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Reconstruction of dorsal and palmar defects of hand with anterolateral thigh flaps from one donor site

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Summary The anterolateral thigh (ALT) flap is becoming the flap of choice for reconstruction of soft tissue defects with primary donor site closure. The purpose of this report was to review the reconstruction of dorsal and palmar defects of the hand with ALT flaps from one donor site. From 2016 to 2018, seven patients with dorsal and palm defects of the hand were reconstructed with the ALT flaps from one donor site. The cutaneous perforators of the two paddles were from a common vascular supply in five cases. The Michigan Hand Questionnaire (MHQ) score of the function was 37.8 ± 10.0 points, and pain score was 32.9 ± 23.4 points. All of the donor sites healed well in one stage. The use of ALT flaps from one donor site is a good strategy for the reconstruction of dorsal and palm defects of the hand with minimal donor site morbidity and a favorable outcome.

Introduction

Reconstruction of dorsal and palmar defects of the hand is a difficult problem because of the circumferential skin loss that affects the survival of hand and fingers. Selection of appropriate flaps for repair of this injury is challenging for the reconstructive surgeon because of the limited number of arteries in the recipient hand [1]. Either the radial artery or the ulnar artery can be used for anastomosis, and the artery not used for anastomosis will provide vascular supply to the hand and fingers. However, in cases wherein both dorsal and palmar defects need to be covered, the choice of free flaps is limited. Pedicled abdominal flaps are an option for the reconstruction of such injuries [1]. However, the disadvantage of using these pedicled flaps for wound

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closure is the extended immobilization time required to facilitate the healing process, which in turn would affect the function and use of the affected hand and fingers.

The use of double skin paddle anterolateral thigh (ALT) flaps may be a good alternative for tissue reconstruction, as they provide more than two skin perforators from a single source vessel. Marsh and Chana reported satisfactory primary donor site closure and successful outcomes following the use of ALT flaps to repair large defects of the foot and ankle. [2] They split the flap into two skin paddles between the perforators and placed them side by side to double the width of the flap. This technique was successful in repairing large defects with a primary donor site. The use of ALT flaps may therefore prove advantageous for tissue reconstruction and repair. Building on this idea, in the current study, we used the split flaps to cover dorsal and palmar defects of the hand and obtained satisfactory outcomes. The aim of this work was to review the use of ALT flaps from one donor site for the reconstruction of dorsal and palm defects of the hand.

Methods

From January 2016 to May 2018, seven patients with dorsal and palm defects of the hand were reconstructed using ALT flaps from one donor site. The indications for the procedure were the hand with dorsal and palm defects required to be repaired. In addition, the distance between the dorsal and the volar defect was more than 1.5 cm. Patients with systemic diseases such as diabetes mellitus, vascular diseases, and heavy smoking histories and those with injury in the donor site were excluded from the surgery. This study was approved by the institutional review committee of our hospital and was performed in accordance with the ethical standards described in the Declaration of Helsinki. Informed consent was verbally obtained from all patients.

Technique

Two flaps were designed according to the dorsal and palmar defects of the hand. The two flaps were combined to an ALT perforator flap whose length is bigger than the width (Figure 1).

Operative techniques

Prior to the surgery, the location of the perforator vessels was detected with a Doppler probe. Brachial plexus block and epidural anesthesia were used in all cases. After a tourniquet was placed on the upper arm, the injured hand was debrided and the radial artery and vein in the anatomical snuffbox were detected. The fracture and dislocation were treated with K-wire fixation.

The split-skin paddle ALT perforator flap was designed to have two individual skin islands supplied by two separate skin perforators. First, a medial skin incision was made down to the deep fascia. The cutaneous perforators were detected and then traced in a retrograde fashion to the descending branch of the lateral femoral circumflex vessel. Elevation of the flap was continued by identifying the

