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Reconstruction of Multiple-Finger Soft-Tissue Defects Using Dorsal Homo/Heterodigital Flaps: Results from a Single-Centre Cohort

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Abstract

Background: Reconstruction of soft-tissue defects in multiple fingers poses a significant challenge. This article reports simultaneous repair of multiple small-to-moderate soft-tissue defects using two types of island flaps harvested from the dorsum of the fingers and evaluates the efficacy of their application in such complex situation.

Methods: Over 10 years, a retrospective study was conducted with 26 patients who had multiple-finger soft-tissue defects treated with dorsal homo/hetero digital island flaps. There were 64 soft-tissue defects in 64 fingers. The injured fingers included 14 index, 21 long, 20 ring, and nine little fingers. The mean size of soft-tissue defects and flaps was 2.4 ± 0.1 × 1.8 ± 0.1 cm and 2.6 ± 0.1 cm × 1.9 ± 0.1 cm respectively. Soft-tissue defect was reconstructed with the fascia-cutaneous island flap in 43 fingers and the neurocutaneous island flap in 21 fingers, respectively.

Results: Full flap survival was achieved in 58 fingers. Partial distal flap necrosis was noted in six fingers, which healed without surgical intervention. We evaluated flap sensibility in 36 fingers where sensory return was considered important. The sensate island flaps achieved better discriminatory sensation than non-sensate flaps. According to the Michigan Hand Outcomes Questionnaire, 10 patients were strongly satisfied and 11 were satisfied and five were neither satisfied nor dissatisfied with functional recovery of the reconstructed fingers.

Conclusion: A combined use of dorsal homo/hetero digital island flaps is reliable and technically easy for simultaneous reconstruction of small-to-moderate soft-tissue defects in multiple fingers.

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Introduction

Reconstruction of soft-tissue defects in multiple fingers poses a significant challenge. Traditionally, these complex injuries have been tackled by in stage: Coverage with multiple individual flaps or a single large flap harvested from the abdomen, and subsequent division, syndactyly release and thinning procedures [1]. This technique is characterized by several major drawbacks such as overstaffed form, poor sensory recovery and a long recovery time. The dorsum of the finger is a reliable flap donor site in reconstructive hand surgery owning to its similar skin quality to the original [2]. Although the dorsal skin of the finger sometimes is damaged by concomitant injuries, the dorsal homo/heterodigital flaps [3-5] can be an alternative for repairing small-to-moderate soft-tissue defects of multiple fingers by means of an ingenious design.

Anatomical studies have demonstrated that the digital artery gives off the dorsal branches at the level of distal interphalangeal joint and near the proximal interphalangeal joint, and their distribution is regular in the fingers [6-7] (Figure 1). The vascular network between these arterial branches can provide blood supply for a fascia-cutaneous island flap [5] (Figure 1). The dorsal branch of the digital nerve originates from digital nerve at the base of the proximal phalanx at which digital vascular bifurcation usually occurred [8]. It travels dorsally through Cleland's band and usually gives three terminal branches over the dorsum of the middle phalanx [9], and is supplied by the small accompanying arteries around it [5]. There is an interlacing vascular network between these accompanying arteries and the dorsal branches of the digital artery and the dorsal digital artery

[6]. The arterial system is the basis for the use of a neurocutaneous island flaps receiving its blood supply from this vascular network along the dorsal branch of the digital nerve (Figure 2). However, these techniques have been frequently utilized as a single unit to repair the soft-tissue defect of the finger.

In this report, we combined two types of regional dorsal digital flaps for simultaneous reconstruction of multiple-finger soft-tissue defects. At the final follow-up, we evaluated the efficacy of their application in such complex situation.

Patients and Methods

A retrospective study was conducted with 26 patients who had multiple-finger soft-tissue defects treated with dorsal homo/heterodigital flaps. The patients included in the study were selected from all 41 patients who underwent similar injury in hand surgery center of the Third Hospital of Hebei Medical University from July 2008 to June 2018. Of these, nine patients lost to follow-up were excluded. In addition, six patients treated with cross-finger flap or the abdominal flap was also excluded. Twenty-six patients remained in the study included 21 males and 5 females, with an average age of 33 years (range, 17 to 48 years). There were 64 soft-tissue defects in 64 fingers. The injured fingers included 14 index, 21 long, 20 ring, and nine little fingers. There were separate defects in two fingers in 15 patients, in three fingers in 10 patients and in four fingers in one patient. The mean size of soft-tissue defects was 2.4 ± 0.1 cm in length and 1.8 ± 0.1 cm in width. The flaps include 21 neurotized island flaps including dorsal branch of the digital nerve or dorsal digital nerve, and 43 non-neurotized island flaps. The average flap size was 2.6 ± 0.1 cm × 1.9 ± 0.1 cm. The pedicle length ranged from 0.7 mm to 4.4 cm, with an average of 1.6 ± 0.1 cm. Flap transfer was carried out acutely in 17 patients and was delayed 1 to 2 days after the primary surgery in six patients. For the remaining three patients who underwent secondary skin and soft tissue necrosis, flap transfer was postponed 7 to 14 days after emergent operation. The average time of flap transferring was 3.5 ± 1.0 h.

