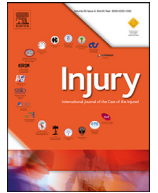




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# Bilateral flaps based on the dorsal branches of the proper digital artery: A reliable reconstruction in one-stage for the multiple defects in one finger

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## ABSTRACT

**Purpose:** To repair multiple skin soft tissue defects of one finger is a challenge to hand surgeons. We introduce a method which can be used to repair multiple skin soft tissue defects of one finger with bilateral flaps in parallel pattern flap based on the dorsal branches of the proper digital artery.

**Method:** A patient suffered electric injury in her left index finger with two soft tissue defects, and the areas were 1.6 cm × 1.0 cm and 2.2 cm × 1.2 cm, respectively. And who underwent a homodigital parallel flaps based on the dorsal branches of the proper digital artery to repair in January 2018. The donor sites were covered by full-thickness skin grafting.

**Results:** The flaps and the skin grafting survived uneventfully. All incisions achieved primary healing. The follow-up was 19 months, and the shape of the flaps was satisfactory with soft texture and suitable appearance. TAM of the injured finger was 210°, the level was excellent. The score of VAS was 9.

**Conclusion:** The homodigital bilateral flaps in parallel pattern based on the dorsal branches of the proper digital artery are a potential treatment in one-stage for multiple skin soft tissue defects of one finger with reliable blood supply, satisfactory results and simple surgical procedure.

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## Introduction

The flap based on the dorsal branch of the proper digital artery (PDA) is commonly used to repair the skin soft tissue defect of finger, including dorsal or palmar defect of the finger, particularly for fingertip, and the outcomes are satisfactory, associating with the properties of reliable and rich blood supply, easy technique, texture and hairless, and the dorsal branch of the proper digital nerve can also be included in the flap, if necessary [1–9]. Coverage of the multiple skin soft tissue defects of one finger represents a challenging problem, including multiple defects without adjacent edge and the limitation of flaps mobilization in the injured finger. Furthermore, exposure of deep structures such as tendon, bone and even joint, then the surgical therapeutic intervention should be typically required to perform [3,5]. In the case, flap is the first choice which would effectively address the problem. Although nu-

merous flaps had been used to cover the defect of hand [6], there was bare to be used to repair the multiple defects in one finger. In this article, we describe a parallel flaps which we have successfully used for repairing the multiple soft tissue defects of one finger in one-stage.

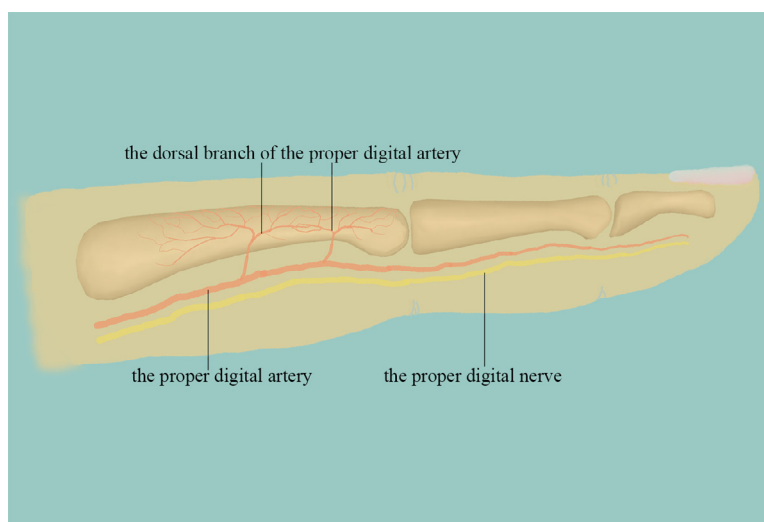
## Materials and methods

On January 2018, a 33-year-old woman who suffered electrical injury during repairing electrical appliances, and resulted in the two nonadjacent skin necrosis in the dorsal of her left index finger. The debridement of the necrotic skins was performed 12 days after the injury. The "wound 1" was located at the distal dorsal of the middle phalangeal neck and the dorsal of the distal interphalangeal (DIP) joint, and the size of defect was 1.6 cm × 1.0 cm. "Wound 2" was located at the radial dorsal side of the proximal interphalangeal joint, and the size was 2.2 cm × 1.2 cm (Fig. 1). The homodigital bilateral flaps in parallel pattern based on the dorsal branches of digital artery which were designed on the dorsal of the injured finger were used to repair the multiple defects after debridement.

