

Tailored Skin Flaps for Hand Reconstruction

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Introduction: Acquired soft-tissue defects of the hand can be a result of different types of trauma, infection, tumor resection, or burns. The evolution of the design and types of flaps have optimized the reconstruction and, nowadays, it is important to achieve not only a functional result but also an aesthetic result. The aim of the present study is to propose a model for treating a wide variety of skin defects in the hands based on our flap experience.

Methods: We conducted a retrospective study from February 2019 to January 2022, which included all patients who underwent a skin flap for hand reconstruction. Patients' medical records were reviewed and data collected included demographics, smoking status, presence of risk factors, type of trauma, flap reconstruction, dimensions, reoperations, and long-term complications.

Results: A total of 99 patients underwent skin flap-based reconstruction for hand trauma between February 2019 until January 2022. The mean age was 43.9 (range 38.3–49.5), 87.9% of patients were male, and follow-up was between 2 and 30 months; 90.9% of the flaps were free flaps, and the rest were pedicle flaps (3% of them being propeller flaps).

Conclusions: When planning a hand reconstruction, it is vital to ensure that the outcomes are not only functional but also aesthetic, with minimum donor site morbidity; in this study, we showed a variety of flaps that can be applied to achieve this goal. We believe that the final decision should be made after comprehending the defect and the patient's preferences. (*Plast Reconstr Surg Glob Open* 2022;10:e4538; doi: 10.1097/GOX.0000000000004538; Published online 30 September 2022.)

INTRODUCTION

Acquired soft-tissue defects of the hand can be the result of different types of trauma, infection, tumor resection, or burns. The evolution of the design and types of flaps has optimized the reconstruction and, nowadays, it is important to achieve not only functional but also aesthetic results.^{1–4}

Different from the dorsal skin, which is thin, pliable, and designed for mobility, the palmar surface has a specialized glabrous skin that is firmly tethered to the underlying

fibrous framework, making it relatively immobile, which explains the use of other flaps than local ones.

When planning a reconstruction, it is essential to ensure that the fingers are restored to normal or near-normal motion. This necessarily requires thin and flexible skin that allows for digital flexion and gliding of the underlying tendons.^{5,6}

The aim of the present study is to propose a model for treating a wide variety of skin defects in the hands based on our flap experience.

METHODS

We conducted a retrospective study from February 2019 to December 2021, which included all patients who had undergone a skin flap to hand reconstruction from the senior author L.T. as the first surgeon. There were no exclusion criteria. Patients' medical records were reviewed and included demographics, smoking status, presence of risk factors, type of trauma, flap reconstruction, dimensions, reoperations, operative time, ischemia time, and long-term complications.

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Summary statistics were calculated. Quantitative data are expressed as the mean ± SD, whereas nominal data are expressed as a percentage. Analyses were performed using SPSS software ver 26.0 (IBM, Armonk, N.Y.).

RESULTS

A total of 99 patients underwent skin flap reconstruction for hand trauma between February 2019 to January 2022. Demographic and comorbidity data are shown in Table 1. The mean age was 44 (range 38.3–49.5), 87.9% of patients were male, and follow-up was between 2 and 30 months; 90.9% of the flaps were free flaps, and the rest were pedicle flaps (3% of them being propeller flaps).

Table 2 lists all of the reconstruction methods employed, with the following being the preferred choice: great toe pulp (GTP) flap, 44%; proximal ulnar perforator flap (PUPF), 15.2%; anterolateral thigh (ALT) flap, 7.1%; superficial circumflex iliac artery perforator (SCIP) flap, 6.1%; medial sural artery perforator (MSAP) flap, 5.1%; and medial plantar flap, 5.1%. Trauma was the most common reason for hand reconstruction (86.1%), followed by infection (11.1%) and sequelae burns (2.8%).

