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Original Article

Toes lateral free flap is an ideal method to repair the soft tissue defect of the finger: a single-center retrospective efficacy evaluation of 106 patients

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Abstract: Objective: To compare the clinical efficacy of transverse wrist crease perforator flap, the retrograde island flap of proper digital artery, the nutrient vascular fascial pedicled skin flap and the toes lateral free flap in the repair of finger soft tissue defects. Methods: We reviewed the data of 106 patients with finger soft tissue defects who were admitted to Longgang District Orthopedic Hospital from January 2017 to December 2020. The patients were divided into four groups based on the treatment method: Group A (transverse wrist crease perforator flap repair group, N = 27), Group B (retrograde island flap of proper digital artery repair group, N = 23), Group C (nutrient vascular fascial pedicled skin flap repair group, N = 26) and Group D (toes lateral free flap repair group, N = 30). There was no significant difference in sex ratio, age, cause of injury, time of injury and area of defect between the four groups ($P > 0.05$). We compared the clinical efficacy (including total active motion, two-point discrimination, and cold intolerance), complications, and patient satisfaction. Results: There was no significant difference in wound recovery time among the four groups ($P > 0.05$), and the evaluation of skin flap recovery, including color, skin temperature, elasticity, and texture, was superior in Group D compared to Groups A, B, and C ($P < 0.05$). After one month of follow-up, the total active activity of the affected finger was lower in Group A and Group B than in Group C and Group D ($P < 0.05$), while there was no significant difference in S2-PD (two-point discrimination) among the groups ($P > 0.05$). The results of the Cold Intolerance Symptom Severity (CISS) scale after one month of follow-up were highest in Group B, followed by Group A, Group C, and then Group D. After six months and one year follow-up, there was no significant difference in the total active activity among the 4 groups ($P > 0.05$), and the scores of S2-PD and CISS decreased in each group ($P < 0.01$). Additionally, Group D exhibited better S2-PD and cold tolerance compared to the other three groups. All patients recovered well after surgery, with one case of vascular crisis in Group A, and no complications such as joint stiffness and postoperative infection were observed in any of the groups. The results indicated that group D had the highest satisfaction level ($P < 0.01$), with no significant difference among Groups A, B, and C. Conclusion: The lateral free flap from the toe is an ideal method for repairing soft tissue defects of the finger, as it effectively restores the finger's shape and skin sensation with minimal complications and a concealed donor site.

Keywords: Flap repair, finger soft tissue defects, toes lateral free flap, clinical efficacy

Introduction

The hand exhibits intricate and refined functions, serving as both an aesthetic and functional organ of the human body. Beneath the skin of the finger pulp lies a fibrous mediastinum, while the dermis is abundant in nerve endings and sensory corpuscles [1], rendering this region the most sensitive part of the hand. Soft tissue defects of the finger are a prevalent injury in clinical settings. Repairing these defects poses a considerable functional and aesthetic challenge due to the unique anatomical features and diverse injury types. Various reconstruction methods exist for such defects. While traditional skin grafting offers technical simplicity and easy donor-site availability, it is associated with significant limitations including poor color match, graft contracture, and conspicuous donor-site scarring, often resulting in

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suboptimal restoration of both finger aesthetics and function that fails to meet patient expectations. With the rapid advancement of microsurgical techniques, flap transplantation has become increasingly prevalent in clinical practice for treating hand injuries. Common skin flap repair methods include the transverse wrist crease perforator flap, the retrograde island flap of the proper digital artery, the nutrient vascular fascial pedicled skin flap, and the lateral free flap from the toe.

The transverse wrist crease perforator flap has been widely used in clinical practice for repairing finger soft tissue defects due to its convenient harvesting, consistent vascular pedicle anatomy, excellent flap texture, minimal donor-site morbidity, and inconspicuous scar formation that blends naturally with the wrist crease when closed primarily [2, 3].

