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Treatment of fingertip avulsion injuries using two periposition pedicled flaps



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KEYWORDS

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Abdominal flap

Summary We described a treatment of fingertip avulsion injury by two periposition pedicled flaps, the reversed pedicle island flap of dorsal branch of proper digital artery and the cross-finger flap. From February 2009 to January 2017, 22 patients (22 fingers) with fingertip avulsion injury were treated with two periposition pedicled flaps, 14 male and 8 female, aged from 17 to 47 years (mean 32 ± 9 years). All of the patients were followed up more than 6 months after operations (mean 9.6 ± 2.6 months). All flaps survived completely. Compared with the traditional abdominal flaps, two periposition pedicled flaps had less pedicle division time. At last follow-up, the 2PD of the palmar part of the flaps, the TAM of the injured finger and the MHQ summary score of the two periposition pedicled flaps were much better than the traditional abdominal flaps. The reconstruction using two periposition pedicled flaps is a versatile treatment with better functions, less morbidity and better aesthetics.

Level of evidence: Therapeutic, level III.

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Introduction

Finger avulsion injuries result in significant morbidity, and until now it is a great surgical challenge in an emergency context.^{1,2} Avulsion injury usually keep phalanges, joints and tendons intact, but the soft tissue, including vessels

and nerves, are damaged severely. Although replantation can achieve a good function and appearance in selected patients,^{3,4} the characteristics of avulsion injury result in the lower survival rate of replantation.^{5,6} When the degloved skin is deemed non-replantable, some form of flaps coverage should be considered.

A wide range of techniques can be used to treat soft tissue defects in the fingertip avulsion injuries, but their results are not always satisfactory. The ultimate goal of

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avulsion injuries is not only the survival of the injured fingers but also a favorable functional recovery and appearance. Hashem reported covering the volar surface of avulsion injuries with a heterodigital island flap from the adjacent finger, while a full thickness graft was applied to the dorsum.⁷ However, the method requires sacrifice the one proper digital artery of the healthy adjacent finger which becomes cold intolerance after operation. Feng et al. used the cross-finger flap on sensory and motion reconstructions of the fingertip avulsion injury, but the technique did great harm to donor finger and lead donor finger dysfunction because of donor site contracture.² Zhang et al. designed a free dorsal nail-skin flap from ipsilateral second toe combined with a flap from the medial side of contralateral second toe for the reconstruction of the finger avulsion injuries, and has reported satisfactory functional and cosmetic results.⁸ However, the donor site morbidity is significant and the method requires microvascular expertise and facilities. Therefore, we designed two periposition pedicled (TPP) flaps to solve the problem of repairing the fingertip avulsion injury. The TPP flaps are made up of a reversed pedicle island flap of dorsal branch of proper digital artery and a cross-finger skin flap. To explore the clinical outcome and clinical feasibility, we report our experience on reconstruction of fingertip avulsion injuries with the two periposition pedicled flaps and compare them with traditional abdominal flaps.

Patients and methods

Patient summary

From February 2009 to January 2017, the cases of the fingertip avulsion injury were reviewed. Inclusion Criteria: 1. single finger injured; 2. soft tissue defect distal to the distal interphalangeal joint; 3. the second finger to the fifth finger. Exclusive Criteria: 1. with fracture or tendon injury; 2. follow-up time within 6 months. Finally, 54 cases (54 fingers) were included in our study, including 33 males and 21 females, aged 17~60 years (mean 36 ± 11 years). The causes of the injury were belt-twisting (31 cases), machine-crushing (10 cases) and machine-wringing (13 cases). Affected fingers included 15 index, 23 middle, 10 ring and 6 little fingers. The interval from injury to surgery was 2~8 h (mean 4.78 ± 1.28 h). 22 fingers of 22 cases were treated by TPP flaps (Group TPP-flaps), and the others (32 fingers of 32 cases) were treated by abdominal flaps (Group Abdominal-flaps). All operations were performed by the same surgical team.

