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ORIGINAL RESEARCH ARTICLE

Comparison of the clinical effects of reverse digital artery island flap and dorsal branch digital artery island flap on digital tip reconstruction: a single-center retrospective study

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ABSTRACT

Background: This study aimed to compare the repairing effects of reverse digital artery island flap and dorsal branch digital artery island flap on fingertip defects.

Methods: From January 2023 to January 2024, analyzed retrospectively clinical data of 41 patients with fingertip defects who underwent two kinds of surgery. There were 24 patients in the reverse digital artery island flap group and 17 patients in the dorsal branch digital artery island flap group. The size of the defect area of the affected finger, the range of motion (ROM) of the interphalangeal joint, the operation time, the hospital stay and the cold tolerance were evaluated and compared.

Results: There was a significant difference between the reverse group and the dorsal branch group in the ROM of the proximal interphalangeal joint of the affected finger. The appearance of the affected finger was significantly better in the reverse group than in the dorsal branch group. There was no significant difference between the two groups in the area of defect of affected finger, ROM of distal interphalangeal joint, operation time, hospital stays, function of affected finger and cold tolerance of skin flap.

Conclusions: Compared with the dorsal branch digital artery island flap, the reverse digital artery island flap can provide better hand appearance. However, in terms of proximal interphalangeal joint ROM , the effect of dorsal branch digital artery island flap is better than that of reverse digital artery island flap.

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KEYWORDS
Surgical flaps; reverse digital artery island flap; finger injuries; treatment outcome

Introduction

Traumatic fingertip defects are common in clinic, often accompanied by skin and soft tissue defects, tendon or bone exposure, which seriously affect the quality of life of patients. Surgery is an important treatment, and common surgery includes stump suturing, V-Y advance flap, reverse digital artery island flap and dorsal branch digital artery island flap [1–4]. Among them, the reverse digital artery island flap and the dorsal branch digital artery island flap are widely used by clinicians because of their advantages such as preserving the length of the fingers, covering the bare deep tissue, and obtaining relatively aesthetic and durable tissue without invading the palm and restricting the movement of adjacent fingers [5, 6].

In this study, the repair effects of reverse digital artery island flap and dorsal branch digital artery island flap in Ishikawa fingertip area I and II were retrospectively compared, in order to provide more references for clinical use.

Materials and methods

Forty-one patients with fingertip defects admitted to our department from January 2023 to January 2024 were retrospectively selected as the research objects. They were divided into groups according to the surgical method. The patients undergoing reverse digital artery island flap were in the reverse group, and those undergoing dorsal branch digital artery island flap were in the dorsal branch group. Each patient was informed of the indications, surgical risks, advantages and disadvantages of the two surgical methods before surgery. Patients choose the type of surgery themselves.

Inclusion criteria

(1) Single finger injury except thumb; (2) The diameter of soft tissue defect at the tip of the finger is greater than 1.5 cm, and the extent of the defect does not exceed 2/3 of the finger pulp and does not exceed the distal interphalangeal point (DIP); (3) The follow-up time was more than 1 year, and the case data were complete; (4) Fingertip injury (Ishikawa's classification I-II)

Exclusion criteria

(1) Thumb injury; (2) The diameter of soft tissue defect at the fingertip is less than 1.5 cm or more than 2/3 of the fingertip, or exceeds DIP; (3) Digital artery injury; (4) Loss of follow-up, incomplete case data; (5) Patients with contraindications to surgery.

According to the inclusion and exclusion criteria, there were 24 cases in the reverse group with a mean age of 50.21 ± 6.98 years. There were 17 cases in the dorsal branch group. The mean age was 51.06 ± 6.38 years. All patients were followed up for longer than 12

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Table 1. Comparison of preoperative general data of two groups of patients.

