Reversed Flow Homodigital Island Flap for Fingertip Defects Reconstruction

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Abstract
Background: The retrograde homodigital island flap is a reliable and predictable option for reconstructing fingertip defects. It can be used to cover extensive soft tissue and bone defects and has a reported 98% survival rate with favorable functional outcomes. It does not require interphalangeal joint flexion and can incorporate a nerve for improved sensory outcomes.
Objectives: The present study aims to evaluate its effectiveness in terms of flap survival and sensory outcomes.
Patients and methods: This was a prospective interventional study conducted on 10 patients who admitted to Plastic Surgery Department in Qena University Hospital, and presented with fingertip injury and underwent reconstruction by reversed flow homodigital island flap from April 2022 to January 2023.
Results: Total flap loss was observed in 2 (20%) of cases, while partial flap necrosis was observed in 2 (20%) of cases which healed with conservative wound management. Two patients (20%) exhibited contracture and decreased joint mobility. Cold intolerance and hypersensitivity substantially reduced over the follow-up period. Abnormal Semmes-Weinstein tests was not observed after 3 months postoperatively till end of follow up period. Two -point discrimination has improved significantly.
Conclusion: Although reversed flow homodigital artery flap is a reliable method for fingertip reconstruction, we experienced a relatively high rate of flap loss, which may be related to smoking in our study group. Nevertheless this technique improves cold intolerance, hypersensitivity, and two-point discrimination. It benefits patients with extensive tissue damage, and bone or joint involvement, greatly enhancing their quality of life and functional abilities.
Keywords: Homodigital; Island-Flap; Fingertip; Reconstruction.
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Introduction

Anomalies of the fingertip or pulp are among the most common traumatic hand injuries. It may impact the skin, soft tissues, and bone, and it can manifest itself in a variety of patterns such as transverse, dorsal oblique, volar oblique, and vertical oblique. The amount and direction of soft tissue loss often dictate how the injury is treated. The optimum functional fingertip restoration should include both sensate and glabrous skin, which might be challenging **(Besmens et al., 2020).** A Several flaps, including local advancement flaps, cross finger flaps, thenar flaps, and various local island flaps, have been reported for concealing homodigital fingers when there is significant bone exposure; each has advantages and disadvantages **(Kawaiah et al., 2020; Gad et al., 2021).**

The retrograde homodigital island flap is an effective method for repairing severe defects, such as finger pulp amputations, as it creates a large vascularized glabrous skin flap that is close to the incision site and can conceal defects. Unlike the antegrade homodigital island flap, the retrograde flap is supplied by the digital artery on the opposite side of the digit **(Xiong et al., 2022).**

Regmi et al. (2016) proposed using the middle transverse anastomotic arch of the main digital arteries in the finger at the C3 pulley to create a retrograde flap. This flap enables the performance of distal neurorrhaphy on the contralateral distal nerve stump, even if severing the correct digital nerve or the dorsal digital nerve branch is necessary to complete treatment. The authors suggest that adding distal neurorrhaphy could potentially enhance sensory outcomes for patients.

This flap has a high survival rate of 98% and produces satisfactory results, including near-normal interphalangeal joint range of motion and an average return to work after 7 weeks. The flap's tension-free inset does not require interphalangeal joint bending, and it provides good sensory outcomes whether the digital nerve or dorsal sensory branch is incorporated, with a static 2PD of 4 to 10 mm **(Seah et al., 2020).**

The present study is aimed to evaluate the reversed retrograde homodigital island flap technique in terms of flap survival, post-operative complications, static 2-point discrimination, cold intolerance, and hypersensitivity.

Patients and methods

This was a prospective interventional study conducted on 10 patients who admitted to Plastic Surgery Department in Qena University Hospital, and presented with fingertip injury and underwent reconstruction by reversed flow homodigital island flap from April 2022 to January 2023. All patients who gave consent for participation were recruited in the study.

This research was open to patients who satisfied the following criteria: a. be above the age of 18 and capable of providing informed consent. b. Fingertip or pulp defects with bone exposure, c. Defects bigger than 1cm, d. No concomitant fracture of the middle or proximal phalanx.

If any of the following criteria were satisfied, patients were excluded from participating in this trial: Concomitant injuries, especially fractures in the affected areas; b. Digital artery damage; and c. Dupuytren contracture and diabetic patients. d. A significant infected wound.

All patients in this study had the following procedures: a full history, a thorough hand examination, which included: 1. an assessment of neurovascular health and tendon damage. 2. The extent of the wound defect. 3. The presence of exposed bone. 4. The geometry of the soft tissue defect. In every case, digit-specific radiographs are acquired to detect concurrent hand fractures and foreign bodies. Preoperative and

postoperative photographs were obtained of all patients.