Surgical technique

All of cases were anesthetized by nerve block in the affected limb's axillary and inflated a tourniquet around upper arm. Then debrided completely, removed onychostroma completely and filed phalangeal trochanter blunt if it became sharp due to the defect. In Group Abdominal-flaps, the donor area was performed under local anesthesia.

22 cases was treated by TPP flaps: the dorsal defect was repaired with a reversed pedicle island flap of dorsal branch

of proper digital artery on the dorsum of middle phalanx of the injured figure, and the palmar defect was repaired with a cross-finger skin flap (Fig. 1). Release the tourniquet and obtain absolute hemostasis. Observe the blood supply of the two flaps, and suture the two flaps to that edge of the finger after the two flaps could quickly turn ruddy. Cut two thick split graft from the forearm and suture them to the donor areas. Leave the sutures long at the edges of the free split graft and fashion a stent dressing.

32 cases was treated by abdominal flaps: basing on the size and shape of the finger defect, dissect sharply and raise the skin flap of the desired size and thickness. Maintain hemostasis and handle the fat carefully to avoid necrosis. Close the donor site defect by widely undermining the skin margins and suture them together. Roll the flap into a tubed flap and suture the edges of the flap. Slightly undermine the edges of the defect on the finger, make the tubed flap over the entire defect and suture the free edge of tubed flap to that edge of the finger.

Postoperative treatment

After surgery, all cases were treated with anti-infection, symptomatic treatment, changing dressing every other day and raised the affected limb to reduce swelling. All the flaps in two groups were survived finally. The stent dressings in Group TPP-flaps were removed after 10-14 days postoperatively. After 2-3 weeks postoperatively, the pedicles in Group TPP-flaps were divided. After 3-4 weeks postoperatively, the pedicles in Group Abdominal-flaps were divided and skin flaps were properly trimmed. All cases started functional exercises under the guidance of a physiotherapist in 48 h after pedicles division. At the last follow-up, each patients was assessed and the results were recorded.

Evaluation of outcomes

A senior hand surgeon who did not attend the surgical cases performed all assessments. At last follow-up, the sensibility of the palmar part of the flaps was measured using static two-point discrimination (2PD). The modified American Society for Surgery of the Hand guidelines were used to classify the 2PD (<6 mm for excellent; 6-10 mm for good; 11-15 mm for fair; >15 mm for poor).⁹ The Total Active Movement (TAM) of the injured fingers was measured using a standard hand goniometer, which was compared to that on the healthy side finger.¹⁰ The system sums the degrees of active flexion at the interphalangeal joints and metacarpophalangeal joint and subtracts the degrees of the extension deficits (100% for excellent; >75% for good; >50% for fair; <50% for poor). The MHQ (Michigan Hand Questionnaire) was used to subjectively evaluate outcomes of the repaired hands. The MHQ includes 6 subscales (overall hand function, activities of daily living, pain, work performance, aesthetics, and satisfaction).¹¹ Each subscale scores are transformed to range from 0 to 100, and higher scores indicate better performance for all scales, with the exception of the pain subscale. The MHQ summary score was cal-

