Original Article

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Repair of Fingertip Defect Using an Anterograde Pedicle Flap Based on the Dorsal Perforator

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ABSTRACT

Background. The hand is the most frequently injured body part. Injuries to the fingertips are among the most common hand injuries. In this article an anterograde pedicle flap based on the dorsal branches of proper digital artery from the dorsum of the middle phalanx was used to reconstruct the fingertip defect as described by Peng Wei MD in a single stage to provide a durable, sensate coverage with the least possible complications.

Aim of study. To introduce and assess the result and long term follow up of using an anterograde pedicle flap based on the dorsal branches of proper digital artery from the dorsum of middle phalanx.

Patients and method. A total of twelve male patients were presented to us between November 2016 and January 2018. All of them had history of fingertip injuries and had undergone reconstruction using anterograde pedicle flap based on the dorsal branches of proper digital artery from the dorsum of the middle phalanx" the period of follow up ranged from one month to six months with an average of three months.

Result. In this study 12 patients presented with fingertip defect were surgically treated by using an anterograde pedicle flap based on the dorsal perforator. All the patient had satisfactory result with good pliable contour coverage of their injured fingertip with no restriction of finger movements.

Conclusion. The use of anterograde island flap based on the dorsal branches of proper digital artery from the dorsum of middle phalanx is suitable for reconstruction of fingertip defects of various amputation planes, it provided good contour texture with preservation of digital artery and nerve, it also provides patient with acceptable fingertip appearance.One of the major drawbacks of this procedure is that it requires tedious and meticulous dissection and that donor site requires full-thickness skin graft, which leads to donor site morbidity and scarring.

Keywords.

INTRODUCTION

Not only can we use tools, carry things, eat and drink with our hands but hands also help us express and describe ourselves in social life while talking. Children unhesitatingly explore the world with their fingers. Therefore, fingertip injuries constitute the majority of the cases of hand trauma among children. (1)

Soft tissue reconstruction in cases of fingertip injuries remains a challenge for hand surgery. Tissue loss of multiple digits is a serious problem for hand surgeons, the goals of fingertip tissue

injury treatment are the preservation of functional length, sensibility, the normal anatomy of nail complex, prevention of symptomatic neuromas, adjacent joint contracture, and cosmesis. [(2)]

Although a variety of homodigital and hetrodigital flaps have been described for repair of complicated fingertip defects with exposing tendons and bones, many issues including increased donor site morbidity, lack of adequate tissue for flaps, insufficiency of pivotal arc and length of pedicle, restriction of motion and postoperative loss of size of fingers, inability to provide a well-padded, functional and sensate fingertip, and aesthetic discomfort, have not been resolved.[(3)]

In this study, we used the anterograde pedicle flap based on the dorsal perforator for treatment of fingertip defect. This island flap is harvested from middle phalanx skin. The anterograde pedicle flap is nourished by 2-3 perforators. These perforators, which are nourished by the dorsal branch of the proper digital artery (DBPA), are in a relatively constant position. This is because of the presence of 2-3 branches of the proper digital nerve within the flap.[(4)]

PATIENT AND METHOD

Between November 2016 and January 2018, 12 patients (aged 13–45 years) were presented to us with history of fingertip injuries. These patients were surgically treated using an anterograde pedicle flap based on the dorsal perforator at Al-Wasity teaching Hospital. The patient data are shown in table (1).

Exclusion criteria

Those patients with severe crushed hand, children or elderly patient (extremely old), those of critically unstable condition and those with thumb injuries were excluded from this study.

Preoperative assessment of the patients was done in the emergency room and such data as the complete history of the mechanism of the injury, the time of injury, hand dominance, patient's occupation, and associated systemic problems such as history of diabetes mellitus, smoking were obtained from the patient and recorded. Physical examination was conducted which included a systemic examination to rule out any other associated injuries, then the examination was focused on hand to exclude any other hand injury, nail bed injury and to note the degree of contamination, level, and zone of amputation, and presence of exposed bone spikes. The patients were X-rayed to rule out any associated fractures and the presence of foreign bodies. Doppler or CT angiography was not required, and vascularity was confirmed with the Allen test.