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**Fig. 1.** The anatomical pattern diagram of the dorsal branches of the proper digital artery.

## Anatomical basis

The dorsal vascular network of the finger was constituted by the dorsal digital arteries (the terminal branches of the dorsal metacarpal arteries) and the dorsal branches of the PDAs. The anastomosing branches between the dorsal and palmar vascular systems are present in all three phalanxes, and there are four constant and larger dorsal branches arteries. The proximal branch and the second dorsal branch located at the middle point and distal one third of the proximal phalanx, the diameter of the dorsal branch was mean 0.44 mm (0.3–0.6 mm) and 0.3 mm (0.3–0.4 mm), respectively, and the third dorsal branch located at the middle point of the middle phalanx, the diameter was mean 0.45 mm (0.3–0.6 mm), the forth located at the DIP joint, the diameter was mean 0.3 mm (0.4–0.5 mm) [10–13]. The venous drainage was through the cutaneous veins and the venous network associated with the dorsal arterial network (Fig. 1) [9]. Beyond all question, the potential anatomy characters make the designing of the homodigital bilateral flaps in parallel pattern possible.

## Surgical procedure

The operation was performed under an axillary block with tourniquet control and a loupe magnification. After debridement, the extensor tendon of the finger exposed with remaining consecutiveness, and partial exposure of the lateral collateral ligament of the proximal interphalangeal (PIP) joint.

### Flap design

According to the defects of the left index finger, the bilateral flaps based on the dorsal branches of PDA were designed on the dorsum of the injured finger, and the flaps were slightly larger than the wounds. The size of the “flap 1” was 2.0 cm × 1.3 cm and located at the distal one third of the dorsal of the proximal phalanx, the “flap 2” was 2.5 cm × 1.5 cm and located at the middle of the dorsal of the proximal phalanx. The vascular pedicles of the flaps were represented by the proximal and second dorsal branches of the ulnar PDA, and the two flaps were in parallel relationship with an adjacent edge. The pedicle of the homodigital parallel flaps was designed along the PDA, and the pivot point of the retrograde transfer was located at the level of the midpoint of the middle phalanx (Fig. 2A–D).

### Flap dissection

The initial incision was made along the proximal edge of the “flap 2”, and the flap was elevated at the superficial plane of the extensor tendon aponeurosis. The vein at the edge of the flap was ligated and cut off, and the dorsal branch of the ulnar proper nerve in the proximal edge of the flap was dissected. The dorsal branch of the PDA was included in the 5-mm-wide pedicle of the flap, and similarly the PDA was surrounded by fascia in the 5-mm-wide as the pedicle of the homodigital bilateral flaps. The vascular pedicle was dissected and harvested to achieve enough length for tension-free to cover the defects. The digital nerve was carefully separated from the neurovascular bundle and left intact continuity. After the homodigital bilateral flaps were completely elevated, the tourniquet was released, to identify the blood supply of the parallel flaps was adequate, then the adjacent edge was dissected away from each other along the designed line.