Surgical procedure

All operations were performed under general anesthesia and followed **(Yazar et al., 2010)** instructions. The reverse pedicle digital island flap is designed along the lateral border of the proximal phalanx of the affected digit, with a slightly larger size than the actual defect to account for primary skin contraction. A skin incision is made from the proximal site of the flap and continued distally over the digit's lateral surface. During the dissection, it is necessary to identify the digital nerve, which must be gently separated from the vascular pedicle. After division of the proximal end of the digital artery, the digital vessel is ligated proximally.

Proximal to distal dissection is performed until a long enough pedicle is established, which is often at the DIP joint level. A little remnant of tissue now encircles the vascular pedicle. To prevent kinking of the vascular pedicle, the raised flap is rotated into the defect and lightly sutured. Primary closure is used to seal the donor site of a flap.

After the tourniquet is removed, hemostasis is performed, and the flap is inset with interrupted 4/0 nylon sutures. A wooden splint will be used to immobilize the affected fingers.

Postoperative follow-up schedule

All patients have been seen in the outpatient clinic after 1 week, 1 month and every month up to 6 months of surgery.

Primary outcome evaluation included flap survival/loss and the presence of associated complications such as partial flap necrosis, infection, hematoma, joint stiffness and contractures. All survived flaps were subjected to the following evaluation

- Flap sensation was assessed using Semmes-Weinstein monofilaments. Using the opposite hand, we likewise evaluated and compared static and moving 2-point discrimination.
- Pain: To measure pain at the site of injury, a 5-point response scale **(Chanques et al., 2010)** was utilized.
- Cold intolerance: To test the flap's cold sensitivity, we employed the Cold Intolerance Severity Score questionnaire **(Irwin et al., 1997).** We used the same finger on the opposite hand as a control.
- Joint mobility: We used goniometry to evaluate the active range of motion of the PIP and DIP joints in the damaged and donor fingers to the undamaged hand **(Nizamis et al., 2018).**

Ethical Approval: All subjects provided informed written consent, and the study was sanctioned by the university's ethics board. Both the Helsinki Declaration and the Code of Ethics for Medical Research Involving Human People were adhered to throughout the study. The ethical approval code of our study was **SVU-MED-SUR011-1-23-3-580**.

Statistical Analysis

In May 2016, the data was analyzed using IBM-SPSS version 24. The Kristall-Wallis and Wilcoxon tests, Spearman's correlation, and logistic regression analysis were employed to establish statistical significance. Each variable was examined according to the sort of data it contained, whether parametric or not. If the P-values were less than 0.05, or 5%, the results were judged statistically significant.

Results

The mean age of the patients is 33.1 ± 12. Most of cases were males (80%). Manual workers represented half of the patients. Sixty percent of the patients had the right hand affected, while the remaining 40% had the left hand affected. Smoking was reported by 40% of cases. Eight cases

were injured through sharp object and only two had blunt trauma. No tendon injury was reported. Mean length of defect was 1. 1.44 ± 0.31 and mean width was 1.54 ± 0.36, (**Table.1**).

Table 1. Demographic data and basal characteristics of included subjects

Parameter	Value (N = 10)
Age (Years)	33.1 ± 12
Sex	
• **Male**	8 (80%)
• **Female**	2 (20%)
Occupation	5 (50%)
Affected Hand	
• **Right**	6 (60%)
• **Left**	4 (40%)
Smoking	4 (40%)
Mechanism of injury	
• **Sharp object**	4 (40%)
• **Blunt trauma**	6 (60%)

The ring finger was the most commonly affected (40%). The most common defect geometery was oblique volar (50%), followed by oblique dorsal (30%) then transverse (20%), (**Table.2**). Total flap loss was observed in 2 (20%) of cases, while partial flap necrosis was observed in 2 (20%) of cases which healed with conservative wound management without the need for any further surgical interventions. Contracture and Diminished Joint mobility were observed in 2 (20%) of cases after 6 months. No cases reported neuroma occurrence. Hyperthesia was observed in 2 cases after 1 week and 1 month then improved with treatment, so no cases showed hyperthesia from 3 months till end of the study, **(Table.3**).

Table 2. Hand evaluation of included subjects

Parameter	Value (N = 10)
Tendon injuries	0 (0%)
Two-point discrimination (mm)	6.7 ± 1.16
Defect size (Cm)	
• **Length**	1.44 ± 0.31
• **Width**	1.54 ± 0.36
Affected Finger	
• **Index**	2 (20%)
• **Middle**	3 (30%)
• **Ring**	4 (40%)
• **Little**	1 (10%)
Site	
• **Finger tip**	10 (100%)
Type of lesion	
• **Oblique Dorsal**	3 (30%)

• **Oblique Volar**	5 (50%)
• **Transverse**	2 (20%)

Table 3. Post operative flap evaluation data through follow up period (6 months)

Variables	1 week	1 months	3 months	4 months	5 months	6 months
Cold intolerance	8 (80%)	4 (50%)	2 (25%)	2 (25%)	2 (25%)	2 (25%)
Hypersensitivity	8 (80%)	8 (100%)	6 (75%)	4 (50%)	2 (25%)	2 (25%)
Semmes-Weinstein monofilament testing	2 (10%)	2 (25%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
2-point discrimination	9.5 ± 1.72	7.11 ± 1.9	4.89 ± 1.36	4 ± 1.58	3.56 ± 1.24	3.11 ± 1.05
5-point pain response scale	4.6 ± 0.84	4.44 ± 1.13	3.89 ± 1.76	2.78 ± 1.72	2.11 ± 1.83	0.89 ± 1.62

*P<0.05 Statistically significant.

