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A Comparison between Reversed Cross Finger Flap and Reversed Island Homo-digital Flap in Reconstruction of Distal Dorsal Digital Defects

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ABSTRACT

Background: The reversed cross-finger flap is a modification for cross-finger flap with the strategies of the hetero-digital island flap. In the reversed cross-finger flap, the digital artery opposing the distal communicating arch and the pedicle are included. **Objective:** This work aimed to assess reversed cross finger flap with reversed island homo-digital flap in reconstructing distal dorsal finger defect regarding functional, reliability and esthetic results.

Methods: This prospective study was performed on 30 cases with distal dorsal digital defects and deformities, size of the defect ranged from 1-3 cm in length and 1-2 cm in width and availability of a healthy donor site. All patients were subjected to laboratory investigations [Prothrombin time (PT) and complete blood count (CBC)], radiological examination and photographs.

Results: In reversed cross-finger flap, the size of the flap ranged from 2 to 4 cm in length and 1 to 3 cm in width and in Reversed Island homo-digital flap, it ranged from 1 to 3 cm in width and 4 to 6 cm in length. Reversed island homo-digital flap was done in 15 patients with distal flap necrosis only in one case.

Conclusions: Both reversed cross finger flap and reversed island homo-digital flap are dependable alternatives for treatment of minor to moderate size deformities and defects on the fingers' dorsum up to fingertip.

Keywords: Homo-digital flap, Reversed cross finger flap, Reconstruction, Hand reconstruction, Distal dorsal digital defects.

INTRODUCTION

The hand is a vital organ required for social interaction, expression, production, and synergy with the surroundings. The hand soft tissue is a complicated structure that conceals the deeper structures with specific components (motor and sensory) [(1)]. The palm's thick glabrous skin sustains shearing forces associated with daily activities and functions as a pain and temperature sensory organ and communicating touch, but the dorsal skin is malleable and movable, allowing the hand to move in a wide range of motions such as pinching and gripping [(2)]. Hand soft tissue abnormalities are frequently observed as a consequence of infection, burns, trauma, and tumour removal [(3)].

The finger's dorsum is covered by a thin skin, with a minor amount of subcutaneous tissue beneath, bone structures and the extensor tendons. As a result, it is critical to obtain covering following dorsal digital injury in order to maintain these tissues. Proper treatment must maximise the utilization of local tissue, protect the aesthetic look, offer consistent skin cover, reduce donor-site abnormalities, and maintain the finger's motor function [(4)]. Surgeons use repair algorithms like the reconstructive ladder to determine the most suitable soft-tissue repair technique [(5)].

The reversed cross-finger flap is a modification cross-finger flap with the principles of the hetero-digital island flap. The reversed cross-finger flap is performed on the digital artery directly in front of the pedicle and on the distal connecting arch. This is advantageous since the vascular pedicle already has protection by its connection to the flap skin [(6)]. Therefore, the digital artery is not visible as it is concealed beneath the pedicle skin. As a result, it is supported by a firm soft tissue. The skin attachment contributes to the flap's distal feasibility by limiting pedicle motion and avoiding congestion of the veins [(7)].

The use of reversed homo-digital artery island flaps for fingertip reconstruction was first introduced. This flap was lifted from the lateral phalanx and centred on an artery pedicle. Retrograde origin of the blood supply comes from the connecting divisions of the radial and ulnar digital arteries in the distal phalanx areas and nail bed [(8)]. This single-phase surgery, which does not need immobilisation or harm to neighbouring fingers, can result in a bigger flap size and a wider rotational arc, making it an attractive choice for distal digital finger defects. The drawbacks involve the loss of one of two proper digital arteries, increased morbidity for a wounded finger, and technically difficult fine dissection, all of which contribute to the lengthier operational duration [(9)].

The purpose of this research was to assess the reliability, functionality, and aesthetic results of the reversed cross finger flap versus the reversed island homo-digital flap in reconstructing the distal dorsal finger defects.

PATIENTS AND METHODS:

The study was prospective, done on 30 subjects with distal dorsal digital defects and deformities. Size of defect

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varied from 1-3 cm in length and 1-2 cm in width, with healthy donor site available.

Exclusion criteria: Chronic heavy smokers and patients with a traumatic injury to the perforator and donor site, major uncontrollable medical illness, as well as severe injured hand.