### Flap transferring

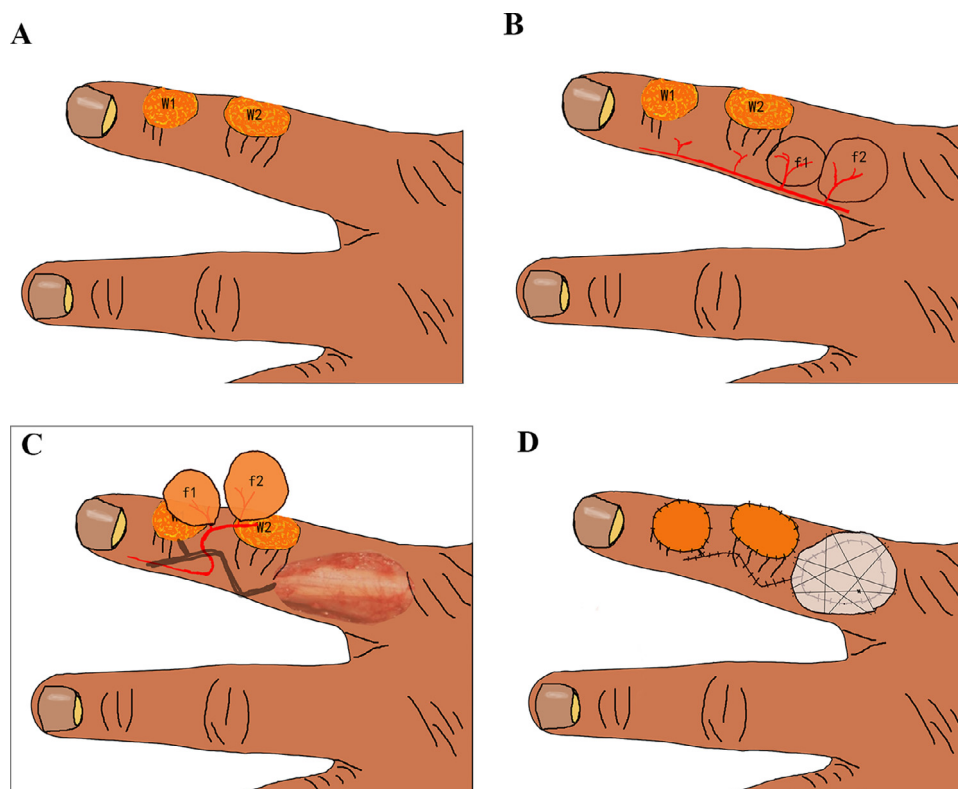
The “flap 1” was transferred to “wound 1” through an open tunnel, and the “flap 2” passed through a subcutaneous tunnel to covered “wound 2”. The flaps were sutured in an interrupted fashion simultaneously without any tension, whereafter, the donor site was covered by full-thickness skin grafting which achieved from the transverse grain of the wrist. And a long line was used for continuous and across suturing the gauze packaging to compress the skin grafting.

### Postoperative treatment

The left hand of the patient was prohibited activity with a splint to maintain a tension-free pedicle for 1 week. The color and capillary refilling of the flap was monitored every 2 h for 3 days. A physical rehabilitation program containing active and passive began when the splint was removed.

### Assessment of outcomes

At the final follow-up, the sensory restoration of the flap was measured using the static two-point discrimination (2PD) test [14]. The range of the motion of the finger was measured by a goniometer, and calculated the total active motion (TAM) [15]. The self-assessment of patients was used to assess the satisfaction of



**Fig. 2.** The pattern diagram of the injury finger and the flap design. A, The soft defects of the finger B, The flap design C, The flap harvesting and transferring D, The pattern diagram of the gauze packaging to compress the skin grafting with a long line which was used for continuous and across suturing.

the recovery outcome. There is a visual analog scale ranging (VAS) from 0 (completely disappointed) to 10 (completely satisfied) and the results were divided into three classes (good 10–8, fair 7–5, poor < 5) [16].

## Results

The homodigital bilateral flaps and skin grafting survived uneventfully. All the incisions were primary healing. The follow-up period was 19-month, at the latest follow-up, the homodigital bilateral flaps had satisfactory appearance, soft texture and good elasticity. The static 2PD was 8.6 mm, and the sensory function of the flap was restored to S3. There were no complications in the donor and recipient sites such as scar hyperplasia or contracture, tendon adhesion and others. The functions of the left index finger were evaluated by TAM method, and the metacarpophalangeal (MP) joint flexed to 90°, the PIP joint flexed to 90°, and the DIP joint flexed to 30°, hereby the TAM was equal to 210°, the level of the function was excellent. The score of VAS was 9 (Fig. 3A-E).