Table 1. Demographics, including Age, Comorbidities, and Smoking Situation

		Demographics			
		N	%	Median	SD
Sex	F	12	12		
	M	87	87.9		
Age, y		—		44	18
Smoking status	No	90	90.9		
	Yes	9	9.1		
Comorbidities	None	87	87.9		
	Hypothyroidism	2	2		
	Hypertension	2	2		
	DBT	2	2		
	Polyomyelitis	1	1		
	Pituitary adenoma	1	1		
	Parkinson	1	1		
	Obesity	1	1		
	FA	1	1		
	Acute Coronary Syndrome	1	1		

Table 2. Complete List of Flaps Employed in This Study

		Types of Flaps	
		N	%
Large defects	ALT	7	25.9
	SCIP	6	22.2
	Medioplantare	5	18.5
	MSAP	5	18.5
	Scapular + parascapular	2	7.4
	Groin flap	1	3.7
	Scapular	1	3.7
Small defects	GTP	44	61.1
	PUPF	15	20.8
	Intermetacarpal flap	5	6.9
	Dorsali pedis	3	4.2
	FDMA	1	1.4
	First web space flap	1	1.4
	Quaba	1	1.4
	DIMA	1	1.4
	Radial artery perforator flap	1	1.4

DIMA, dorsal intermetacarpal artery flap; FDMA, first dorsal metacarpal artery flap; Medioplantare, medial plantar flap.

Takeaways

Question: How to easily plan the coverage of a skin defect in hand reconstruction.

Findings: Over the course of 23 months, we observed that 90% of the hand reconstructions were free flaps, with good aesthetic and functional outcomes.

Meaning: Hand reconstruction should be planned not only for function but also for aesthetics, using the reconstruction toolbox to determine the best coverage.

One case of complete flap failure was seen on a scapular-parascapular flap, a 55-year-old patient who had been involved in a crushing trauma. Minor complications occurred in 7% of cases, including four epidermolysis and one partial necrosis. Long-term complications included impossibility of finger extension and chronic pain in the apex stump. There were no wound infections or hematomas in the flaps or donor sites.

DISCUSSION

Finding the optimal approach to restore hand defects is still a challenge for surgeons. Because every lesion has several potential solutions, soft-tissue restoration of the hand is a complicated topic. Despite the well-known reconstructive ladder, which recommends choosing the simplest rebuilding of the defect, the reconstructive elevator concept allows for more sophisticated reconstructions to account for specialized function and aesthetic outcome.⁷⁻⁹ To achieve a satisfactory reconstruction, it is essential to consider not only a functional but also an aesthetic outcome, and balancing the recipient area's result with the donor area's morbidity.¹⁰⁻¹² In this study, we propose different skin tailored pedicles and free flaps for different hand defects; for a proper understating, we divided them into two groups: small (defects that compromise one digit or part of it) and large (defects affecting the palmar or dorsal region of the hand, as well as when more than one digit is affected) reconstructions (Fig. 1).

Small Reconstructions

The GTP flap was the most commonly used flap in our study for covering smaller defects. We utilized this flap to repair digits, particularly the P3 zone when bone exposure was present, but it was also used for P2-P3 coverage. The average size of the flap was 1.5×1.5 cm with a maximum of 3.5×2.5 cm and the average pedicle length was 4.1 cm (2–11 cm). Unlike the technique described by Wei and Yim,¹³ the retrograde dissection of the vascular pedicle was conducted purely dorsally, without harming the plantar side also, and nerve anastomosis was not performed. In regards of donor site morbidity, no patient expressed concern about gait alteration or the great toe scar, which is conveniently hidden and does not come into contact with the ground during ambulation. In the variety of reconstructive surgical options, the great toe pulp flap manages to fulfill all the like with like prerequisites, providing tissue match with glabrous skin, fat lobule architecture, deep