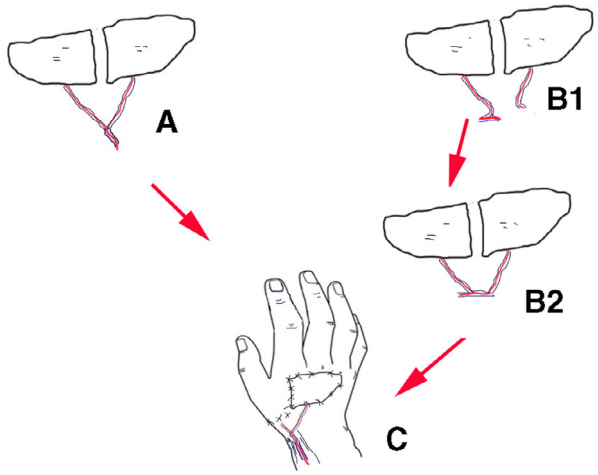

Figure 1 (A) Anterolateral thigh flaps from one donor site based on one pedicle.
(B1) Anterolateral thigh flaps from one donor site based on two pedicles.
(B2) One cutaneous perforator was anastomosed to the branch of the other cutaneous perforator of the paddle to make a common vascular supply.
(C) The injured hand was repaired with the anterolateral thigh flaps based on one pedicle.

cutaneous perforators supplying the complete skin paddle. At this stage, depending on the pedicle length requirement, the pedicle was divided immediately distal to the origin of the branch supplying the proximal flap.

In the flaps transferred to the injured hands, the distal edges of the two flaps were loosely sutured onto the recipient hand. The artery and vein of the pedicle were anastomosed to the radial artery and vein in the recipient site through the way of end-to-end anastomosis or vascular flow-through anastomosis, respectively. The skin edge was trimmed and loosely sutured. The donor site was closed without skin graft.

Postoperative treatment

All patients remained on bed rest for 7 days. The repaired hand typically was positioned at the heart level, and a plaster splint was applied to the dorsal surface to support the fingers, hand, and wrist. Dipyridamole (25 mg, three times daily), combined with acetylsalicylic acid (25 mg, three times daily) was routinely administered for 5 days postoperatively. No dextran was used. Anisodamine, 10 mg once a day for 3 days, and papaverine, 30 mg four times daily for 7 days, were routinely used. Antibiotics were administered routinely for 1 week after surgery. The donor leg was kept elevated for 7 to 10 days to facilitate proper healing. When the wound healed, approximately 2 weeks after surgery, progressive rehabilitation of the hand began. Further, when healing had occurred at the donor site on the leg and edema was resolved, the patients were exposed to a gradual progressive rehabilitative program of walking.

Table 1 Patients' demographic data.

	Sex	Age (years)	Injured hand	Injury Pattern	Emergency	Area of dorsal defect (cm^2)	Area of palmar defect (cm^2)	Distance between two defects (cm)	Bone fracture
1	M	38	R	Twist trauma	N	10×5	8×5	1.5	Y
2	F	49	L	Machine crush	Y	9×4	8×3	3.0	Y
3	F	27	R	Twist trauma	N	8×4	7×3	2.0	Y
4	F	48	R	Machine crush	N	9×4	8×3	1.5	Y
5	M	45	R	Machine crush	N	5×3	5×3	5.0	Y
6	M	31	R	Machine crush	N	7×4	6×3	2.0	Y
7	M	25	L	Thermal injury	N	14×6	16×6	3.0	N
Average		37.6						2.6	
STDEV		10.1						1.2	

M, Men. F, Female. L, Left. R, Right. Y, Yes. N, No.

Evaluation of outcomes

An independent senior hand surgeon performed the assessments. We used the Michigan Hand Questionnaire (MHQ) for subjective functional evaluation (except pain scoring, range: 0–100) and pain scoring (range: 0–100). The Vancouver Scar Scale was used for validated assessment of the scar quality of the donor site.[3]

Results

Seven hands in seven patients with a mean age of 37.6 (range 25–49) years were treated in this group. Four of the patients were male and three were female. There were two cases of reconstructions of the left hand and five cases of reconstructions of the right hand. In one case, reconstruction was performed immediately following injury, while in the other cases, reconstruction was performed at the second stage. Patients' demographic data are summarized in Table 1. All flaps survived completely. No necrosis was observed in the flaps.