The routine preoperative investigation included the measurement of hemoglobin level, renal function, bleeding profile, and virology screening. The patients' photographs were registered, preoperative colored photographs and videos were recorded. Later, postoperative photographs and

videos were recorded. Preoperatively, the prognosis and the complications of the procedure were explained to all patients and their informed consent was obtained

Table 1. Patient data.

Patient	Sex	Age	Digit	Cause of injury	Ishikawa zone	Amputation plan
1	male	15	Lt (middle, ring)	Sharp cut	II	Transverse
2	male	41	Rt Index	Crush	III	Volar oblique
3	male	33	Lt middle	Crush	II	Volar oblique
4	male	24	Lt middle	lacerated	I	Transverse
5	male	45	Lt middle	Crush	II	Volar oblique
6	male	13	Rt Index	Shell injury	III	Volar oblique
7	male	21	Lt middle	lacerated	II	Transverse
8	Male	23	Lt middle	Crush	II	Volar oblique
9	Male	22	Lt middle	Crush	III	Transverse
10	Male	17	Rt index	lacerated	IV	Volar oblique
11	male	27	Lt index	Crush	II	Volar oblique
12	male	21	Lt index	Crush	III	Lateral oblique

Surgical operation

All surgeries were performed under local anesthesia or Biers block with pneumatic arm tourniquet under direct vision with loupe magnification (x 3.5). Usually selected site was of the non-dominant digital artery, which is radial digital artery in the index and middle fingers and the ulnar digital artery in the ring and little fingers.

After cleansing with butadiene, debridement, and excision of devitalized tissue, bone spikes, if any, were trimmed off without shortening the bone. The defect was measured. The average size of the defect was 2.5cm x 3.0 cm. A flap of the shape and size of the injury was then marked on the skin of the middle phalanx.

The distal border of the flap was located around the DIP joint. A Brunner zigzag incision was marked along the non-dominant side of the injured finger. Using no. 15 scalp, an incision was made along the previously marked Brunner zigzag incision. The incision was deepened gradually down to the subcutaneous tissue in the mid-axial

digit. The incision could be deepened down to the commissural level if necessary. This was followed with the dissection of the neurovascular bundle with blunt, fine-tipped scissors. A perpendicular cuff of fatty tissue, about 2mm-3 mm thick was elevated with pedicle. The pedicle was dissected proximally as far as the commissural level in order to allow free mobilization of the neurovascular bundle. Meticulous and precise cautery, while the pedicle was elevated, ensured adequate hemostasis. When the release of the pedicle was complete, the island skin flap matching the previously measured defect size was elevated from the dorsum of the middle phalanx. The island skin flap with 2-3 perforators from the proper digital artery was elevated carefully with blunt dissection, the level of the elevation of the island was above the parthenon. After complete separation of the flap from its underlying bed, the flap is transferred with its neurovascular bundle to the recipient site and inset into the recipient site using simple interrupted prolene suture (5/0), ensuring that the suture is without tension. Before in setting of the flap, the tourniquet is released, and the vascularity of the flap is observed to look for sluggish blood supply or sign of venous congestion. After making sure of the vascularity of the flap, the defect donor site is covered using full-thickness skin graft harvested from the medial side of the arm and it is fixed in its position using (4/0) silk sutures with a tie-over. The mid-axial Brunner incision is closed by simple interrupted suture using 4/0 prolene stitches.

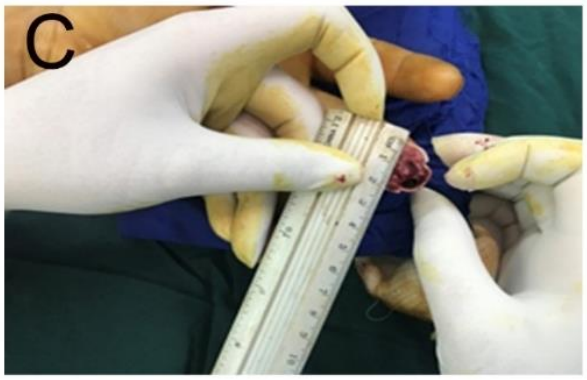
The wound is dressed with an antibiotic (Fucidin ointment) impregnated gauze with a light pressure bandage without a splint. At the donor site of the full-thickness skin graft (medial upper arm or wrist crease), simple interrupted suture and a simple dressing were used. Immediate postoperative photographs of all the patients were taken and also during follow up period.