Regarding cold intolerance, there was high decrease in number of patients suffered from cold intolerance over time. There were only 25% of our patients still suffered from cold intolerance at the end of the follow up period. Regarding hypersensitivity, 6 (75%) cases still suffered from hypersensitivity at the end of 3 months follow up period, however, there were only 25% of our patients still suffered from hypersensitivity at the end of the follow up period. While abnormal Semmes-Weinstein testing was not observed in any of our cases after 6 month follow-up. There was significant improvement in 2-point discrimination at 6 months post-operative, (**Table.3**).

Cases

Case.1 (**Fig.1-6**)

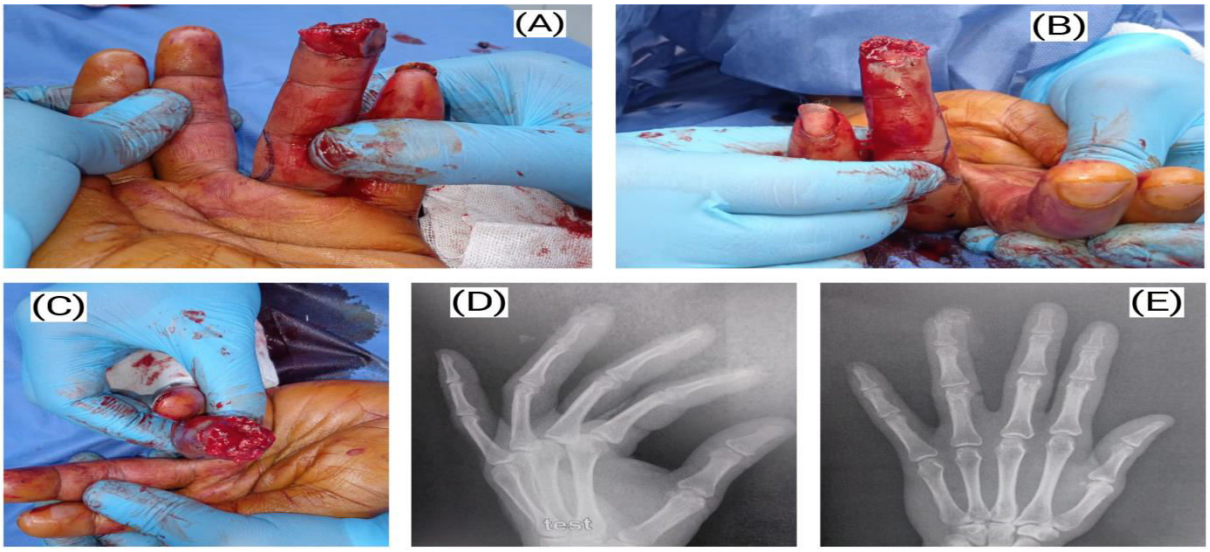

Fig.1. Oblique dorsal fingertip injury of left ring finger. (a) Volar aspect view. (b) Dorsal aspect view. (c) Finger tip injury with exposed bone. (d) Lateral view hand x-ray. (e) Antero-posterior view hand x-ray

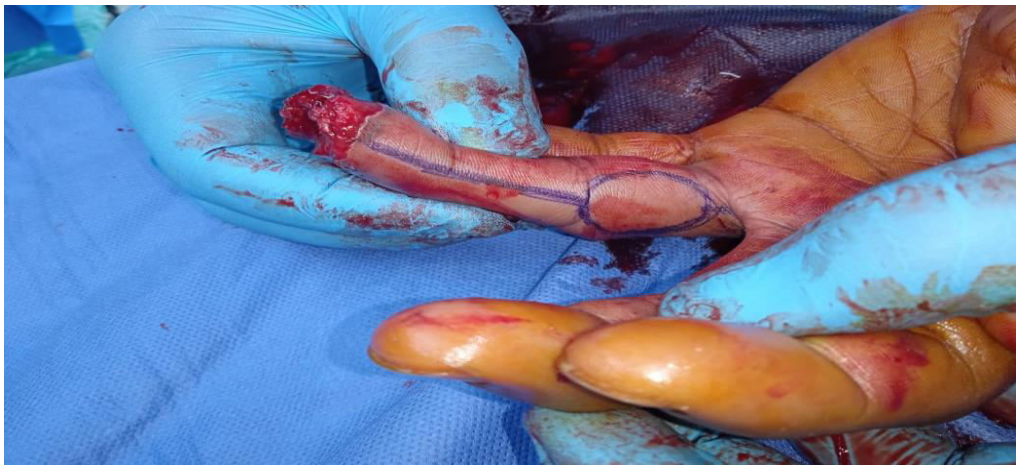

Fig.2.Defect of 1.4 cm width and 2 cm length with size of flap 1.8 cm width and 2.6 cm length.

