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The Use of Composite Bone and Nail Bed Graft Combined with Cutaneous Flaps for Reconstruction of Fingertip Amputations

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Abstract

Background: The approach of using a composite graft consisting of bone and nail bed from the amputated part, along with a local skin flap, may offer a promising solution for managing fresh fingertip amputations to preserve its length and restore its shape.

Objectives: This study aimed to evaluate the effectiveness of combining composite bone and nail bed grafts with different local skin flaps for fingertip reconstruction.

Patients and Methods: This clinical study prospectively examined 16 patients, with an age ranging from 5 to 65 years, of both sexes, who had fingertip amputations at any level through the nail bed and distal phalanx, with the amputated part preserved.

Results: The Flap used was cross finger in 15 patients (93.25%), and V-Y flap in 1 patient (6.75%). Flap viability was viable in 13 patients (81.25%), partial loss in 2 patients (12.5%) and flap loss in 1 patient. Nail bed survival was viable in 6 patients (37.5%), partial loss in 5 patients (31.25%), and total loss in 5 patients (31.25%). Bone graft survived in 12 patients (75%), partial loss in 2 patients (12.5%) and total loss in 2 patients (12.5%). Bone union was united in 12 patients (85.71%), and ununited in 2 patients (14.29%).

Conclusions: The use of bone and nail bed as composite grafts combined with local and regional cutaneous flaps can effectively salvage fingertip amputations, particularly in patients where replantation is not feasible. Despite most favorable outcomes regarding flap viability and bone union, there were notable instances of nail bed loss.

Key Words: *Composite Bone – Nail Bed Graft – Cutaneous Flaps – Reconstruction – Fingertip Amputations.*

Ethical Committee: The Medical Research Ethics Committee (MREC) of the faculty of medicine, Sohag University approved the study on 12/7/2023 under IRB Registration number: Soh-Med-23-07-02MS.

Disclosure: No disclosure.

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Introduction

Fingertip injuries are one of the most frequent hand injuries across all age groups, as the fingertip is a highly visible and heavily utilized part of the hand. However, there is still no clear consensus on the best approach for reconstructing fingertip injuries involving nail bed defects, and the available reconstruction methods remain limited **[1]**.

Allen **[2]** categorized fingertip amputations into four types. Type I affects only the finger's pulp. Type II involves the loss of both the pulp and the nail. Type III includes partial loss of the terminal phalanx along with the pulp and nail. Lastly, Type IV extends to the lunule, involving the pulp, nail, and partial terminal phalanx loss.

Fingertip amputations that extend through the proximal half of the nailbed present a challenge, as the remaining nailbed is too short to support proper nail growth. While replantation at this level can yield excellent functional and cosmetic outcomes, it is a complex procedure that requires microsurgical expertise, specialized equipment, and favorable conditions, making it not always feasible **[3]**. If replantation is not an option, a local advancement palmar flap helps maintain digital length and preserves the remaining nail bed.

However, if the amputation occurs in the proximal third of the nail, this method results in a minimal nail bed, often leading to nail deformities **[4]**. To prevent these deformities, the nail bed and germinal matrix are typically fully removed, followed by closure using a palmar advancement flap or shortening. However, these procedures often do not meet the patient's wish to preserve their nail **[5]**.

If replantation is not possible, an alternative approach involves advancing a palmar V–Y flap and attaching the nail bed from the amputated part to the dorsal side of the flap to restore nail bed length **[6]**. The use of a composite bone and nail bed graft from the amputated segment, combined with a local

cutaneous flap, can be a viable treatment option for fresh fingertip amputations. This approach helps restore the fingertip's shape and maintain its length, particularly in cases where microsurgical replantation is not possible.

The objective of this study was to assess the results of using a composite bone and nail bed graft in combination with various local cutaneous flaps for fingertip amputation reconstruction.