In total, 14 flaps were used. The area of flap varied from 7.0 cm $\times$ 4.0 cm to 18.0 cm $\times$ 18.0 cm. The total surgery time ranged from 3.5 h to 8.0 h with an average time of 5.6 h. The flaps from a single ALT site were not based on one pedicle and needed a vascular anastomosis in two cases (Supplementary figure). The follow-up time was from 6.0 months to 15 months with an average of 11.1 months. The MHQ score of the function was 37.8 ± 10.0 points, and pain score was 32.9 ± 23.4 points. The flap was bulky in two cases. The contracture of the first web and flap bulky occurred in two cases. All these four flaps received secondary surgery. The sensation in the flaps was S2. All of the donor sites healed well in one stage. The scar scoring was from 3 to 8 with an average of 1.8 (Table 2).

Case report 1

A 38-year-old male manual worker (Case 1) damaged his right hand in a rolling machine sustaining complete degloving of the index and middle fingers, including palmar and dorsal skin of the hand (Figure 2A and B). The third metacarpophalangeal joint and the distal interphalangeal joints of the ring and small fingers were damaged. Replantation was performed in emergency. Necrosis occurred in the palm and dorsal skin of the hand and index and middle fingers after operation. Two months after the first operation, the patient received the second operation. The necrotic index and middle fingers were treated by amputation. ALT flaps from one donor site were designed for the repair of the palmar and dorsal defects of the hand (Figure 2C). The two flaps were found to be based on one pedicle after harvest (Figure 2D). The artery and vein of the pedicle were anastomosed to the radial artery and vein in the recipient site, respectively. The flap survived completely 7 days after operation. The patient received the third operation because of contracture of the first web and bulky flap. He was followed up 10 months after flap operation. The appearance was satisfactory according to the patient (Figure 2E, F, and G). The patient could accomplish grasping and writing function well (Figure 2H, Video). The MHQ score of the hand function was 59.6 points, and pain score was 0. The sensation in the flaps was S2. The donor sites healed well in one stage. The scar scoring was 8 points (Figure 2I).

Discussion

Dorsal and palmar soft tissue defects of the hand are challenging to treat for surgeons because of the large area of these defects; paucity of recipient blood vessels; and exposure of blood vessels, nerves, and tendons. Skin grafts are not suitable for use in reconstruction in the case of such injuries, as very few free flaps can be selected. The pedicled flaps serve as a viable option for the repair of such injuries.[4] Although the radial antebrachial flaps are a good choice for the repair of soft tissue defects of the hand, they typically are only used for the repair of dorsal hand defects and not dorsal and palmar soft tissue defects because of the limited available donor site area.[5] Recently, Sabapathy et al. used the pedicled abdominal flaps to repair acute circumferential degloving injuries of the hand.[1] After immobilization for four weeks, the flaps were totally divided and survived providing wound coverage. Al-Qattan recently reviewed specific advantages of using pedicled groin and abdominal flaps for the repair of soft tissue defects of the hand.[6] However,