Selection criteria

(1) the separate soft tissue defects with exposed bone or tendon in different fingers in same hand;

(2) the soft-tissue defect ≥ 1.5 cm and ≤ 3.5 cm in length;

(3) necessity to preserve finger length;

(4) regional or local tissue near the defects can be used as the donors; and

(5) A patient between 16 and 60 years of age. Patients were excluded when they had one of the following:

(1) concomitant injuries to the dorsum of multiple fingers that precluded their use as donor sites;

(2) a defect <1.5 cm or >3.5 cm in length;

(3) an accompanying finger degloving injury;

(4) An accompanying soft-tissue defect of the thumb.

All operations were performed by the same surgical team. The data of the postoperative results were collected from office visits and household interviews and outcomes were assessed by an independent senior surgeon who was blinded to the procedures. The study was approved by the ClinicalTrials.gov. Health Insurance Portability and Accountability Act consents were obtained from each patient. In addition, all patients were consented for purposes of this study before surgery.

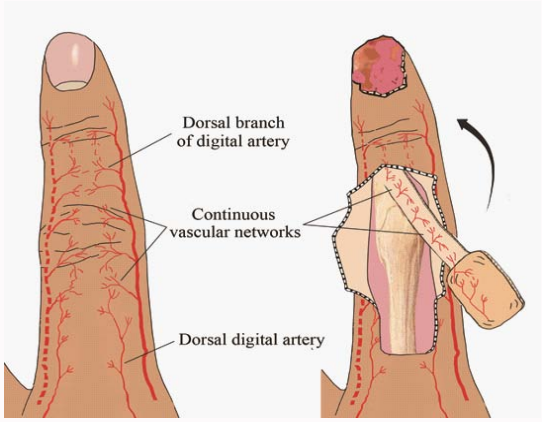

Figure 1: The digital artery gives off dorsal branches in each phalanx, which shows a regular repetitive distribution. The dorsal homodigital fascia-cutaneous island flap receives blood supply from dorsal vascular networks between the dorsal branches of the digital artery and the dorsal digital arteries.

Surgical technique

Dorsal digital fascia-cutaneous island flap [4]: Based on the pattern of the defect, the flap was designed on either the proximal or the middle phalanx, and the pivot point of the flap was designed on the dorsolateral aspect proximal to the distal interphalangeal joint. The pedicle was dissected carefully with the surrounding 8- mm-wide fasciocutaneous tissue above the tenosynovium. The dorsal veins contained in the pedicle were ligated with 9/0 nylon to avoid flap venous congestion. The flap was transferred to the defect through an open tunnel. The dorsal branch of the digital nerve or dorsal digital nerve can be included in the flap for sensory reconstruction in some important regions (Figure 1).

Dorsal digital neurocutaneous island flap [5]: The flap was designed on the dorsum of the adjacent finger between the distal interphalangeal joint and the distal 1/3 of the proximal phalanx. As the flap received blood supply from the vascular network around the dorsal branch of the digital nerve, the pedicle was dissected proximally from the dorsal aspect to palmar aspect, and along the dorsal branch of the digital nerve. The pedicle was dissected to the pivot point, at which the dorsal branch stemmed from the digital nerve. To preserve the interlacing vascular network, 1-cm-wide fasciocutaneous tissue should be included in the pedicle. The flap was then transferred through the subcutaneous tunnel into the defect. At last, the donor defect was resurfaced with a split-thickness skin graft (Figure 2).

Postoperative management

For the flap transfer with a neurorrhaphy, the injured fingers were placed in an extension block splint with the interphalangeal joints in full extension. Active range of motion exercises was begun with the help of a physical therapist after 3 weeks postoperatively.