Postoperative care

The patient was kept on injectable 3rd generation cephalosporin for the first postoperative three days and then kept on an oral antibiotic for at least 14 days till the stitches were removed. The patient was kept in the hospital for one day after the operation and discharged on the next day after inspection of the flap to ensure its viability. The patient was instructed to keep the finger elevated and was started on early physiotherapy consisting of active flexion and extension after two weeks. A six-month postoperative follow up with the patient was done.


A


B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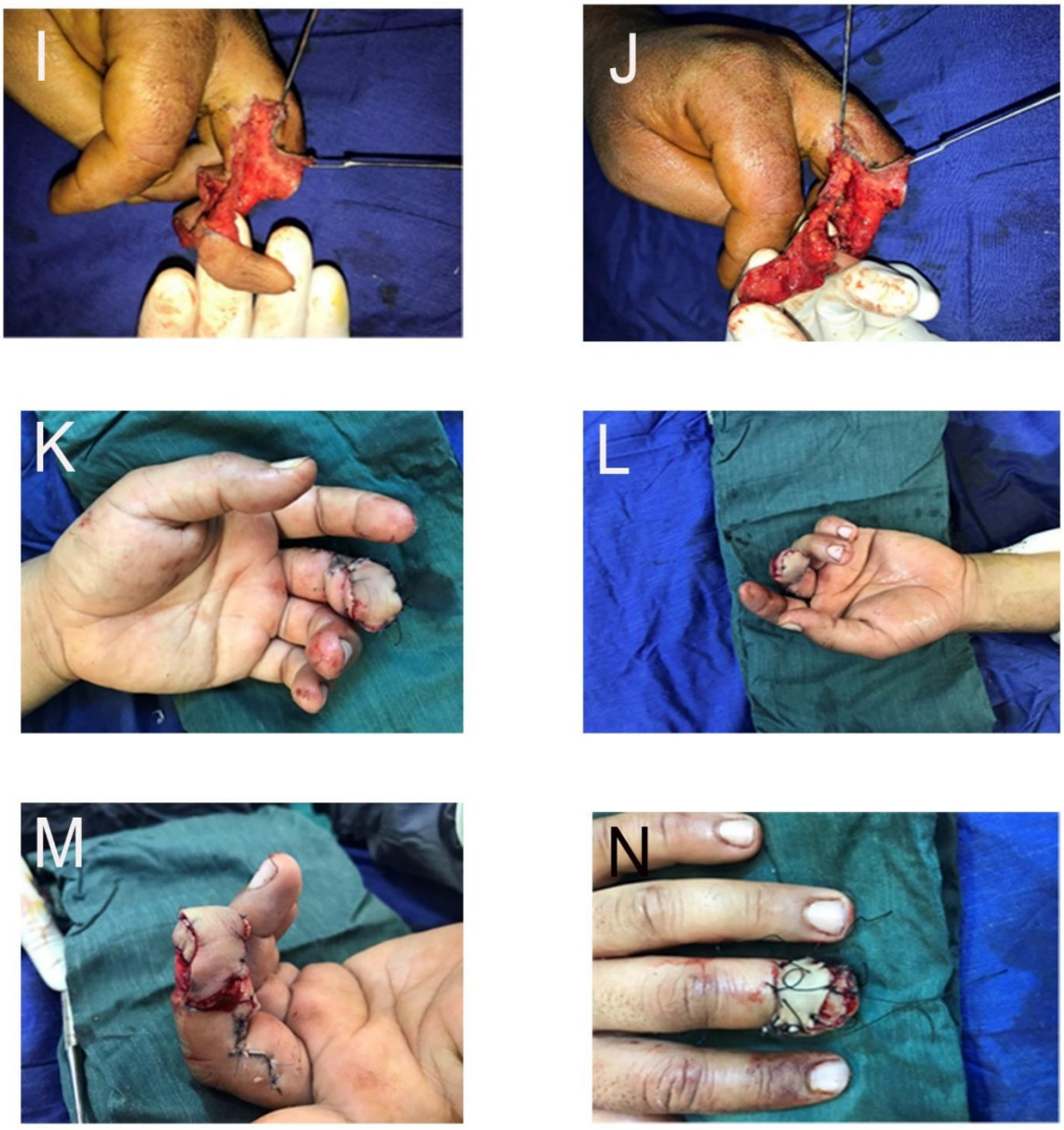