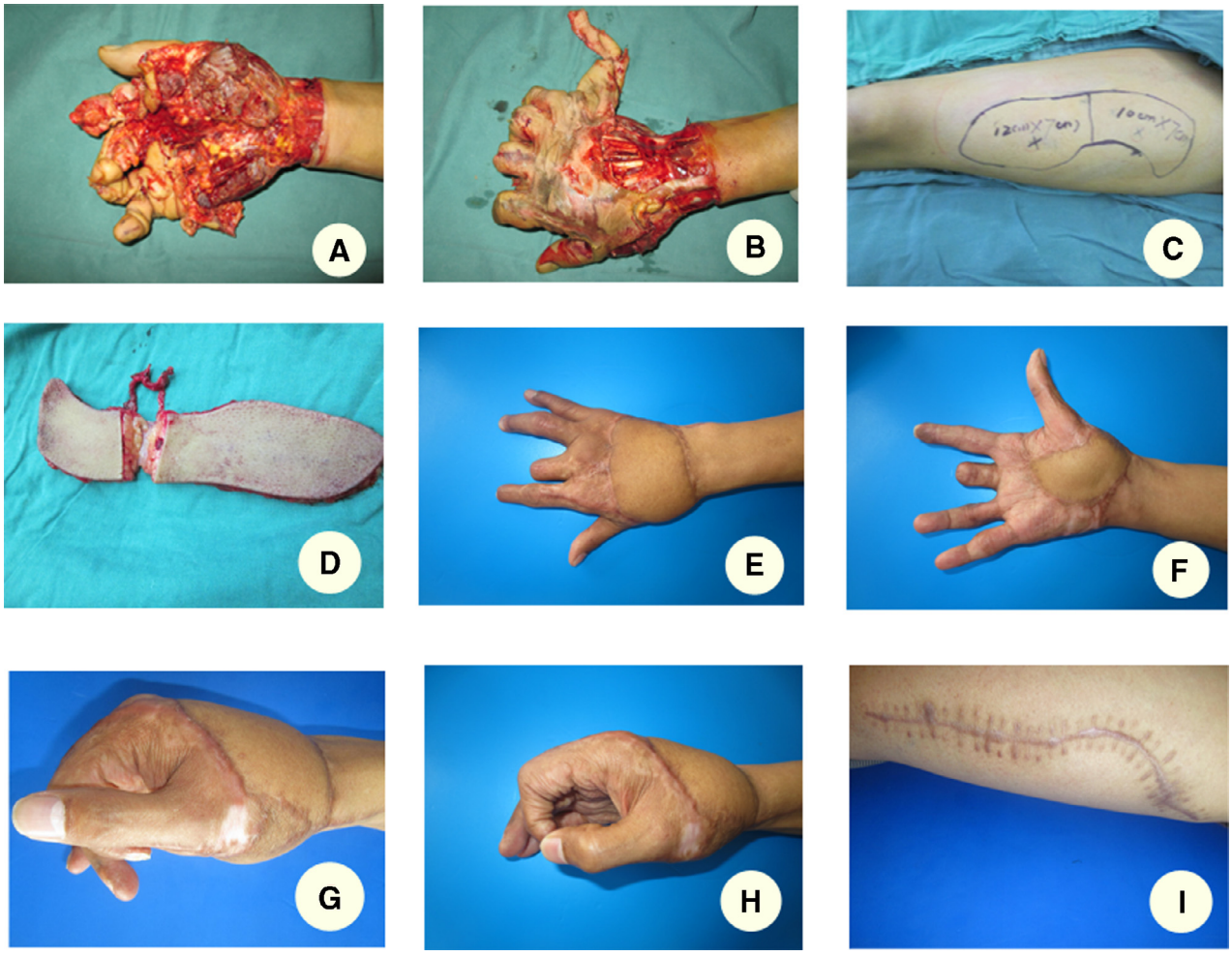

Figure 2 (A) Palmar defect of the right injured hand of Case 1.
(B) Dorsal defect of the right injured hand.
(C) Design of anterolateral thigh flaps from one donor site.
(D) Harvest of anterolateral thigh flaps based on one pedicle.
(E) Appearance of the repaired hand 10 months after operation (dorsal view)
(F) Appearance of the repaired hand 10 months after operation (palmar view).
(G) Appearance of the repaired hand 10 months after operation (Radial view)
(H) Function of the repaired hand 10 months after operation.
(I) Appearance of the donor site 10 months after operation.

the use of pedicled abdominal flaps has some disadvantages such as the requirement of two-stage procedures and long-term immobilization. Alternatively, the use of free flaps for reconstruction is advantageous, as it involves single-stage procedures, less discomfort to the patients, and fewer hospital inpatient days. In addition, it enables the primary reconstruction of other injured structures and reduces patient discomfort associated with the period of "attachment" to the abdomen.[7] Considering these advantages, we were interested to find a suitable free flap for the repair of dorsal and palmar soft tissue defects of the hand.

To cover separated soft-tissue defects from one donor site, Chou et al. reported a technique that involved harvest of two independent ALT free flaps from the same descending branch of the lateral circumflex femoral vessel.[8] Using this technique, they were able to successfully treat trauma of the lower extremity and oral contracture. In another report, Caulfield et al. described the use of three free flaps harvested from a single ALT donor site for the successful salvage of three fingers, with necrosis in only one of the fingers.[9] In a different report, Daniel et al. used the free flaps from a single ALT donor site based on one pedicle and utilized them for coverage of the defects of the lower limb.[2] Based on one pedicle, the two flaps could cover the defect with primary closure of the donor site.

