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ARTICLE

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

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ABSTRACT

Since the first description many variations of the dorsal metacarpal reverse island flap have been published but there is still uncertainty about which vascular component should be included for an optimal result. Therefore, it was the aim of this study to analyze vascular reliability and ischemic complications of dorsal metacarpal artery perforator (DMAP) flaps and dorsal finger perforator (DFP) flaps in our patient collective. We performed 40 of these flaps from the dorsum of hand and fingers for finger injuries. The choice of donor site was made according to the defect's location. Patients were analyzed with respect to flap necrosis, ischemic complications and achievement of overall reconstruction goals. In addition, we divided our patients in two groups, one group where we raised the flap from the dorsum of the proximal phalanx and a second one where the flaps were raised from the intermetacarpal space to identify complication rates based on the pedicles location. Of the 40 flaps, 36 survived completely. 4 partial necroses were observed in flaps transferred to more distal defects and in one flap that was used in a wrap-around technique for both dorsal and palmar proximal phalanx. These perforator flaps are a reliable method to cover finger defects and the dorsal metacarpal artery is not necessary for their survival, since the blood supply comes from perforating branches of the palmar vascular system. There is a clear trend for a higher complication rate in flaps raised from the dorsum of the fingers compared to the intermetacarpal space.

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Finger reconstruction; pedicled flaps; dorsal metacarpal artery; outcome

Introduction

Finger reconstruction with dorsal metacarpal artery (DMA) reverse island flaps was first described in the beginning of the 1990s [1,2]. Since then, many technical refinements have been published to make these flaps more reliable and to widen their arc of rotation to reach the tip of the fingers. For instance, it was revealed that the inclusion of the dorsal metacarpal artery itself is not necessary for the survival of the flap [2,3] and that the vascular network around the metacarpophalangeal joint with the dorsal branches of the palmar digital arteries contribute to the flap vascularization [4]. These findings were the basis for the development of the DMAP flaps and of the DFP flaps [5]. In the following, more reports on these flaps were published [6,7]. However, these papers are limited by including different flap types (DMA DMAP, DFP flaps and variations) thus making it difficult to interpret the specific complication rates of individual flaps.

Despite the knowledge about the vascular anatomy and the potential indications, there is still uncertainty about the sustainable arc of rotation of the different flaps and about the inclusion of the vascular systems for an optimal result with a minimal complication risk.

This paper reports our experience with DMAP flaps and DFP island flaps based on the dorsal branches of the palmar digital artery with emphasis on complications and their correlation with the pattern of vascularization. By definition DMAP flaps are based on consistent dorsal perforating branches from the palmar digital arteries at the webspace, the commissural branches of the palmar digital artery while DFP island flaps are based on dorsal perforating branches of the radial or ulnar digital artery located at the neck of the proximal phalanx.

Patients and methods

From 2007 to 2017 we treated 40 consecutive patients with digital skin defects with reverse flow island flaps from the dorsal aspect of the hand or fingers, based on the dorsal collateral branches of the palmar digital arteries. We operated on 32 men and 8 women with an average age of 49 years (range 20–71).

The defects were located on the index finger in 10 patients, on the middle finger in 10, on the ring finger in 11 and on the small finger in 9 patients. The skin defects were located on the dorsal aspect of the finger up to the distal third of the middle phalanx in 28 cases and over the DIP joint and/or up to the nail bed in 12 cases (Figure 1). In 8 patients the defect was partially located on the palmar side of the digit.

To address the question whether or not the particular feeding vessels of the flaps have an influence on the postoperative outcome, the flaps were separated in two groups. The first group was comprised of the cases where the consistent dorsal perforating branch from the palmar digital arteries at the webspace, the commissural branch of the palmar digital artery, was included and the second group included those cases where the flaps were