Variable	The reverse group (n = 21)	The dorsal branch group (n = 17)	P
Age (year)	50.21 ± 6.98	51.06 ± 6.38	0.693
Sex, male/female	17/7	13/4	0.697
Defect area (cm2)	2.33 ± 0.55	2.19 ± 0.35	0.360
Hospital stays (day)	7.88 ± 0.99	7.82 ± 0.81	0.861
Operation time (min)	67.96 ± 4.85	69.12 ± 5.07	0.464
Follow-up time (month)	15.38 ± 2.3	14.59 ± 2.79	0.329

months. There was no significant difference between the baseline data of the reverse group and the dorsal branch group ($P > 0.05$), it was comparable (Table 1).

Surgical procedure

Reverse digital artery island flap

Flap design: According to the size of the wound and the injury, the flap was designed on the side of the proximal segment of the injured finger, and the flap area was slightly larger than the wound. Design between the flap and the wound with the proper digital artery running along the axis Z-shaped incision, the rotation point of the flap should not exceed 1/4 far from the mid finger segment to ensure blood supply.

Excision and repair of skin flap: After brachial plexus block anesthesia takes effect, tourniquet is applied and routine debridement is carried out. According to the flap design, the skin and subcutaneous tissue were cut layer by layer, and the intrinsic digital vascular nerve bundle was exposed at the proximal end of the flap, and the proximal end of the intrinsic digital artery was cut and ligated. The reverse free flap is transferred to the rotation point through the skin down way, and the flap is rotated to cover the wound with the rotation point of the flap as the center. Generally, the rotation angle is about 160°. Check that the rotated vascular pedicle is not compressed or distorted. Intermittent suture of skin flap and wound margin. Full-thickness skin on the medial side of the ipsilateral upper arm was repaired by free graft at the donor site of the flap, packaged and compressed, and the skin area was directly sutured [7] (Figure 1).

Dorsal branch digital artery island flap

Flap design: According to the shape and size of the wound defect, the flap is designed at the dorsal part of the middle segment of the injured finger, and the rotation point is the starting end of the terminal dorsal branch of the digital artery, that is, the palmprint end of the distal interphalangeal joint. The vascular pedicle is the terminal dorsal branch of the digital artery and its surrounding fascial pedicle with a width of about 5 mm and a length of 1.0–1.2 cm.

Excision and repair of skin flap: After brachial plexus block anesthesia takes effect, tourniquet is applied and routine debridement is carried out. The skin flap was designed according to the size of the wound and the injury. The dorsal branch of the proper digital artery was used as the rotation point to cut the skin and gradually separate it downward, and the Z-shaped incision was adopted for the lateral side. The pedicle length of the flap is about 5 mm, and the flap is rotated to cover the wound with the rotation point of the flap as the center. After the rotation, the vascular pedicle is not compressed or twisted, and the flap and wound margin are sutured intermittently. Full-thickness skin on the medial side of the ipsilateral upper arm was repaired by free graft at the donor site of the flap, packaged and compressed, and the skin area was directly sutured [8] (Figure 2).

Postoperative management

All patients received anti-infection, anti-spasmodic, anti-coagulant and anti-swelling drugs after operation. The room temperature is maintained at 20–25°C and irradiated with a bake lamp if necessary. The patient was absolutely bedridden for 7 days, carefully examined for color and capillary filling until the flap reached a steady state.