The retrograde digital artery island flap can preserve the length of the injured finger, avoiding shortening caused by stump revision. However, harvesting this flap requires sacrificing one of the finger's main arteries - the proper palmar digital artery - which may reduce the finger's cold tolerance. Additionally, since the proper digital artery is not accompanied by a vein, venous drainage of the flap relies on microvascular reflux within the fascial tissue of the pedicle, increasing the risk of venous congestion [4, 5].

During the transplantation of the nutrient vascular fascial pedicled skin flap, the inclusion or anastomosis of the cutaneous nerve facilitates rapid sensory recovery [6]. Additionally, because the pedicle is narrower and more elongated compared to the reversed tissue flap of the adjacent finger, early postoperative flexion and extension exercises of the affected finger can be performed, preventing joint stiffness caused by prolonged immobilization. However, the flap has a limited donor area, making it unsuitable for large defects. Furthermore, the relatively small external diameter of the vascular pedicle increases the risk of venous drainage impairment. Moreover, since the procedure requires separate handling of the cutaneous nerve, there is a potential risk of partial sensory loss on the dorsal side of the hand.

The lateral toe flap has emerged as an ideal donor site for digital pulp reconstruction due to its anatomical similarity and tissue homology with fingertip pulp tissue. Clinically, its application has been increasingly widespread, demonstrating excellent outcomes in flap survival, vascularity, elasticity, texture, as well as finger contour and sensory recovery. The lateral toe flap offers several distinct advantages: (1) Incorporation of two digital nerves enables optimal pulp sensory reconstruction and tactile recovery; (2) The consistent plantar vascular anatomy obviates dorsal foot vessel dissection, thereby simplifying the harvesting procedure; (3) Preservation of native toe length minimizes donor-site morbidity. Furthermore, its versatile design permits composite tissue reconstruction incorporating tendons or joints when addressing combined defects. Notably, this technique presents specific limitations: (1) It demands advanced microsurgical skills and carries higher operative risks compared to conventional flaps. (2) The harvestable area is restricted (typically 3×5 cm maximum), limiting its application to moderately-sized defects [7-11].

Nevertheless, the optimal surgical approach remains a subject of ongoing debate. To address this, the present study evaluates and compares four surgical techniques in terms of skin flap recovery, clinical efficacy, complication rates, and patient satisfaction. By systematically analyzing their respective advantages, limitations, and clinical indications, this study seeks to establish an evidence-based foundation for the management of finger soft tissue defects.

Materials and methods

General data: Data were collected from patients with acute small-area finger to Longgang District Orthopaedic Hospital between January 2017 and December 2020. Inclusion criteria: (1) Emergency operation for finger soft tissue defect, fresh wound with injury time ≤ 8 hours. (2) Repair of finger soft tissue defect without direct suture. (3) Good general condition and there was no significant contraindication to the operation before the operation. (4) The patients agreed to be included in this study with complete clinical data and good compliance. Exclusion criteria: (1) The patients who were older than 70 years old or less than 3year old. (2) The patients with diabetes mellitus and poor control of blood glucose. (3) The patients who had

long-term oral corticosteroid treatment affected the wound healing, and the patients who had long-term oral corticosteroid treatment had poor control of blood glucose. (4) The patients who had long-term oral corticosteroid treatment had no effect on the wound healing. (5) The patients who were discharged from hospital. (6) The patients whose wound healed badly after the operation. (7) The patients who were seriously damaged and could not be repaired, and the patients who were amputated. Based on the inclusion and exclusion criteria, a total of 106 patients were included in this study. These patients were divided into four groups: Group A (transverse wrist crease perforator flap repair, N = 27), Group B (retrograde island flap of proper digital artery repair, N = 23), Group C (nutrient vascular fascial pedicled skin flap repair, N = 26) and Group D (toes lateral free flap repair, N = 30).

