distinction. From September 1991 to February 1993, Till fulfilled his alternative compulsory community service at the Laurentius Hospital of the Rummelsberger Anstalten, working in internal medicine and orthopedics.

From November 1993 to November 1999, he studied medicine at the Friedrich-Alexander University of Erlangen-Nürnberg. He successfully passed all stages of the German medical examinations with excellent results. Their doctoral research was conducted under the supervision of Professor B. Fleckenstein at the Institute for Clinical and Molecular Virology. The thesis was awarded magna cum laude.

As part of his medical education, he completed numerous clinical clerkships and electives, both in Germany and abroad. These included placements in dermatology at the University Hospital Zurich, in surgery at Saint John's Regional Hospital in New Brunswick, Canada, and in pediatric orthopedics at Shriners Hospital for Children in Honolulu, Hawaii. Further placements were undertaken in anesthesia (Galway, Ireland), cardiology, neurology, traumatology, and molecular biology.

After graduating in 1999, Till began his clinical career as a Junior House Officer in the Department of Plastic Surgery at Kreiskrankenhaus Hameln. Between 2001 and 2007, he held a series of progressive posts as Senior House Officer in plastic and hand surgery, general and vascular surgery, anesthesia and intensive care, at several hospitals in Hannover and Bückeburg.

From 2008 onward, he assumed senior clinical positions, including Senior Registrar at the Department of Plastic and Aesthetic Surgery at Fachklinik Hornheide, affiliated with the University of Münster, and later as Vice Head of the Department of Plastic and Aesthetic Surgery / Hand Surgery at Sana Klinikum Hameln-Pyrmont.

Since April 2012, he has been working as a Consultant in the Department of Plastic Surgery at Radboud University Medical Center (Radboudumc), the Netherlands.

His clinical focus includes reconstructive and pediatric procedures, complex hand surgery, and craniofacial surgery.

Till Wagner is a Plastic and Aesthetic Surgeon (since February 2007) and a certified Hand Surgeon (since September 2011). He is a full member of the following professional organizations:

- German Society of Plastic, Reconstructive and Aesthetic Surgeons (DGPRAEC) – since 2007
- German Society for Hand Surgery (DGH) – since 2011
- Dutch Society of Plastic Surgeons (NVPC) – since 2012
- Dutch Society for Cleft and Craniofacial Abnormalities (NVSCA) – since 2022
- Sigma Xi, The Scientific Research Honor Society – since 2025

9 789465 152387

Radboudumc university medical center

IN DEI NOMINE FELICITER

Radboud University