All patients were subjected to: physical examination (general & local examination), history taking, laboratory investigations (Prothrombin time (PT) and complete blood count (CBC)) and radiological examination and photographs.

Operative steps of reversed cross finger flap (fig 1 a, b, c, d): Antibiotic prophylaxis (one hour preoperatively), patient positioning: (a supine position with extended arm on side table), anaesthesia: (local anaesthesia of Lidocaine Hydrochloride Injection BP 2% with arm tourniquet).

Operative procedure: pre-operative marking: flap was a rectangle on the middle phalanx's dorsum, limited between proximal and distal interphalangeal joint.

Disinfection: by povidone-iodine.

Skin is incised on proximal and distal limits of flap with lateral incision. Skin is elevated as a flap in subdermal plane away from site of trauma towards opposite border. Subcutaneous tissue is incised from the far lateral border down to level of paratenon of underlying tendon. Dissection is carried to lateral border adjacent to site of trauma with complete separation of proximal and distal borders. Good haemostasis by bipolar diathermy and compression. Subcutaneous tissue flap is turned over and is anchored by VICRYL 4/0 sutures to recipient site. Donor site is covered by the elevated dermal flap, by VICRYL 4/0 sutures.

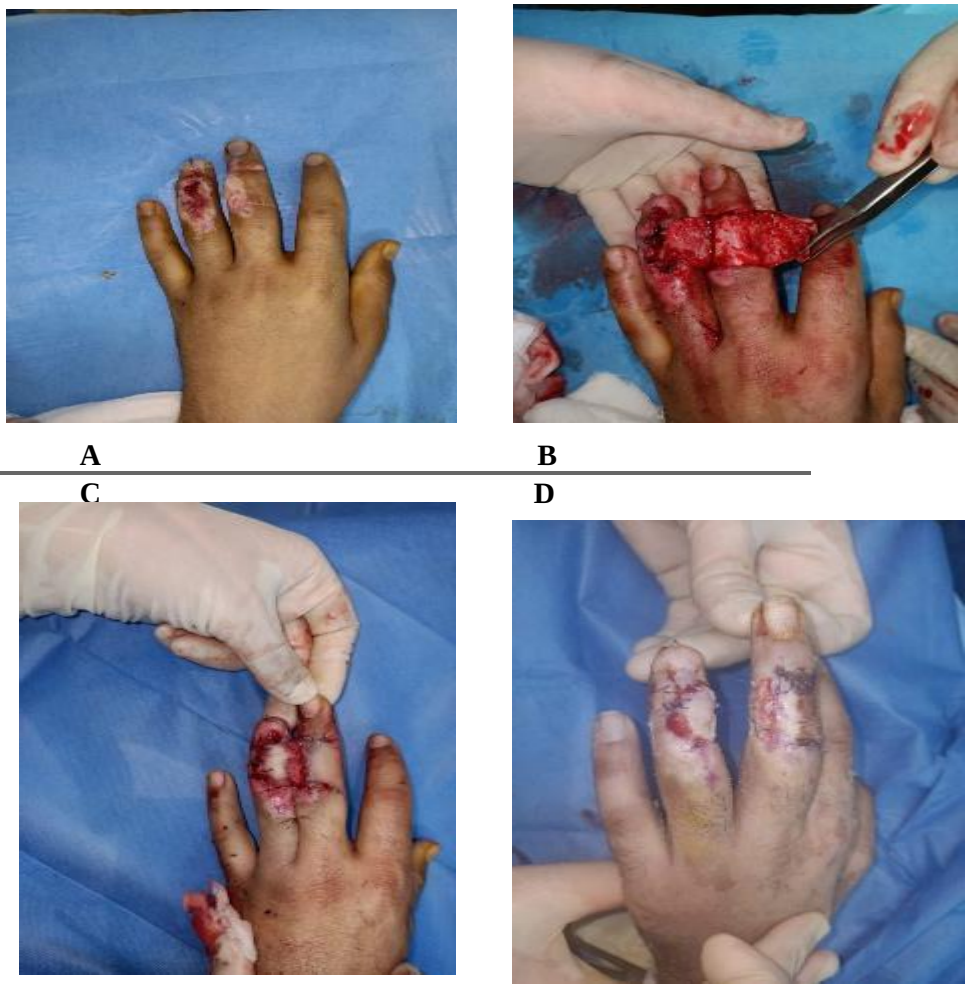

Fig (1): (a) soft tissue defect with exposed extensor tendon in middle phalanx dorsum of the ring finger (b) reversed cross finger flap elevation from middle finger (c) donor site closure by the elevated dermal flap and flap coverage by STG (d) flap separation after 3 weeks.