Operative method

Transverse wrist crease perforator flap: This flap was designed to be slightly larger than the defect on the ipsilateral limb, based on the wound size. The radial skin of the flap was incised to locate the superficial branch of the radial nerve and the venous branch within the flap. The proximal skin at the distal end of the flap was cut, and the branch of the flap was traced along the superficial palmar branch of the radial artery. Once the superficial branch of the radial artery entered the skin flap, the flap was elevated on the deep surface of the musculofascia, freeing the entire flap except for the blood vessel and nerve connections. The skin flap was well-ventilated, and the distal branch of the superficial palmar branch was ligated and cut. The blood vessels and nerves were then dissected and separated as needed for the recipient area. After severing the pedicle of the flap, the donor area was sutured or repaired with a full-thickness skin graft.

Retrograde island flap of proper digital artery: Based on the location and area of soft tissue defect, the skin flap with an area greater than 10% of the wound surface was designed. An incision was made on the proximal side of the design the designed flap line, and the proper palmar digital artery and nerve bundle were identified near the medial line of the lateral finger. The proper digital nerve of the finger was dissected and freed from the skin flap, and the proximal digital artery was ligated. The pedicle of the free skin flap was freed to the point of rotation, and the skin flap was rotated to cover the wound. Care was taken to protect the vascular pedicle, ensuring a soft tissue cuff of approximately 0.5 cm around the pedicle to facilitate blood reflux and retrograde transfer. The rotation point did not exceed the interphalangeal joint. A Full-thickness skin graft was taken from the forearm or groin to repair the flap donor site.

The nutrient vascular fascial pedicled skin flap utilizes the dorsal digital cutaneous nerve as its axis. The flap is designed to address soft tissue defects located at the middle or proximal ipsilateral region of the affected finger. The rotation point of the flap should be positioned approximately 5 mm from both the proximal and distal interphalangeal joints. It is important to note that the lateral margin of the flap should not extend beyond the midline of the lateral aspect of the finger. The patient was anesthetized using a brachial plexus block while in the supine position, and the limb was abducted to facilitate the removal of necrotic and inactivated tissue. At the proximal end of the designed flap, the skin and subcutaneous tissue were incised, and the proximal end of the cutaneous nerve was identified. A medial or lateral incision was then made to observe the deformation of the cutaneous nerve. The skin flap was elevated over the superficial surface of the extensor tendon, the skin on the opposite side was incised, and the flap was repositioned on the superficial layer of the extensor tendon before being separated. The pedicle, which was approximately 0.5 cm wide, could support a skin flap that was 0.3 cm wide. Subsequently, the flaps were transferred to cover the wound surface of the finger pulp, and a full-thickness skin graft was harvested from the forearm or inguinal region to repair the donor site wound.

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The lateral free flap procedure involving the second toe was performed as follows. Initially, the first dorsal metatarsal artery and the tibialis propria artery of the second toe were identified using Doppler imaging and marked accordingly. Based on the defect area of the volar skin of the finger, a skin flap was designed on the

tibial side of the second toe. The patient was positioned supine, and general anesthesia was administered via intubation. An incision was made through the skin and subcutaneous tissue in the designated flap area. Subsequently, the dorsal vein of the foot, dorsal vein of the toe, first dorsal metatarsal artery, proper artery of the toe, and proper nerve of the toe were dissected and isolated. The free flap, which included the dorsal digital artery and digital nerve, was carefully harvested while preserving the peritendinous tissue. The vascular and nerve pedicle were then severed, and the flap was transferred to the wound site. The artery and nerve in the flap were anastomosed to the proper digital artery and nerve, respectively, while the vein was anastomosed to either the dorsal finger or dorsal metacarpal vein. The donor site was repaired using a full-thickness skin graft.