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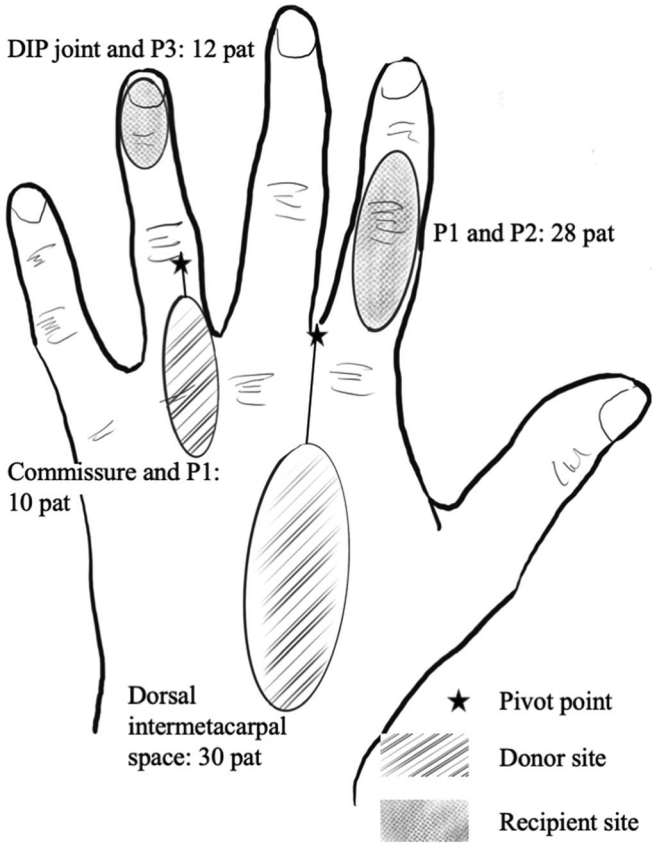

Figure 1. Defect characteristic and flap donor sites.

based on dorsal perforating branches of the radial or ulnar digital artery located at the neck of the proximal phalanx.

Surgical technique

The skin island was planned according to the size of the defect. Moreover, a strip of subcutaneous tissue as wide as the skin island was planned from the distal edge of the flap to the flap's pivot point. After proximal harvest of the flap, the skin over the distal pedicle was elevated subdermally and the subcutaneous pedicle was then dissected up to a pivot point located at either commissural level (commissural perforating branch) for the DMAP flap or at the distal third of the proximal phalanx for the DFP (dorsal branches of the palmar digital artery). Care was taken to include as many dorsal veins and subcutaneous tissue as possible in the pedicle, while leaving the paratenon intact. If extra pedicle length was needed, the perforating commissural branch was carefully mobilized from the fascial plane and tilted distally (Figure 2). Importantly, the dorsal metacarpal artery was never included in the flaps and no preoperative diagnostics was performed to confirm its presence.

The choice of donor site was made according to the defect's location: the flap was raised from the dorsal intermetacarpal space (DMAP flap) for defects up to the distal third of the middle phalanx. For defects distal to this point, the DFP flaps where harvested at the distal part of the intermetacarpal space close to the finger web or from the dorso-lateral side of the proximal phalanx with the same technique (Figure 1). The difference is that in these cases the pivot point was placed at the neck of the P1 using a more distal branch. Finally, the flaps were rotated into the defect and the donor area was closed primarily. Flap harvesting was

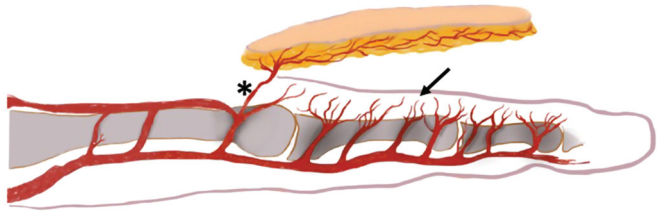

Figure 2. When further pedicle length is needed the perforating commissural branch (*) can be carefully mobilized from the fascial plane and tilted distally. The arrow dorsal to the proximal phalanx indicates the location of the DFP flap perforating vessels.

performed under tourniquet but before final inset, the tourniquet was released and the perfusion of the flaps was evaluated.

Patients were analyzed concerning flap survival, achievement of reconstructive goals and subjective satisfaction. Flap necrosis was measured as percentage of the total original flap surface area.

Results

Twelve flaps were harvested from the second, 12 from the third and 6 from the fourth inter-metacarpal space. In the remaining 10 cases, the donor area was located more distally at the dorso-lateral side of the proximal phalanx. Flap size ranged from 1×1 cm to 5×1.5 cm. The pedicle was tunneled in five cases and was left partially exposed in four cases with secondary epithelialization. To avoid additional scarring on the finger, 8 cases with exteriorized pedicles underwent excision under local anesthesia 2 weeks later. In the remaining cases it was possible to close the skin over the pedicle without tension.

