Case Report

Bilateral Multiple Fingertip Reconstruction with Free Medialis Pedis Flaps for Treating Frostbitten Fingertips: A Case Report

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ABSTRACT

Fingertip reconstruction requires flap transplantation rather than a skin graft. Depending on the amputation level, or the lack of volar side, palmar side, or nail matrix, surgeons can consider some surgical strategies for the reconstruction of a single fingertip, and various flap-implantation methods have been reported. However, there are few reports describing multiple fingertip reconstructions. This case report describes a 55-year-old man diagnosed with bilateral multiple fingertip necrosis caused by frostbite. A multiple fingertip salvage procedure with a piece of free medialis pedis flap was performed for the non-dominant left hand, and the donor site was transplanted with an artificial dermis. Three weeks later, the flap was cut to separate the fingers, and a full-thickness skin graft taken from the left inguinal region was transplanted to the donor site. Subsequently, the same procedure was performed for the dominant hand. The course of treatment allowed the patient to return to his original job with minimal hand dysfunction. The outcomes were functionally and aesthetically satisfactory, and no additional surgery such as debulking was required. This report showed the usefulness of a free medialis pedis flap for multiple fingertip reconstruction.

Key words: bilateral multiple fingers, fingertip reconstruction, free medialis pedis flap

Introduction

Flap transplantation is the main treatment for fingertip defects associated with traumatic finger injury, industrial accidents, or tumor resection, and is one of the important reconstructive surgeries for treating hand trauma. For fingertip reconstruction of a single finger, it is easier to set up a certain treatment strategy depending on the presence or absence of nail matrix preservation, the defect site such as the volar side, the dorsal side of the finger, etc.14 Surgeries with homodigital flaps such as oblique triangular flaps13, retrograde digital artery island pedicled flaps14, and digital artery perforator flaps15 are simple procedures, and are commonly used at various medical facilities. Because of no requirement for vascular anastomoses, surgical techniques with these flaps can repair fingertip defects and can be performed in facilities without microscopes at lower technical risks. However, as a disadvantage, the long axis of the finger can be incised for harvesting the flap to reconstruct the fingertip, possibly leading to the contracture of the interphalangeal joint and scar formation on the exposed part.

Other procedures include surgeries with distant pedicle flaps such as thenar flap16 and groin flap17 are known. These procedures with flaps are probably the easiest procedure with high reliability. However, for elderly patients, the period between flap transplantation and the separation of fingers may require approximately 3–4 weeks and provides various adverse events such as joint contracture in the treated fingers. On the other hand, for young patients, the period may be comparable with that of elderly patients and provides a lower possibility of inducing adverse events. However, due to their higher social motivation and activities, it is difficult to impose idleness until finger separation, and the possible failure of transplantation may be induced. Free flap transplantations with hemipulp flaps18, the superficial palmar branch of the radial artery flaps19, posterior interosseous artery perforator flaps20, medial planter artery perforator flaps21, and medialis pedis flaps22, are used for reconstructing fingertips. To reconstruct fingertips and nail matrices23-24, free vascularized nail flaps were harvested from the toes and transplanted to the finger. Recently, surgical
techniques involving free flaps with short pedicles that reduce damage in both donor and recipient sites, are available. However, there have been few reports showing multiple fingertip reconstruction methods, and no standard surgical procedure has been established.

This report describes a case of bilateral multiple fingertip reconstruction with a free medialis pedis flap for treating frostbitten fingertips.

Case report

The patient was a 55-year-old man who worked in a dry ice handling company and unloaded large blocks of dry ice from a truck wearing special gloves during the work. In 2016 he noticed that the color of his fingers gradually became darker and black, as indicated by the white arrows, the nail matrices were preserved, as indicated by the black arrows. Photographs C and D show the volar side of the left and right hands, respectively. As indicated by the white arrows, necrotic tissues were observed at the distal phalanx parts of the middle, ring, and little fingers of both hands.