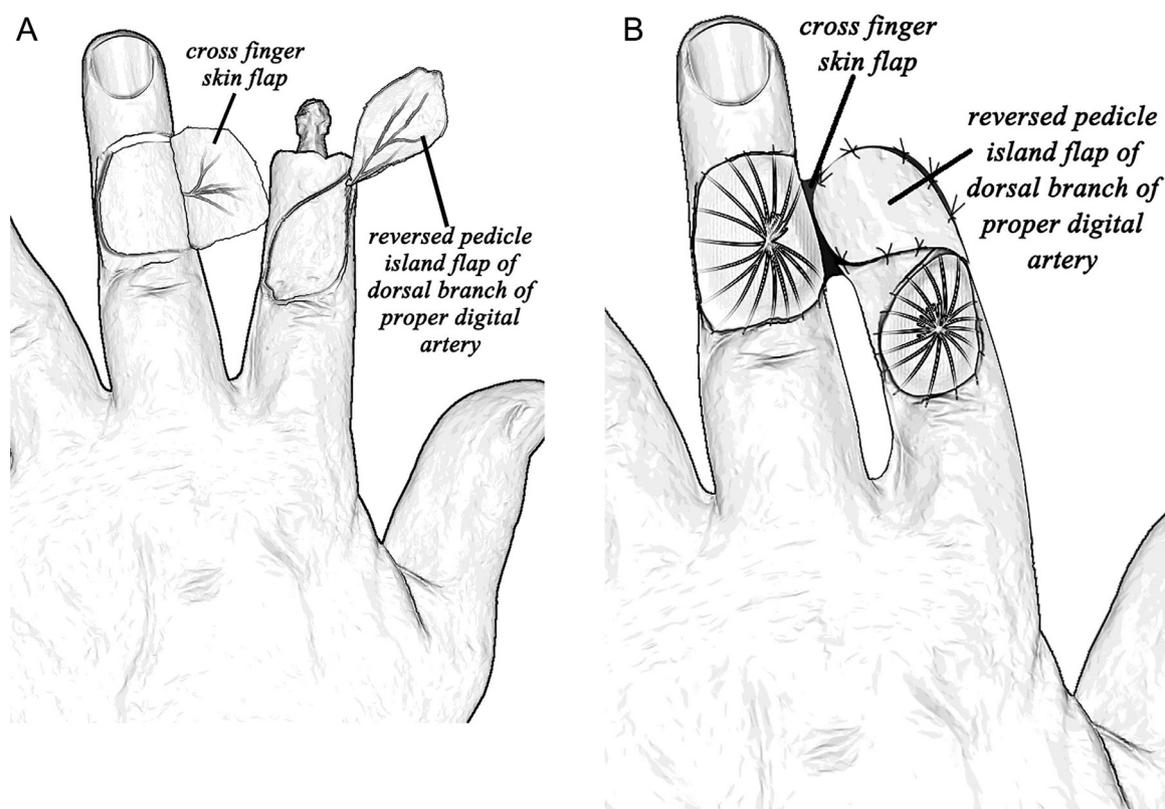


Figure 1 Schematic drawing of the TPP flaps harvest. (A) A cross-finger skin flap and a reversed pedicle island flap of dorsal branch of proper digital artery are harvested. (B) The TPP flaps reconstruction and skin grafts are completed.

culated by averaging the scores for each domain, after reversing the pain score.

Statistical analyses

The statistical analyses were conducted using IBM SPSS Statistics version 22 (IBM Corp.). Categorical data are reported as proportions, continuous data are described as means (standard deviation, SD). Chi-square tests, *t*-tests and nonparametric rank test for unpaired samples were used to compare the difference between the two groups. The level of significance was set at 5%, where $P < 0.05$ was considered statistically significant.

Results

All of the patients were followed up for at least six months (mean 9.5 months, range 6-25 months), and all the flaps and the skin grafts survived completely in the two groups. The characteristics of the study samples are detailed in Table 1. Patients in two groups did not differ with respect to age, gender, the cause of injury, the finger type, the interval between injury and surgery and the duration of surgery ($P > 0.05$ for each). There was no difference with operative duration and follow-up time in two groups ($P > 0.05$ for both) (Table 1). Accordingly, the patients' baseline assessment indicated that the two groups were functionally similar, and the selection bias appears to have been limited.

Patients in Group TPP-flaps had much less pedicle division time than in Group Abdominal-flaps ($P < 0.001$) (Table 1). At last follow-up, the frequency distributions of the static 2PD of the flaps in the two groups were presented in Figure 2, and the 2PD of the palmar part of the flaps and the TAM of injured figures in Group TPP-flaps were much better than in Group Abdominal-flaps ($P < 0.01$ for both) (Table 2). The MHQ summary scores in Group TPP-flaps were much higher than in Group Abdominal-flaps ($P < 0.01$). Evaluation of the MHQ subscale performance showed that the overall hand function, activities of daily living, work performance and pain score had no differences, but aesthetics and satisfaction score was higher in Group TPP-flaps ($P < 0.01$ and $P < 0.05$, respectively) (Table 3).