Evaluation of outcomes

For the recipient where sensory restoration is important, sensation of the flaps was assessed using static two-Point Discrimination (2PD) [10] and Semmes-Weinstein Monofilament (SWM) testing [11] at final follow-up. The cold intolerance of the injured finger was

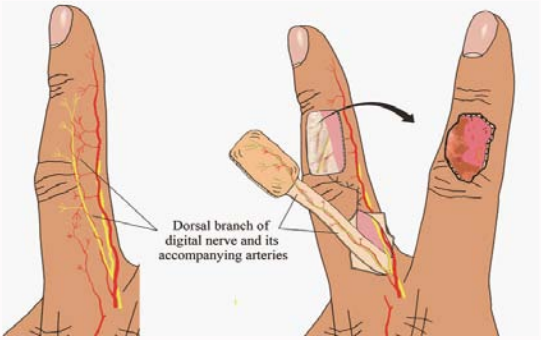

Figure 2: The dorsal branch of the digital nerve innervates the dorsal skin of the middle phalanx and proximal 1/3 of proximal phalanx (Left). Dorsal hetero digital neurocutaneous island flap receives its blood supply from the small arteries around the nerve branch and is harvested from the middle phalanx of adjacent finger (Right).

measured using the self-administered Cold Intolerance Severity Score questionnaire [12] that was rated into mild, moderate, severe, and extreme (0-25, 26-50, 51-75 and 76-100). The pain of the injured finger was given subjectively by the patient using a grading system [13] that included grade 1, none; grade 2, mild, no interference with daily activities; grade 3, moderate, patient works but has some limitation in use of the hand because of pain; and grade 4, severe, cannot work or use hand. To sum up, patients reported their satisfaction with functional recovery of the reconstructed fingers according to the Michigan Hand Outcomes Questionnaire that was based on a 5-point response scale [14].

Results

Full flap survival was achieved in 58 fingers and partial distal flap necrosis was noted in six fingers, which healed without surgical intervention. No wound infection was observed. The patients were followed up an average of 22 months (range 18 to 25 months). Soft-tissue defect was reconstructed with the fascia-cutaneous island flap in 43 fingers and the neurocutaneous island flap in 21 fingers, respectively.

Sensory recovery

We collected data regarding flap sensibility only in 36 fingers where sensory return was considered important. These anatomical regions included the fingertip, the pulp, the volar aspect of the finger, the radial aspect of the index finger, and the ulnar aspect of the little finger. Of these, the sensate and non-sensate flaps were used in 21 and 15 fingers, respectively. At final follow-up, the mean static 2PD and SWM scores were 8.4 mm (range, 6 mm to 12 mm) and 4.02 (range, 3.61 to 4.56) on the sensate flaps, and 9.7 mm (range, 7 mm to 13 mm) and 4.14 (range, 3.84 to 4.56) on the non-sensate flaps. Significant difference was found in static 2PD (P=0.022), but no difference was seen in SWM score between the two groups (P=0.129). By comparison, better discriminatory sensation was obtained on the sensate island flaps.

Figure 4: A) Appearance and B) range of motion of the reconstructed fingers 3 months after surgery.

Cold intolerance and pain

According to the Cold Intolerance Severity Score, 47 reconstructed fingers had no cold intolerance and 12 experienced mild cold intolerance and five underwent moderate cold intolerance. In addition, 46 fingers had no pain, and 14 experienced mild pain and four experienced moderate pain.

Patient satisfaction

According to the Michigan Hand Outcomes Questionnaire, 10 patients were strongly satisfied (score 5) and 11 were satisfied (score 4) and five were neither satisfied nor dissatisfied (score 3) with functional recovery of the reconstructed fingers.

Figure 3, 4 shows a case in which three separate soft-tissue defects in the index, middle and ring fingers were repaired using three fascia-cutaneous island flaps. Figure 5 shows a case in which the soft-tissue defect in the ring finger was reconstructed with a reversed fascia-cutaneous island flap, and the defect in the little finger was covered with a direct neurocutaneous island flap.

Discussion

As multiple-finger injury is severe and complicated, the

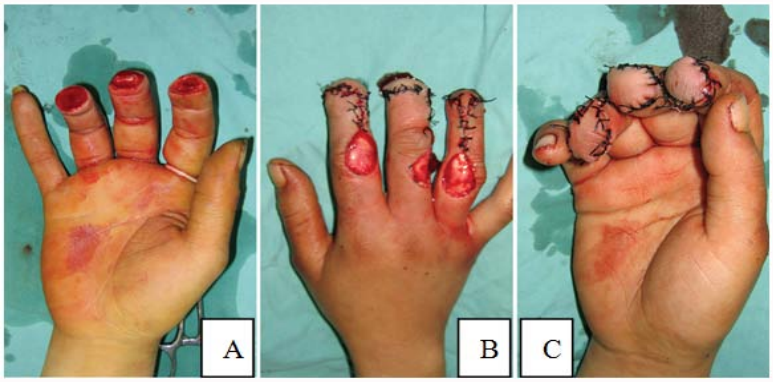

Figure 3: A) Multiple soft-tissue defects in the index, middle and ring fingers. B) Three dorsal fascia-cutaneous island flaps were harvested from the dorsum of the injured fingers. C) The defects were covered with the three flaps.