Observation indicators and evaluation criteria

Baseline data, including sex, age, time of injury, etiology, and defect area, were recorded. Clinical effects were assessed based on skin flap recovery, two-point discrimination, total active motion of the affected finger, cold intolerance of the skin flap (CISS), and the occurrence of complications. Skin flap recovery was evaluated based on postoperative recovery time, skin flap blood circulation, and general condition (color, elasticity, skin temperature, and texture). Two-point discrimination was classified according to the modified American Society of Hand Surgery guidelines as excellent (< 6 mm), good (6-10 mm), fair (11-15 mm), or poor (> 15 mm). Total active motion was also assessed. Cold intolerance of the flap was scored on a scale of 0-100, with lower scores indicating better tolerance (0-25: mild; 26-50: moderate; 51-75: severe; 76-100: extremely severe). Complications, including vascular crisis (arterial and venous), joint stiffness (functional impairment of flexion and extension joints, manifested by decreased range of motion), and infection (inflamed and swollen wounds with inflammatory secretions), were recorded. Patients were followed up for one year post-operatively, and their satisfaction with the appearance and function of the flap was evaluated using a digital scoring method (0: very unsatisfactory; 10: very satisfactory).

Statistical methods

The data were analyzed using SPSS 23.0. Continuous data, including patient age, injury duration, wound defect area, total active motion (TAM) of the affected finger, static two-point discrimination, cold intolerance (CISS score), and patient satisfaction, were tested for normal distribution and homogeneity of variance. Data conforming to a normal distribution are expressed as mean ± standard deviation (mean ± SD), and intergroup differences were compared using one-way ANOVA, while the non-parametric rank sum test was employed for data that did not conform to a normal distribution. Frequency (percentage) was used to describe the categorical data, including patient gender, etiology, and flap recovery status, and the chi-square test was applied for comparisons between groups. A *P*-value < 0.05 was considered statistically significant.

Results

Baseline characteristics

At baseline, all patients underwent surgery successfully. There were no significant differences in sex, etiology, age, injury time, or defect area among the 4 groups ($P > 0.05$, **Table 1**). Wound recovery time did not differ significantly among the four groups ($P > 0.05$, see **Figure 1**).

Flap recovery status

The color, temperature, elasticity and texture of the flaps were significantly different among the groups ($P < 0.05$).According to the results (**Table 2**), pigmentation cases were observed in all groups, with the highest incidence in group C (50%) and the lowest in group D (10%). Specifically, there were 4, 7, 6, and 0 cases of pigmentation in groups A, B, C, and D, respectively. Regarding flap inelasticity, group C had 3 cases, while groups A, B, and D each had 1 case. The recovery of elasticity and texture was better in group D compared to the other three groups.

The total active activity

One month after the operation, the total active activity of the patients' fingers in Group A and B was less than that in Group C and D ($P < 0.05$). However, there was no significant difference

Table 1. General information of four groups of cases

Group	n	Sex n (%)		Etiology n (%)			Age ($\bar{x}$±s)	Injury time [*M* (P_{25}, P_{75})/h]	Defect area [*M* (P_{25}, P_{75})/cm^2]
		Male	Female	Cut wound	Crush injury	Others			
A	27	14 (51.85)	13 (48.15)	14 (51.85)	7 (25.93)	6 (22.22)	44.11±14.42	3.00 (2.00, 4.00)	3.500 (2.000, 4.500)
B	23	11 (47.83)	12 (52.17)	12 (52.17)	8 (34.78)	3 (13.04)	38.22±8.33	2.00 (1.00, 3.50)	2.500 (1.500, 3.500)
C	26	12 (46.15)	14 (53.85)	11 (42.31)	11 (42.31)	4 (15.38)	40.38±9.02	2.00 (1.00, 2.25)	2.400 (1.500, 3.750)
D	30	17 (56.67)	13 (43.33)	11 (36.67)	15 (50.00)	4 (13.33)	37.90±14.01	2.00 (1.50, 4.25)	2.750 (1.975, 4.000)
H/*F*/χ^2		0.730			4.266		1.270	7.41	3.729
P		0.866			0.641		0.293	0.06	0.292