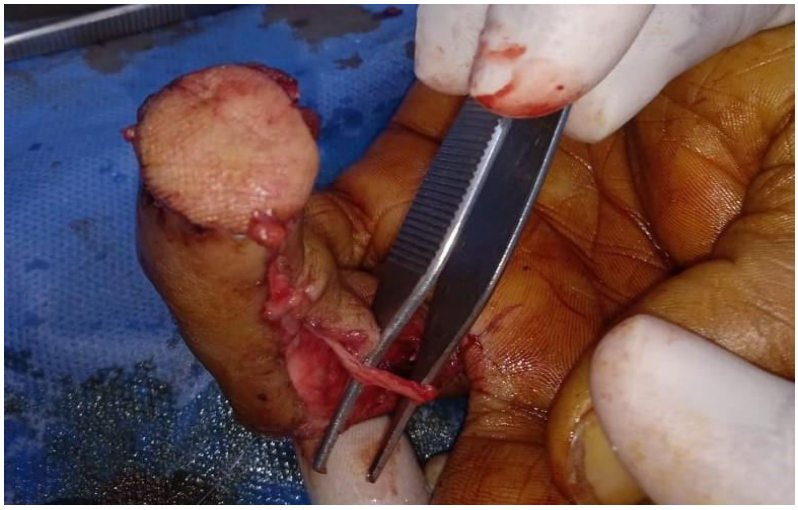

Fig.3. Preservation of digital nerve (radial side)

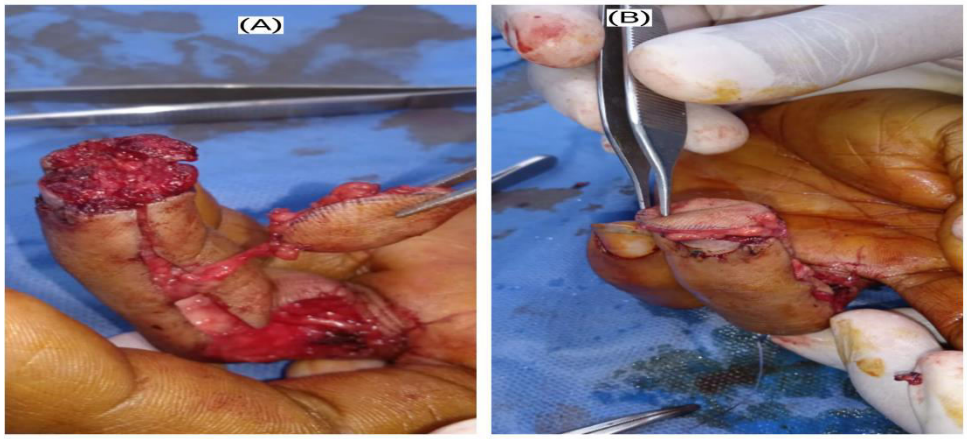

Fig.4. The elevated flap is then rotated into the defect and sutured loosely to avoid compression of the pedicle and to ensure that the rotation of the flap doesn't kink the vascular pedicle. (a) Lateral view. (b) Dorsal aspect view.