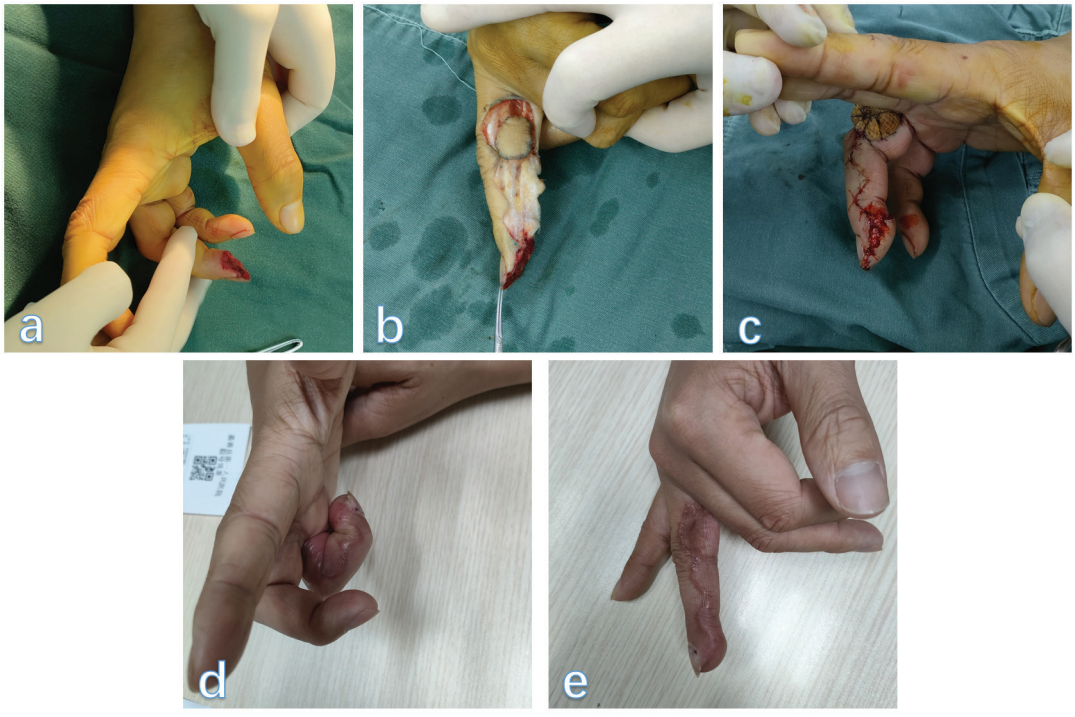

Figure 1. Case of reverse digital artery island flap. (a) Ring finger injury, phalanx exposed. (b) Flap design. (c) Flap covering finger defect. (d, e) Finger appearance and interphalangeal motion at the last follow-up.

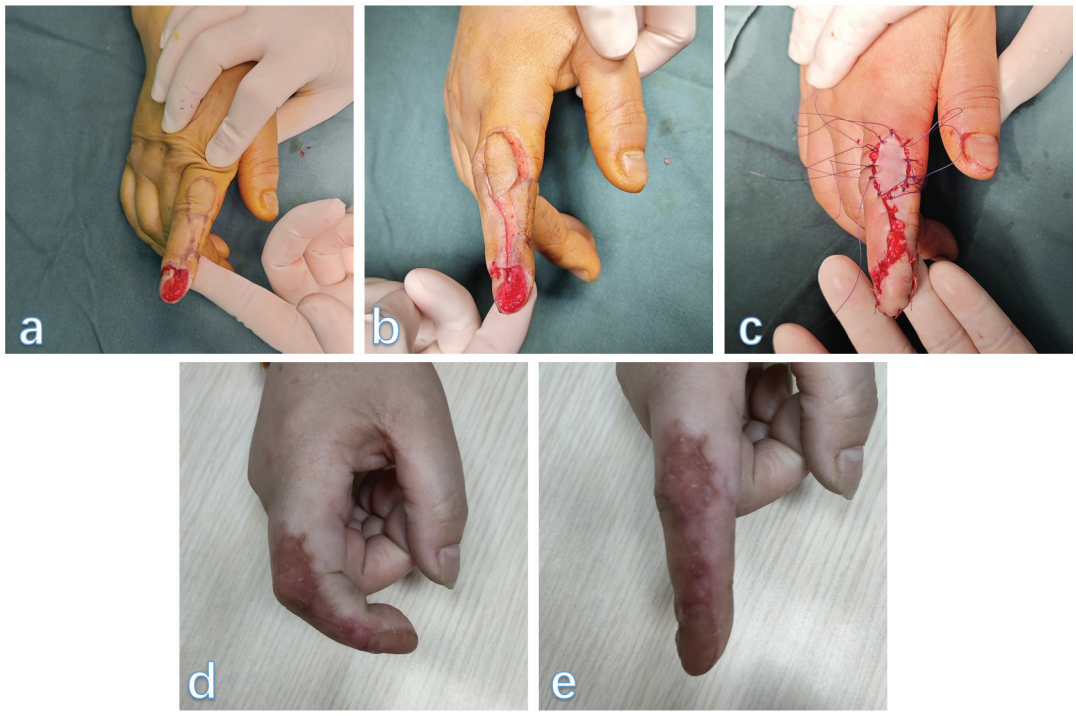

Figure 2. Case of dorsal branch digital artery island flap. (a) Injury of index finger and defect of nail bed. (b) Flap design. (c) Flap covering finger defect. (d, e) Finger appearance and interphalangeal motion at the last follow-up.