Patients and Methods

This prospective observational study was conducted on 16 patients aged 5 to 65 years, of both sexes, with fingertip amputations through the nail bed and distal phalanx, provided the amputated part was preserved. The study was conducted from June 2023 to June 2024 after getting an approval from the Ethical Committee of Sohag University Hospitals, Egypt. on 12/7/2023 under IRB Registration number: Soh-Med-23-07-02MS.

Informed written consent was obtained from patients or their relatives Patients with a crushed amputated segment, peripheral vascular disease, or diabetes were excluded. All patients underwent a comprehensive medical history assessment, clinical examination, laboratory tests (CBC and coagulation profile), along with a radiological evaluation (plain X-ray). Allen classification was based on the involvement of the pulp, nail (it's lunula), and terminal phalanx. The deformities and late functional outcomes documented. Type I involved only the pulp, Type II included the pulp and nail bed, Type III involved a distal phalanx fracture along with the pulp and nail bed, and Type IV affected the lunula, distal phalanx fracture, pulp, and nail bed.

Surgical technique:

The amputated fingertip was irrigated with normal saline for cleansing, and a composite graft containing the nail bed and distal phalanx bone was obtained from the severed part. The bone was then secured to the remaining distal phalanx stump using either a 21-gauge axial needle or a 0.8mm K-wire. The nail bed graft was sutured to the remaining nail bed using 6–0 polyglactin suture.

To cover the volar aspect and tip of the distal phalanx, a local or regional cutaneous flap such as a V-Y advancement flap, thenar flap, or cross-finger flap was utilized. The flap was extended beyond the tip, creating additional skin that was reshaped to form a rounded fingertip. To prevent synechiae between the nail fold and the injured nail bed, the nail plate was placed inside the nail fold. The finger was then immobilized for two weeks using a below-elbow dorsal slab.

Patients were monitored for four months, with postoperative complications assessed clinically and radiologically. Potential complications included infections, impaired vascularization due to damaged blood supply, hypertrophic scars or keloids at graft and flap sites, deformities or contractures, and delayed healing caused by poor vascularization, pre-existing health conditions, or surgical complications. Fig. (1).