Figure 1 Steps of surgical operation. (A), (B) amputated tip of the left middle finger. (C), (D) measurement of the length and width of the defect. (E) marking of the neurovascular bundle. (F) marking of the dorsal flap. (G) the proposed incision on the mid-lateral aspect of the digit. (H) elevation of the flap above the extensor Paratenon. (I) dissection of the flap with its neurovascular bundle attached. (J) the neurovascular bundle arrows. (K), (L), (M) in the setting of the flap over the tip of the defect. (N) covering the donor defect with a full-thickness skin graft from the medial upper arm.

RESULTS

In this study, 11 patients presented with fingertip injury of various Ishikawa zones of injury and different amputation planes. The patients were surgically treated using an anterograde pedicle flap based on the dorsal perforator. All our patient had satisfactory results with good pliable contour coverage of their injured fingertip with no restriction of finger movements. Also, these patients had a good sensory recovery with static 2-point discrimination ranging between 3mm to 4 mm with an adequately light touch and pinprick sensation. No cold intolerance or skin hypersensitivity was noted and the scar was accepted. The first two cases developed venous congestion with epidermal loss, total flap necrosis was not observed. This may have been caused by the skeletonization of pedicle. Therefore, in subsequent cases, we preserved a cuff of tissue around the pedicle. One case developed hyperpigmentation in the grafted donor area. All of our patients had a satisfactory postoperative appearance and, in the case of the patient who had nail eminence, the nail grew to regain near-normal appearance. The results were good and all the patients were satisfied with the restored fingertips.

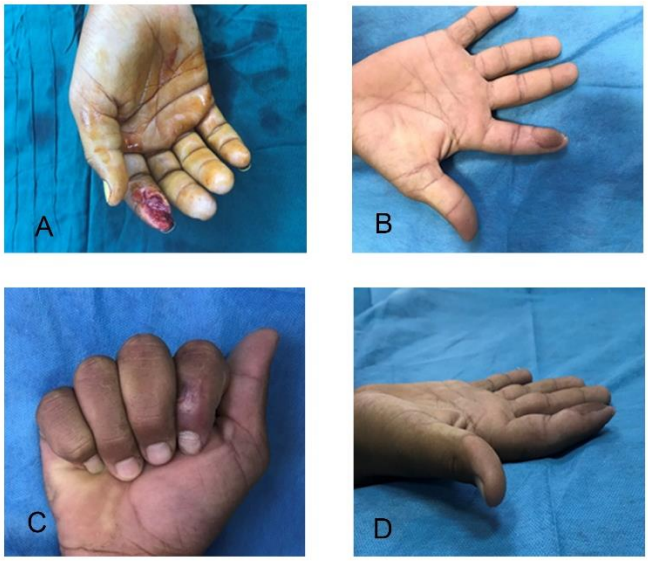

Fig.2 Patient no. 6 (A) volar oblique injury of right index fingertip, (B) 1 month postoperative (C),(D) 2 months postoperative.