Thereafter, encourage active and passive range of motion (ROM) exercises. One week after the operation, the skin grafting area was unpacked, and the stitches were removed 2 weeks after the operation. Finger extension and flexion function exercises and finger strength training were strengthened, and sensory training was given.

Main observation indicators

Observe and compare the two groups in terms of shape, feeling, ROM of proximal interphalangeal point (PIP) of affected finger, ROM of DIP of affected finger and static two-point resolution of flap.

The ROM of the proximal and DIP of the injured finger at the last follow-up visit was measured. The Cold Intolerance Severity Score (CISS) questionnaire was used to assess the level of cold intolerance at the fingertip repair site on a score of 100 points on 4 scales (0–25 mild, 26–50 moderate, 51–75 severe, and 76–100 extremely severe). The sensitivity of the flaps was measured using the Semmes-Weinstein (SW) monofilament test. The appearance and function of the affected fingers were assessed according to the Michigan Hand Outcomes Questionnaire (MHQ) (out of 100 points, with scores directly proportional to hand function).

Statistical analysis

In this study, SPSS 24.0 software was used for data analysis. Independent sample t test was used to compare the age, defect area, follow-up time, ROM of DIP and PIP, and MHQ (appearance and function) between the two groups. Pearson χ^2 test was used for counting data such as gender and CISS. The difference was statistically significant with $P < 0.05$.

Results

A total of 41 flaps in both groups survived without secondary intervention. Venous reflux obstruction occurred in one finger of reverse group, blisters appeared, which improved after puncture and aspiration. Vascular crisis occurred in one finger of the dorsal branch group, and normal blood supply was restored after loosening the dressing and removing the stitches. There was no significant difference between the reverse group and the dorsal branch group in age, gender, defect area, hospital stays, follow-up time, and CISS results ($P > 0.05$).

In the reverse group, the mean ROM of DIP was 78.13 ± 5.48°, the SW test result was 3.99 ± 0.42, and the MHQ hand function score was 81.43 ± 7.67. In the dorsal branch group, the mean ROM of DIP was 76.18 ± 6.26°, the SW test result was 4.03 ± 0.43, and the MHQ hand function score was 80.39 ± 7.76. There was no significant difference between the two groups in the ROM of DIP, SW test results and MHQ hand function ($P > 0.05$) (Figure 3).

The appearance of the MHQ hand in the reverse group (81.02 ± 6.68) was significantly better than that in the dorsal branch group at the last follow-up (76.12 ± 7.73) ($P = 0.036$). The mean ROM of PIP was 95.83 ± 3.19° in the reverse group and 98.24 ± 3.03° in the dorsal branch group, which was significantly better in the dorsal branch group than in the reverse group ($P = 0.020$) (Figure 4).

Discussion

With the development of modern industry, soft tissue defect of fingertip is a common disease of hand trauma. For non-phalangeal exposure and soft tissue defects at the tip of the finger with exposed tendons and skin loss less than 2 cm^2 can be subjected to conservative dressing change, skin grafting, stump repair or V-Y flap advancement. However, for hand trauma combined with exposed phalanges and tendons and finger injuries with large defect area, skin flap reconstruction is usually needed.