Thirty-six flaps survived completely and 4 exhibited partial necrosis (Table 1). Of note, 3 of the 4 partially necrotic flaps were reverse flow DFP flaps, resulting in a vascular complication rate for these flaps of 33.3% (3/10). In contrast, the vascular complication rate of the DMAP flaps was only 3.3% (1/30).

We did not note any significant venous congestion in the flaps that survived, even though venous drainage depends on flimsy concomitant veins and reversed flow. The four flaps with partial necrosis were characterized by a livid color in the early postoperative phase, which turned into skin necrosis of variable extent. Partial necrosis was observed in flaps transferred to more distal defects and in one flap that was used in a wrap-around technique for both dorsal and palmar proximal phalanx (Figure 3).

In all cases but one a conservative treatment with progressive debridement and local wound therapy allowed secondary healing without additional surgery. However, one patient had to be re-operated due to partial flap necrosis after an avulsion where the finger stump had to be further shortened and the wound closed primarily.

All patients were discharged the day after surgery. The donor site was always closed primarily and without complications. None of the patients complained about the resulting scars and the aesthetic result was judged as acceptable or good. One patient with dark skin disliked the flap color on the palmar side of her finger. Secondary thinning of the pedicle was performed as elective surgery in 2 patients. (Figures 4–7 show illustrative cases).

Discussion

In our series of perforator flaps from the dorsum of the hand or fingers based on the dorsal branches of the palmar digital arteries an overall complication rate of 10% is reported. However, looking

Table 1. All patients and the defect coverage they underwent.

Patient no.	Age	Finger	Defect location	Donor area	Commissure	Size (cm)	Result	Comments
1	41	Index	Distal P1	IMCSP	2nd	2 × 1.5	Good	Tunneled pedicle
2	38	Middle	Distal P1	IMCSP	2nd	2 × 2	Good	
3	52	Index	PIP Joint	IMCSP	2nd	3 × 1.5	Good	Exteriorized pedicle
4	49	Small	Distal P1	IMCSP	4th	1.5 × 1	Good	Tunneled pedicle
5	28	Small	DIP Joint	PP	4th	3 × 1.5	Good	
6	29	Small	P2	PP	4th	2 × 1.3	Good	Exteriorized pedicle
7	32	Ring	P2 and P3	PP	3rd	4 × 1.5	80% Superfic. necrosis	Exteriorized pedicle
8	61	Middle	Distal P1	IMCSP	2nd	3 × 1.2	Good	Tunneled pedicle
9	64	Ring	PIP Joint	IMCSP	3rd	3 × 1.5	Good	
10	26	Middle	Distal P1	IMCSP	2nd	1.5 × 1	Good	Palmar defect
11	31	Ring	PIP Joint	IMCSP	3rd	3 × 1.5	Good	
12	44	Small	PIP Joint and P2	IMCSP	4th	2 × 1	Good	Tunneled pedicle
13	35	Small	Distal P1	IMCSP	4th	2 × 1.5	Good	Exteriorized pedicle
14	71	Ring	P3	PP	3rd	2 × 1.2	Good	
15	63	Index	P3	PP	2nd	3 × 1	Good	
16	54	Index	DIP and P3	PP	2nd	2 × 1.5	40% Necrosis	
17	53	Index	P3	PP	2nd	1.5 × 1	Good	
18	62	Index	P3	PP	2nd	2.5 × 1.5	30% Necrosis	
19	53	Middle	Distal P1	IMCSP	2nd	2.5 × 1.5	Good	
20	48	Small	Distal P1	IMCSP	2nd	2.5 × 1.3	Good	
21	28	Index	P3	PP	2nd	1 × 1	good	
22	54	Middle	DIP Joint	PP	2nd	2 × 1.5	Good	
23	44	Small	PIP and P2	IMCSP	4th	3 × 2	Good	
24	23	Ring	P1	IMCSP	3rd	2 × 2	Good	
25	31	Ring	P1	IMCSP	3rd	2 × 1	Good	2nd Thinning
26	41	Middle	P1 dorsal + palmar	IMCSP	3rd	2 × 5	50% necrosis	Further Shortening of an avulsed finger
27	41	Middle	Ulnopalmar bis DIP	IMCSP	2nd	6 × 1	Good	Burn
28	21	Ring	P1 Dorsal and palmar	IMCSP	3rd	2 × 5	Good	
29	20	Ring	P1 Dorsal and palmar	IMCSP	3rd	2 × 4	Good	
30	41	Middle	PIP	IMCSP	2nd	1.5 × 3	Good	
31	68	Index	P1	IMCSP	2nd	2 × 1.5	Good	
32	54	Small	P1	IMCSP	4th	2 × 2	Good	
33	37	Index	Dorsoulnar P1 + PIP	IMCSP	2nd	3 × 2	Good	
34	70	Middle	Ulnar P1-P3	IMCSP	3rd	5 × 1.5	Good	2nd Thinning
35	31	Ring	P1 Dorsal and palmar	IMCSP	3rd	4 × 1.5	Good	
36	28	Index	PIP	IMCSP	2nd	2 × 1.5	Good	
37	62	Ring	PIP	IMCSP	3rd	1.5 × 3.5	Good	Tunneled pedicle
38	23	Small	P1 Dorsal and palmar	IMCSP	4th	2 × 5	Good	
39	40	Middle	Palmar P1–P3	IMCSP	3rd	2 × 5.5	Good	
40	66	Ring	P1 dorsal and palmar	IMCSP	3rd	1.5 × 5	Good	