Case report I

A 35-year-old man's left index finger was twisted by belts at work. The defect of soft tissue was far beyond the distal interphalangeal joint level (Figure 3A). A reversed pedicle island flap of dorsal branch of proper digital artery was designed on the dorsum of the middle phalanx of the injured finger. A cross finger skin flap was designed on the dorsum of the middle phalanx of the middle finger. The two flaps together reconstructed the avulsion injury of the index finger (Figure 3B). The flap survived completely. At 2 weeks after surgery the sutures were removed (Figure 4). At a follow-up of 6 months after surgery, the appearance, function and psychological adaptability of the injury finger and flap were good (Figure 5).

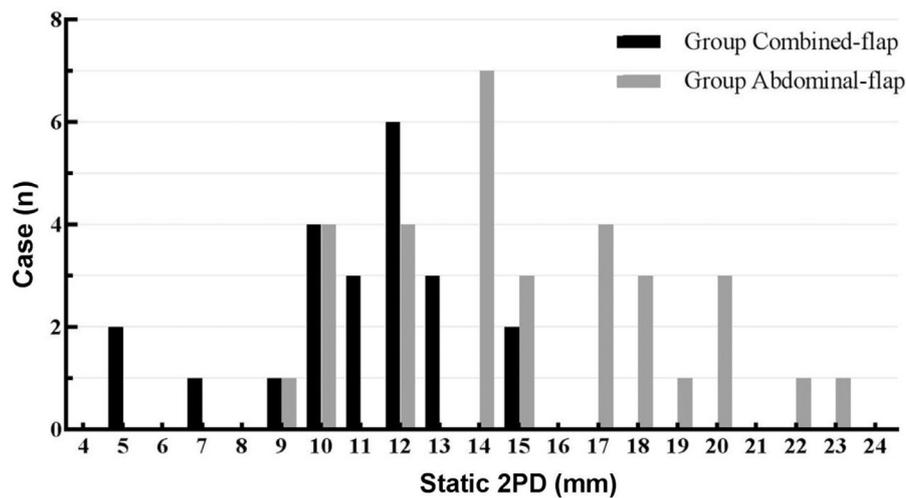
Table 1 Characteristics of the sample.

Variable	TPP-flaps	Abdominal-flaps	P value [△]
Age (year)	32 (SD 9) (range 17-47)	36 (SD 11) (range 19-60)	0.187*
Gender (n)			0.752 [▲]
Male	14	19	
Female	8	13	
Cause of injury (n)			0.804 [▲]
Twisting	12	19	
Crushing	5	5	
Wringing	5	8	
Finger type (n)			0.683 [▲]
Index fingers	6	9	
Middle fingers	10	13	
Ring fingers	5	5	
Little fingers	1	5	
Interval between injury and operation (h)	4.68 (SD 1.25) (range 2.0-7.5)	4.86 (SD 1.32) (range 2.5-8.0)	0.622*
Operation duration (min)	98.86 (SD 10.90) (range 80-125)	104.53 (SD 11.03) (range 85-125)	0.068*
Pedicles division time (day)	16.73 (SD 1.67) (range 14-21)	28.31 (SD 5.12) (range 23-45)	0*
Follow-up time (month)	9.61 (SD 2.55) (range 6-14)	9.35 (SD 3.84) (range 6-25)	0.787*

[△] A value of $p < 0.05$ was considered statistically significant.

* Independent sample t -test.

[▲] Chi-Square test or continuity correction Chi-Square test.