Operative steps of reversed island homo-digital artery flap (fig 2 a, b, c. d, e): Antibiotic prophylaxis (one hour preoperatively), patient positioning (a supine position with extendedarm on side table), anaesthesia: (general or supra-clavicular anaesthesia with tourniquet on the arm after hand elevation without exsanguination).

Pre-operative marking: On the proximal phalanx's dorsum, a mark was made for the flap. Disinfection by povidone-iodine. An incision was done on the radial side of the flap proximally, the neurovascular bundle is visible by splitting Grayson ligament. A vascular clamp is used to temporarily close the proximal digital artery; the bandage is removed, and perfusion of the flap and finger is established. After attaining haemostasis, proximally, the digital artery is tied. Following that, the flap is raised in anterior-to-posterior and proximal-to-distal orientation. Vessel was raised superficially to the extensor tendon paratenon and flexor sheath. Beyond the midway of the middle phalanx, the vascular pedicle was not dissected. To avoid harming the deeper anastomotic arteries, in a subdermal plane, open the skin between the distal end of pedicle dissection and the digit defect. After that, the flap is turned 180 into the flaw and positioned. A full-thickness skin graft is used for covering the donor site.

Postoperative care included drugs (e.g. Analgesics and antibiotics), splinting by volar hand slap for 2 weeks, dressing every 3 days. Stitch removal was done after 2 weeks, and hand physiotherapy started from 3rd week postoperatively.

Follow up data was obtained by serial clinical examination, manual goniometry and two point discrimination tests.