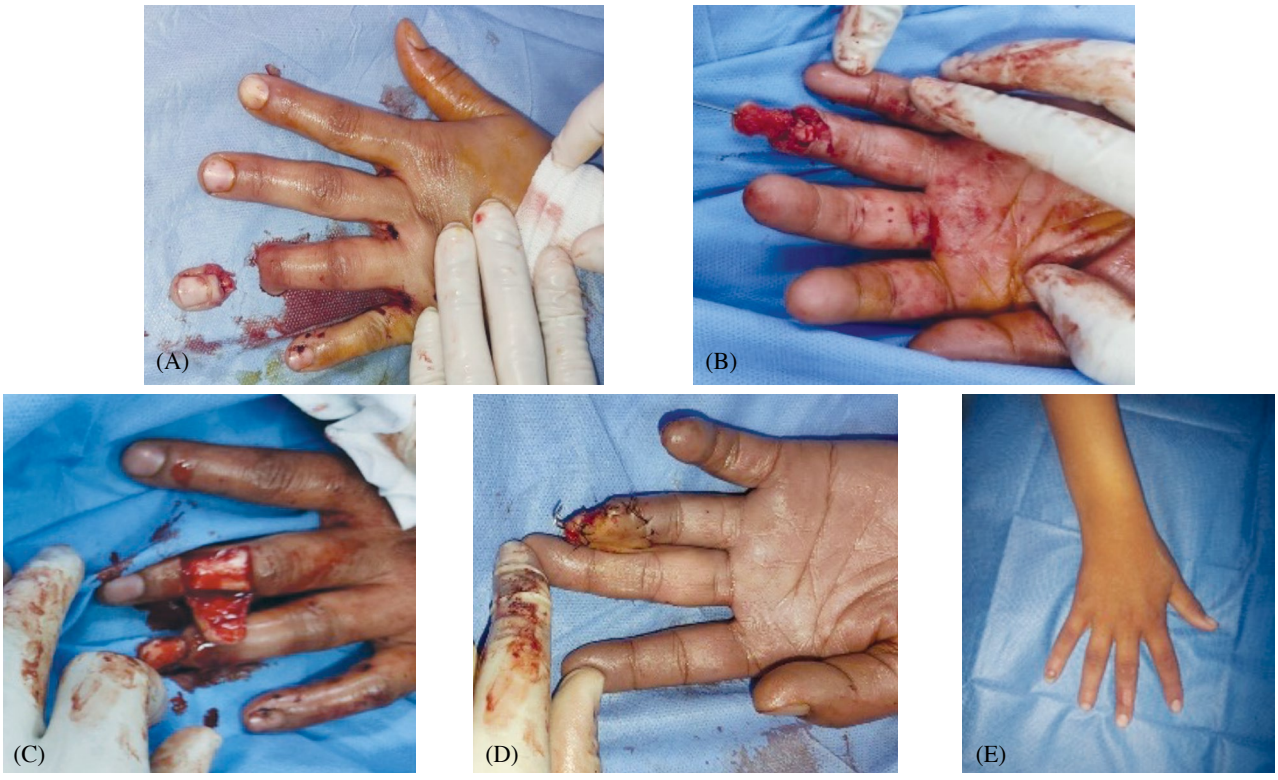


Fig. (1): (A) Cleaning of the amputated part. (B) Fixation of the bone and nail bet graft by K-wire. (C) Elevation of cross finger flap. (D) Flap inset and (E) Late postoperative.

Outcome assessment:

Flap viability: Viable, partial loss, total loss. Nail bed survival: Viable, lost. Bone graft survival: viable, lost. Bone union: United, ununited. Nail appearance: Normal, short, hook, split, absent. Pulp condition: Padded, deficient. Fingertip length: Normal, short. Pain on touch: Present, absent. Sensation: normal, reduced, absent. Functional outcome: range of motion, pinch strength, return to work.

Statistical analysis:

Statistical analysis was performed using SPSS version 26 (IBM Inc., Chicago, IL, USA). The normality of the data distribution was assessed using the Shapiro-Wilks test and histograms. Parametric quantitative data were expressed as the mean and standard deviation (SD), while non-parametric quantitative data were presented as the median and interquartile range (IQR). Qualitative variables were reported as frequency and percentage (%).

Results

Demographic data, mechanism of trauma, ischemia time, contamination and Allen classification were enumerated in this table. Table (1).

Injured finger, flap used, flap viability, nail bed survival and bone graft survival, bone union and nail shape were enumerated in this table. Table (2).

Pulp, fingertip length, pain on touch, sensation, range of motion and return to work were enumerated in this table. Table (3).

Table (1): Demographic data, mechanism of trauma, ischemia time, contamination and Allen classification of the studied patients.

	N=16
Age (years)	22.9±18.8
Sex:	
Male	9 (56.25%)
Female	7 (43.75%)
Mechanism of trauma:	
Door crush	4 (25%)
Machine injury	6(37.5%)
Two-wheeler chain	3 (18.75%)
Knife injury	3 (18.75%)
Ischemia time (hr.)	5±2.03
Contamination	13 (76.47%)
Allen classification:	
III	1 (5.88%)
IV	16 (94.12%)

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

Table (2): Injured finger, flap used, flap viability, nail bed survival and bone graft survival, bone union and nail shape of the studied patients.

	N=16
Injured finger:	
Index Finger	10 (62.5%)
Middle finger	1 (6.25%)
Ring finger	5 (31.25%)
Flap used:	
Cross finger	15 (93.75%)
V-Y Flap	1 (6.25%)
	N=16
Flap viability:	
Viable	13 (81.25%)
Partial loss	2 (12.5%)
Lost	1 (6.25%)
Nail bed survival:	
Viable	6 (37.5%)
Partial loss	5 (31.25%)
Lost	5 (31.25%)
Bone graft survival:	
Viable	12 (75.0%)
Partial loss	2 (12.5%)
Lost	2 (12.5%)
	N=14
Bone union:	
United	12 (85.71%)
Ununited	2 (14.29%)
Nail shape:	
Normal	5 (35.71%)
Short nail	4 (28.57%)
Hook nail	1 (7.14%)
Absent nail	4 (28.57%)

Data is presented as frequency (%).