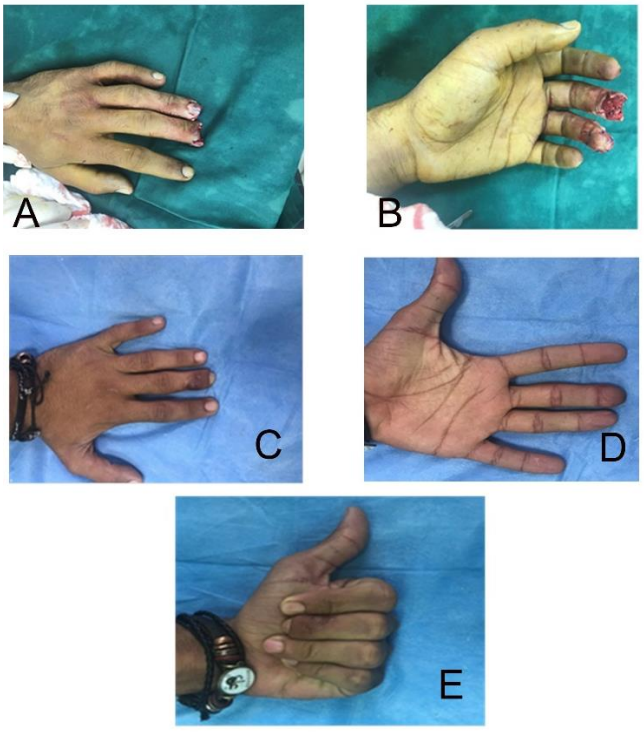

Fig.3 (A), (B) patient No.9 with crush injury to the left middle fingertip. (C), (D), and (E) 6 months postoperative