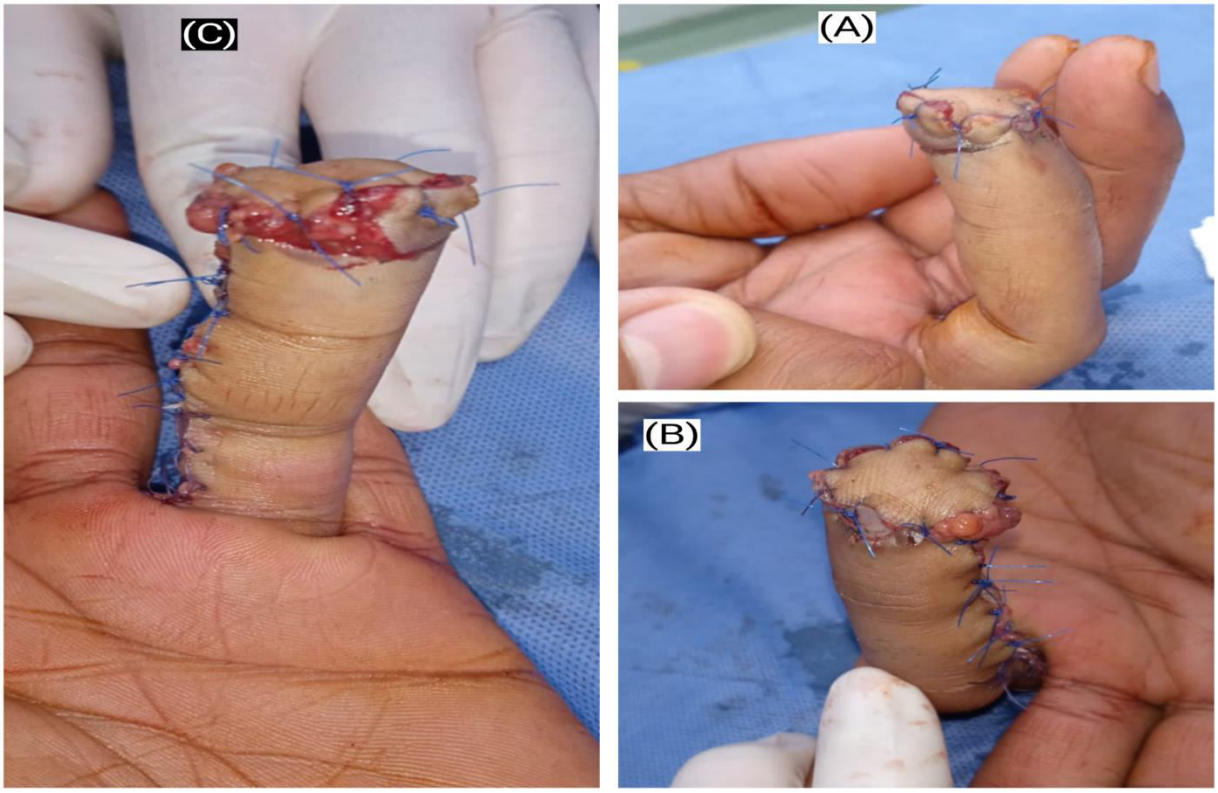

Fig.5. The flap donor site was closed by primary closure and the flap is inset with interrupted 4/0 nylon suture. (a) lateral view. (b) dorsal aspect view. (c) volar aspect view.

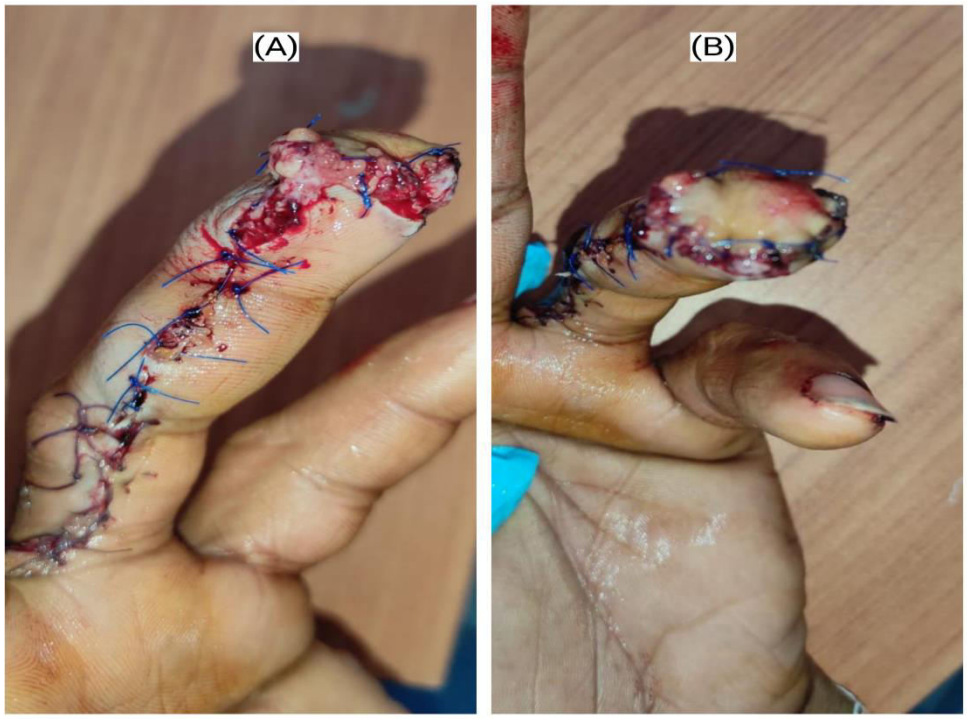

Fig.6. Follow up after 2 weeks. (a) Lateral view. (b) Volar aspect view.

Case.2 (**Fig.7-13**)

Fig.7.Transverse fingertip injury of left middle finger with bone exposed. (a) volar aspect view. (b) dorsal aspect view. (c) finger tip injury with exposed bone. (d) lateral view hand x-ray.

