



Homodigital Unipedicled Islanded Neurovascular Pulp Advancement Flap/Colombo Flap for Fingertip Reconstruction: A Case Series with a Novel Technique

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Abstract

Fingertip injury is the most common type of upper extremity injury. Operative treatment with flap cover is required for tissue loss causing bone exposure and when there is a compelling need to preserve the length, unless microvascular replantation is possible. There are many techniques described for this purpose offering varying degrees of good outcomes. Yet there are limitations and long-term problems. We report a case series with a novel technique named “Colombo flap,” which is a neurovascular islanded advancement flap based on a single pedicle. Five fingers of four consented patients were operated using this technique and they were followed up for 2.5 years. All had satisfactory sensory recovery (S3 +/S4), preserved range of motion (ROM) at interphalangeal joints, good grip strengths, and satisfactory outcomes based on Michigan Hand Questionnaire (MHQ). There were no complications such as flap necrosis, infection, and neuroma formation. Hook nail deformity was minimal and none had pain or cold intolerance.

Keywords

- ▶ fingertip injuries
- ▶ advancement flaps
- ▶ pedicled flaps
- ▶ neurovascular flaps

Introduction

Fingertip injury is the commonest type of traumatic upper extremity injuries.¹ The majority of these injuries result from crush mechanisms, which generally preclude microvascular replantation.² Having a larger defect, volar oblique (VO) injuries, bone exposure, and associated distal phalangeal fracture usually indicate the need for operative management.³ Preservation of length and sensation, prevention of nail deformity and painful neuromas, early return to work, as well as achieving acceptable cosmetic appearance are the treatment goals.²

Revision amputation, composite grafting, skin grafting, and local or regional flaps are the available treatment options under these circumstances. However, the latter option is generally indicated when there is bone exposure and the patient insists on preservation of length. Homodigital flaps avoid the intrusion of other digits for donor sites, immobilization, and the need for a second procedure. Volar V-Y advancement (Atasoy), lateral V-Y advancement (Kutler), oblique triangular (Venkataswami), and reverse flow homodigital islanded flaps are the commonly utilized homodigital flaps that could provide glabrous skin to the fingertip, replacing like

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Table 1 Demographic and injury-related characteristics of participants

| | Patient 1 | Patient 2 | Patient 3 | | Patient 4 |
|------------------------------|----------------------------------|---------------------------|---------------------|--------------------|--------------------------------|
| Age (y) | 34 | 69 | 35 | | 33 |
| Sex | Female | Male | Male | | Male |
| Occupation | Meat processing machine operator | Printing machine operator | Data entry operator | | Supervisor (taking down notes) |
| Dominant hand | Right | Right | Right | | Right |
| Injured finger | Left index finger | Left ring finger | Left index finger | Left middle finger | Right index finger |
| Type | Transverse | Transverse | VO | Transverse | Modest VO |
| % of intact nail bed | 30 | 25 | 25 | 25 | 30 |
| PNB classification of injury | 366 | 366 | 466 | 366 | 466 |

Abbreviations: PNB, pulp, nail, and bone; VO, volar oblique.

with like. However, these flaps have their own limitations. We describe a novel homodigital flap technique that addresses these limitations with successful results.

Case Series

Five fingertip injuries of four patients treated using the described novel homodigital flap technique, from January to June 2020 at the Plastic Surgical Unit, National Hospital of Sri Lanka. The inclusion criteria were the following:

- Traumatic single or multiple fingertip injuries.
- Amputated part not suitable for replantation (e.g., crush mechanism, gross contamination, and multiple comorbidities).
- Proximal Allen zone 3 injury with minimal residual nail bed (25–30%) and VO orientation, which were considered not favorable for conventional Atasoy- or Kutler-type flaps.

Thumb injuries, patients with comorbidities like diabetes mellitus, peripheral vascular disease, and nonconsenting patients were excluded from the study (►Table 1).

The participants were regularly followed up for 2.5 years and were evaluated for sensory recovery (two-point discrimination and Modified Medical Research Council [MMRC] grading), range of motion (ROM) of proximal interphalangeal joint (PIPJ) and distal interphalangeal joint (DIPJ), grip power (power grip, key pinch, and pulp pinch), pain, cold intolerance, and outcomes with Michigan Hand Questionnaire (MHQ; ►Table 1).