**Figure 2** The frequency distribution of the static 2PD values of the flaps in Group TPP-flaps and Group Abdominal-flaps.**Table 2** Clinical examination.

Variable	TPP-flaps	Abdominal-flaps	P value [△]
2PD of the palmar part of the flap (n)			0.001*
Excellent	2	0	
Good	6	5	
Fair	14	14	
Poor	0	13	
TAM of the injured finger (n)			0.003*
Excellent	17	12	
Good	4	11	
Fair	1	9	
Poor	0	0	

[△] A value of $p < 0.05$ was considered statistically significant.

* Nonparametric rank test.

Table 3 Michigan Hand Outcomes Questionnaire (MHQ).

Domain	TPP-flaps	Abdominal-flaps	P value ^Δ
Overall hand function	94.77 (SD 3.61)	92.97 (SD 4.73)	<i>P</i> = 0.137*
Activities of daily living	96.82 (SD 2.44)	95.38 (SD 3.35)	<i>P</i> = 0.09*
Work performance	95.23 (SD 3.27)	94.38 (SD 3.65)	<i>P</i> = 0.374*
Pain	4.32 (SD 4.44)	5.63 (SD 4.71)	<i>P</i> = 0.310*
Aesthetics	92.05 (SD 7.66)	86.56 (SD 5.60)	<i>P</i> = 0.004*
Satisfaction	91.76 (SD 5.91)	86.72 (SD 8.21)	<i>P</i> = 0.017*
Summary scores	94.39 (SD 3.00)	91.73 (SD 3.41)	<i>P</i> = 0.005*

^Δ A value of *P* < 0.05 was considered statistically significant.

* Independent sample *t*-test.

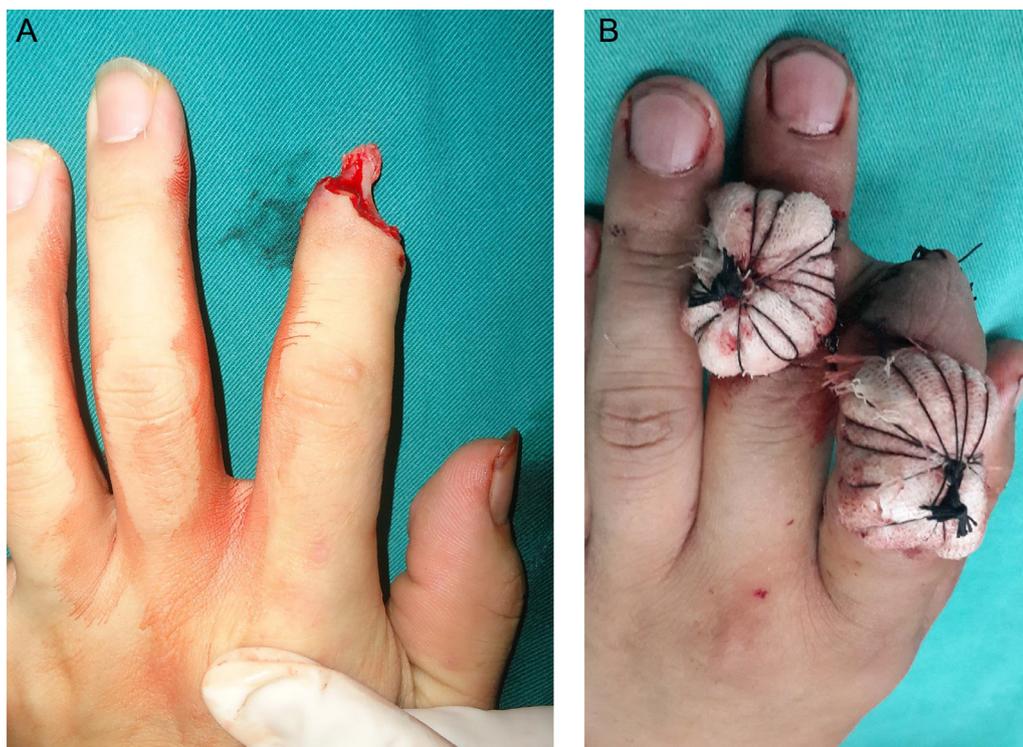


Figure 3 Intraoperative appearance: (A) A 35-year-old man with a left distal index finger avulsion injury suffered a belt-twisting injury. (B) The distal index finger avulsion injury was reconstructed by the TPP flaps.