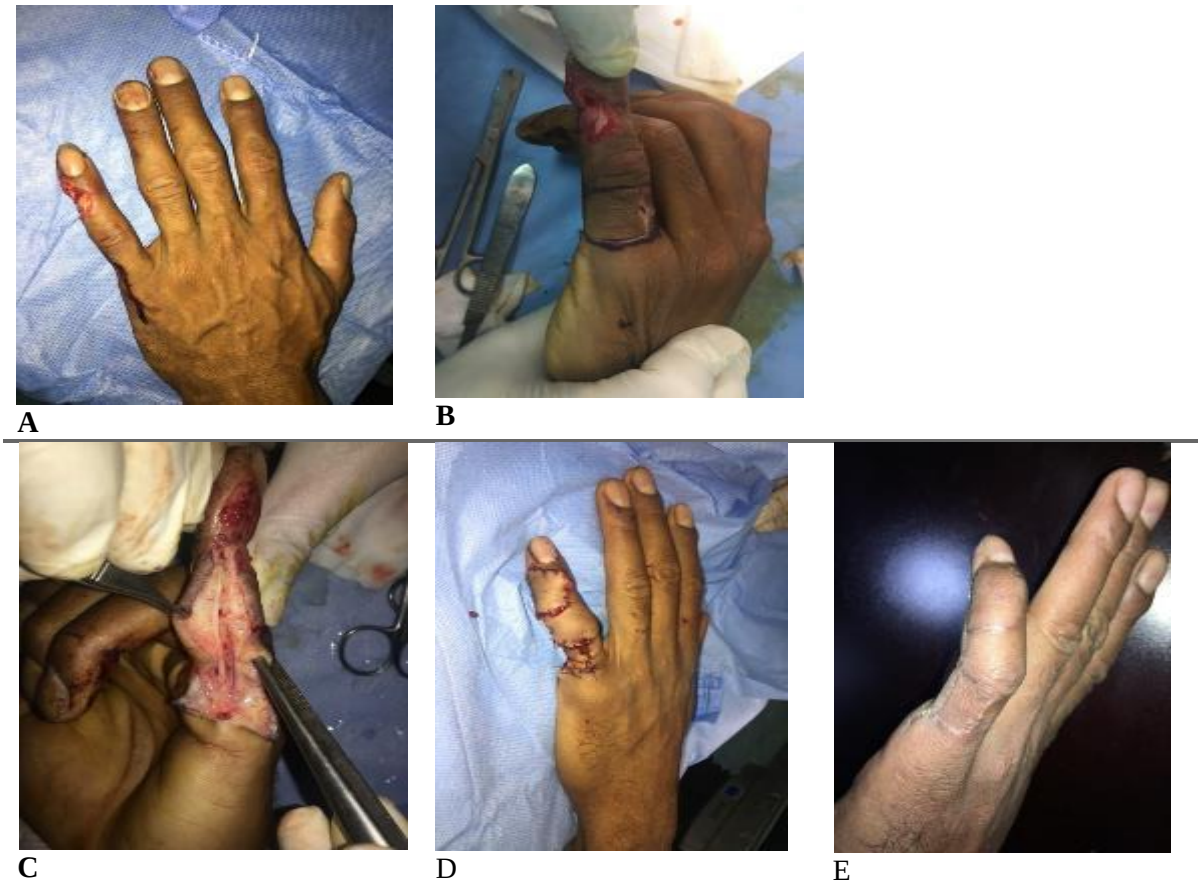

Fig (2): (a) Soft tissue defect with exposed extensor tendon in the dorsum of distal phalanx of the little finger, (b) Flap marking in the dorsum of proximal phalanx, (c) Digital neurovascular bundle exposure and nerve separation from the artery, (d) Coverage of the donor by full thickness skin graft and (E) follow-up after 6 month.

Ethical Approval:

The study was approved by the Ethics Board of the Sohag University and an informed written consent was taken from each participant in the study. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

Statistics were analysed using SPSS version 25 (IBM Inc., Chicago, IL, USA). The paired Student's t-test was used to compare the mean and standard deviation (SD) of quantitative variables within the same group. Qualitative data were analysed using frequency and percentage counts (%). P values with two tails, < 0.05 was considered to be statistically significant.

RESULTS

The study included thirty patients (24 males & 6 females) ranged in age from 10 to 70 years old who had soft tissue defect in dorsum of the hand distal to PIP and have been reconstructed by reversed cross-finger flap or reversed homo-digital artery. Twenty eight patients in our study had post-traumatic defects and two patients had post-tumor resection deformity on dorsum of fingers. Table 1

Table (1): The studied cases' distribution according to demographic data and aetiology (n=30)

	No	**%**
Sex		
Male	24	80.0
Female	6	20.0
Age (years)		
< 30	17	57.0
≥ 30	13	43.0
	33.1 ± 10.85745	
Etiology		
Post traumatic	28	93.3
Post tumor resection	2	6.7

Data are presented as frequency (%) or mean± SD.

Twenty-three patients of had no comorbidities or risk factors, while three patients were smokers ,two patient had controlled DM and two patients had controlled HTN. Table 2.

Table 2: Incidence of comorbidities and /or risk factors in our studied cases (n= 30).

Comorbidities	7(23.3%)
Diabetes mellitus (DM)	2(6.6%)
Smoking	3(10%)
Hypertension (HTN)	2(6.6%)

Data are presented as frequency (%).

The flap size ranged from 2 to 4 cm in length and 1 to 3 cm in width in reversed cross-finger flap and from 4 to 6 cm in length and 1 to 3. cm in width in Reversed island homo-digital flap. Table 3

Table 3: flaps' Data

flaps' Data	**Characteristics**	
Flap type:	**Reversed cross finger flap**	**Reversed island homo-digital flap**
Flap size:		
Range of length (in cm)	2- 4 cm.	4- 6 cm.
Range of width (in cm)	1 – 3. cm.	1 – 3. cm.
Duration of flap elevation range (in minutes)	50- 60 min.	60-80 min.
Donor site closure:		
Skin graft	0(0.0%)	15(100 %)
primary closure	15(100 %)	0(0.0%)

Data are presented as frequency (%).

The duration of hospital stay was 1 day. There was no post-operative wound infection or dog-ear formation in the donor site and no post-operative hemorrhage or local abscess was recorded. Reversed crossfinger flap was done in 15 patients, two cases suffered from total flap necrosis, distal flap necrosis occurred in one case. Reversed island homo-digital flap was done in 15 patients with distal flap necrosis occurred only in one case. Table 4

Table 4: post-operative complications Data

Post-operative complications Data	**Characteristics**	
	Reversed cross finger flap	**Reversed island homo-digital flap**
Donor site:		
Wound infection	1 (6.6%)	0 (0 %)
Wound dehiscence	0 (0 %)	0 (0 %)
Dog ear	0 (0%)	0 (0%)
Recipient site:		
Total flap necrosis	2 (13.3 %)	1 (6.6 %)
Distal flap necrosis	1 (6.6 %)	1 (6.6 %)
Hemorrhage	0 (0%)	0 (0%)
Bulkiness of the flap	0 (0%)	1(6.6%)

Data are presented as frequency (%).

