SCIENTIFIC ARTICLE

Comparison of Homodigital Dorsolateral Flap and Cross-Finger Flap for the Reconstruction of Pulp Defects

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Purpose The homodigital dorsolateral flap (HDF) was described to treat various types of pulp and fingertip defects. The aim of this study was to analyze the intermediate-term function after fingertip reconstruction with HDF and compare these results with the cross-finger flap.

Methods We analyzed a retrospective cohort of 25 patients. The HDF group consisted of 16 patients (18 fingertip defects) with a mean age of 44 years (range, 16−63 y). The cross-finger flap group consisted of 9 patients (10 fingertip defects) with a mean age of 33 years (range, 16−47 y). The average follow-up time was 12 months (range, 6−36 mo).

Results Patients with homodigital reconstruction demonstrated better sensibility in terms of mean static 2-point discrimination. Two-point discrimination was also better when the flap was advanced compared with when the flap was rotated. Mean distal interphalangeal joint range of motion for the HDF group was significantly better compared with the cross-finger flap group. Proximal interphalangeal joint range of motion was significantly better in the HDF group.

Conclusions The HDF for reconstruction of pulp defects is a reliable option for 1-stage reconstruction. Related complications are minimal, and the intermediate-term functional results are better compared with cross-finger flaps. *(J Hand Surg Am. 2019;44(7):616.e1-e7. Copyright © 2019 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study/level of evidence Therapeutic IV.

Key words Cross-finger flap, finger injuries, fingertip reconstruction, homodigital dorsolateral flap, pedicled flap.

Online Exclusive

FINGERTIP AMPUTATIONS CAN PRESENT in a wide variety of configurations including transverse, dorsal oblique, volar oblique, or vertical oblique patterns and can involve skin, soft tissues, and bone. The extent and direction of the soft tissue loss often dictates how the injury should be managed. Replantation or composite grafting of the amputated part and utilization of local flaps for coverage are treatment options if there is substantial bone exposure; otherwise, the wound can be safely left to heal by secondary intention.[1−8]

Various flaps have been proposed to cover volar oblique or transverse amputations presenting with a pulp defect and bone exposure. The cross-finger flap (CFF), homodigital reverse flow island flap, homodigital lateral flap, and homodigital dorsolateral flap (HDF) are some of the options that are used frequently.[4,5,7,9] Taking the advantage of relying on an uninjured digit for blood supply, a substantial amount of soft tissue can be transferred using a CFF, but it carries the disadvantage of finger stiffness, presence of hair on the transferred skin, and unsatisfactory

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sensibility.[4] As an alternative, several authors have proposed the use of soft tissue from the dorsolateral side of the same digit as described by Shibu et al for adequate coverage of the tip with good sensibility.[10–13]

In this study, we aimed to compare the clinical results of the HDF and CFF.

MATERIALS AND METHODS

We analyzed a retrospective cohort of 25 patients (28 fingertip injuries) treated with an HDF or a CFF within a period of 5 years. All patients who presented with a traumatic fingertip defect and underwent reconstruction with an HDF or a CFF during the initial 2 years of the study period were included. Patients with concomitant injuries to the hand, besides fingertip injuries, patients with incomplete medical records, and patients with less than 6 months of follow-up were excluded from the study. The study was approved by the local institutional review board.

Sixteen patients with 18 fingertip defects underwent reconstruction with an HDF. The group consisted of 1 female and 15 male patients with a mean age of 44 years (range, 16–63 y). Nine male patients (10 fingertip defects) with a mean age of 33 years (range, 16–47 y) were treated with a CFF. The median follow-up time was 9 months (range, 6–36 mo) for the HDF group and 11.5 months (range, 6–22 mo) for the CFF group. Follow-up for the CFF group was calculated from the time of flap division and inset. Fingertip defects were due to a crush injury in 16 cases in the HDF group, and in 9 cases in the CFF group. Clean-cut fingertip injuries accounted for 2 cases in the HDF group and for 1 case in the CFF group.