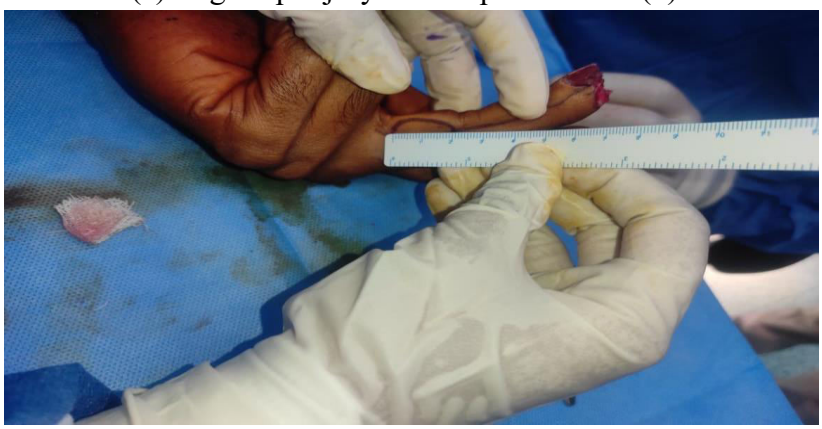

Fig.8.Defect of 1.5 cm width and 2.1 cm length with size of flap 1.9 cm width and 2.7 cm length.

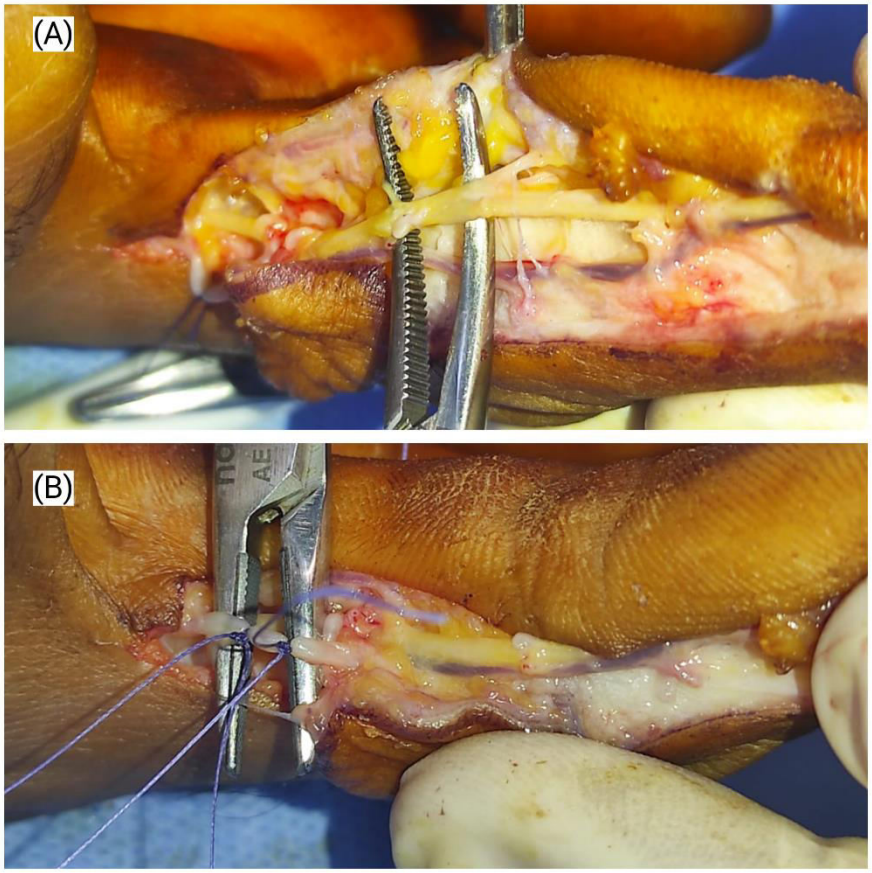

Fig.9. (a) Preservation of digital nerve (radial side). (b) ligation of digital artery (radial side).

Fig.10. Elevated flap rotated into the defect and sutured loosely to avoid compression of the pedicle and to ensure that the rotation of the flap doesn't kink the vascular pedicle. (a) lateral view. (b) volar aspect view.

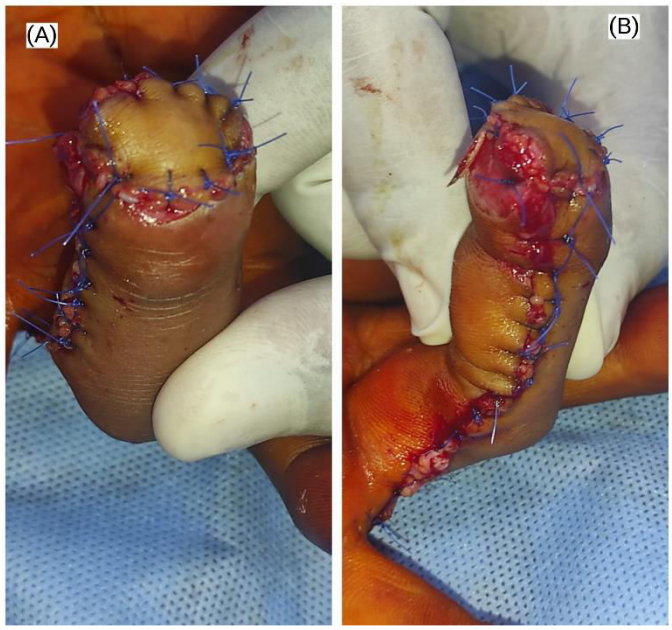

Fig. 11.Flap donor site closed by primary closure and the flap inset with interrupted 4/0 nylon suture. (a) dorsal aspect view. (b) lateral view.