On the basis of evidence from the above-mentioned reports, we decided to use two flaps from a single ALT donor site based on a pedicle, which was anastomosed to the radial artery on the recipient hand. The donor site was sutured directly. In our study, the results were satisfactory with the survival of all the flaps. This method provides several advantages as described here: 1) it could provide coverage for a relatively large area of soft-tissue loss. In our case, the largest area of the flaps were 16×8 cm and 18×8 cm from

Table 2 Surgical outcomes.

	Location of anterolateral thigh flap	Area of dorsal flap (cm^2)	Area of palmar flap (cm^2)	Based on one pedicle	Operation time (hours)	Flap survival	Follow-up time (months)	MHQ Score	Pain score	Complication	Second surgery	Vancouver Scar Scale
1	L	12 × 7	10 × 7	Y	7.25	Complete	10	59.6	0	Contracture of first web, bulky flap	Y	8
2	R	11 × 5	10 × 5	Y	5.5	Complete	8	32.4	40	Bulky flap	Y	6
3	L	10 × 5	9 × 5	Y	3.5	Complete	6	30.4	45		N	4
4	R	11 × 6	10 × 4	Y	8.0	Complete	7	37.4	45	Contracture of first web, bulky flap	Y	5
5	L	7 × 5	7 × 4	N	4.0	Complete	19	31.5	40	Bulky flap	Y	3
6	L	9 × 5	8 × 5	Y	3.75	Complete	13	38.3	60		N	6
7	R	16 × 8	18 × 8	N	7.5	Complete	15	35.2	0		N	3
Average					5.6		11.1	37.8	32.9			5
STDEV					1.9		4.7	10.0	23.4			1.8

L, Left. R, Right. Y, Yes. N, No. MHQ: Michigan Hand outcome Questionnaire.

a single ALT donor site.[10] (2) The vascular pedicle is long enough to target the recipient radial artery outside the zone of injury. (3) Primary closure of the donor site is done after harvest of the flap. This is critical for satisfactory functional outcomes from the perspectives of both the patient and the surgeon.[11] Although the defect in all the cases was covered well, the function of the hand was not satisfactory because of the severity bone and joint injury. A long follow-up is needed to evaluate the function results.

Some critical aspects contribute to the overall success of this technique. As the preoperative Doppler sound of the perforator vessels may not completely correlate with the true anatomical locations, the ultimate design of the flap units can be established only after deciding the perforators to be used.[8] After detection, if the perforators of the two flaps happen to be from different arteries, a perforator can usually be found from the transverse branch of the lateral circumflex femoral artery (LCFA). Vascular anastomosis can then be performed at the level of the LCFA, proximal to the division of the descending and transverse branches.[2] The width of the flap used is also important; it has been reported that a flap width of 9 to 12 cm facilitates primary wound closure.[10, 12] Boca et al. reported that the reference point of the donor sites can be closed primarily if the flap width was less than 16% of the thigh circumference.[11] In all the patient cases presented in our report, the flap width was less than 8.0 cm, and all the donor sites were sutured directly.

We did observe some deficits in healing following the use of this method. The sensation was poor and was graded as S2. Therefore, this technique may be preferable for the repair of the dorsal and palmar defects of the hand but not for the fingers, especially the digital pulp. The flap was bulky in some cases, wherein it required a subsequent surgery. Moreover, the formation of scars occurred at the donor site. The scar score ranged from 3 to 8, with an average of 5. However, because the donor site was at a secluded location on the body, all the patients were satisfied with the outcome and preferred to choose this technique when given an option.

Conclusion

The use of ALT flaps from one donor site is a good choice for the repair of large dorsal and palm defects of the hand with minimal donor site morbidity.

Declaration of Competing Interest

All named authors hereby declare that they have no conflicts of interest to disclose.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.bjps.2019.08.002.

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