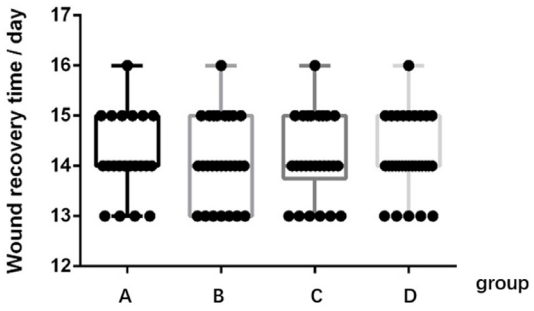

Figure 1. Comparison of the recovery time of operation.

between Groups A and B, or between Groups C and D ($P > 0.05$). At 6 months and 1 year after the operation, there was no significant difference in the total active activity among the four groups ($P > 0.05$). The comparison of total active range of motion (**Figure 2**) revealed that the early postoperative range of motion in Group C and D was greater than that in Group A and B. Nonetheless, after 6 months, and there was no significant difference among the four groups.

S2-PD

There was no significant difference in S2-PD among the four groups at 1 month after the operation ($P = 0.846$ and $P > 0.05$). The S2-PD in Group D was significantly lower than that in Group C ($P < 0.01$). Additionally, S2-PD decreased in all groups ($P < 0.01$), with the order of S2-PD being B > A > C > D. According to the results, there was no significant difference in S2-PD among the four types of flaps used to repair finger skin defects within one month after the operation. As postoperative rehabilitation time increased, the S2-PD in all groups improved compared to preoperative levels. The S2-PD of patients in the toe side flap repair group was superior to that of the other three groups. The results are presented in **Table 3**.

CISS scores

Postoperative cold tolerance scores were compared among the four groups at 1 month, 6 months, and 1 year after the operation (**Table 4**). The results indicated that the CISS score for each group followed the order B > A > C > D after 1 month of follow-up and decreased at 6 months and 1 year postoperatively ($P < 0.05$). The recovery of cold tolerance varied among the four repair methods. Patients who underwent the reversed digital artery island flap procedure had higher CISS scores, indicating poorer cold tolerance. Conversely, patients repaired with the lateral flap of the toe had lower CISS scores, suggesting better cold tolerance.

Complication profile

Patients in Groups B, C, and D recovered well postoperatively, with no cases of vascular crisis, joint stiffness, or infection. In Group A, one case of vascular crisis was observed, but no obvious joint stiffness or infection was found in the other cases.

The patients' satisfaction scores

The patients' satisfaction scores for the four groups are presented in **Table 5**. The results showed that patient satisfaction in Group D was significantly higher than that in Groups A, B, and C ($P < 0.01$). There was no significant difference in patient satisfaction among Groups A, B, and C ($P > 0.05$).

Discussion

Finger soft tissue defects are a common injury in hand surgery. Repairing these defects often presents significant functional and aesthetic challenges due to the unique anatomic characteristics and various injury types of fingers. Accurately and effectively restoring hand func-

Table 2. The recovery of skin flap in four groups

Group	Color n (%)		Temperature n (%)		Elasticity n (%)			Texture n (%)		
	Normol	Pigmentation	Normol	Lower than normal	Good	General	Inelastic	Soft	Slightly hard	Harder
A	22 (81.48)	5 (18.52)	23 (85.10)	4 (14.81)	22 (81.48)	5 (18.52)	0 (0.00)	22 (81.48)	5 (18.52)	0 (0.00)
B	18 (78.26)	5 (21.74)	16 (69.57)	7 (30.43)	21 (91.30)	2 (8.70)	0 (0.00)	21 (91.30)	2 (8.70)	0 (0.00)
C	13 (50.00)	13 (50.00)	20 (76.92)	6 (23.08)	18 (69.23)	5 (19.23)	3 (11.54)	18 (69.23)	5 (19.23)	3 (11.54)
D	27 (90.00)	3 (10.00)	30 (100.00)	0 (0.00)	30 (100.00)	0 (0.00)	0 (0.00)	30 (100.00)	0 (0.00)	0 (0.00)
χ^2	13.157		10.257		17.115			17.115		
P	0.004		0.017		0.009			0.009		