Case report II

A 38-year-old man with a right distal middle finger avulsion injury suffered a machine-wringing injury at work (Figure 6). The injury finger was reconstructed using the TPP flap. At a follow-up of 3 months after surgery, the appearance, function and psychological adaptability of the injury finger and flap were satisfactory (Figure 7).

Discussion

Hand injuries are very common in daily life and work, and a variety kind of damage has been seen in clinic. The finger avulsion injury is so difficult to reconstruct that finger amputation is usually considered in the past.¹² Revision amputation may be the most expedient treatment, but it is unsatisfied for the patients because of the loss of

appearance and function.^{13,14} The application of abdominal flaps make finger salvage possible.^{15,16} However, abdominal flaps are the distant skin flaps and there are some unavoidable drawbacks: inferior wear resistance, bloated appearance, poor tactile sensation, hand attachment to another part of the body for 3 weeks and multiple-stage procedures.^{17,18} With the development of the flap technique and microsurgery, regional pedicled skin flaps and free skin flaps become the better options. However, the above two kinds of flaps also have their own imperfections. Regional flaps can gain similar textures and sensory as the defect areas, but they make great damage to the donor site and have drawbacks when the defects are large and located distally.^{19,20} Free flaps can provide easy movement of tissue and good restoration of aesthetic outcomes in a single stage compared with regional flaps,²¹ however the surgical procedure and postoperative care are too complicated and the risk of failure is higher.^{22,23} Therefore, we try to design the

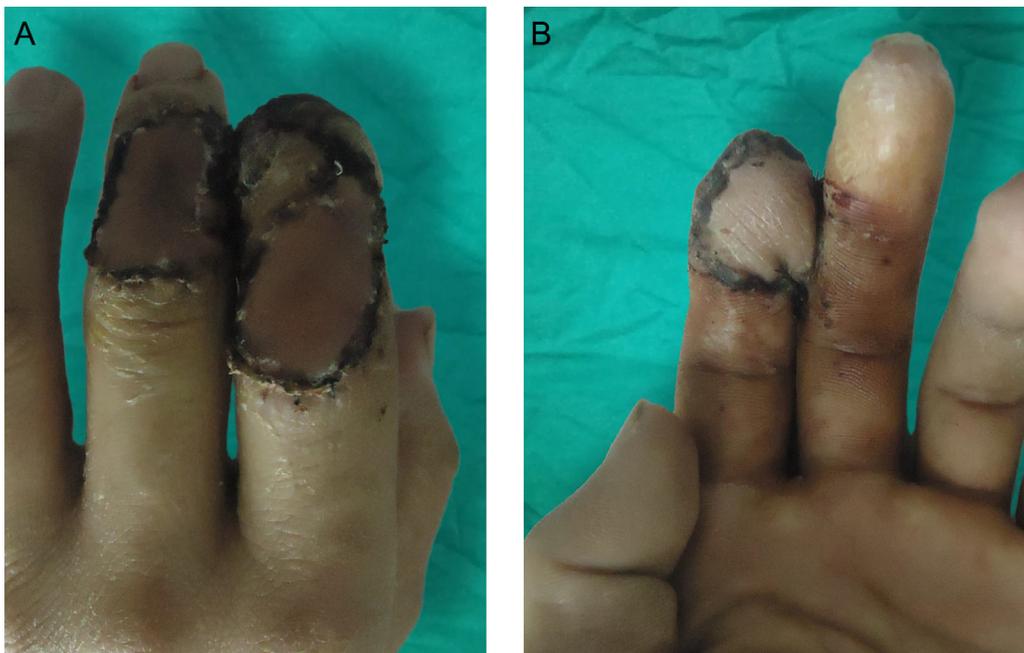


Figure 4 The TPP flaps' appearance at 2 weeks after operation. (A) Dorsal appearance. (B) Palmar appearance.