Fingertip defects were classified according to their location, depth, and shape. The defect area was calculated by multiplying the maximum transverse and longitudinal dimensions measured with a ruler before surgery for fingertip reconstruction. We also recorded the mechanism, nail bed involvement, status of the remaining soft tissues, and comorbid conditions for each patient.

Surgical indications for pulp reconstruction were fingertip amputation injuries with preservation of at least 5 mm of nail bed distal to the lunula. When the amputation was through the lunula level (if less than 5 mm of nail matrix was present distal to the eponychial fold), our recommended treatment was revision amputation or replantation when possible. If the amputation was through the middle of the distal phalanx and the dorsolateral tissue was found uninjured, the HDF was used for coverage.

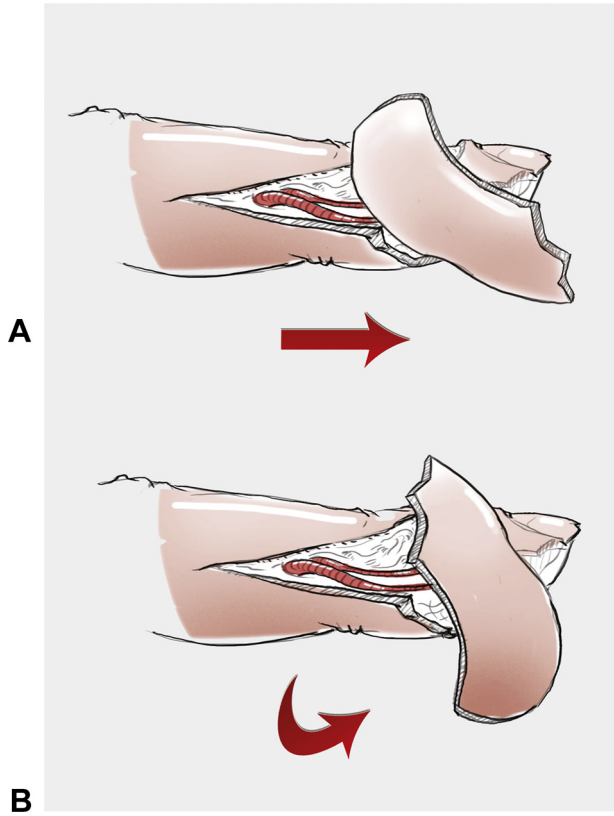

FIGURE 1: Homodigital dorsolateral flap elevation. The digital neurovascular bundle is identified and dissected. The flap was inset by either of the 2 methods. **A** Sliding and advancement of the flap to cover the pulp defect. **B** Dorsolateral flap is rotated 180° over the pulp defect. The skin island is mobilized and will be transferred over the exposed bone.

We used Allen's classification for clinical assessment.[14] The majority of the cases included in the study presented with injuries involving only soft tissues (Allen Zone II). In the HDF group, 13 of the 18 fingertip amputations were in Zone II and 5 were in Zone III based on Allen's classification. In the CFF group, 7 of the 10 fingertip amputations were in Zone II and 3 were in Zone III.

All range of motion (ROM) measurements were made by a certified hand therapist. The final ROM was defined as the ROM at the point of "maximum improvement" for all patients included in the study, when the progress of the ROM has plateaued and the patient was discharged from physical therapy.

The Mann-Whitney *U* and Kruskal-Wallis tests were used for comparison of continuous variables. The chi-square test was used for comparison of categorical variables. Data were presented as the mean ± standard deviation of the mean, and a *P* value of $<.05$ was considered significant.