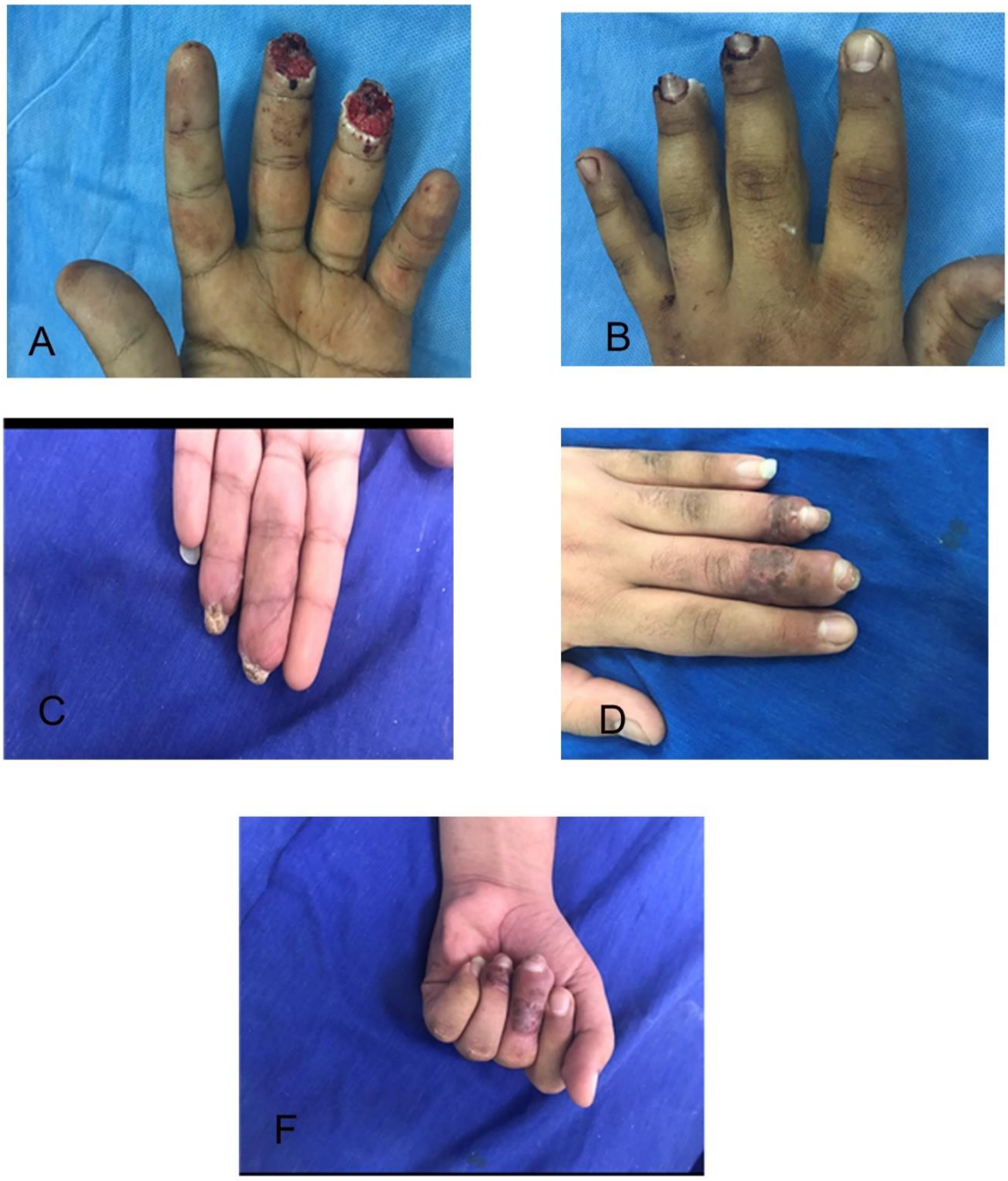

Fig.4 Patient no. 1 (A), (B) volar oblique amputation of left middle and ring fingertips (C), (D), (E), 4 months postoperative