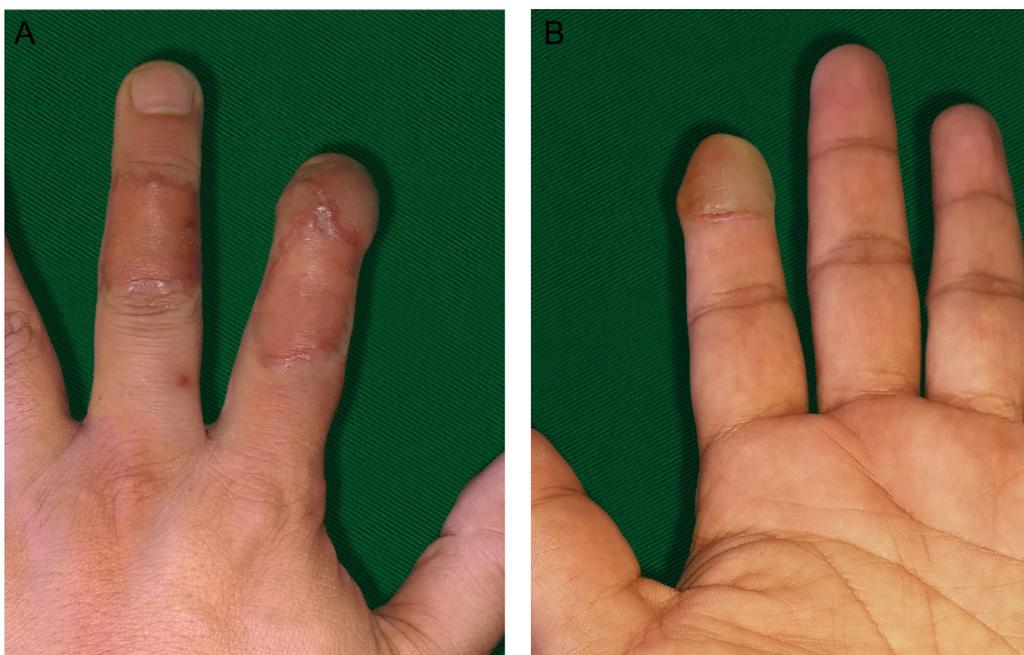


Figure 5 The TPP flaps' appearance at 6 months after operation. (A) Dorsal appearance. (B) Palmar appearance.

TPP flaps to avoid the above problems. We use a reversed digital arterial dorsal branch island flap and a cross-finger flap together to repair the fingertip avulsion injury, because these two flaps not only can together repair larger skin defects but also are reliable flaps and have higher survival rates. In addition, the TPP flaps is a versatile method that does not need microvascular surgery and complicated postoperative care, and it is widely used to reconstruct the fingertip avulsion injury in clinic.

Reconstruction of the fingertip injury aims to achieve stable coverage, restore acceptable appearance, obtain sensi-

tivity, preserve length and allow activities to be resumed as quickly as possible.²⁴ In our study, the TPP flaps are superior to the abdominal flaps in appearance and satisfaction, but no significant difference in other subscales. The TPP flaps are comprised of two kinds of regional flaps whose tissue is similar to that of the defect area, so the injured finger can achieve a better look, flexible texture and wear resistance after the surgery and the patients in Group TPP-flaps show a better psychological adaptability. Due to the similar structures, the nerves of the wound's basement grow easily into the flaps. That is why the sensation function of the TPP flaps



Figure 6 Intraoperative appearance: A 38-year-old man with a right distal middle finger avulsion injury suffered a machine-wringing injury.

is better than that of the abdominal flaps. Moreover, due to the rich blood supply of fingers, the pedicle division time of the TPP flaps is less than 3 weeks, and much shorter than that of the abdominal flaps. The earlier the pedicles are divided, the earlier the patients can do functional exercises. The longer immobilization time will lead to adhesion of tendon and articular stiffness of the wrist, elbow and shoulder.²⁵ Therefore, the injured finger and donor finger have a better and quicker motion recovery in Group TPP-flaps. In addition, the shortening of pedicle division time had a good effect on reducing the hospitalization time and the cost of the patients.