Table (3): Pulp, fingertip length, pain on touch, sensation, range of motion and return to work of the studied patients.

	N=16
Pulp:	
Well padded	13 (92.86%)
Poorly padded	1 (7.14%)
Fingertip length:	
Normal	9 (64.29%)
Short	5 (35.71%)
Pain on touch:	
Present	1 (7.14%)
Absent	13 (92.86%)
Sensation:	
Normal	13 (92.86%)
Hypoesthesia	1 (7.14%)
Range of motion:	
Full range	14 (100.0%)
Return to work (weeks)	6.1±1.41

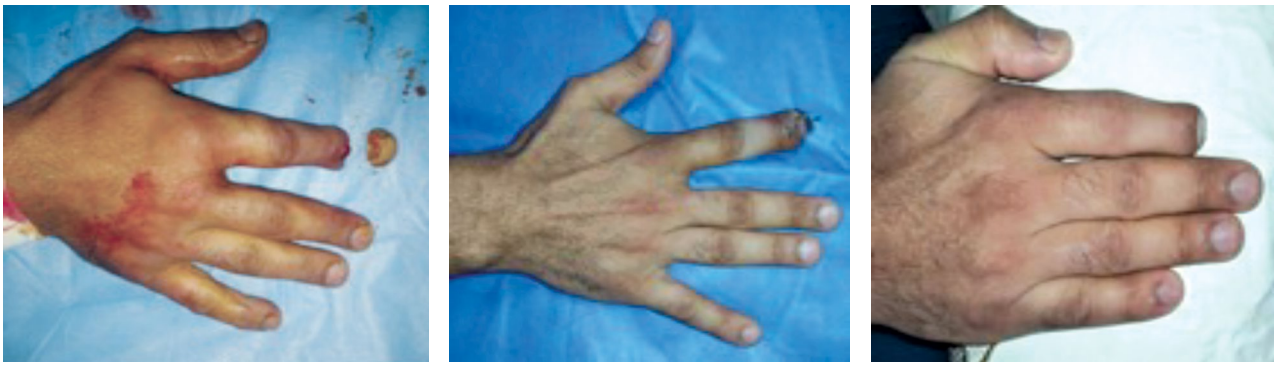
Data are presented as mean ± SD or frequency (%).

Case (1): A 12-year-old male patient arrived with a complete amputation of the distal part of the distal phalanx of the right ring finger (Allen type III) caused by a machine injury. The injury was reconstructed using a composite bone and nail bed graft, along with a cross-finger flap. Fig. (2).

(A) (B) (C)

Fig. (2): (A) Pre-operative, (B) Three weeks and (C) Four months post-operative (after separation).

Case (2): A 33-year-old male patient arrived with a complete amputation of the distal portion of the distal phalanx of the right index finger (Allen type IV) caused by a knife injury. The injury was repaired using a composite bone and nail bed graft, along with a V-Y advancement flap. Fig. (3).



(A) (B) (C)

Fig. (3): (A) Pre-operative, (B) Three weeks and (C) Four months post-operative.

Discussion

Fingertip injuries are among the most common hand injuries, affecting individuals of all ages. However, repairing a volar pulp defect with nail bed loss is a difficult task. If the amputated part is available, replantation may be a better option [7].

In our study, approximately 94% of the cases involved Allen type IV fingertip amputation. In contrast, Zhou et al. [8] in a similar case series of 14 patients found that 50% had type III and 35.7% had type IV fingertip amputation. Additionally, Malshikare [9] reported using composite bone and nail bed grafts with flaps in 15 patients with fingertip amputations, all of whom had Allen type IV.