At present, there is no standard clinical treatment method for soft tissue defects of fingertips. How to repair fingertips defects and restore the function and shape of affected fingers has been a hot topic [9]. There are many ways to repair soft tissue defects of fingers

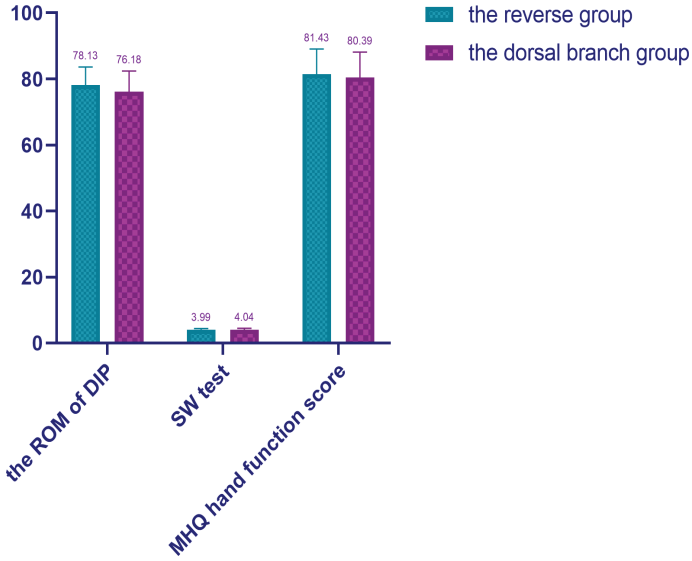

Figure 3. Comparison of the ROM of DIP, SW test results and MHQ hand function between the two groups.

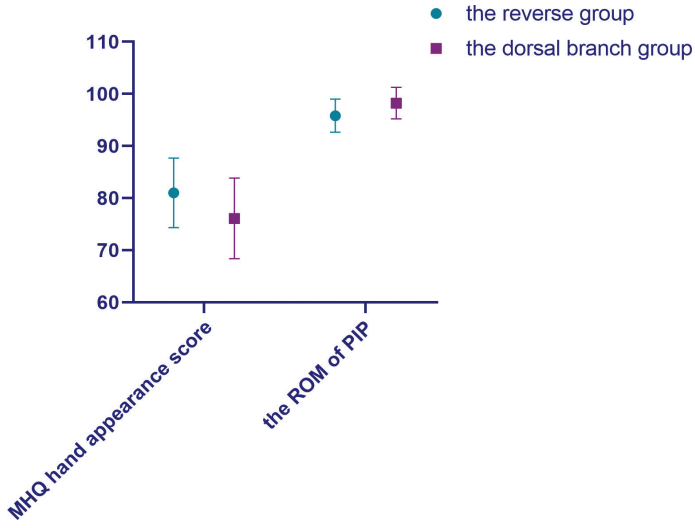

Figure 4. Comparison of MHQ hand appearance and the ROM of PIP between the two groups.

and reverse digital artery island flap is a simple and safe surgical method, especially for affected fingers with phalangeal fractures and exposed bones and tendons. The skin flap has the advantages of easy cutting, convenient operation and high safety factor. The flap has abundant blood supply and low incidence of vascular crisis [4, 10]. However, the flap also has some shortcomings. It is necessary to cut off the proximal end of one proper digital artery, and rely on the contralateral and distal communicating branches for reverse blood supply, which may lead to low cold tolerance of the fingers. The lateral scar of the finger is long, and skin grafting is needed at the donor site, which may affect the ROM of the interphalangeal joint due to scar contracture after operation. The proper finger artery has no obvious accompanying vein. In order to maintain the venous return of the flap, the vascular pedicle needs to carry a fascia about 5 mm wide [4, 6, 11]. Dorsal branch digital artery island flap is also a common surgical method to repair soft tissue defects of fingers. This operation does not sacrifice the proper digital artery of one side and has little influence on the blood supply of the affected finger. The position of the dorsal cutaneous branch is relatively constant, with less variation, simple operation and easy promotion [11]. However, the flap also has some shortcomings. The blood supply of the flap depends on the supply of tiny arteries, which is prone to vascular crisis, and in severe cases, it can lead to flap necrosis. The area of skin flap incision is limited, so it is not suitable for excessively large fingertip defects. The donor area of the flap still needs skin grafting, and the scar formation after operation will affect the function and appearance of fingers to some extent [11, 12]. Studies have shown that the homodigital dorsal branch of proper digital artery flaps was an optimal and reliable alternative to repair various distal soft tissue defects of fingers, despite a lower absent rate of dorsal branch [13]. Some studies have also confirmed that the homodigital dorsal neurofascial broaden pedicle island flaps is a promising strategy that achieves good curative effects and recovery of fingertip functions [14].