There are some imperfections: first, the TPP flaps are restricted by the anatomy of dorsal branch of digital artery,²⁶⁻²⁸ and the abdominal flaps have more advantages in covering the wide defects.^{29,30} Second, donor site of the TPP flaps needs cut thick split graft from the forearm to transplant. Although the forearm wound can be sutured directly, there will be a long linear scar after operation. In addition, the injured finger and the dorsal side of donor finger will form flaky graft scars, which are less favorable in aesthetics. The abdominal flaps donor can be sutured directly without skin graft in repair of the single finger injury. Although there will be a larger scar, the donor site is relatively concealed. Third, the TPP flaps are only suitable for the repair of single finger avulsion injury, but not suitable for the repair of multiple fingers or thumbs injuries.

Conclusion

The reconstruction using two periposition pedicled flaps is a versatile treatment with better functions, less morbidity and better aesthetics. This method is a better choice for reconstruction of fingertip avulsion injury.

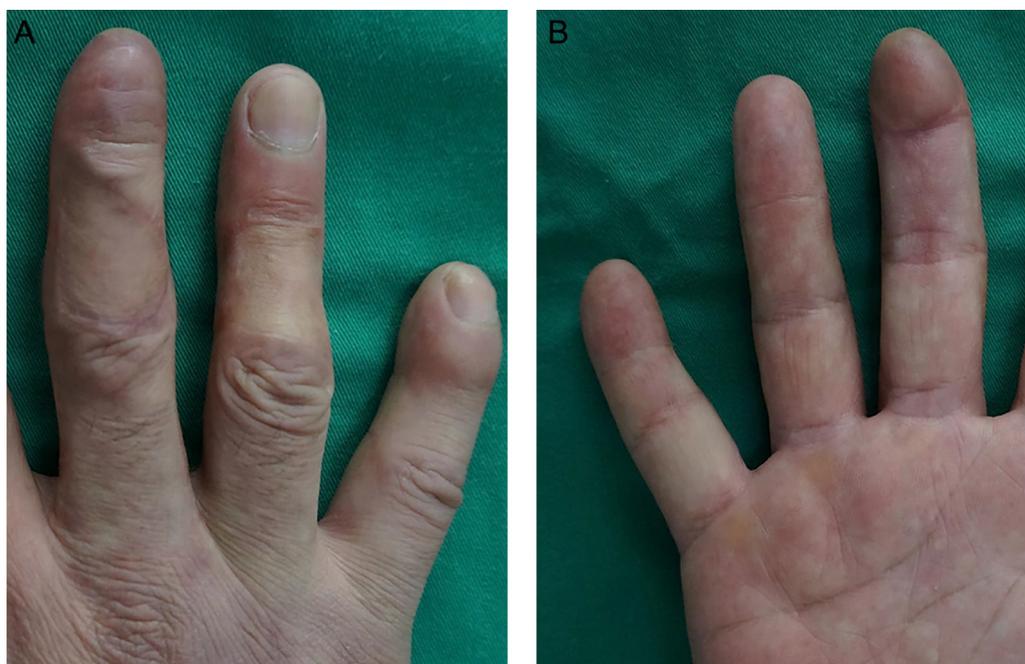


Figure 7 The TPP flaps' appearance at 3 months after operation. (A) Dorsal appearance. (B) Palmar appearance.

Conflicts of interest

None.

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