Fig. 1. Pre-operative findings.
Photographs A and B in the upper row show the dorsal side of the left and right hands of a 55-year male patient, respectively. Although the fingertips of the middle, ring, and little fingers of both hands became darker and black, as indicated by the white arrows, the nail matrices were preserved, as indicated by the black arrows. Photographs C and D show the volar side of the left and right hands, respectively. As indicated by the white arrows, necrotic tissues were observed at the distal phalanx parts of the middle, ring, and little fingers of both hands.
roentgenography confirmed no bone translucency in the phalanxes as osteomyelitis (Fig. 2). As the first step, multiple fingertip reconstruction surgery with a free medialis pedis flap for covering his three fingertips simultaneously was planned, and as the second step, the connected fingertips would be separated. The surgery was started on his non-dominant left hand (Fig. 3). In a supine position under general anesthesia, the necrotic tissues of the left middle to little fingers were excised, and the tips of the distal phalanxes were decorticated. The radial proper palmer digital artery and dorsal cutaneous vein of the middle finger as the recipient vessels in the distal area of the middle phalanx were identified (Fig. 4A), and the subcutaneous veins in the ulnar paronychia of the three fingers were also identified (Fig. 4B). For harvesting an 80 × 25-mm medialis pedis flap, a design marking line was drawn from the left tubercle of the navicular bone to the big toe (Fig. 5A). Upon harvesting, three subcutaneous veins were identified and confirmed to be included in the flap, resulting in the fascial flap (Fig. 5B and C). The fingertips of the middle, ring, and little fingers were reconstructed simultaneously with the medialis pedis flap (Fig. 5D). The main pedicle that contains the deep branch of the medial plantar artery was anastomosed to the recipient vessels in the distal middle pharynx of the middle finger in an end-to-end anastomosis manner with 10-0 nylon, and one of the venae comitantes was connected to the subcutaneous vein in an end-to-end anastomosis manner in the distal middle pharynx with 10-0 nylon, and the other venae comitantes was ligated. Then, three subcutaneous veins in the flap were anastomosed to the subcutaneous veins in the paronychium of the three fingers to avoid venous congestion. As it was not possible to close it directly, the main pedicle was covered with a split-thickness skin graft taken from the palm with a razor (Fig. 5D). At the donor site, the surface of the navicular bone was covered with the abductor hallucis, and an artificial dermis was implanted thereon and fixed by the tie-over method. At 1 week after surgery, the flap survived completely on the fingertips, and the range of motion exercises for the middle finger, ring finger, and little finger were started. The delayed procedure with a vascular clamp was performed between the middle and ring fingers, and the ring and little fingers at 2 weeks (Fig. 6). At 3 weeks after surgery, the flap was cut among the fingers (Fig. 7A and B). A full-thickness skin graft was harvested from the left groin and transplanted to the donor site that had provided the medialis pedis flap (Fig. 3D). The right side also underwent the same reconstructive surgery one week after the first left-side surgery. The patient was discharged 2 weeks after the last surgery, without any complications originating from the four operations. At 12 months after the initial operation, the color and texture matching those of the surrounding tissue around the transplanted flap were excellent (Fig. 8A-C), and the sensory recovery of the reconstructed fingertip was evaluated as purple by the Semmes-Weinstein test with an evaluator size of 4.08 to 4.56. There was no restriction on the range of motion of the interphalangeal joints, and the Disability of the Arm, Shoulder and Hand Questionnaire (disability/symptom) was 18/100.
Fig. 4. Intraoperative findings.
A: As shown by the black arrow, in the distal part of the middle phalanxes, the radial proper palmer digital artery and the subcutaneous vein were identified as the recipient vessels, and the recipient artery and vein were anastomosed with the main pedicle, which was the deep branch of the medial plantar artery and vein.
B: As indicated by the white arrows, after the debridement of volar side, the distal phalanx was decorticated. Subcutaneous veins on the ulnar side of the paronychium were identified for anastomosing to the subcutaneous veins of the medialis pedis flap, as shown by the black arrow.

Fig. 3. Schematic illustrations showing the whole surgical procedures in this case.
A: The design of a medialis pedis flap drawn from the left tubercle of the navicular bone to the big toe of the patient at the first surgery.
B: The transplanted medialis pedis flap was temporarily sutured, and the deep branch of the medial plantar artery and vein were anastomosed to the proper palmar digital artery and the subcutaneous vein at the radial side of the middle finger.
C: The expanded illustration shows vein anastomosis in the eponychium of the ulnar side of the little finger in addition to the main pedicle to avoid venous congestion. For the middle and ring fingers, similar procedures were performed.
D: As the second operation, a full-thickness skin graft was obtained from the left inguinal region and transplanted to the donor site where the artificial dermis had been implanted in the first operation.
E: The fingertips of the middle, ring, and little fingers were covered with the medialis pedis flap.
F: At 3 weeks after the first operation, the fingers were separated individually.
allowing the patient to return to his original job.