IMCSP: intermetacarpal space; PP: proximal phalanx; PIP: proximal interphalangeal; DIP: distal interphalanageal.

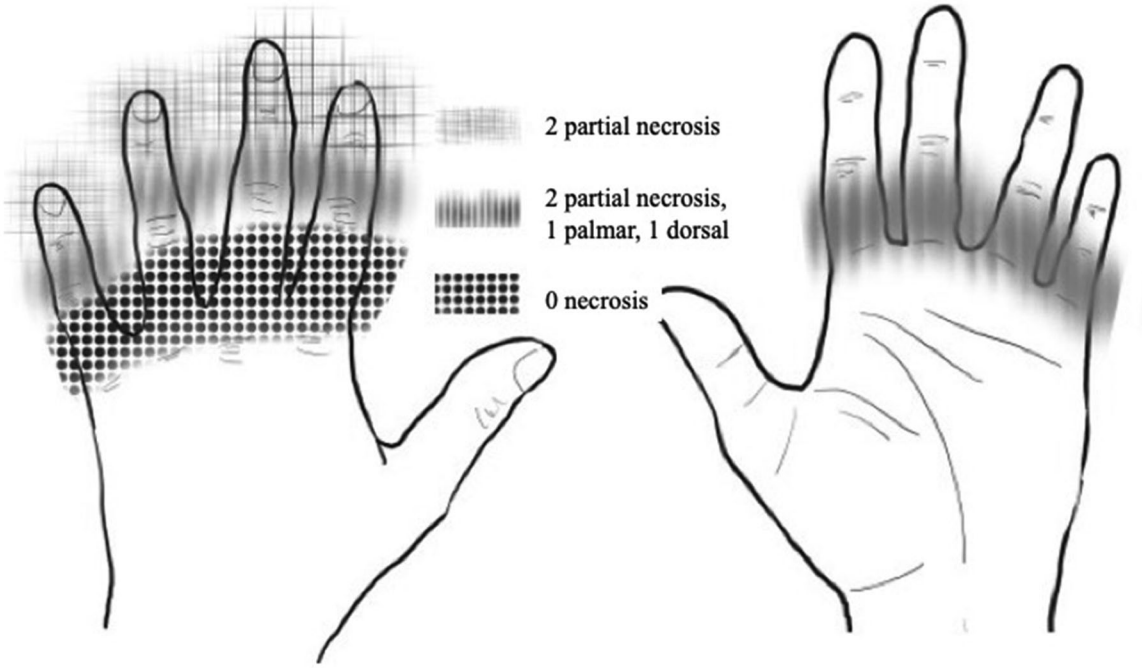

Figure 3. Distribution of complications according to reconstruction site position.