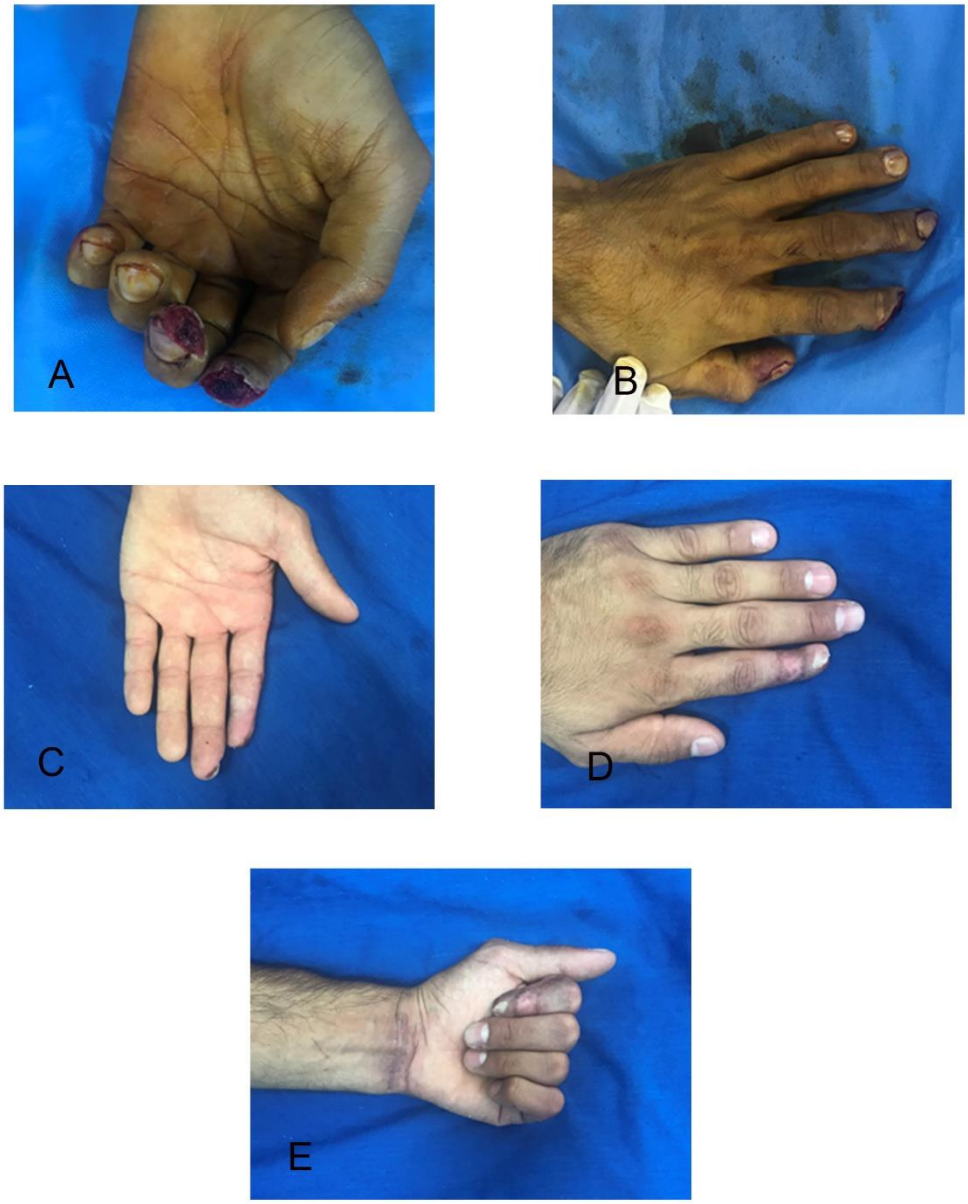

Fig.5 Patient no. 12 (A), (B) patient with Lateral oblique amputation of left index fingertip (C), (D), (E), 4 months postoperative

Complications

There were no major postoperative complications apart from mild flap congestion seen in two patients. This was relieved spontaneously after one week on conservative measurement without any sequelae.

DISCUSSION

Surgical treatment of fingertip injury remains a difficult task. Though numerous and wide variety of flaps available today, when the bone is exposed and healing by granulation has taken place, epithelization does not provide adequate painless pulp coverage. [(5)]

Homodigital artery flap reconstruction is well known to provide satisfactory texture and cosmetic appearance in addition to favorable sensibility. Anterograde pedicle flap based on the dorsal perforator which was used in this study is among various homodigital artery flap reconstructions procedures. [(6)]

Anterograde pedicled flap based on the dorsal perforator was used successfully in 12 patients who were presented to us with fingertip injuries of the various amputation planes with zones (Ishikawa I, II, III, IV). Anterograde pedicled flap based on the dorsal perforator flap gives pliable coverage without compromising the digital length or interfering with the joint movement. Since it is a sensate flap, all of our patients achieved 2_point discrimination sensation ranging between 3 mm-4 mm. postoperative aesthetic result was satisfactory for all of our patients.

Of all our cases, only 2 cases (the first two) develop mild venous congestion probably attributable to the technical error of failing to maintain at least 2 mm-3 mm of perpendicular fatty tissue when the pedicle was dissected. This undesirable effect was avoided in later cases by preserving the fatty tissue. In all our cases, the pedicle was not rotated more than 90°, when more advancement was needed, the neurovascular pedicle was dissected more proximally. The two maneuvers, i.e., not rotating the flap through more 90° and dissecting more proximally reduced the torsion on the flap during mobilization, which reduced the incidence of ischemia.

Our result is in general consistent with the results obtained by Peng Wei et al. using anterograde pedicle flap based on the dorsal perforating on 31 patients with a defect size range of between 1.3 cm-1.5 cm to 2.4 cm_3.0 cm. In the study made by Peng Wei et al. all the flap and skin grafts survived with soft pliable coverage. One case had a mildly purple color of the distal flap, which was resolved spontaneously without any intervention. In one case staphylococcus infection developed, which responded to antibiotic treatment without any sequelae. [(4)]

In this study, all patient achieved good sensory recovery, and 2-point discrimination sensation ranging between 4.96± 1.47 mm. The total active movement was good in general.

Joshi was among the first to use homodigital island unipedicle flap for covering fingertip injuries. [7] Since then, many modifications have occurred in the design of homodigital island flap. One of these modifications was used in Joshi's study. It was the use of digital perforator flap originally described by Koshima.