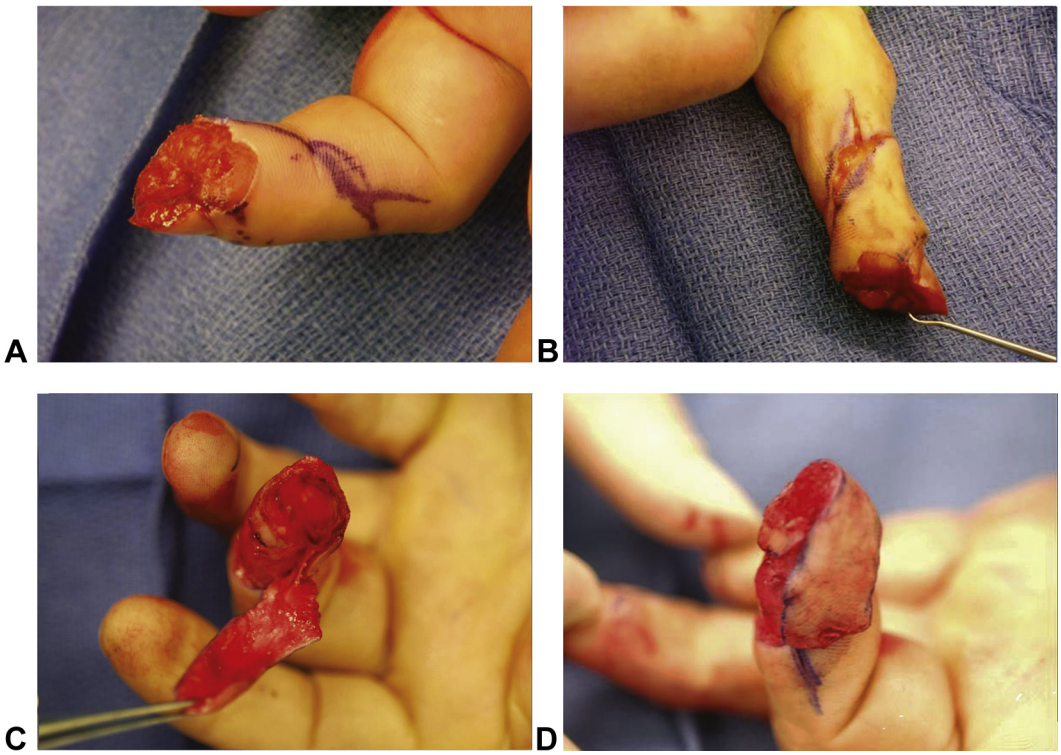

FIGURE 2: **A** Design of the homodigital dorsolateral flap, **B** elevation, **C** mobilization, and **D** inset to cover a pulp defect with bone exposure.

Homodigital dorsolateral flap technique

The surgical planning starts with a digital Allen's test that verifies the patency of both digital arteries. The wound is debrided and the flap is designed on the uninjured dorsolateral skin of the finger over the distal interphalangeal (DIP) joint according to the size of the resultant defect after debridement. We elevate the dorsal skin and dissect toward the lateral digital sheet. At the lateral digital sheet level, one should dissect deeper, at the level of collateral ligament, to include the dorsal lateral branch of the digital artery. We dissect the flap off the flexor tendon with the digital nerve and artery incorporated in the flap. Then the dissection follows in a distal to proximal direction: we divide the lateral digital sheet and release the digital artery and nerve up to the proximal interphalangeal (PIP) joint level.

After the flap elevation, the flap can either be advanced or rotated 180° to cover the pulp defect. Sliding and advancement covers the pulp with the volar skin of the flap (Fig. 1A). When the flap is rotated 180°, the pulp defect is covered with the dorsal skin (Figs. 1B and 2A–C).

We harvest a full-thickness skin graft from the amputated part if possible or from another appropriate site to cover the flap donor defect using a tie-over dressing. After skin closure, we apply an aluminum orthosis immobilizing the DIP joint in extension with the PIP joint free for 1 week followed by active ROM of the finger. Each patient underwent therapy for scar massage, desensitization, and sensory reeducation, guided by a hand therapist for the first 6 weeks and continued as a home-based exercise program afterward.

