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Original Research Article

Digital artery perforator flap for reconstruction of soft tissue defects of the finger distal to the distal interphalangeal joint - the functional outcomes

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ABSTRACT

Background: Fingertip injuries involving the distal phalanx often lead to functional and aesthetic impairment, requiring reliable reconstruction methods that preserve length, sensation, and mobility while minimizing donor site morbidity. The purpose of the study is to evaluate the functional outcomes of digital artery perforator flap reconstruction for soft tissue defects distal to the distal interphalangeal joint. The aim of the study was to evaluate the functional outcomes of digital artery perforator flap reconstruction for soft tissue defects distal to the distal interphalangeal joint
Methods: This prospective observational study at the Department of Plastic Surgery, Dhaka Medical College Hospital, Dhaka, Bangladesh (July 2018 to June 2019) included 20 patients with distal phalanx soft tissue defects. Flaps were raised on distal digital artery perforators, rotated 90°–180°, and donor sites closed primarily or grafted. Postoperative care included dressings, splinting, and early motion. Outcomes were assessed by goniometer; data were analyzed with SPSS v23.0.
Results: Among 20 patients, most were males (18, 90%) aged 16–25 years (9, 45%). Machinery injury was most common (9, 45%). Flap length 2.0–4.0 cm, width 1.0–2.0 cm. Wounds were mainly left-sided (11, 55%). Complications included venous congestion (11, 55%) and marginal necrosis (4, 20%), with donor sites mostly uneventful (18, 90%). Full DIP movement achieved in 11 (55%); flap outcome excellent in 14 (70%).
Conclusions: DAP flap provides reliable fingertip reconstruction with excellent functional outcomes without compromising the digital artery.

Keywords: Digital artery, Perforator flap, Fingertip reconstruction

INTRODUCTION

The finger is the most sensory organ for tactile stimulation.[1] The distal segment of the fingers is a highly specialized part of the hand that performs pinching and grasping functions, allows for certain sensations, and provides an important aesthetic feature. Injuries to the distal segment may involve various types of fingertip trauma, including amputation and digital pulp loss with exposed bone and tendons. The objectives of distal phalangeal or fingertip reconstruction include the preservation of functional length and protective sensation, prevention of symptomatic neuromas, acceptable donor site morbidity, adequate distal interphalangeal joint motion, absence of cold intolerance, minimization of

aesthetic deformity, and rapid return to occupational activities.

Management of these injuries remains controversial. Treatment options vary from the simplest conservative measures to sophisticated microsurgical reconstruction techniques using various types of flaps. Although multiple methods exist to address these problems, surgeons continue to explore simple and reliable flaps for reconstruction of the terminal digital segments. Skin grafts often provide poor functional results. Local homodigital advancement flaps, including V-Y closure from the ipsilateral or bilateral side of the finger, have been popular. While these methods are convenient, major disadvantages include limited flap length and size. Cross-finger flaps and thenar flaps require second-stage operations.[2-4]

In 1973, Weeks and Wray first applied the distally based arterial island flap for fingertip reconstruction.[5] Later, Han et al.[6] studied the reverse digital artery flap, although it did not restore sensation. Foucher et al.[7] described the homodigital neurovascular island flap for digital pulp loss. Littler's heterodigital neurovascular island flap is a reliable option due to its constant pedicle, single-stage procedure, early mobilization of the hand, and good functional and cosmetic results.[8] However, it has disadvantages, including potential damage to an uninjured finger and the need for cortical adaptation. The free hemi-pulp flap, venous flap, median plantar perforator flap, and trimmed toe-tip method require specialized microsurgical techniques.[9,10]

Perforator flaps have evolved, providing numerous new flaps with novel pedicles throughout the body, offering important advantages.[11] Later, Mardini et al and Wei et al introduced the concept of free-style perforator flaps.[12-13] In 2006, Koshima described the digital artery perforator (DAP) flap, based on the cutaneous perforators originating from the proper digital arteries.[14] The DAP flap allows simple, one-stage homodigital fingertip reconstruction, providing wound coverage from the DIP joint to the fingertip while preserving the digital nerve and artery. It enables early finger mobilization, less invasive surgery, a painless fingertip, and minimal disability time. Limitations include the need for skin grafting at the donor site, detection of perforators under loupe magnification, limited flap size, potential venous congestion, pincushion effect, and arterial flow instability.

The main advantages of the DAP flap are sparing the neurovascular pedicle, replacing like-with-like tissue, being less invasive, allowing a single-stage procedure, and enabling early return to work. These features recommend DAP flaps as a valuable and modern alternative in fingertip reconstruction. The purpose of the study is to evaluate the functional outcomes of digital artery perforator flap reconstruction for soft tissue defects distal to the distal interphalangeal joint.

Objective

To evaluate the functional outcomes of digital artery perforator flap reconstruction for soft tissue defects distal to the distal interphalangeal joint.