Table 5 shows the follow up data in our studied cases

Table 5: Follow up Data

Follow up Data	Characteristics	
	Reversed cross finger flap	**Reversed island homo-digital flap**
Donor site: functional outcome		
Movement restriction	4 (26 %)	6 (40 %)
Sensory disturbance	5 (33 %)	3 (19.5 %)
Cold intolerance	2 (13.3 %)	2 (13.3 %)
Donor site: aesthetic outcome		
Hypertrophic scarring	1 (6.6 %)	1 (6.6%)
Keloid formation	0 (0 %)	0 (0 %)
Hyperpigmentation	2 (13.3 %)	2 (13.3 %)
Hypopigmentation	1 (6.6%)	2 (13.3 %)
Contour defect	11 (73.3 %)	9 (60 %)
Recipient site: functional outcome		
Movement restriction	0 (0 %)	0 (0 %)
Recipient site: aesthetic outcome		
Color mismatch	8 (53.3 %)	0 (0 %)
Contour defect	0 (0 %)	0 (0 %)
Flap bulkiness	0 (0 %)	1 (6.6 %)

Data are presented as frequency (%).

In our study, total flap necrosis occurred in two cases (13%) and was managed by full-thickness skin graft after frequent dressing. partial flap necrosis occurred one time and was managed by dressing. 5 patients suffered from sensory disturbance (33%). Cold intolerance occurred in two patients (13.3%) color mismatch appeared in 7 patients (46%), movement restrictions was reported in four patients (26%), while 11 patients (73%) complained with donor's site contour defect (Fig 3 a & b).

A B

Fig 3(a, b) late follow-up with good functional and aesthetic outcomes

DISCUSSION

Soft-tissue defects and deformities of dorsum of fingers are considered challenges for plastic and hand surgeons. The cause of these defects may be trauma, with post-burn contracture release or post-neoplastic excision [(10)].

In the study done by **Karthikeyan *et al*.** [(11)] the most popular reason was occupational injury (in 35.5%), but there were nearly similar numbers of patients with finger injuries as a result of road traffic accidents (30.5%). Domestic injuries were the third most common, accounting for (13.6%). Additionally, electrical traumas, deformities from excising benign lesions, and deformities resulting from the relaxation of skin contractures were possible causes. In our study, 28 cases (93.3%) were post-traumatic while 2 cases (6.6 %) were due to post tumour resection.

Reversed cross-finger flaps are used frequently to transfer tissue between digits. The flap has an excellent track record of dependability and survival. Its value is established by the amount of vascularized tissue transferred to shield and protect exposed tissues in a neighbouring digit. [(12)].

The reversed cross finger flap can also be utilized to give bulk after releasing scars and to reconstruct dorsum of finger. The flap provides bulk and a resilient surface for secondary skin grafting. Being a sensate flap, it aids the functionality of the fingers. Reversed cross finger flaps carry donor site morbidity that includes reduction in range of motion of finger and reduced grip strength. The cosmetic outcomes can be improved by using full thickness grafts instead of split skin grafts [(13)]. In **Karthikeyan *et al*.** [(11)] study, the reversed cross finger flap was done in 23 subjects; the size was determined to be between 1.8 and 6 cm. The majority of cases had a range of flaps' sizes from 2 to 4 cm, in length. Duration of flap elevation was approximately 15-20 minutes. While in study done by **Atasoy,** [(14)] reversed cross finger flap was done in 30 patients under general anesthesia with arm tourniquet. The flaps varied in size from 1.5 to 4.5 cm in length and 1.5 to 4 cm in width. Duration of flap elevation ranged about 10-15 minutes.

The flap was designed precisely to fit within the confines of the functioning phalanx unit. We liked to infuse the flap with physiological saline to facilitate dissection. Distal, proximal and mid-lateral incisions are made on the defect's side. Incisions were made in the sub cutis on the proximal, distal, and lateral sides, and the flap was elevated to reveal the entire region of muscle between the paratenon and dermis. Then, the flap was moved on associated base laterally in order to access the defect on the opposite side. Following attachment of the flap to flaw, the skin over the donor area is relocated over the paratenon, and the raw surface of the reversed flap is

covered with a split-thickness skin transplant. The flap division can be performed between the 7th and 12th day due to the flap's outstanding revascularization [15].