Cross-finger flap technique

We designed the flap using a template of the defect over the donor finger. We chose the finger radial to the injured one as the donor finger, and the middle finger was used for index finger pulp defects. We raised the flap from the plane between the paratenon of the extensor mechanism and the subcutaneous fat overlying the middle phalanx. The edges of the flap are adapted to the recipient site while leaving 1 of the 4 margins attached to the donor finger as a pedicle. We used a full-thickness skin graft to cover the defect on the extensor surface of the donor digit with a tie-over dressing, harvested from the amputated part if possible or from another appropriate site. A dorsal plaster orthosis was used until the third postoperative week when the flap was detached and inset.

One week after flap division, each patient underwent therapy for scar massage, desensitization, and sensory re-education, guided by a hand therapist for

TABLE 1. Comparison of Postoperative Range of Motion (ROM) and Static 2-Point Discrimination Between Homodigital and Cross-Finger Groups

	Homodigital (n = 18)	Cross-Finger (n = 10)	*P* Value
Mean static 2-point discrimination	7.8 mm (SD 1.3)	10.7 mm (SD 2.3)	<.05
Mean DIP joint ROM	56° (SD 18.5)	36° (SD 12.2)	<.05
Mean PIP joint ROM	90° (SD 6.6)	71° (SD 9.9)	<.05
Patients with 2pd ≤8 mm	12	1	<.05

2pd, 2-point discrimination; DIP, distal interphalangeal; PIP, proximal interphalangeal; SD, standard deviation.

TABLE 2. Comparison of Postoperative Range of Motion (ROM) and Static 2-Point Discrimination Between Rotation and Advance Variations of Homodigital Flap

	Homodigital—Rotation (n = 6)	Homodigital—Advance (n = 12)	*P* Value
Mean static 2-point discrimination	9 mm (SD 0.9)	7.3 mm (SD 1.1)	<.05
Mean DIP joint ROM	60° (SD 16.2)	54° (SD 19.9)	.74
Mean PIP joint ROM	96° (SD 8.2)	88° (SD 4)	<.05
Patients with 2pd ≤8 mm	2	10	<.05

2pd, 2-point discrimination; DIP, distal interphalangeal; PIP, proximal interphalangeal; SD, standard deviation.

the first 6 weeks and continued as a home-based exercise program afterward.

RESULTS

Patients with the homodigital reconstruction demonstrated better sensibility in terms of mean static 2-point discrimination compared with the CFF group (Table 1). When the flap was advanced, the sensation was better than when the flap was rotated and the dorsal skin was transferred to the pulp (Table 2). The proportion of patients with 2-point discrimination equal to or less than 8 mm was higher in the HDF group when compared with the CFF group, and higher in the flap advancement subgroup compared with the flap rotation subgroup of the HDF group. The mean area of the fingertip defect was 244 mm^2 (range, 190−308 mm^2) in the HDF group and 241 mm^2 (range, 221−298 mm^2) in the CFF group.

ROM at the DIP joint was satisfactory, and all patients were able to return to their work and everyday activities. For the HDF group, the mean DIP joint ROM was significantly better compared with the CFF group. The PIP joint ROM was significantly better in the HDF group when compared with the CFF group (Table 1). The mean tourniquet time was 23 minutes (range, 16−48 min) for the homodigital flap elevation and 21 minutes (range, 18−32 min) for the CFF elevation.

Complications were noted in this HDF series: partial necrosis of the tip in 1 flap, superficial skin infection of the flap edge that resolved during follow-up in 1 flap, and a mild hook nail deformity in another. Two patients developed mild hypersensitivity with pain and tingling that improved over time after desensitization therapy, and cold intolerance was encountered in one of the patients. Complications reported in the CFF group were hook nail deformities in 2 patients who had amputations at the Allen Zone III level.