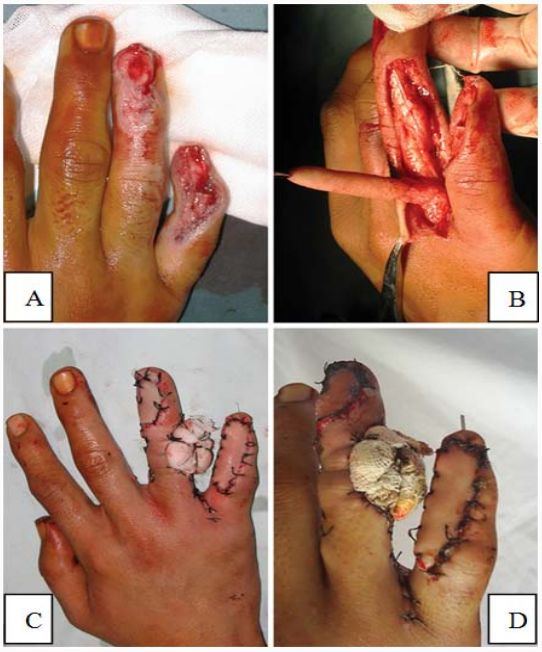

Figure 5: A) Two soft-tissue defects in the ring and little fingers. B) As a soft-tissue defect was located in the distal phalanx of the ring finger and the dorsal skin of the middle and proximal phalanx was intact, a dorsal heterodigital neurocutaneous island flap was harvested from intact donor to reconstruct the soft-tissue defect of the little finger. C) A reversed dorsal homodigital fascia-cutaneous flap was transferred to cover the defect of the ring finger. D) Ten days after surgery.

alternatives for soft-tissue coverage are limited. The reconstruction can be planned as either multistage operations or as simultaneous transfer of different flaps for repairing the soft-tissue defects in multiple fingers [15]. In this article, we tried to use two types of regional flaps harvested from the dorsum of the fingers to repair multiple small-to-moderate defects in a single operation.

The abdominal flaps are commonly used for repairing these complicated defects. The advantages of the techniques are minimal donor morbidity and coverage of relative large defects, but they are characterized by several drawbacks, such as long-term immobilization, the prolonged rehabilitation, and bulky and insensate tissue coverage [16]. Although cross-finger flap can resolve this problem, it requires an attachment between fingers for 2 to 3 weeks. In addition, different levels of the defects may limit its transfer and immobilization [17]. Transferring a free flap can provide adequate tissue coverage in multiple finger injuries, but it requires vascular anastomosis and prolonged operating time and carries a risk of anastomotic failure [18]. The regional dorsal digital flaps can provide small-to-moderate tissue coverage but not sacrifice the digital artery. Furthermore, these flaps can complement one another when one of them is not available due to accompanying damage on donor site. These features make dorsal homo/hetero digital flaps more versatile for reconstructing multiple-finger soft-tissue defects.

Sensory acuity on important anatomical regions of the finger, such as fingertip and volar surface, enables fine manipulation. Sensory restoration to these areas is a reconstructive challenge, especially under the condition of multiple-finger injury. Using our method, the dorsal branch of digital nerve or dorsal digital nerve can be harvested with the fascia-cutaneous flaps to restore neurosensory function. Furthermore, dorsal digital neurocutaneous island flap can also provide good sensory quality [5]. Thus, it may become one valuable option as selective sensory reconstruction for these important regions in multiple-finger injury. In addition, for the patients in our study, more scars in injured hand are inevitable due to severe injury involving multiply fingers. Thus, functional recovery rather than aesthetics is considered first. We selected split skin grafts to cover the donor defects because its potential advantage is shorter healing time, though full thickness grafts seemed to have a trend of better aesthetic outcome [19].

For the fascia-cutaneous island flap, its pivot point is located in the dorsolateral aspect, and thus being suitable for reconstructing a defect in the dorsal or lateral aspect of the distal phalanx. For the defect in the proximal phalanx, the neurocutaneous island flap can be used as an additional treatment option when the fascia-cutaneous island flap is not available due to the concomitant injuries. Moreover, a delicate operating technique and experience are essential requirements of the hand surgeon for the success of regional dorsal digital island flaps.

The advantages of this combined use of dorsal homo/heterodigital flaps include simultaneous coverage of multiple-finger soft-tissue defects in a single procedure and selective sensory reconstruction. Limited flap size and more scars on the injured hand are major disadvantages of this method.

Conclusion

A combined use of dorsal homo/heterodigital flaps is reliable and technically easy for simultaneous reconstruction of small-to-moderate soft-tissue defects of multiple fingers.

Permission Note

It should be noted that Figure 1, 2 were reused content from our previous article published in Injury. Article Title: Direct and reversed dorsal Digital Island flaps: A review of 65 cases. Confirmation Number: 11834817

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