In both **Karthikeyan *et al*. [11]** and **Atasoy, [14]** in all subjects, The donor site was covered with a split-thickness skin graft. After dressings are applied, plaster of Paris must be used with the volar side to ease monitoring and dressing changes of the flap. After approximately two weeks, the orthosis, dressing, and sutures are eliminated, and under local anaesthesia, the flap was divided between the fingers. In our study, in all cases, the donor place was closed primary with the elevated dermal flap and the flap was completely covered by a full-thickness or split-thickness skin graft. On the same day, the case was dismissed and advised to keep the limb elevated. Under local anaesthesia, the flap was divided between the fingers after 3 weeks. Passive physiotherapy is advised after one week, sutures are removed in two weeks then active physiotherapy after 3 weeks.

In **Karthikeyan *et al*. [11]** study, the total healing time recorded for the flaps was 5- 8 weeks. There were no significant difficulties, such as flap loss in its entirety. Three cases who underwent a marginal loss suffered minor problems**.** These flaps had partial necrosis, but they healed effectively with dressings. In four patients, there were modest issues of partial graft loss at the donor site, which were similarly handled with dressings alone. In two individuals, movement limitations in the donor finger were handled with physiotherapy.

The homo-digital reverse vascular island flap is useful for reconstructing extensive pulp injuries, dorsal and lateral distal phalanx defects, middle phalanx defects, defects up to the PIPJ and on the distal interphalangeal joint [8].

In **Huang *et al.* [8]** study, the flap has been used in 45 cases to reconstruct and cover fingertip, distal phalanx and middle phalanx and the mean duration of operation was 105 minutes. Some necrosis of the flap was observed on 3 (6%) flaps and cured with little debridement. The affected finger had a range of motion of 255 degrees. 3 participants (6%) had minor pain in the flap, and 2 reported discomfort in the flap donor location (2%). Paresthesia was detected in 4 (8%) cases with flap places and 7 (15%) cases with donor places. Eight cases (17%) reported cold intolerance at the flap and donor locations. The donor place was closed with a full-thickness skin graft taken from the ipsilateral forearm [8].

In **Niranjan and Armstrong, [15]** this flap has been effectively employed in 25 patients, as described in this article. Thirteen fingers and five thumbs had distal phalangeal defects, in case of the finger repair using the middle phalanx's flap and in case of the thumb using a flap from proximal phalanx. Six patients had their secondary defect closed directly, while the remaining 18 patients had their defect grafted with a full thickness skin graft and one with a split thickness skin graft. There were partial flap loss in 2 cases (8%), infection in 5 cases (20%), cold intolerance in 9 cases (36%) and graft loss (partial) in 5 cases (20%).

In our study, reversed island homo-digital flap was done in 15 patients. The flap size varied from 4 to 6 cm in length and 1 to 3 cm in width. Average operative time was 55 minutes and the donor site was closed in all cases with grafting without wound dehiscence or infection. Only one flap (6%) was completely lost due to injury of the perforator, which was managed by debridement and STG later, one flap (6%) suffered distal necrosis due to distal reach of the flap near DIP joint and was managed by daily dressing. Mmovement restriction was reported in 6 patients (40%), donor site contour defect in 9 cases (60%) and cold intolerance in 2 cases (13%). One case (6.5%) had hypertrophic scarring.

CONCLUSIONS

The two reversed cross finger flap and reversed island homo-digital flap are dependable alternative for handling small to moderate size deformities and defects on the fingers' dorsum up to fingertip. However, reversed island homo-digital has a higher morbidity but restricted to the same digit, unlike reversed cross finger, which has a lower morbidity but including two digits. The choosing between them when none of them is contraindicated can be based on several factors: patient age, occupation, preference, injured finger, site of defect and surgeon`s experience.

DECLARATIONS

- **Consent for Publication:** I confirm that all authors accepted the manuscript for submission
- **Availability of data and material:** Available
- **Competing interests:** None
- **Funding:** No fund
- **Conflicts of Interest:** The authors declared no conflicts of interest regarding the publication of this paper.

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