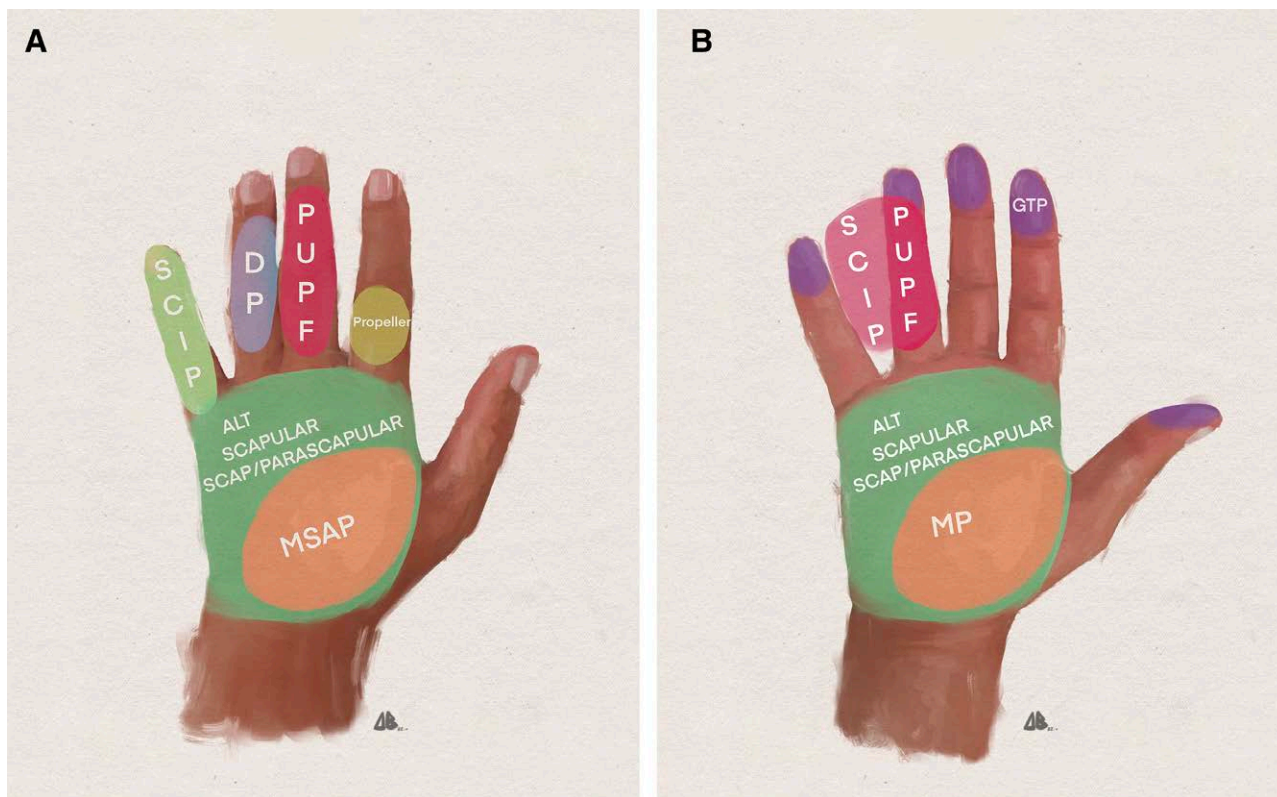


Fig. 1. Preferred flaps employed to reconstruct small and large defects. A, Dorsal view. B, Palmar view.

papillary ridges, and fibrous septal that radiate from the periosteum to the skin to minimize the shearing and slippage with gripping. It also allows the addition of a nail component in the case of nail bed injury^{14,15} with minimal donor site morbidity^{14,16} (Fig. 2).

In this study, the PUPF was the second most commonly used flap; based on the perforator of the ulnar artery, it was employed in 13.9% of our small defect repair interventions (the surgical technique employed to harvest the flap is well described in a previous article).¹⁷ The PUPF also has been used to cover digits but with larger defects, mostly when two adjacent fingers were injured, covering both defects and performing the syndactyly release in the second intervention.