Surgical Technique

Surgery is performed under a regional block with loop magnification and a tourniquet is utilized. The fingertip is washed and debrided preserving as much of viable tissues and nail bed as possible. Bone is minimally nibbled and the edge is smoothed. The edge of the nail bed is sharply cut transversely. The flap is marked as shown in ►Fig. 1, one limb along the midlateral line up to the PIPJ crease level and the other limb along the midlateral line up to the DIPJ crease level and then across the middle phalanx to meet the straight limb at the PIPJ crease level. Skin incisions are made and flap is dissected in distal to proximal direction. On the long straight limb side, the incision is deepened

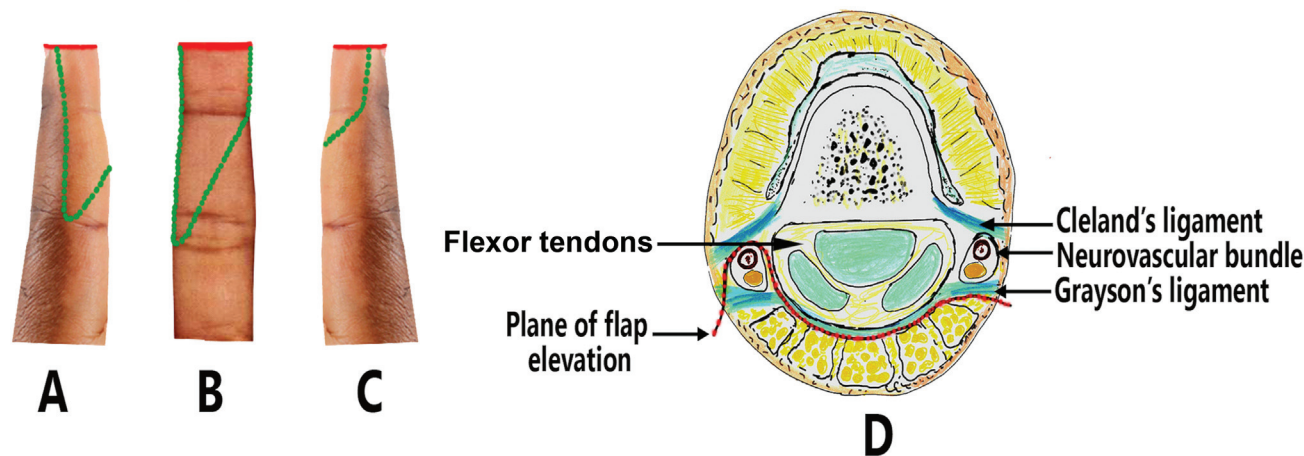


Fig. 1 Flap markings and dissection. (A,C) Lateral views. (B) Anterior view of flap marking. (D) Cross-section of a finger across the middle phalanx level to depict the plane of flap elevation.