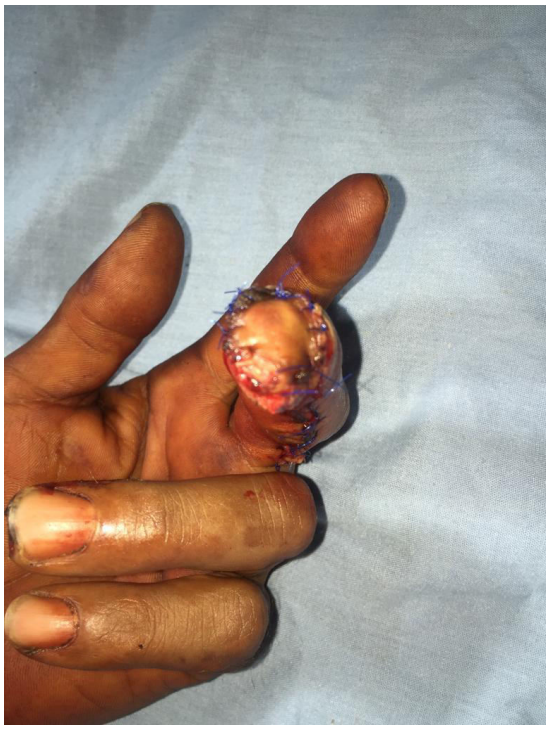

Fig.12. Follow up after 1 week.

Fig.13. Follow up after 1 month with good capillary refill and pricking with some sort of superficial ischemia. (a) lateral view. (b) volar aspect view.

Discussion

Fingertip or pulp defects refer to injuries or abnormalities in the soft tissue or bone at fingertips **(Elliot et al., 2018).** Such defects can be a result of various etiologies, including trauma, infection, or congenital anomalies, and may present with symptoms such as pain, paresthesia, deformity, and functional limitation **(Karakas and Yuce, 2020).**

Hand surgeons have struggled with fingertip reconstruction. Primary closure, local advancement flaps, cross finger flaps, and homodigital and heterodigital island flaps are some of the therapies used to reconstruct this difficult disease, depending on the damage patterns. The ideal repair will maintain digital length while also providing long-term sensory cushioning for the distal phalanx and appearing attractive. These injuries are often accompanied by fractures and nail bed destruction, and the concomitant injuries must also be considered **(Adani et al., 2022; Martin-Playa and Foo, 2019).**

Of the several reconstructive techniques available, reverse-flow homodigital island flaps have been shown to be especially beneficial. These flaps need accurate digital artery and digital nerve dissection while allowing a wide range of motion for soft tissue covering to retain finger length and nail attractiveness. Moreover, these flaps may allow for single-stage healing with little immobilization, as well as long-term skin replacement of the same color, thickness, and flexibility. These flaps, however, have been connected to a variety of problems, including venous congestion, partial flap necrosis, flexion contracture, and cold sensitivity **(Usami et al., 2022).**

The main aim of the study was to evaluate the reversed retrograde homodigital island flap technique in terms of flap survival, postoperative complications, static 2-point discrimination, cold intolerance, and

hypersensitivity over a mid-term follow-up period.

As regard demographic data, we found that the mean age of the patients is 33.1 = 12, indicating a relatively young population. Most of cases were males (80%). 50% of the patients were manual worker.

The increased incidence of traumatic fingertip or pulp defects in the young adult population, males, and those engaged in occupational activities may be attributed to several factors. Young adults typically participate in activities that involve an increased risk of hand and finger injuries, such as sports, and other recreational activities. They may also be more inexperienced in certain tasks, leading to an increased risk of accidents and injuries **(Abebe, 2019; Kawaiah et al., 2020; Lemsanni et al., 2021).**

Males are more likely to be involved in activities that necessitate tool usage and work in occupations that demand manual intensive work, both of which can increase the probability of sustaining fingertip injuries. Occupied populations are also at risk due to prolonged use of machinery and tools, which can result in fatigue, decreased focus, and a higher likelihood of accidents and injuries **(Abebe, 2019; Dębski and Noszczyk, 2021; Nagi and Singh, 2019).**

In the current study, we found that all of the injuries occurred at the fingertips, with the ring finger being the most commonly affected (40%). The increase incidence of fingertip injuries in ring finger may be attributed to its relative length, location, and frequent use in activities that pose a higher risk of finger injuries because it is the last to be withdrawn from the machine or car door **(Gulec et al., 2019).**

However, **Regmi et al., 2016** who conducted meta-analysis to assess the outcomes and complications of fingertip reconstruction and reported that index fingers (38 %) being the most commonly affected followed by long fingers (33 %) then ring fingers (23 %).