METHODS

This prospective observational study was conducted at the Department of Plastic Surgery, Dhaka Medical College Hospital, Dhaka, Bangladesh, from July 2018 to June 2019. A total of 20 patients with soft tissue defects of the distal phalanx of the fingers were included based on predefined inclusion and exclusion criteria.

Inclusion criteria

Soft tissue defects distal to the distal interphalangeal (DIP) joint. Maximum wound dimension <3 cm.

Exclusion criteria

Previous trauma or surgery causing potential injury to the perforator at the DIP joint. Polytrauma or other life-threatening injuries (e.g., head injury) causing delayed resuscitation. Patients unwilling to participate. Presence of phalangeal fracture.

Data were collected using a structured form through direct observation and patient interviews, including demographic variables (age, sex, occupation) and clinical parameters such as wound dimensions, affected finger, flap measurements, complications, donor site morbidity, and functional outcomes.

RESULTS

The most distal digital artery perforator was used as the pedicle. The flap was designed on the lateral or medial aspect of the finger, elevated in a subfascial plane under digital block and tourniquet, and rotated 90°–180° to cover the defect without tension. Donor sites ≤1 cm were closed primarily, while larger defects were covered with full-thickness skin grafts. Postoperatively, light dressings and hand elevation were maintained, splints were removed after 5 days, and active motion was initiated. Follow-up visits were conducted on the 7th, 14th, and 21st postoperative days; the first 10 cases were followed up to 3 months.

Functional outcomes were assessed using a goniometer and categorized as excellent, satisfactory, or poor based on flap survival, donor site morbidity, and joint movement. Data were analyzed using SPSS version 23.0. Ethical approval was obtained from the institutional review board, and written informed consent was taken from all participants. Equipment used included a digital camera, measuring caliper, goniometric scale, hand-held Doppler, and surgical loupes.

The majority of patients were aged 16–25 years (9, 45.0%), followed by ≤15 years (4, 20.0%), 26–30 years (4, 20.0%), and ≥30 years (3, 15.0%). Male patients predominated (18, 90.0%) compared to females (2, 10.0%). Machinery injury was the most common cause (9, 45.0%), followed by trauma (7, 35.0%) and burns including flame, chemical, and others (4, 20.0%).

The flap length ranged from 2.0–4.0 cm, with 10 (50.0%) flaps measuring 2.0–3.0 cm and 10 (50.0%) measuring 3.1–4.0 cm (mean±SD: 3.15±0.58 cm). The flap width ranged from 1.0–2.0 cm, with 2 (10.0%) flaps measuring 1.0 cm, 5 (25.0%) measuring 1.5 cm, and 13 (65.0%) measuring 2.0 cm (mean±SD: 1.77±0.34 cm).

The majority of wounds were located on the left hand (11, 55.0%), while 9 (45.0%) were on the right hand.

Venous congestion was the most common complication (11, 55.0%), followed by marginal necrosis (4, 20.0%) and flap loss including partial, subtotal, or total (2, 10.0%). Infection occurred in 1 (5.0%) case, and 2 (10.0%) flaps healed uneventfully.

Most donor sites (18, 90.0%) healed uneventfully. Infection (mild, moderate, or severe) occurred in 1 (5.0%) case, and re-skin grafting was required in 1 (5.0%) case.

Full range of movement was achieved in 11 (55.0%) patients, 5–10° restriction in 6 (30.0%), 10–20° restriction in 1 (5.0%), and no movement was observed in 2 (10.0%) patients.

Most flaps were rated excellent (14, 70.0%), satisfactory in 4 (20.0%) cases, and poor in 2 (10.0%) cases, reflecting the functional and aesthetic results of the reconstruction.

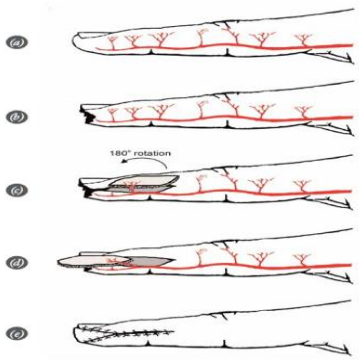

Figure 1: Schematic illustration of the DAP flap. (a) Uninjured finger showing the anatomy of the digital artery. (b) Fingertip amputation. (c) Elevation and 180° rotation of the DAP flap. (d) Advancement of the flap. (e) Closure of the defect and donor site.[15]