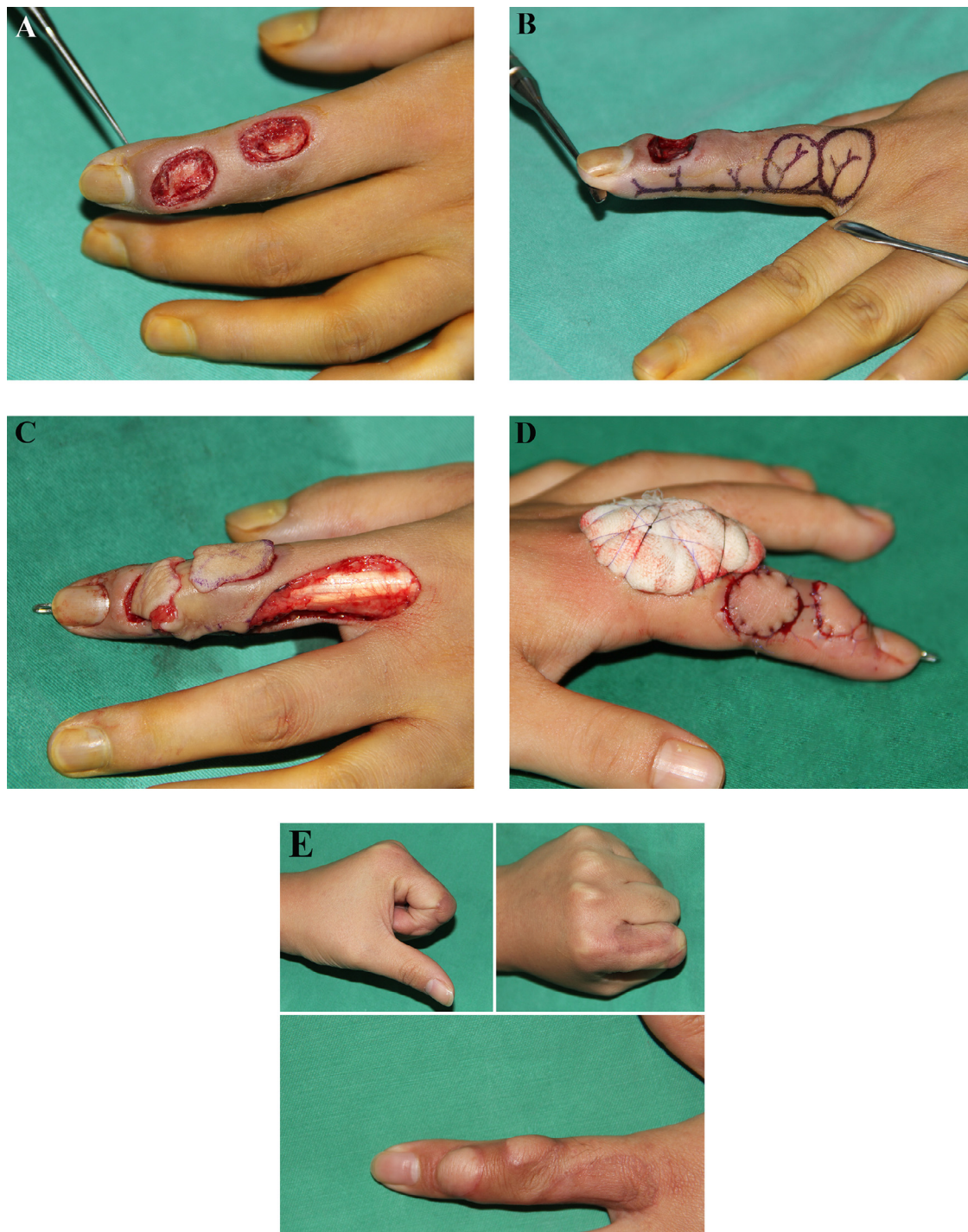
## Discussion

The traumatic soft tissue damage and loss of soft tissue of the hand is one of the most frequent injured type of hand injuries in clinical practice, and there are many treatments in literature with desirable outcomes [3,17]. The flaps which are based on the PDA system make a great contribution to reconstructing hand defect and are widely indicated in clinical and literature [5,18]. Repairing multiple defects on one finger represent a reconstructive challenge for surgeons, in particular when there are multiple soft tissues loss and accompany with deep structures exposure. The challenge lies in whether the reconstructive method could implement one-stage to cover multiple wounds and restores a physical integrity with a good functionality and cosmetic result in this case.

The anatomic studies have demonstrated that the dorsal branches of the PDA and the terminal branches of the metacarpal arteries are constant, participate in the formation of the vascular network at the dorsal of the fingers [6,12,19]. Hence, the dorsal of the finger has become an excellent donor area of various flaps in reconstructive hand surgery because it includes, but not limited to, rich and complex arterial pattern, texture and hairless [20]. Thereby those are the anatomic basis of the homodigital bilateral flaps which could be designed and dissected from the dorsal of the injured digit.

The bilobed flaps have been reported for finger or hand defects based on numerous arteries in clinical studies, and the results of the studies have exhibited that the flaps have reliable blood circulation and can produce satisfied results [21–23]. The model provides a potential method to repair the tissue defect in one-stage. To our knowledge, the bilateral flaps based on the PDA are still rarely used to repair the homodigital defects. Consequently, one-stage to cover multiple defects in one finger was uneventfully achieved in our center, and good appearance and function was also obtained at the latest follow-up. The score of VAS of the herein patient was 9, and she was satisfied with the result, and the TAM of her left index finger was 210°, the level of the function was excellent.