In this study, the index finger was the most commonly affected, seen in 59% of patients, followed by the ring finger in 30%. Consistent with our results, Malshikare [9] reported that the index finger was predominantly injured. Notably, Han et al. [10] and Zhou et al. [8] also employed the same technique of composite nail bed and bone grafting, covered by a flap, for reconstructing thumb fingertip amputations.

In the current study, the most commonly used flap was the cross-finger flap (94%), followed by the V-Y volar advancement flap (6%). Similarly, Malshikare [9] employed various soft tissue flaps, with the cross-finger flap used in 46% of cases, the thenar flap in 26%, and the V-Y volar advancement flap in the remaining 26%. Zhou et al. [8] exclusively used the V-Y volar advancement flap for all patients in their study. Dubert et al. [11] and Alagoz et al. [12] applied a similar approach, utilizing composite bone and nail bed grafts for the reconstruction of fingertip amputations with a homodigital neurovascular flap. Han et al. [10] combined a homodigital soft tissue flap with periosteum and a bone-nail bed composite graft.

In the current study, the flaps remained viable in 80% of patients. Consistent with our findings, Alagoz et al. **[12]** reported a flap viability rate of 90%. Malshikare **[9]** found that flaps were viable in 93% of patients. Additionally, Han et al. **[10]** and Zhou et al. **[8]** demonstrated 100% flap viability in their cases.

In the present study, nail bed grafts were fully or partially viable in approximately 67% of patients. This aligns with the findings of Malshikare **[9]**, who reported normal nail bed grafts in 66% of cases. In contrast, Han et al. **[10]** and Zhou et al. **[8]** found that the nail bed was viable in 100% of cases.

Regarding bone grafts, our study found a viability rate of 87.5%. Zhou et al. **[8]** and Malshikare **[9]** reported a 100% viability rate for bone grafts using the same technique.

Additionally, bone union occurred in 85.7% of patients in our study, while Zhou et al. **[8]** and Malshikare **[9]** observed bone union in all cases.

In the current study, 35.71% of patients had a normal nail shape, 28.57% had short nails, 7.14% had hook nails, and 28.57% had absent nails. Other studies, such as those by Zhou et al. **[8]** and Malshikare **[9]**, reported that all patients had normal nail shapes, with only one case showing thick nails. Shawer et al. **[13]** observed that all nails were clawed, while Han et al. **[10]** found that all nails were thick, particularly in the distal portion.

In the current study, fingertip length was normal in 64.29% of patients. In contrast, Malshikare **[9]** reported that 93% of cases had a typical digital length. Alagoz et al. **[12]** and Han et al. **[10]** both observed that fingertip length was normal and accepted in all cases. On the other hand, Dubert et al. **[11]** found that all patients had shortened fingertip lengths due to bone resorption.

In our study, 86.6% of patients had normal sensation. Similarly, Alagoz et al. **[12]** found that only one patient had cold intolerance, while the rest exhibited normal sensation. However, Han et al. **[10]** reported no sensory abnormalities in any of their cases.

In our study, all patients demonstrated a full range of motion. Consistent with our results, Malshikare **[9]** reported excellent mobility at the PIP and DIP joints of the affected finger. On the other hand, Dubert et al. **[11]** found flexion contractures at the DIP joint in three cases and at the PIP joint in one case. Zhou et al. **[8]** observed that the loss of mobility in the MPJ and PIP joints was less than 10°.

The limitations of our study included a relatively small sample size, its single-center design, and the potential impact of contamination in most cases, which could influence healing and outcomes, making it challenging to independently assess the effectiveness of the techniques used without considering infection risks.

Conclusions:

Composite bone and nail bed grafts, along with local and regional cutaneous flaps, can effectively restore fingertip amputations, especially when replantation is not an option. Although the results showed excellent flap viability and bone healing, there were still significant occurrences of nail bed loss.

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