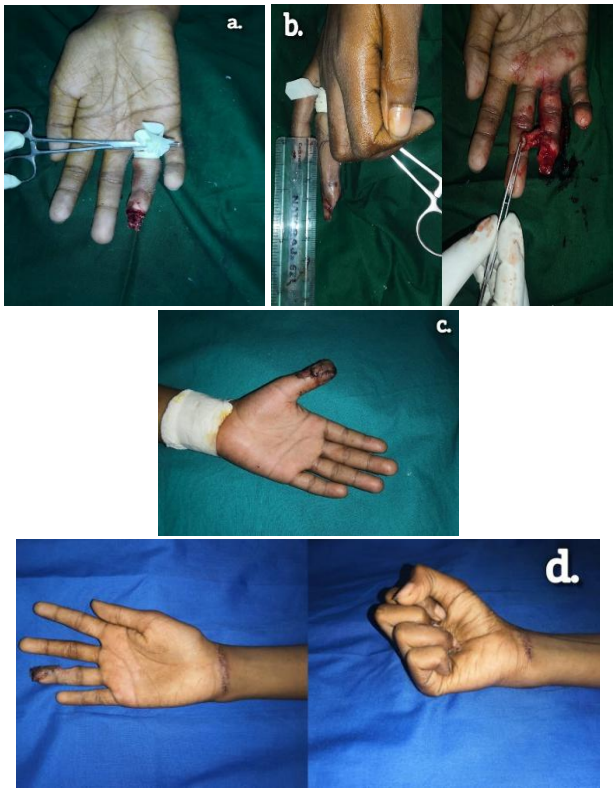

Figure 2: Clinical stages of DAP flap reconstruction for soft tissue defects distal to the DIP joint: (a) preoperative picture, (b) elevation of the flap, (c) immediate postoperative picture, and (d) 21st postoperative day.

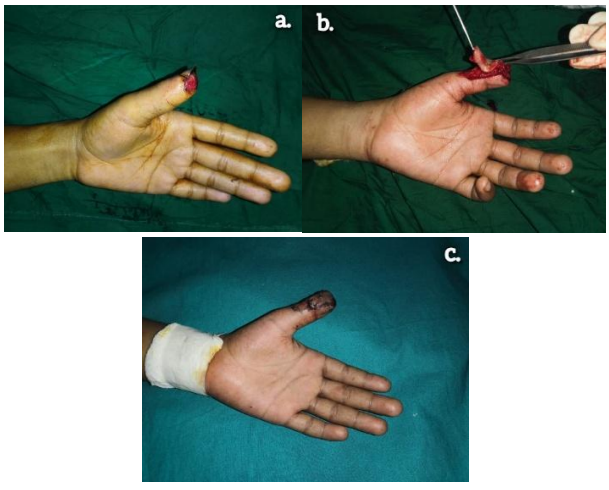

Figure 3: Clinical progression of DAP flap reconstruction: (a) preoperative picture, (b) elevation of the flap, and (c) 14th postoperative day.

Table 1: Demographic characteristics of the study population (n=20).

Characteristic		Frequency	Percentage
Age (years)	≤15	4	20.0

Continued.

Characteristic		Frequency	Percentage
	16–25	9	45.0
	26–30	4	20.0
	≥30	3	15.0
	Mean±SD	22.6±2.3	
	Range	3–32	
Sex	Male	18	90.0
	Female	2	10.0
Cause of injury	Trauma	7	35.0
	Burn (Flame, Chemical, Others)	4	20.0
	Machinery injury	9	45.0

Table 2: Flap dimensions of the study population (n=20).

Characteristic		Frequency	Percentage
Flap length (cm)	2.0–3.0	10	50
	3.1–4.0	10	50
	Mean±SD	3.15±0.58	
	Range	2.0–4.0	
Flap width (cm)	1	2	10
	1.5	5	25
	2	13	65
	Mean±SD	1.77±0.34	
	Range	1.0–2.0	

Table 3: Flap complications in the study population (n=20).

Flap complications	Frequency	%
Venous congestion	11	55.0
Infection	1	5.0
Marginal necrosis	4	20.0
Flap loss (partial, subtotal, total)	2	10.0
Uneventful	2	10.0

Table 4: Morbidity of flap donor site in the study population (n=20).

Morbidity of flap donor site	Frequency	%
Infection (mild, moderate, severe)	1	5.0
Re-skin graft required	1	5.0
Uneventful	18	90.0

Table 5: Range of DIP joint movement in the study population (n=20).

Range of DIP Joint Movement	Frequency	%
Full range of movement	11	55.0
5–10° restricted	6	30.0
10–20° restricted	1	5.0
No movement	2	10.0

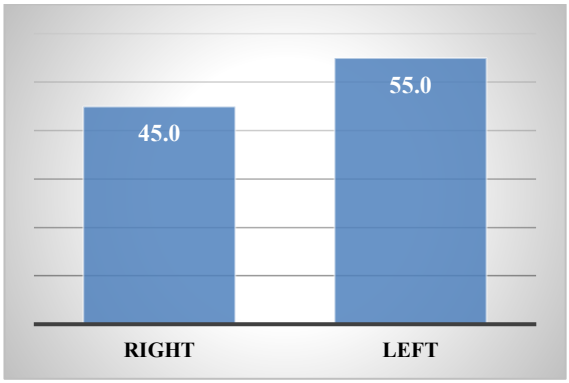

Figure 4: Location of the wound in the study population (n=20).