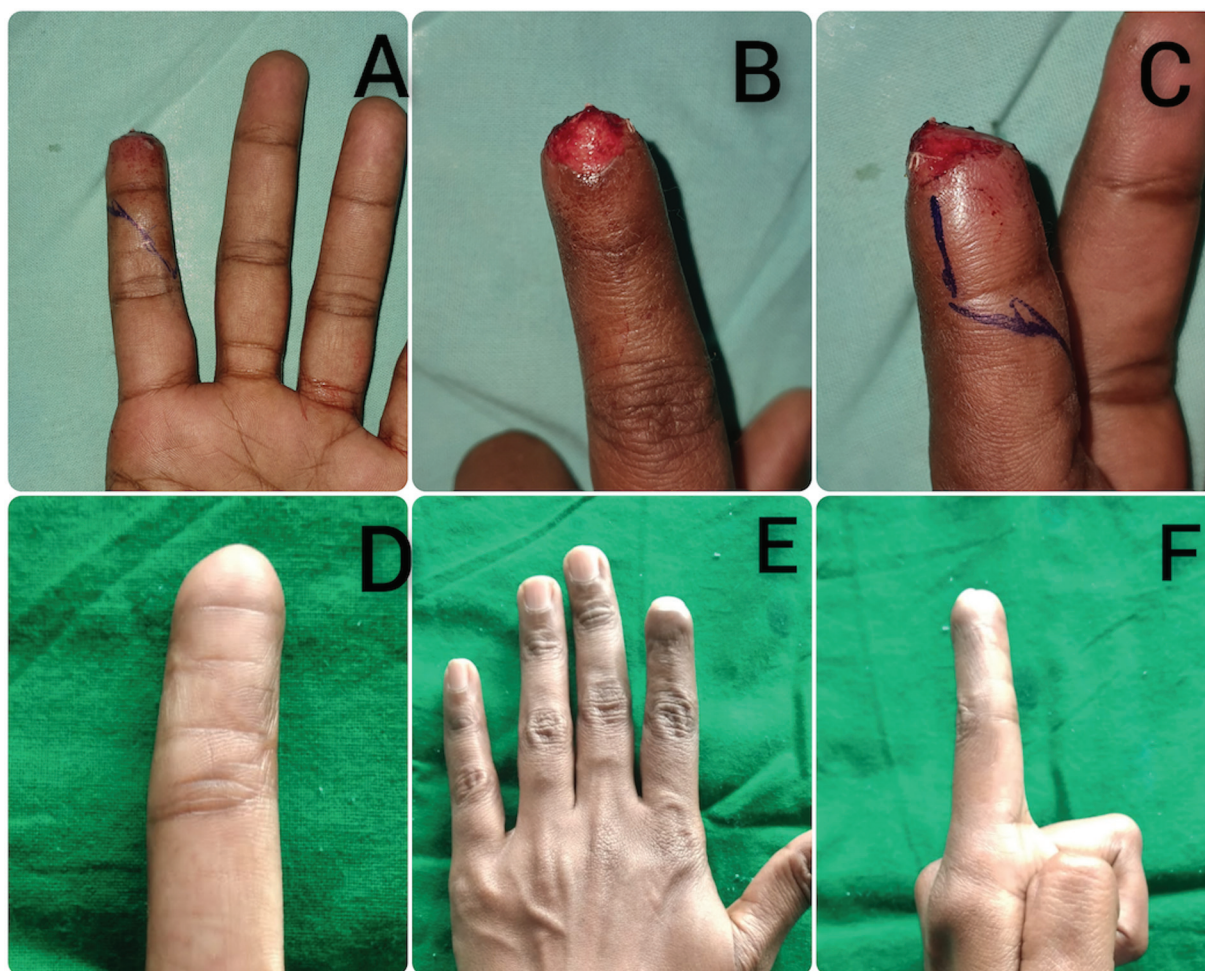


Fig. 2 Patient 1. (A–C) Intraoperative pictures. (D–F) After 2.5 years.

and Grayson's ligament is incised carefully. The neurovascular bundle is incorporated in the flap by careful division of the periosteal branches using low bipolar diathermy. On the other side, in the straight part of the incision, dissection is made volar to Grayson's ligament and the minute vascular branches are taken away by cautery. The oblique part of the incision is completed and the flap is islanded by dissecting it off the periosteum distally and volar to flexor sheath proximally (► Fig. 1). Division of the branches of the digital artery proximal to the PIPJ level by lifting the skin with blunt hooks increases flap advancement by few more millimeters. Flap viability is assessed by releasing the tourniquet and it is inset using 5–0 polypropylene or polyamide, proximal to distal, thereby achieving a V-Y advancement at the apex. Nonadherent absorbent dressing is applied. The patient is given oral antibiotics for a week and the hand is kept elevated. Dressings are changed at 48 hours and after a week, and sutures are removed in 10 to 14 days. ROM exercises are soon started. Once healed well, scar therapy is initiated (► Fig. 1).

Results

All the flaps survived and settled well with no short- or long-term complications such as infection, scar complications, or

neuroma formation. Primarily closed donor sites showed satisfactory healing with no flexion contracture. Hook nail deformity was minimal with Lim grade 2 deformity in three fingers and grade 1 deformity in 1 finger (► Figs. 2–4). All the patients could return to work in 3 to 4 weeks' time. None reported pain or cold intolerance in assessment with the Numeric Pain Rating Scale and Cold Intolerance Severity Score. All the fingers had satisfactory sensory recovery (S3 +/S4). The ROM at the PIPJ and DIPJ was comparable to the contralateral normal finger in all patients except for limitation of the ROM at the DIPJ in the 69-year-old patient (30 vs. 60 degrees). All the patients had power grip, key pinch, and pulp pinch comparable to the uninjured hand. Outcome evaluation with MHQ revealed a score over 85% in all sections and the overall mean was 97.6% in the affected hands, revealing a highly successful outcome (► Table 2; ► Figs. 2–4).