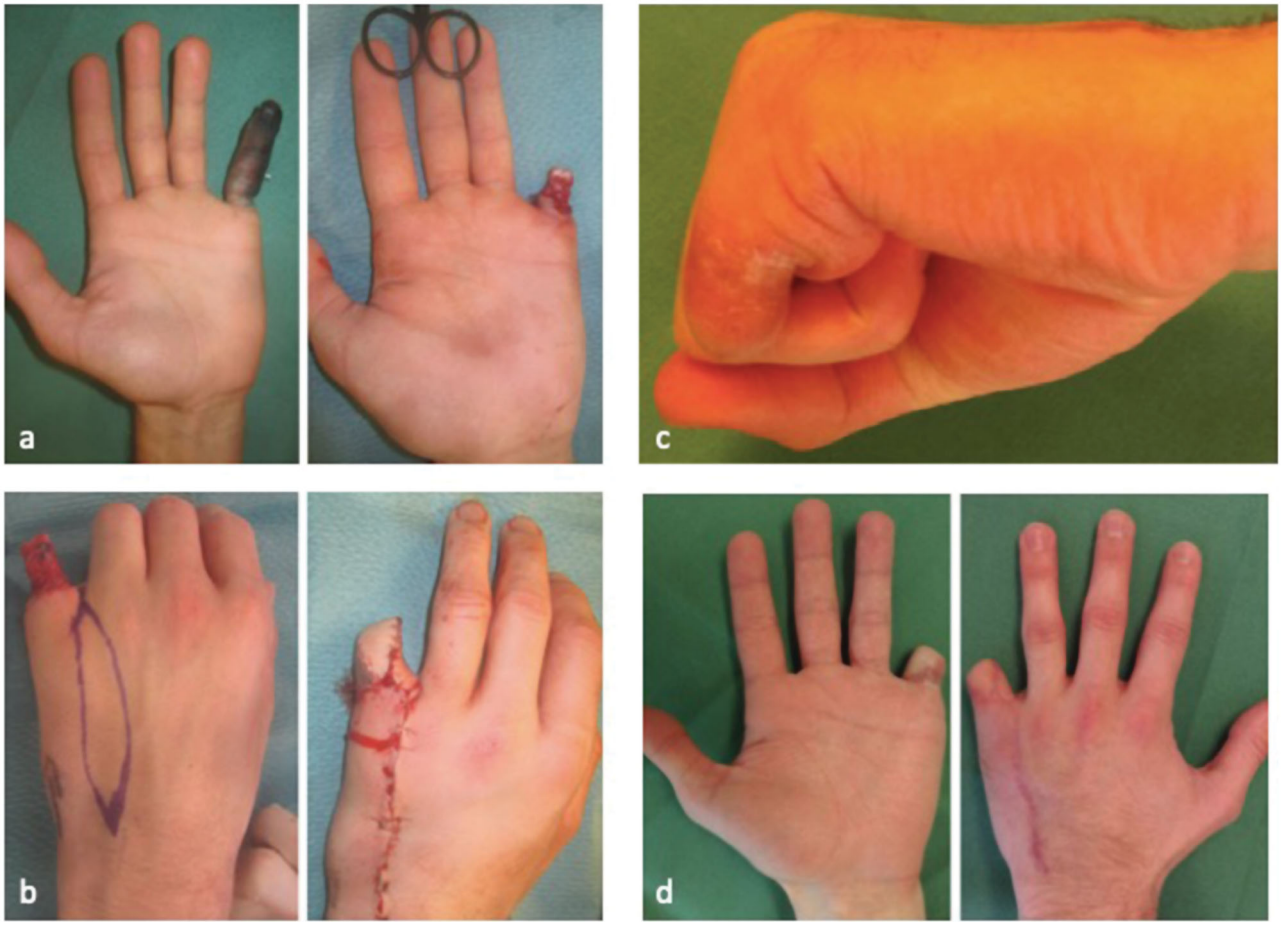

Figure 4. (a and b) A 23-year-old patient was transferred to our institution after a surgeon from a different clinic had forgotten to remove the finger tourniquet after K wire fixation of a P2 fracture. The percutaneous is visible on the ulnar side of the little finger. Most of the finger was necrotic when the patient arrived at our clinic but the patient wanted to save as much finger length as possible. To remove all necrotic tissue the finger had to be amputated as illustrated. The soft tissue defect was covered with the marked flap in a wraparound technique. (c and d) 3 months postop we see good aesthetic and functional results the patient is planning on getting a fitted silicon prosthesis.

separately at the two different flap groups, the vascular complication rate of the DMAP flaps is only 3.3%. In contrast, we report a complication rate of 33.3% in the DFP group. Most of the published case series contain non-specified results after DMA, DMAP and DFP flaps making it difficult to evaluate the complication rates for the different flap techniques [6,8–10]. Newer studies have demonstrated a low complication rate for DFP flaps, but so far only case series have been published [11].