Despite being first described in 1984 by Lovie et al,¹⁸ the PUPF is not well documented in the literature, unlike other flaps^{19,20}; however, it offers significant advantages. In 2014, Wei et al¹² published a study that confirmed the PUPF's continuous and stable blood supply, as well as its advantages over the radial flap in terms of donor site care, scar placement, and skin graft loss. If the medial cutaneous nerve of the forearm is included, it is possible to harvest a sensory flap, and residual sensory loss in the donor site is minimal due to the presence of numerous cutaneous nerves in this area.^{12,21,22} Also, the donor area of the flap is frequently intact even after significant hand trauma, because the flap is on the nondominant side of the forearm.²³ Multiple perforators feed the ulnar skin of the forearm, the majority of which are musculocutaneous.²⁴ On average, there are five

to seven ulnar artery perforators with a caliber of at least 0.5 mm and an average length of 27 mm, each of which can supply an area of skin measuring 19 to 33 cm^{20,25,26}; in our patients, we found a similar pedicle of length 25 mm, with one of the flaps requiring a vein graft, and the dimensions average was 9.6×4.1 cm. The PUPF's main disadvantage is the perforator's small diameter, which demands precise supermicrosurgical abilities to complete the anastomosis, as well as the flaps' diameter, which, when larger than 6 cm, is mostly impossible to close the donor site, possibly requiring grafting.¹⁷ In our study, no complications were observed in the long-term follow-up (Fig. 3).

Other free flaps utilized to cover small defects were the dorsalis pedis and the commissural flap. Several authors have shown that, when used properly, the dorsalis pedis can be a suitable choice to reconstruction, but the necessity for a skin graft on the donor site is a disadvantage.^{27–29} In our experience, this flap is a good option when thin flaps are needed and the donor site should be closed primarily.

When the defect was located on the dorsal side of P1 or the proximal zone of P2, pedicle flaps were utilized, as the dorsal metacarpal artery flap (QABA), radial perforator flap, dorsal ulnar artery fasciocutaneous flap (Becker flap), and propeller flaps based on the intermetacarpal artery.

Large Reconstruction

Crash injuries were the most common cause of bigger defects, requiring the use of larger flaps for reconstruction.