Discussion

The Atasoy flap is preferred for dorsal oblique amputations, while the Kutler flap is preferred for transverse amputations of the fingertips. However, both have limitations in advancement, making them unsuitable for larger defects and for VO defects. Many studies have shown good patient satisfaction and sensory

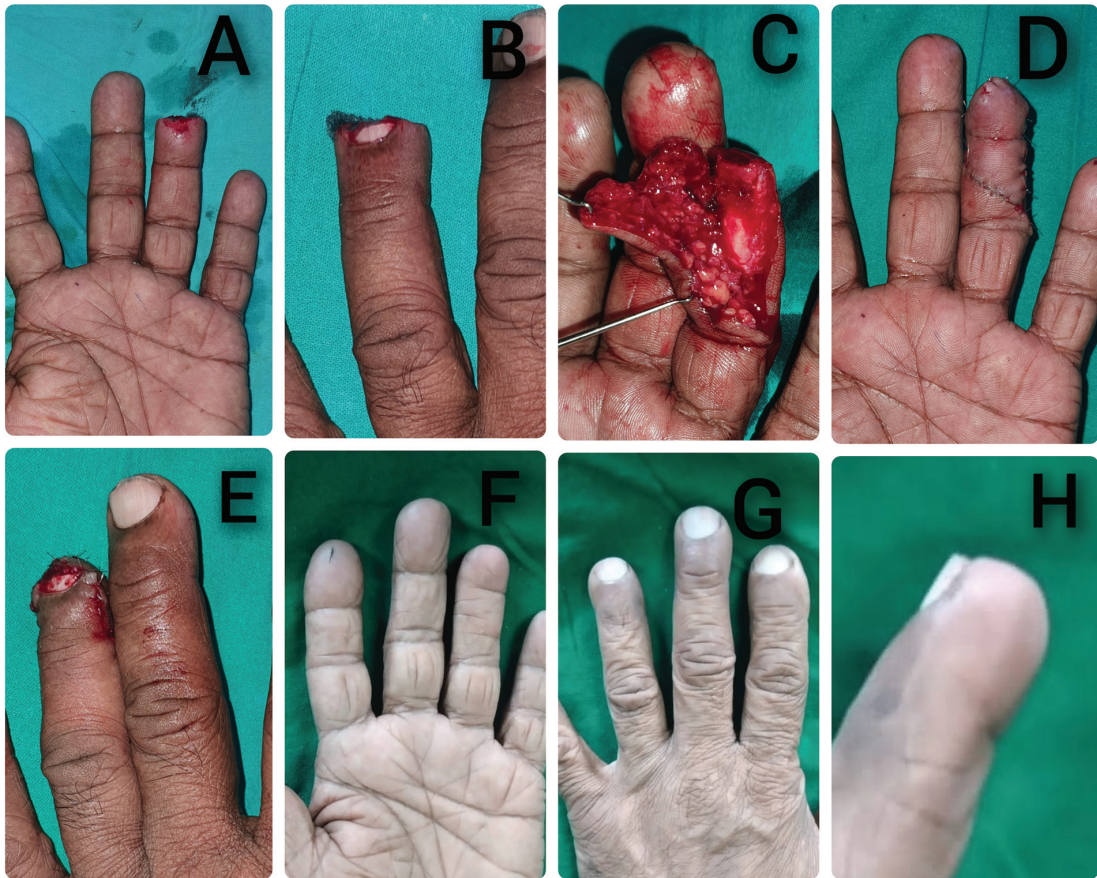


Fig. 3 Patient 2. (A,B) Preoperative view. (C) Flap elevation. (D,E) After inset. (F-H) After 2.5 years.



Fig. 4 Patient 3. (A) Preoperative view. (B) After flap elevation. (C) After flap inset. (D-G) After 2.5 years.