Pelissier et al. published a review of 27 reverse dorsal digital and metacarpal flaps and saw no complications at all [8]. Unlike in our series they closed distal flap harvest sites relying on feeding vessels at middle phalanx level with split thickness skin grafts, an approach we would not consider favorable on the fingers. However, skin closure in the fingers over the adipofascial pedicle could kink the minuscule arterial perforators or compress the draining venous network in the adipofascial bridge. There is not much space in the fingers to allow for the extra volume of the pedicle leave alone postoperative swelling. It is thus possible that the complications we saw in our series might have been reduced by skin grafting of the donor site.

The authors recommend putting the flap back in its original position before tourniquet release to ensure an adequate refill. This approach would of course make insetting of the flap more difficult but seems like a good suggestion to optimize vascularization, which is already draining the flap in retrograde flow.

Preisser et al. published a series of 12 cases with incomplete healing in 2 patients [6]. Vuppalapati reported 5 complications in 49 patients [10]. In his publication he reports on reverse dorsal metacarpal artery flaps based on the distal perforators as in the design suggested by Quaba and Davison [2], DFP flaps and reverse dorsal digital artery flaps that are based on more distal dorsal communicating branches which the authors located with a Doppler probe. Our overall results are similar to those published with 4 partial or total necrosis in 40 flaps, but when analyzing the complications separately for DMAP and DFP flaps, our results indicate lower complication rates for the DMAP flaps.

Considering the question whether or not the pedicle's point of rotation has an influence on the postoperative outcome, even though our series is limited by rather small numbers and a statistical analysis is not feasible, there is a trend to a higher complication rate in flaps with a distal pivot point. This could be explained by a reduced flow in the more distal feeding vessels. The size of the flaps in our series was rather homogenous and we couldn't correlate it with the complication rate. Some authors report venous congestion leading to (partial) necrosis as a common postoperative problem [10,12]. A possible explanation for this phenomenon is the fact that the drainage is reversed in the dorsal venous system, which is included in the fat of the pedicle and extreme care should be taken not to compress or twist the pedicle too much. In our series we didn't encounter this complication.