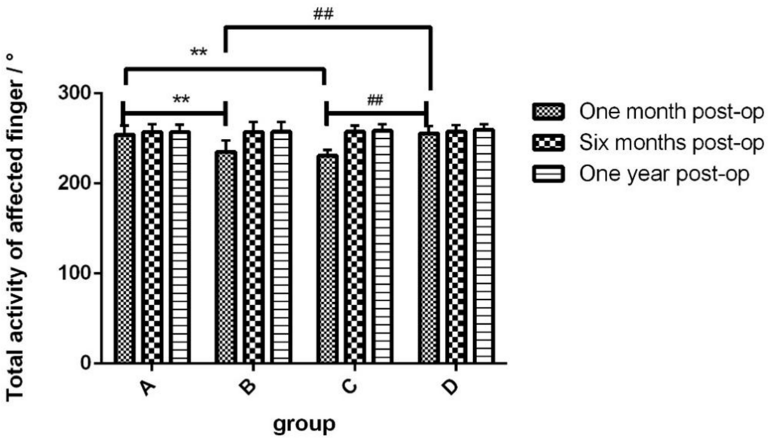

Figure 2. Comparison of patient finger motion after operation.

Table 3. Comparison of postoperative S2-PD in four groups [(x±s)/mm]

Group	N	One month post-op	Six month post-op	One year post-op	*F1*	*P1*
A	27	13.30±1.30	11.93±1.54*	10.52±1.89#	20.496	0.000
B	23	13.13±1.06	12.13±0.81*	11.22±0.67#	28.288	0.000
C	26	13.15±1.38	10.27±1.48*	8.00±1.20#	93.939	0.000
D	30	13.00±1.20	6.83±1.23	5.10±0.88	413.325	0.000
F2	-	0.271	123.880	277.718		
P2	-	0.846	0.000	0.000		

(1) *P*1: analysis and comparison of two-point discrimination sense in different time after the same operation. *P*2: analysis and comparison of two-point discrimination sense in the same operation time after the same operation. (2) *indicates S2-PD at 6 months vs Group D, *P*2 < 0.01. (3) #indicates S2-PD at one year vs Group D, *P*2 < 0.01.

tion while maintaining normal appearance remains a difficult problem. Although finger soft tissue defects are small in size, they often involve damage to the inherent arteries on both sides of the finger, leading to obstructed blood supply to the distal finger and exposure of deep tissues such as bone and tendon. Traditionally, these wounds were repaired using skin flap transplantation. Previous studies have shown that while the traditional method of skin graft repair easily closes the wound and has a high survival rate, it often results in pigmentation, skin graft contracture, and obvious scarring in both the donor and recipient areas. If the wound involves bone exposure or defect, poor blood supply can easily lead to skin graft failure [12]. Some studies have reported that inguinal and periumbilical skin flaps used to repair finger skin defects can result in a bloated finger flap with poor mobility [13]. With the advancement of microsurgery and the evolution of wound repair concepts, the lateral free flap from the toe has become the preferred choice for repairing finger soft tissue defects. This type of free flap has high tissue homology with finger skin, minimal impact on joint range of motion, and can fully establish finger pulp sensation by carrying two digital nerves. Additionally, it causes less damage to the donor area [14], making it increasingly popular for repairing finger tissue defects.