Koshima used digital perforator flap in five patients between 1998 and 2004. Four of his cases were of chronic wound in the fingertip, while one patient had a fresh wound, the size of the defect ranged between 2 ×0.7 cm to 4× 2 cm. All flaps survived. Sensory recovery in Koshima series was good and no patient had postoperative hypersensitivity or cold intolerance. Two difference between the modifications used in Koshima's study and ours. First, in Koshima method, the flap was elevated on the lateral aspect of the injured finger, which limited the tissue available for use in the reconstruction in comparison with our modification where the flap was obtained from the dorsal aspect of the middle phalanx. Second, in the original Koshima method, the flap was transposed through 180° rotation. This may have caused increased torsion and kinking of the pedicle as compared to our modification that limited the arc of the flap's rotation to less than 90° which reduced the probability of necrosis and failure. [7]

Salih et al. adopted the original Koshima technique in five patients. The average flap size in the study was 4.25 cm^2. All flaps survived except one. That case had partial skin necrosis, which was treated conservatively. No cold intolerance was noted, and sensation was recovered. [9]

Chao Chen et al. used reverse dorsal digital island flap in 30 patients. Flap ischemia was observed in three cases and venous congestion was noted in seven cases. Partial distal flap necrosis was noted in five cases (15%), which represented 10-20% of the originally used flaps in their study. [10] In general, in the reverse-flow blood supply flap, the blood comes from the contralateral digital artery, so that caused a higher rate of blood flow insufficiency, which may adversely affect the survival of the flap. [9]

One of the advantages of digital artery perforator flap used in our study is that it is a sensate flap and does not require nerve anastomosis to the recipient area since it contains 2-3 dorsal branches of the proper digital nerve. The presence of a nerve within the flap and neurorrhaphy being unnecessary, reduced the cost and the duration of the operation. One of the disadvantages of the reverse skin island flap is the sacrifice of both the digital artery and nerve. Although this sacrifice seems acceptable and justified for the pulp; however, such scarification is not accepted when the flap, i.e., the reverse skin flap, is used for covering the dorsal fingertip defect.

For resensitization of reverse skin island flap, microsurgical suture neurorrhaphy is performed between the distal end of the contralateral normal

digital nerve and the nerve within the flap. This maneuver (i.e., neurorrhaphy) adds to the duration and complexity of the operation. Also, it results in relatively lower sensation than achieved in direct pedicle flap as nerve needs more time to regrow after the microsurgical repair. [7]

Lei Zhu used free digital perforator flap for fingertip reconstruction in six cases of fingertip injury. In all the cases, the flaps survived and skin grafting at the donor sites was successful. The 2-point discrimination was 3 mm-8 mm. However, this method needs meticulous dissection and the use of microsurgical anastomosis. Also, there is the risk of donor site scar contracture, especially when the donor site is large, though this was not observed in this study. [11]

Cross-finger flap is one of the methods used for fingertip injuries, F. Rabann et al. used it in 28 patients with very long follow-up period (19.7 years). Their results, in general, showed no postoperative complication such as neuroma and no donor site morbidity. The patient satisfaction score was 9 (range 8–10). The sensation regained was observed within 12 to 18 months postoperatively. However, cross-finger flap is a two-stage operation, pulp quality postoperatively is poor and donor site morbidity is observed. [12]

Paterson had reported donor site stiffness when cross-finger flap was used. Despite partial reinnervation that occurs after cross-finger flap, the sensory return, in general, inadequate for a fine pinch. [13]

Yu Jun Kwon et al. treated 148 fingertip injuries in 120 patients with either single or double thenar flap. They concluded that double thenar flap used for patient with two fingertip amputations had complete survival and the functional result was comparable to that of single thenar flap.

Melone et al. used a thenar flap for fingertip injuries in 150 patients and reported no flap necrosis or loss due to inadequate circulation. However, thenar flap is a two-stage operation with a higher incidence of postoperative finger stiffness due to the prolonged period of immobilization, especially among elderly patients. [14]

CONCLUSIONS AND RECOMMENDATIONS

Anterograde island flap based on the dorsal branches of the proper digital neurovascular bundle for the dorsum of middle phalanx is suitable for reconstruction of fingertip defects in various amputation plane. The procedure provides good contour texture, preserves digital artery and nerve, and gives the fingertip an acceptable appearance.

One of the major drawbacks of anterograde pedicle flap based on the dorsal perforators is the tedious and meticulous dissection that is needed. The difficult procedure requires longer time and the donor site requires a full-thickness skin graft, which may cause donor site morbidity and scar effect.

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