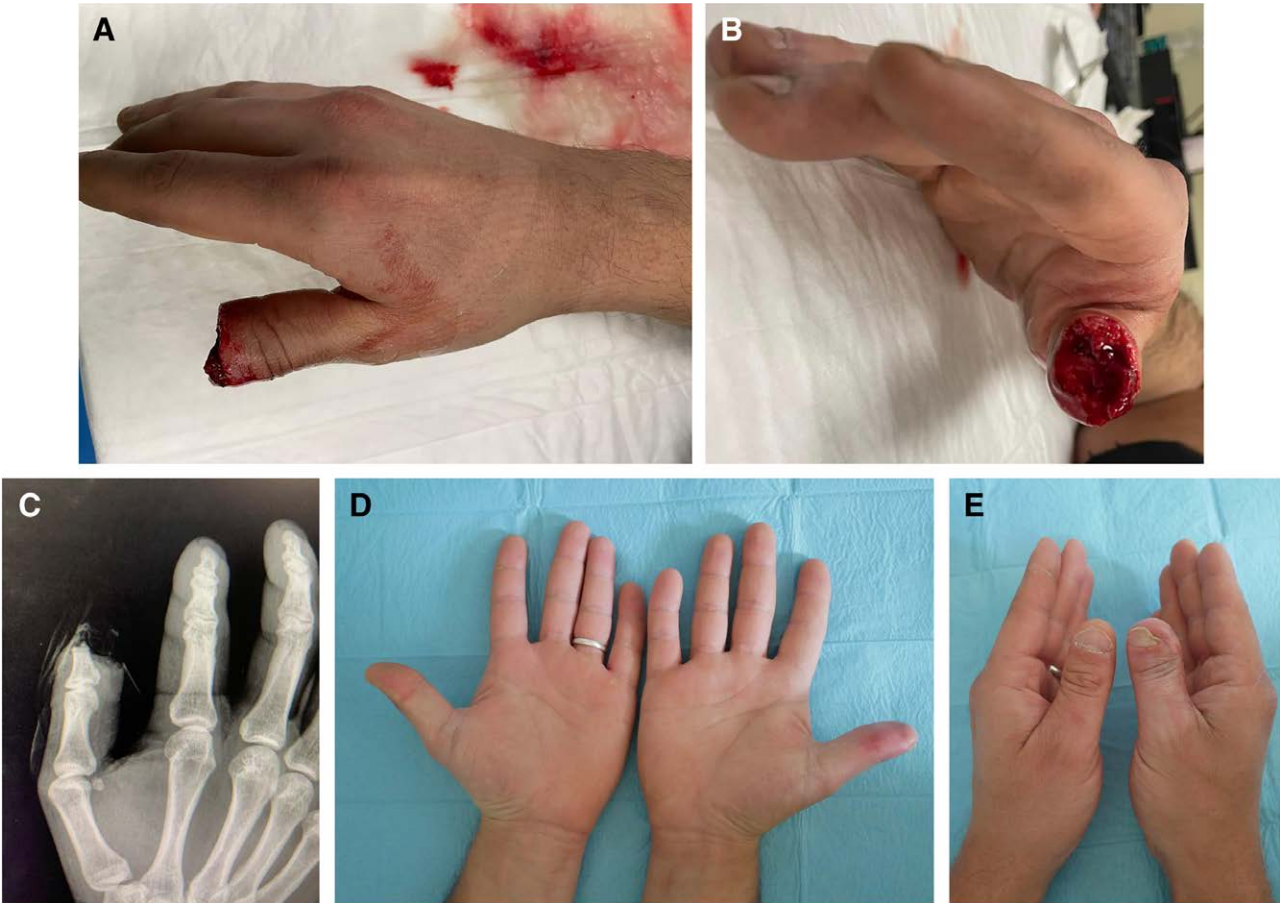


Fig. 2. A 29-year-old male patient with an amputation of the distal P2 of the thumb after trauma. A and B, The defect. C, Rx of the hand. D and E, Results after 6 months with a great toe pulp flap.