The distal phalanx of the finger has a fine structure, soft texture, abrasion resistance, rich nerve endings, sensory corpuscles, a fibrous mediastinum beneath the finger pulp skin, and whorls on the skin. These structures are essen-

Table 4. Comparison of cold tolerance scores in four groups after operation

Group	N	One month post-op	Six month post-op	One year post-op	*F1*	*P1*
A	27	29.70±4.07*	20.33±6.37$^{\#,**}$	19.89±5.69$^{\#,**}$	27.813	0.000
B	23	30.48±3.69**	24.65±0.881$^{\#,**}$	24.52±0.951$^{\#,**}$	28.028	0.000
C	26	27.23±3.52	18.19±3.56$^{\#,**}$	14.88±3.44$^{\#,\blacktriangle,**}$	86.261	0.000
D	30	23.57±3.49	9.80±2.80$^{\#}$	8.67±2.19$^{\#}$	335.248	0.000
F2	-	4.737	258.210	440.204		
P2	-	0.004	0.000	0.000		

(1) Comparison of cold tolerance scores at different time after the same operation: $^{\#}$indicates $P1 < 0.01$ compared to cold tolerance at one month postoperatively. $^{\blacktriangle}$indicates $P1 < 0.01$ compared to cold tolerance at six months postoperatively. (2) Analysis of cold tolerance scores at the same postoperative time for different surgical approaches: *indicates $P2 < 0.05$ compared with group D, **indicates $P2 < 0.01$ compared with group D.

Table 5. Comparison of satisfaction degree among four groups

Group	N	Patients' satisfaction [M (P_{25}, P_{75})]
A	27	7.00 (6.00, 8.00)*
B	23	7.00 (5.00, 8.00)*
C	26	6.00 (5.00, 7.25)*
D	30	9.00 (8.75, 10.00)
P		0.000

*indicates $P < 0.01$ compared with group D.

tial for finger sensation and fine movements, such as holding and pinching objects [15]. Zhou et al. [16] reported that in a study of 18 patients, a free skin flap from the tibial side of the third toe was used to repair finger skin defects in 16 patients (2 patients were lost to follow-up). Postoperatively, the flap was well-shaped, had a good texture, and retained fingerprints. This study compared the clinical effects of four types of flaps. The results showed that the nutrient vascular fascial pedicled skin flap repair group had poor flap recovery, with up to 50% of cases experiencing skin flap pigmentation, 3 cases of inelastic flaps, 3 cases of hard flaps, and 6 cases of abnormal skin temperature. The reversed digital artery island flap group and the carpal transverse striated perforator flap group had varying proportions of abnormal skin temperature cases. The lateral toe flap group had better color, skin temperature, elasticity, and texture compared to the other three groups, with only 10% of cases experiencing pigmentation and no cases of obvious inelasticity, hard texture, abnormal skin temperature, or suture thread issues in the 30 cases in this group. The lateral skin flap of the toe is similar to the skin of the finger and exhibits high tissue homology. Postoperatively, the flap's survival, blood supply, elasticity, and texture are all ideal.

Studies have demonstrated that early active training following finger surgery is beneficial for the complete recovery of finger flexion and extension function [17]. Through clinical observation, the authors found that free flap repair facilitates early functional exercise of the metacarpophalangeal (MP) and interphalangeal (IP) joints due to the small incision size. The fascial flap, pedicled with the nutrient vascular fascial pedicled skin flap of the finger, was harvested from the dorsum of the hand. The proximal IP joint (PIP), 0.5 cm proximal to the joint, served as the rotation axis. The dorsal edge of the finger (radial and ulnar) was extended through the MP joint to the proximal side as the axis, and the pedicle consisted of loose tissue from the superficial vein fascia of the dorsal cutaneous nerve of the finger. The length of the pedicle exceeded the distance from the axis to the proximal side of the wound. However, due to the incision crossing the IP joint, patients often experienced pain and were unable to engage in early activities.

As an example of a free flap, the lateral skin flap of the toe was utilized. The size of the flap was determined by the defect area of the finger skin. The flap was designed on both sides of the axis, with the native artery of the tibial side of the toe serving as the axis. The proper artery and nerve of the tibial side of the toe were included in the skin flap to protect the surrounding tissue around the tendon. The blood vessel and nerve pedicle were severed, and the skin flap was transferred to the wound surface. The vein was anastomosed with the dorsal or dorsal metacarpal vein, and the flap was used to repair the defect. The MP and IP joints could be used for early functional exercise, and the range of motion was greater than that achieved with a pedicled flap.