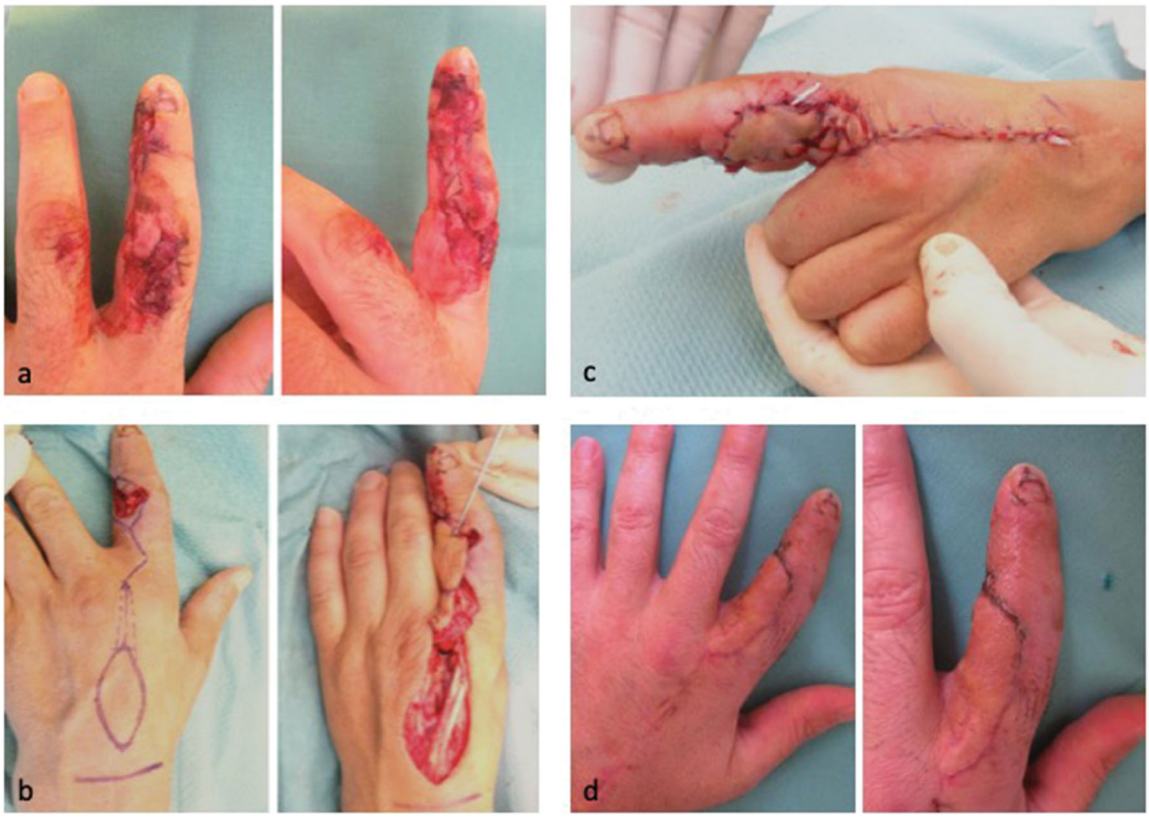

Figure 5. (a and b) This patient was admitted to our emergency room after sustaining the above shown injury working at a milling machine. After the initial surgery and adequate healing time a skin defect persisted dorso-ulnar over the PIP joint. For this classic indication we decided to cover the defect with the above shown flap. The flap was harvested with all subcutaneous tissue while leaving the paratenon intact. (c and d) Initial documentation in the OR shows adequate defect coverage One month postop the flap has already healed nicely with only minimal donor site morbidity.