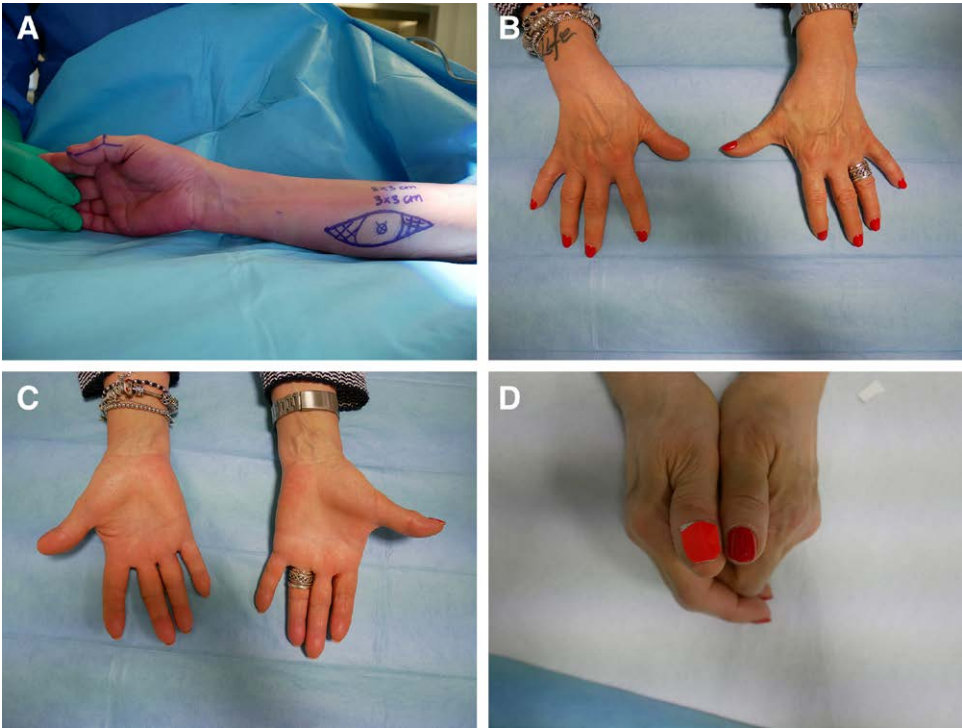


Fig. 3. A 63-year-old female patient with a recurrent glomus tumor in her P2 thumb. A, Design of the resection and the PUPF. B-D, Follow-up after 12 months.

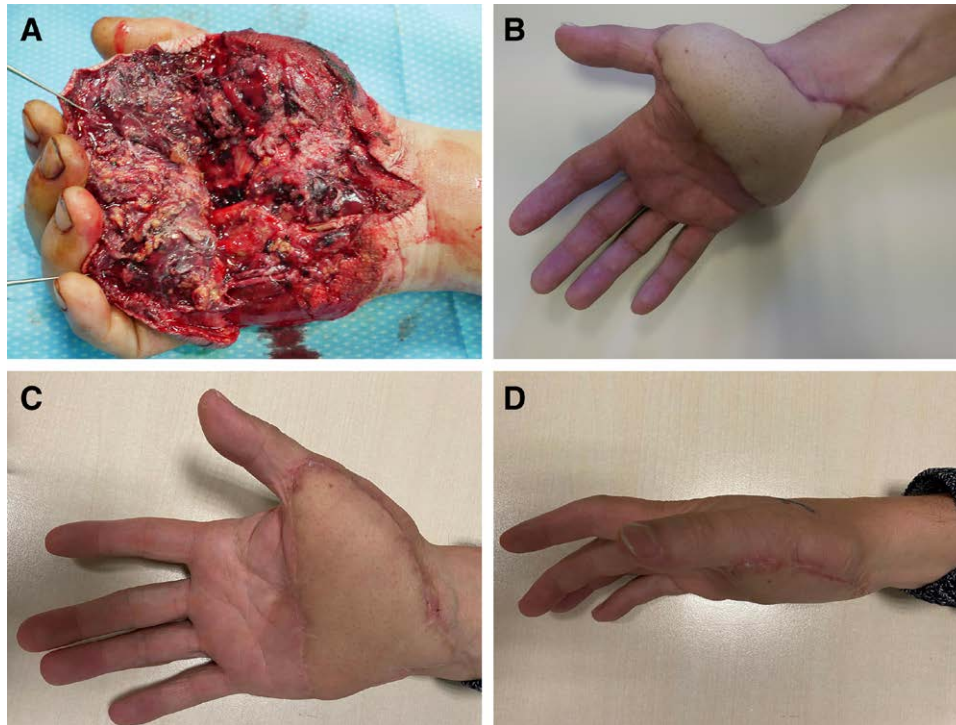


Fig. 4. A 53-year-old male patient with a crash and avulsion injury. A, The defect. B, Results 3 months after an ALT flap reconstruction. C and D, Results after debulking.

The most used flap for this situation was the ALT flap. Because of its diameter, pedicle length, a less noticeable scar than other flaps when closed primarily (on defects smaller than 8 cm), and the possibility of harvesting the flap simultaneously,^{30–32} it has become the workhorse of all microsurgeons since Song et al³³ described it in 1984. Although it is a very well-known flap for microsurgeons, it is not usually used in hand reconstruction, even with the advance of thinner flaps.^{34–36} With a mean dimension of 22 × 9.8 cm, ALT flaps were harvested on 25.9% of our patients with significant defects, usually to cover dorsal injuries or when the defect was so wide that it impacted both the dorsal and palm of the hand. The main disadvantage of ALT is its thickness, which may demand a second procedure to remodeling and debulking if raised in its fasciocutaneous form (Fig. 4).