The homodigital bilateral flaps in parallel pattern were designed with an adjacent edge in one finger based on the dorsal branched of the ulnar PDA, while the flap was completely harvested, and the donor site was restored a large unitary wound which could be covered by one skin grafting, thereafter, the skin grafting was also easy compressed by one gauze packaging, and the subsequent operation becomes simple and convenient. The dorsal of proximal phalangeal of the finger was used as the donor site to repair the skin defect of the dorsal of the middle and distal phalanx, and it achieved the like-with-like desired efficiency because of the homologous skin tissue, the similar structure, and the satisfactory appearance [2]. Moreover, the intact natural skin between the two

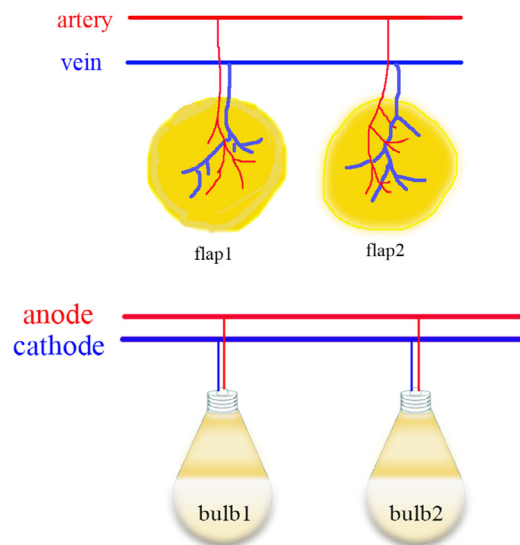


**Fig. 3.** The photographs data of the operation procedure. A, The defects condition after debridement B, The flap design C, The flap harvesting and transferring D, The pattern diagram of the gauze packaging to compress the skin grafting with a long line E, The appearance and function of the finger at the final follow-up.

wounds was restored by the homodigital bilateral flaps which remained optimal appearance. Furthermore, the subsequent operation procedure was easy to perform, which could be frequently applied by any professional hand surgeons.

In our experiences, there are two important details of surgical technique which played a significant role in success of the flap, should be spent special attention. The one is that in order to avoid venous congestion of the flaps, the subcutaneous fascia tissue around the pedicle of the flap at least 5-mm-wide was conserved to protect the drainage vessels; the other one is that the

open tunnel for the vascular pedicle of the flap which far from the pivot point is more optimal, due to the open tunnel benefit for avoiding the pedicle kinked, twisted or compressed, however, it should be adequate width to avoid to be compressed the vascular pedicle by the surrounding tissue [24]. The homodigital bilateral flaps survived uneventfully, attributing to the two flaps in parallel have independent and rich blood supply and drainage, respectively, and that the blood supply of the two flaps is not mutual effect which is equal to the principle of the parallel circuits (Fig. 4). We recommend that continuous and across suturing the packaging



**Fig. 4.** The pattern diagram of the parallel flap and the parallel circuit diagram.

was used to compress the skin grafting with a long line, which could provide a uniform pressure for skin grafting. As a result of that, the gauze packaging is easily shaped and dismantled.

The limited indication of the therapeutic method is the drawback, the location of the wound and the dorsal branch is the determinant factor of whether the homodigital bilateral flaps in parallel pattern can be applied to cover the wounds. The size of the flap is also the limitation, and one of the main blood vessels of the finger is sacrificed, and it is undeniable that the injury of the traumatic finger is increased. Although the diameter of the dorsal branches of digital artery on the proximal phalanx is constant, frankly, they are only mean 0.44 mm (rang 0.3~0.6 mm) and 0.3 mm (0.3~0.4 mm) [2,10–13,25]. The loupe magnification and professional dissection techniques are significantly helpful assistants for the flap harvesting.

## Conclusion

The homodigital bilateral flaps in parallel pattern based on the dorsal branches of the PDA provide a potential one-stage treatment for the multiple defects of one finger. Because the two flaps in parallel pattern have independent and rich blood supply and drainage respectively, and the blood supply of the two flaps is not affected by each other, therefore, the flaps survive uneventfully, and the dorsal of the finger as the donor site, the homologous skin tissue and the semblable structure makes a contribution to satisfactory appearance and function, simultaneously, the donor site morbidity is minimal.

## Declaration of Competing Interest

All of the authors declare no conflict of interest. No benefits in any form have been received or will be received related directly or indirectly to the subject of this article. The study is not supported by any public, commercial or other nonprofit sector. Informed con-

sent of the clinical case has been signed. The study was approved by the committee of medical ethics of the participating hospitals.

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