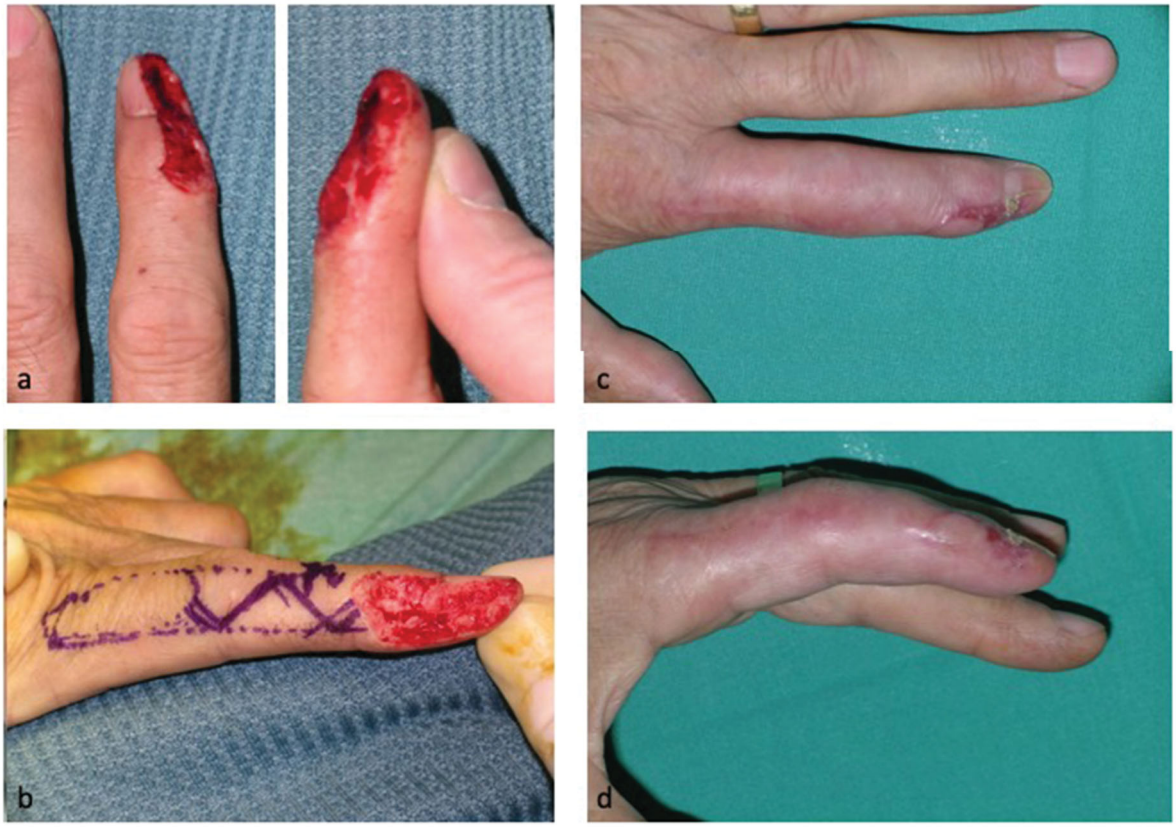

Figure 6. (a and b) This patient presented to our emergency room after suffering the above shown injury while cutting carton with a guillotine. (c and d) One month postop the flap has healed nicely with neglectable donor site morbidity.

Figure 7. (a and b) After having sustained a skin laceration down to the bone with a kitchen knife the skin was initially sutured back in this patient case but become necrotic. The depicted flap was performed to cover the defect. (c and d) One month postop the flap has healed nicely and finger function is steadily improving.

To reduce the risk of venous congestion, the pedicle was always carefully protected and in some cases was exteriorized with secondary healing.

All the flaps in the present series were raised without the dorsal metacarpal artery thus relying solely on the dorsal branches of the palmar vascular system to the dorsum of the hand. For this reason, no pre-operative diagnostics such as ultrasound is required to assess the presence of the dorsal metacarpal artery in the intermetacarpal space where the flap is harvested. The dorsal metacarpal artery was included in the original description of the flap [1], but this significantly limits the arc of rotation. Anatomical studies of the area around the metacarpophalangeal joint by Valenti et al. [4] suggested the possibility of using the dorsal branches of the palmar digital arteries as feeding vessels. This concept was applied by Quaba in his version of the flap [2], which relies on the distal branches of the dorsal metacarpal artery. Finally, Pelissier et al. showed that for very distal finger defects it is possible to rely on the dorsal arterial network of the fingers thus gaining a wider arc of rotation [8].

All flaps in this series were thus based on the dorsal branches of the palmar digital arteries without a higher complication rate compared to the standard flaps confirming the adequacy of the more distal vascular network for the survival of the skin, even though moving the pivot point distally to the level of the P1resulted in a higher percentage of vascular complications. This technique demonstrated to be safe in all intermetacarpal spaces. Previous studies reported that the presence of a dorsal metacarpal artery diminishes progressively from the second to the forth space and that this might affect the reliability of the dorsal metacarpal flaps raised on the ulnar side of the back of the hand. Preisser et al. already in 1990 reported that even when the fourth metacarpal artery is absent this flap can still be safely used [6]. Other authors, however, still affirm that the dorsal metacarpal artery needs to be present and that its presence needs to be demonstrated preoperatively (e.g. by ultrasound) to safely raise the flap [13]. Our case series confirms the findings of Preisser et al. as long as the commissural perforating branch is included in the pedicle [6]. In fact, none of the flaps raised from the 4th intermetacarpal space suffered any vascular complication but we could observe that the more distal branches are not as reliable, leading to the 33.3% of partial necrosis in our series.

The morbidity of the donor area is minimal even though the scar is in an aesthetically exposed area. For this reason, we choose this flap only when it is possible to close the donor site directly. For bigger defects there are other options with donor areas that can be either closed primarily or that are not as conspicuous, for instance free venous flaps harvested from the proximal forearm [14].

Conclusions

The DMAP flaps based on the commissural branch of the palmar digital artery are very reliable. In contrast, the DFP flaps based on the branches at the level of the proximal phalanx exhibit a higher rate of vascular complications. The dorsal metacarpal artery was never included in this series further confirming that it is not

necessary to include it, allowing for a wider arc of rotation that reaches the distal part of the middle phalanx.

Ethical approval

This study has been approved by the Ethics Committee Zurich.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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