The SCIP flap is a well-known and widely used reconstruction flap that evolved from the groin flap, which was first described as a pedicle flap by McGregor and Jackson,³⁷ then as a free flap by Daniel and Taylor,³⁸ but it was not until 2004 when Koshima et al described the possibility of making the flap thinner based on its perforator.³⁹ The SCIP flap was used in 22.2% of our patients with significant defects; it was mostly used for dorsal defects that did not require as extensive a flap as the ALT; the flap's average size was 15.8 × 7.1 cm. The harvest of the flap was made employing TC Teo modifications,⁴⁰ which begin with an exploratory incision immediately above the perforator to locate it and estimate its length and course before deciding the final flap design.

The MSAP flap is based on musculocutaneous perforators that arise from the medial sural artery and pass

through the medial head of the gastrocnemius muscle. Cavadas et al⁴¹ published the first clinical case series in 2001. In our study, the MSAP was used in 18.5% of the patients with large defects, and was employed for both dorsal and palmar sides. The mean size of MSAP was 11.8 × 5.4 cm, which is similar to the previous reports.^{42–44} The MSAP flap has a few disadvantages, including the lengthy intramuscular dissection and ligation of muscular branches, which can be tedious.⁴⁵ Additionally, vein congestion can be a problem because the vein accompanying the medial sural artery pedicle is large in diameter, tortuous, and thin walled, making it extremely susceptible to compression and kinking.⁴⁶ We had two complications with the MSAP flap, one partial necrosis and a long-term complication with impossibility of finger extension (Fig. 5 and Video). (See Video [online], which displays a 50-year-old male patient with an amputation of fourth ray and loss of skin of palm of the hand secondary to fourth finger flexor sheath infection with reconstruction with the MSAP flap.)

Because of the importance in restoring volar defects of the palm and fingers with specialized skin, the medial plantar flap was frequently employed (5.1%). It relies on the principle of replacing like with like, supplying glabrous skin to the wounded hand, and has been described to deliver not only a better grip but also better durability and cosmetic appearance than other flap reconstructions.⁴⁷ The preferred way to harvest the flap was by first recognizing the posterior tibial artery and veins proximally at the level of the tarsal tunnel, then following them distally to the skin paddle, as it was described in a previous study.⁴⁸ The drawback of this flap is its complex dissection, which has a challenging learning



Fig. 5. A 50-year-old male patient with an amputation of fourth ray and loss of skin of palm of the hand secondary to fourth finger flexor sheath infection. A, The defect. B, MSAP flap inset. C, Follow-up 12 months after.

curve. Its dimensions are also a limitation; even though we classify it as a large flap, it cannot completely cover a wide defect, but it is a flap that should be considered when performing a volar and palm reconstruction.

The scapular and scapular-parascapular flaps are other thin and foldable flaps that can cover large defects. They are based on the descending and transverse branch of the circumflex scapular artery's vascular supply,^{49,50} but despite being relatively easy to dissect, having a large caliber vascular pedicle with a constant position of the artery and veins,⁵¹ and having a low donor site morbidity⁵² are not widely used today, possibly due to the side positioning and increased rates of seroma. We used the scapular flap in one patient and a combination of scapular and parascapular flaps in two patients.

As stated in the text, each flap has a distinctive characteristic, and a proper analysis of the defect with its needs, and recipient vessels should be made when choosing the right reconstruction. Relevant information such as the area to be covered, pedicle length, donor site morbidity, and so on should be used to plan the reconstruction. In our opinion, each defect should be treated as a unique circumstance that considers both the patient and the defect. With this in mind, we recommend using the toolbox of reconstructions⁵³ to tailor the reconstruction to the patient's demands.

CONCLUSIONS

Nowadays, when planning a hand reconstruction, it is vital to ensure that the outcomes are not only functional but also aesthetic, with minimum donor site morbidity; in this study, we showed a variety of flaps that can be applied to achieve this goal. We believe that the final decision should be made after a thorough understanding of the defect and the patient's preferences, tailoring the reconstruction to the patient's requirements.

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