The dorsal branch group of this study the ROM of PIP was better than that of the reverse group. This is because the flap donor area in the dorsal branch group is between the dorsal proximal striae of the proximal interphalangeal point, the dorsal distal striae of the proximal interphalangeal point and the lateral midline of both sides of the finger. Its incision only involved the DIP. In the reverse group, the donor area of the flap was near the proximal interphalangeal point and the finger webs, which did not exceed the midline of the dorsal and ventral fingers. The incision involved PIP and DIP. Therefore, the ROM of PIP in the dorsal branch group was better than that in the reverse group.

However, at the last follow-up, the MHQ hand appearance in the reverse group was significantly better than that in the dorsal branch group. This may be because the blood supply of the reverse digital artery island flap is abundant, and the incidence of vascular crisis is low due to the reverse blood supply of the contralateral and distal communicating branches, which can provide better nutritional support for the regeneration of peripheral nerves around the flap [15]. In addition, the reverse digital artery island flap is taken from the lateral skin of the affected finger, and its texture is softer and more sensitive than that of the dorsal branch digital artery island flap, and the donor site is highly concealed, which can form a good appearance [16, 17]. However, some patients with dorsal branch digital artery island flap have obvious scar formation and skin sinking in the donor site, which may lead to better appearance satisfaction of the affected finger hand in reverse group than that in dorsal branch group.

In order to better promote the repair of fingertip defect, combined with the problems encountered in this operation, the experience of repairing reverse digital artery island flap is summarized: (1) The design and cutting of the flap should be about 2 mm longer than the defect edge. (2) The fascial pedicle of the flap should be as wide as possible, and the suture pedicle should be as loose as possible. (3) The skin incision is located in the lateral midline to prevent the skin contracture line after operation and affect the function of the affected finger. (4) The extensor tendinous membrane must be preserved during skin flap excision, so as to improve the survival rate of donor flap transplantation and reduce the incidence of tendon adhesion. (5) Because the reverse digital artery island flap needs to cut off one digital artery, the blood supply of the affected finger is reduced and the cold tolerance is poor, so relevant safeguard measures should be taken. (6) Strengthen postoperative functional rehabilitation exercise to prevent tendon adhesion and restore finger function.

At present, this study also has some limitations. Firstly, the main limitation is the low number of cases and the need for further research on larger sample sizes, making it difficult to generalize our results to the general population. Secondly, the subjective results of MHQ and CISS are evaluated by patients, and the patients choose specific surgeries themselves, which may lead to bias in the results and affect the final results.

Conclusion

In summary, the reverse digital artery island flap and the dorsal branch digital artery island flap have similar results in the ROM of DIP, function, and cold tolerance when repairing fingertip soft tissue defects. Compared with the dorsal branch digital artery island flap, the reverse digital artery island flap can provide better appearance of the hand. However, in terms of the ROM of PIP, the effect of dorsal branch digital artery island flap is better than that of reverse digital artery island flap.

Authors' contributions

Study conception and design: Yue Pan and Hui Yu. Acquisition of data: Jun Yang and Mingwei Dong. Analysis and interpretation of data: Yue Pan and Shengjie Jiang. Drafting of manuscript: Yue Pan and Jun Lei. Critical revision of manuscript: Guangchen Sun and Hui Yu. All authors read and approved the final manuscript.

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Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of the First People's Hospital of Jiashan (No. KT2024005). All patients were informed of the adverse effects of the treatment prior to treatment, and all of them signed informed consent forms for the procedure. Because the study was retrospective, patient consent was waived and all data was anonymized prior to analysis.

Competing interests

The authors declare that they have no competing interests.

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