DISCUSSION

The unique architecture of the pulp, which allows it to withstand substantial pressure and shear forces, can turn fingertip injuries with pulp loss and bone exposure into challenging reconstructive problems.[1,2,7,15,16] The objectives of fingertip amputation reconstruction are to cover the defect with a satisfactory cosmetic appearance, establish functional sensibility, preserve the length of the involved digit, obtain a well-padded pulp, cause minimal donor site morbidity, and minimize time off work. By using local flaps, shortening of bone can be avoided, without requiring microsurgery.[16]

In this study, we found that the skin availability and coverage using the HDF or the CFF were both satisfactory. The mean DIP joint and PIP joint ROM was better in the HDF group compared with the CFF

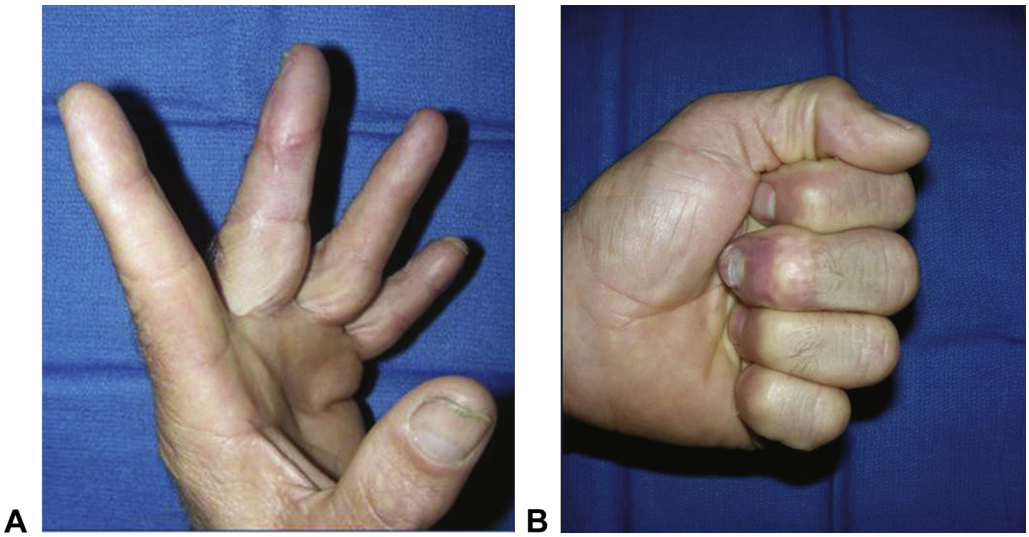

FIGURE 3: A, B Postoperative results of a patient who underwent fingertip reconstruction with a homodigital dorsolateral flap after an injury to the middle finger. The flap was advanced in this case.

group, which can likely be explained by the need for immobilization after a cross-finger procedure. The sensibility after the HDF was superior to the CFF. This result is predictable, nevertheless, because the HDF is a neurovascular flap, but the CFF is insensate at first, acquiring sensibility gradually.

For the HDF, we used the most distal dorsal branch of the digital artery by careful dissection of the neurovascular pedicle *en bloc* with the surrounding subcutaneous tissues.[17–24] Preserving the integrity of the digital nerve, and, at the same time, employing the remaining healthy tissue to advance to the fingertip defect is required to retain the sensibility of the flap. The dorsal branch of the digital nerve accompanies the dorsal branch of the digital artery. It is important to also preserve the nerve supply of the flap to have good sensation postoperatively.[14,23]

Similar to the CFF, the HDF has a broad spectrum of applications in all types of fingertip amputations: transverse, vertical oblique, and volar oblique. The use of the HDF avoids prolonged immobilization and possible PIP joint stiffness. Modifications in flap design allow for volar transposition of the dorsal part converting the flap into an island on the same neurovascular pedicle. In that fashion, it can cover the entire terminal pulp in length and three-quarters of the width.[10–12] In our series, we used the flap in 2 ways: advancing the volar part distally (12 cases) or rotating the flap 180° (6 cases) so the dorsal skin covered the pulp.