Discussion

Reconstruction of the fingertips requires aesthetical and functional reconstruction techniques. Considering the texture and color matches, the homodigital and heterodigital flaps, which can be reconstructed by adjacent tissues, are suitable as reconstruction tissues. However, long scars are formed on the long axis of the fingers, and the extensive incisions of the Cleland’s ligament and Grayson’s ligament can lead to the flexion contracture of the proximal interphalangeal joint due to the volar deviation of the neurovascular bundle. Additional scar formation and the possibility of skin graft on the exposed hands are also aesthetical and functional disadvantages. In previous reports describing other donor sites than the digitals, the medial plantar to malleolus area is excellent because of its color and texture matching those of the fingers, and the area is hairless as an advantage. Furthermore, the diameter of the pedicle nourishing the flap is approximately 1 mm, which is

Fig. 5. Flap harvest and transplantation.
A: For harvesting an 80 × 25-mm medialis pedis flap, purple marking lines were drawn from the left tubercle of the navicular bone to the big toe of the patient’s left foot. The purple, heavy broken line indicates the long axis of the flap.
B: The photograph shows the flap harvesting site just before the detachment of the main pedicle containing the deep branches of the medial plantar artery and vein, as shown by the black arrow.
C: The photograph shows the obtained free medialis pedis flap.
D: Immediately after flap transplantation, the flap had resupplied blood flow expressed as a healthy skin color. As indicated by the white arrow, a split-thickness skin graft was performed on the main pedicle because the incision part was unable to be directly closed.

Fig. 6. Delayed procedure with a vascular clamp for confirming blood circulation in the individual fingertips before finger separation.
Even when the blood flow was blocked from the main pedicle on the middle finger, as marked by an asterisk (*), the skin color of implanted flaps in the ring and little finger were without ischemia (*).
suitable for digital artery\(^{17}\). There is a free medial planter artery perforator flap and a free medialis pedis flap that can be collected from the area and be transplanted to the fingertip. The former flap can be used as an innervated flap, but the transplantation procedures such as the processing of the thin perforator and the abductor hallucis are complicated. In this case, the reconstruction of multiple fingertips with the flap, which would be later cut into three pieces, had no superiority to other flaps in having a sensation. On the other hand, the procedure used in this case did not allow the inclusion of sensory nerves in the medialis pedis flap, but this procedure had a high reliability in preparing the vascular pedicle without requiring the manipulation of the abductor hallucis. Therefore, this procedure can be performed safely with high reliability. In previous reports regarding fingertip reconstruction, nerve endings were found to remain on the amputated surface\(^{18}\), and reinnervation from surrounding tissues is observed\(^{19}\). Therefore, nerve reconstruction is speculated to be not always necessary as long as the reconstruction is only limited to the fingertips. Although in this case nerve reconstruction was not performed, a protective sensation was observed. The maximum size of medialis pedis flaps is reported to be 70 \(\times\) 30 mm in previous reports\(^{20}\). Although the harvested flap in this case was 80 \(\times\) 20 mm, with a length longer than that of the report, the flap was found to have vasa vasorum running from the tubercle of the navicular bone to the big toe and the blood vessels including the peripheral vessels, and the flap was confirmed to survive without any blood flow problems. Because the size of the harvested flaps depends on the host foot size, which varies with the individual, this case harvested an elongated flap because of the patient’s sufficient foot size, resulting in no blood flow problems. One of the drawbacks in reconstructing multiple fingers with one flap, is that it requires flap detachment and delayed procedures such as temporarily stranlging the detached area. In this case, the vascular clip was used considering that the size and banding force were appropriate. On the contrary, if the blood circulation is stable, the patient could be allowed to train the range of motion with the adjacent fingers in the manner of buddy taping before the separation of the plural number of fingers to avoid the contracture of the fingers. In this case, at one week after the free flap transplantation, the range of motion training was started, and no interphalangeal joint contractures were observed. Furthermore, even if flap detachment surgery is behind schedule, rehabilitation can be continued. The wound healing of the donor site is known to be delayed as the disadvantages of the medialis pedis flap, and direct closure of the incision is usually impossible. Therefore, the artificial dermis was transplanted at the first step, sufficient wound bed was prepared before the finger separation, and the skin graft was performed for the donor site as the second step. In addition, no revision surgery such as debulking was performed in this case and excellent outcomes were obtained from both aesthetic and functional aspects. Thus, the surgical technique with a free medialis pedis flap would be one of the options for multiple fingertip reconstruction. As a limitation, a peripheral arterial disease due to arteriosclerosis and especially diabetes mellitus would complicate harvesting of the flaps and delay the wound healing of the donor site.

Fig. 7. Intraoperative findings in the second operation.  
A: The photograph shows the flap-transplanted fingertips before the finger separation surgery.  
B: The fingertips of the separated fingers were firmly covered with the transplanted free medialis pedis flap.
Bilateral multiple fingertip reconstruction is challenging. The surgical procedure in this report is considered to be a useful technique for reconstructing multiple fingertips because it provides an excellent texture and color match for the skin, and is a suitable technique from a functional aspect.

Acknowledgments
None.
Conflicts of interest

None.

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