In this study, four groups of patients were followed up at 1 month, 6 months, and 1 year postoperatively. There was no significant difference in the total active range of motion among the four groups at 6 months and 1 year postoperatively. However, there was a difference at 1 month postoperatively, with the total active range of motion in two groups being lower than that in the other two groups: the retrograde island flap of the proper digital artery and the nutrient vascular fascial pedicled skin flap. This suggests that rehabilitation training commenced earlier in the latter two groups, and the range of motion of the IP joint was also greater in these groups. This conclusion is consistent with the authors' clinical observations.

Sensory recovery is a crucial indicator for assessing hand function. In this study, we compared the S2-PD and CISS scores of patients exhibiting sensory recovery following four different types of flap repairs. The results revealed that the S2-PD and CISS scores for all four groups progressively decreased as postoperative recovery time increased. Notably, the lateral toe flap demonstrated significantly better sensory recovery and recovery speed compared to the other three groups, with the nutrient vascular fascial pedicled skin flap ranking second. Postoperative sensory recovery was found to be associated with the anatomical characteristics of the flap. Specifically, when the dorsal metacarpophalangeal cutaneous nerve was pedicled with a fascial flap, it was anastomosed with the dorsal metacarpophalangeal nerve in the recipient region [18, 19]. In contrast, the reversed digital artery island flap and the carpal transverse striated perforator flap did not include a nerve, resulting in poor postoperative sensory recovery. Additionally, the reversed digital artery island flap required sacrificing the main artery of the affected finger, the palmar proper digital artery. Long-term follow-up showed that the CISS score for this group was higher than that of the other groups, indicating impaired cold tolerance of the finger. This was attributed to the fact that the native artery of the finger was not accompanied by a vein, and the vein of the skin flap relied on the microvessels in the fascia tissue of the pedicle, which could easily lead to venous return obstruction.

The results indicated that all patients in the 4 groups exhibited good postoperative recovery. One patient in the reversed digital artery island flap group had a vascular crisis, but prompt postoperative treatment led to a favorable outcome. No other complications, such as vascular crisis, joint stiffness and infection were observed in the remaining cases. When comparing patient satisfaction scores, the shape, function and sensation of the four flap types were superior to those of the other three groups, resulting in higher patient satisfaction. Consequently, these flaps represent an ideal method for repairing finger skin defects.

However, the lateral toe flap is not universally applicable for all patients with finger skin defect. The following contraindications and considerations should be carefully evaluated when selecting this approach for reconstruction: (1) Postoperative Immobilization Requirements: Patients undergoing lateral toe flap surgery require bed rest for approximately one week postoperatively due to donor site repair. For elderly patients over 65 years old with limited functional demands, the reversed digital artery island flap or the fascial flap pedicled with the nutrient vessels of the dorsal digital cutaneous nerve may be more appropriate. (2) Systemic Comorbidities: Patients with uncontrolled hypertension, diabetes mellitus, or dyslipidemia often exhibit arteriolar vitreous degeneration [20-22]. Following free flap transfer, standard postoperative management - including anti-infection, antispasmodic, and anticoagulation therapy - is required. However, in patients with metabolic disorders, chronic endothelial dysfunction leads to plasma protein infiltration into the subendothelial space, resulting in basement membrane deposition, vascular wall thickening, and medial smooth muscle atrophy. Consequently, the lateral toe flap carries higher risks in this population and is generally not recommended for finger defect reconstruction.

This investigation was conducted at a single center with a relatively small sample size and limited follow-up duration. To strengthen the validity of these findings, future large-scale, multicenter studies with extended follow-up periods are warranted.

Conclusion

In summary, the lateral toe flap offers advantages in terms of good shape, function, sensory

recovery, and high patient satisfaction, making it an ideal choice for repairing finger skin defects currently.

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Disclosure of conflict of interest

None.

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