The CFF and HDF indications are almost identical. In our current series, reconstruction choice was determined by surgeon preference. There were few exceptions where 1 flap was preferred over the other. Age over 50 and the presence of arthritis, diabetes, or other vascular disorder were considered contraindications for CFF. Intact digital arteries on both sides of the digit were a prerequisite for the HDF. When there was an injury at the level of the DIP joint dorsally or dorsolaterally, this was also regarded as a contraindication for the HDF. Advancement of the HDF was done when there was enough pulp tissue that could cover the defect. When there was not enough tissue left in the pulp, we performed rotation of the flap. This can usually be planned preoperatively, but after the dissection of the flap, either can be performed as the flap can be rotated 180°. In all cases, we preferred the pulp tissue over the dorsal skin. In other words, all rotation cases lacked adequate volar skin.

Although the HDF is adjacent to the injury zone, this does not affect its viability.[10,12,13] The main contraindication to use an HDF is injury to the dorsal part of the DIP joint. Injury to the medial and lateral sides of the DIP joint and proximal part of the distal phalanx where the dorsal lateral branch travels are contraindications to the dorsolateral flap. Any injury to the arterial branch would jeopardize the viability of the flap.

Partial superficial loss of the tip of 1 flap was attributed to the surgical dissection. Superficial dissection of the base of the flap at the collateral ligament damaged the dorsolateral branch. During dissection, when one reaches close to the lateral digital sheet, the depth of dissection should be close

to the collateral ligament of the DIP joint. Later the patient developed a superficial infection and was treated with debridement and oral antibiotics.

Complications such as hook nail deformity, cold intolerance, hypersensitivity, and paresthesia have been described after fingertip reconstruction with the dorsolateral flap, although hook nail deformity and cold intolerance can be attributed to the amputation/injury rather than the resurfacing technique. We observed a hook nail deformity in 3 patients. A hook nail deformity might appear when the injured distal phalanx lacks adequate length to support the distal end of the nail bed. This can be avoided by ablation of the distal sterile matrix to a level 1−2 mm shorter than the remaining bone to make up for pulp contracture after wound healing.[25] Tension between the flap and distal part of the nail bed should also be avoided.

There is a noticeable difference in light touch when comparing the 2 mobilization techniques. When the flap is advanced, the sensation is better than when the flap is rotated and the dorsal skin is transferred to the pulp. This can be explained by the abundance of sensory receptors in the volar glabrous skin at the fingertip tip compared with the less sensate dorsal skin in the tip area.

PIP joint stiffness due to immobilization and positioning is a frequent problem in patients who underwent reconstruction with CFFs. Intensive postoperative physical therapy may be necessary to prevent stiffness. In addition, the sensation in the CFF is inferior because of the use of dorsal skin from the adjacent finger to cover a volar pulp defect. Hair in the transferred pulp may also cause discomfort and may be best treated with laser or electrolysis.

The homodigital dorsolateral finger flap for reconstruction of pulp defects seems to be an excellent and safe option for 1-stage reconstruction of fingertip injuries (Fig. 3). The advantages of this flap are the ability of usage in 2 different ways: as an advancement flap or as a rotational flap. In addition, there is no regional or distant donor site morbidity. The patients have better pulp sensation and ROM than the CFF. Still, if the vascular integrity of the digital arteries is questionable, such as in multiple digit crushing injuries, CFFs can be valuable. CFFs may also be useful when multiple fingertips are injured in grinders and other machines, enabling the repaired fingers to be stacked against each other.[15,16] If a proper surgical technique is used, complications related to the homodigital dorsolateral finger flap are minimal and the overall functional results are satisfactory.

The most important limitations of this study are the small size of the groups and its retrospective design. Our study compares all cases of HDF and CFF performed within a period of time and fulfilling inclusion criteria, but the lack of randomization can be regarded as a powerful confounder. In addition, the study groups were not equivalent with respect to age, although normally the younger mean age of the CFF group might be expected to be associated with a better outcome. Our study reveals better functional outcomes in the HDF group in the intermediate term, but the observed difference in the ROM and 2-point discrimination between the groups might be temporary and may disappear in the long term.

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