Flap survival is one of the most important outcomes of reconstruction techniques. In our study, total flap loss was observed in 2 (20%) of cases, while partial flap necrosis was observed in 20% of our cases, which is completely healed by conservative wound care. This may be attributed to a significant proportion of individuals in our study population were observed to be smokers about 40%. Smoking is a significant risk factor for complications in Homodigital Reverse Flow Island Flap surgery. Nicotine in tobacco causes vasoconstriction of blood vessels, leading to reduced blood flow, which can compromise the viability of the flap. Furthermore, smoking can delay wound healing due to reduced oxygen supply and impaired immune response, increasing the risk of infections. Finally, smoking can make the patient more susceptible to infections. Therefore, preoperative cessation of smoking is recommended to decrease the incidence of postoperative complications and improve the outcome of the surgery **(Cho et al., 2021; Neustein et al., 2020).** Therefore, we believe that other techniques such as cross finger flap or thenar flap may be a good and safe alternative in smoker. Also, our limited experiences with the use of reversed homodigital flap may play a role or attribute to relatively high complication rate in our series.

The reverse flow flap method resulted in a 95% flap survival rate, according to **Acar et al. (2014). Regmi et al. (2016)** analyzed the findings of eight clinical studies that included the reverse-flow island flap technique and found that the mean flap survival rate was 98%, with partial flap loss happening in 5% of patients. The overall flap survival rate in the **Gulec et**

al., 2019 study was 100% (including partial survival in 1 patient).

With time, cold intolerance patients decreased significantly. 25% of our patients had cold intolerance after follow-up. 6 (75%) instances of hypersensitivity persisted after 3 months, although only 25% of our patients did.

The retrograde flow digital artery flap technique ensures that the transferred tissue has well-preserved blood supply, which can lead to better tissue perfusion and improved nerve function While the surgery can restore the finger's function and appearance, patients may initially experience cold intolerance due to the surgical trauma and damage to the local tissue. However, with proper rehabilitation and time, the circulation to the reconstructed area can improve, and cold intolerance may gradually decrease. Patients may experience hypersensitivity in the reconstructed area due to nerve damage or trauma during the surgery. However, as the nerve endings heal and regenerate, hypersensitivity may improve over time. In some cases, residual hypersensitivity may persist, but it typically becomes less noticeable over time and does not significantly impact hand function or daily activities **(Wink et al., 2020; Joshua Xu et al., 2021). Yildirim et al., 2022** reported that 47% of their patients reported cold intolerance, revealing that nerve healing may be incomplete.

In the current study, there was significant improvement in 2-point discrimination at 2-months till end of post-operative follow up period. Abnormal Semmes-Weinstein testing was not observed at 3 months post-operative. These improvements is likely due to the restoration of nerve function and improved tissue perfusion achieved through the retrograde flow digital artery flap technique.

Regmi et al. (2016) presented findings for static two-point discrimination (2PD) with sensate flaps average 7.2 mm (n = 126). **Gulec et al., 2019** discovered that the reverse-flow flap group had a good mean static 2-point discriminating distance of 5.2 mm. Moreover, our findings were consistent with those of **Monreal (2017),** who performed one-stage reverse flow homodigital island flap repair of finger pulp abnormalities. It worked well by returning feeling and enabling for early finger movements. **Yazar et al. (2010)** observed normal monofilament testing results in 64 fingers (91.4%) and impaired light touch in 6 fingers in a group of 66 people (70 fingers). 2-PD findings in 40 fingers were normal (6 mm) and fair (6-10 mm) in 30 fingers (mean 5.7 mm, range 4–9 mm).

The main disadvantage of reverse-flow homodigital island flaps is considered to be flexion contracture. We discovered contracture and restricted joint mobility in two (20%) of the patients after three months of testing. In the **Xu et al., 2021** trial, one out of every twenty individuals suffered postoperative flexion contracture. Care must be given during dissection and flap implantation to decrease the risk of contracture. Scar development and flexion contractures may be reduced by inserting smooth nonabsorbable sutures into small, well-planned incisions. **Sundaramurthy et al. (2017)** ascribed the lack of flexion contractures in their group to all incisions being performed in the mid-axial line, with no flaps raised distal to the proximal interphalangeal joint. Patients who experienced contracture in previous trials showed significant improvement when managed with physiotherapy **(Tucker, 2011)**. Therefore, we recommended that all patients who underwent Homodigital Reverse Flow Island Flap should do physiotherapy postoperatively.

Conclusion

Although reversed flow homodigital artery flap is a reliable method for fingertip

reconstruction, we experienced a relatively high rate of flap loss, which may be related to smoking in our study group. Nevertheless this technique improves cold intolerance, hypersensitivity, and two-point discrimination. It benefits patients with extensive tissue damage, and bone or joint involvement, greatly enhancing their quality of life and functional abilities.

Declaration of Conflict of Interest: The authors confirm that they have no conflicts of interest to disclose regarding the research study.

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Author Contributions: The authors of this research study contributed equally to the study.

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