Table 2 Outcomes after 2.5 years

| | | Patient 1 | | Patient 2 | | Patient 3 (left index finger) | | Patient 3 (left middle finger) | | Patient 4 | |
|--------------------------------|--|-----------|-----|-----------|-----|-------------------------------|-----|--------------------------------|-----|-----------|-----|
| | | AF | CEF | AF | CEF | AF | CEF | AF | CEF | AF | CEF |
| Outcome | s2PD (mm) | 6 | 3 | 6 | 6 | 5 | 3 | 4 | 3 | 6 | 3 |
| | d2PD (mm) | 7 | 3 | 5 | 5 | 3 | 2 | 3 | 2 | 3 | 3 |
| | MMRC sensory grade | S3+ | S4 | S3+ | S3+ | S4 | S4 | S4 | S4 | S4 | S4 |
| | ROM: PIPJ | 100 | 100 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 |
| | ROM: DIPJ | 45 | 55 | 30 | 60 | 60 | 65 | 65 | 65 | 55 | 60 |
| | Power grip (Jamar dynamometer) mean of three trials | 45 | 50 | 45 | 45 | 58 | 58 | 58 | 58 | 72 | 74 |
| | Key pinch (pinch gauge), lb | 8 | 11 | 12 | 12 | 10 | 10 | 10 | 10 | 14 | 15 |
| | Pulp pinch (pinch gauge), lb | 6 | 8 | 10 | 10 | 10 | 10 | 10 | 10 | 17 | 17 |
| MHQ outcomes | Function | 85 | 100 | 90 | 100 | 100 | 100 | 100 | 100 | 95 | 100 |
| | ADL | 95 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 97.5 | 100 |
| | Work | 100 | 100 | 100 | 100 | 90 | 100 | 90 | 100 | 100 | 100 |
| | Pain | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | Aesthetic | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 88 | 100 |
| | Satisfaction | 100 | 100 | 100 | 100 | 94 | 100 | 94 | 100 | 95.5 | 100 |
| | Total | 100 | 100 | 98 | 100 | 97 | 100 | 97 | 100 | 96 | 100 |
| Complications | Flap necrosis/infection/scar complications/neuroma formation | None | | None | | None | | None | | None | |
| | Hook nail deformity (Lim grade) | 1 | | 0 | | 2 | | 2 | | 2 | |
| | Pain (Numeric Rating Scale) | 0 | | 0 | | 0 | | 0 | | 0 | |
| | Cold intolerance (CISS) | 0 | | 0 | | 0 | | 0 | | 0 | |
| Time to return to work (weeks) | | 3 | | 3 | | 4 | | 4 | | 3 | |

Abbreviations: ADL, activities of daily living; AF, affected finger; CEF, contralateral equivalent finger; CISS, cold intolerance severity of score; DIPJ, distal interphalangeal joint; d2PD, dynamic two-point discrimination; MHQ, Michigan Hand Questionnaire; PIPJ, proximal interphalangeal joint; ROM, range of motion; s2PD, static two-point discrimination.

recovery with these flaps and their modifications.⁴ However, hook nail deformity, reduction of ROM at the DIPJ, and cold intolerance are still reported as long-term problems.^{4,5}

Pedicled neurovascular flaps provide longer advancement, and they can be used in VO amputations. Biddulph's modifications of the Kutler and Venkataswami flaps are examples for these flaps and they also reported better outcomes in the literature.⁶⁻⁹ However, we observe that these techniques leave a scar across the volar side of the distal phalanx or across the DIPJ crease, which could lead to low patient satisfaction. Mourougayan and Venkat¹⁰ described a modification of the Atasoy flap to address this issue, but it requires dissection of both neurovascular pedicles. We have found that technically this limits tension-free advancement due to tethering by two pedicles. Therefore, the senior author devised the new technique, mainly modifying the oblique triangular flap of Venkataswami and Subramaniam,

placing the oblique incision over the middle phalanx (like a Bruner incision), hence not crossing the DIPJ crease. Further, the distal-most part of the incision is along the mid-lateral line, not leaving a scar on the finger pulp. Inspired by many of these described techniques, our novel/modified technique addresses the various concerns raised about these techniques.

Our technique enables up to 15- to 17-mm advancement of the flap. Therefore, minimal or no bone excision is required to achieve a tension-free inset. For the same reason and by avoiding the pulling effect on the nail bed, the incidence of hook nail deformity is minimal or occur only in low grades. None of the patients reporting pain or cold intolerance with this technique is quite an important finding, as these complications are reported at higher frequencies with other techniques.

Near-normal sensory recovery, good grip strengths, preservation of ROM of the joints, early return to work, and high

aesthetic and overall patient satisfaction as shown in the results suggest that this new technique would be taken by the plastic surgeons for fingertip reconstruction in the future. This technique could be combined with free nail bed grating in selected cases to improve visibility of the nail.

Conclusion

Our novel technique of fingertip reconstruction ("Colombo flap") appears to be a reliable and successful method with satisfactory short- and long-term outcomes.

Ethical Approval

This study conforms to the Declaration of Helsinki.

Conflict of Interest

None declared.

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