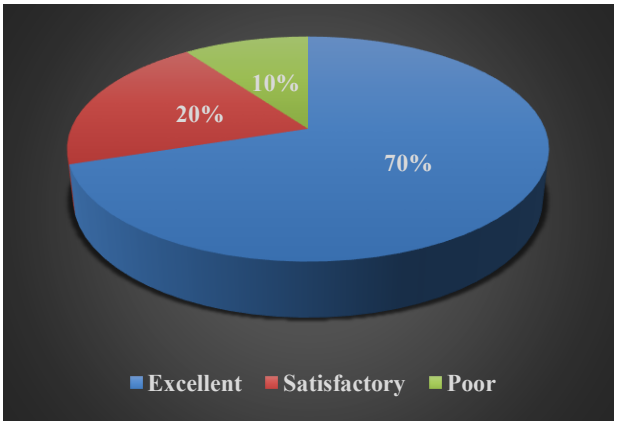

Figure 5: Outcome of flap in the study population (n=20).

DISCUSSION

This prospective observational study was carried out in the Department of Plastic Surgery, Dhaka Medical College Hospital, Dhaka, from July 2018 to June 2019, including all patients presenting with soft tissue defects of the distal phalanx of the fingers. The digital artery perforator (DAP) flap is suitable for repairing fingertip defects, providing good texture and fine sensation without sacrificing the digital artery or nerve. It can be used to cover the thumb, index, middle, ring, and little fingers. The study comprised 20 cases of fingertip injury.

The mean age of patients was 22.6±2.3 years (range 3–32), indicating that the most affected group was young and active, likely due to greater exposure to occupational hazards. Yıldırım et al. reported a mean age of 37 years (range 20–67), and Basat et al observed a mean age of 27.5 years (16–60), consistent with our findings.[8,15]

Among the cases, 18 (90.0%) were male and 2 (10.0%) were female, with a male-to-female ratio of 9:1. This may be attributed to males being more actively involved in work or domestic activities, exposing them to trauma. Similar male predominance has been reported by Yenidunya et al, Kostopoulos et al, and Basat et al.[15-17]

Consistent with previous studies by Yenidunya et al and Yıldırım et al, machinery injuries were the most common cause of fingertip defects (9, 45.0%), followed by trauma (7, 35.0%) and burns (4, 20.0%).[16,18]

The mean flap length was 3.15±0.58 cm (range 2.0–4.0 cm), and the mean width was 1.77±0.34 cm (range 1.0–2.0 cm), with 13 (65.0%) patients having flaps 2.0 cm wide. Basat et al reported flap sizes ranging from 2.5–8 cm^2 (average 4.25 cm^2), and Koshima et al reported flap sizes of 2 × 0.7 cm to 4 × 2 cm.[14,15]

DAP flaps were used on the left hand in 11 (55.0%) cases and on the right hand in 9 (45.0%). The index and ring fingers were the most commonly affected (14, 70.0%), whereas the little finger and thumb were least affected. The ring finger was often chosen as the donor site, consistent with findings from Yıldırım et al and Kostopoulos et al.[17,18]

Complications included venous congestion (11, 55.0%), marginal necrosis (4, 20.0%), and partial flap loss (2, 10.0%), while 2 (10.0%) flaps survived without complication. Venous congestion mostly resolved spontaneously. A small cuff of subcutaneous tissue was preserved to maintain venules around the perforator, and some cases were managed by removing a few stitches. In the last ten cases, subperiosteal dissection at the distal flap was performed to prevent congestion. Shen et al noted venous congestion as the major complication of flaps elevated from the dorsal arterial system.[18] Basat et al reported one case of partial flap necrosis among seven DAP reconstructions.[15] Ozcanli et al observed temporary venous congestion in 12 of 15 patients, all resolving without intervention.[19] Lee et al treated partial necrosis (<10%) successfully with secondary closure; one case with 30% necrosis required additional skin grafting.[20] Complete flap necrosis occurred in two cases with infected recipient beds, with survival rates significantly influenced by recipient bed vascularity (p=0.015). No other specific complications were observed.

All donor sites were covered with full-thickness skin grafts. In 18 (90.0%) cases, healing was uneventful. One case (5.0%) required re-skin grafting, and one case (5.0%) developed infection, which was managed based on culture and sensitivity without surgical intervention. Zhu et al and Basat et al similarly reported successful graft survival at donor sites.[15,21]

Functional assessment of the distal interphalangeal joint showed full range of motion in 11 (55.0%) patients, 5–10° restriction in 6 (30.0%), 10–20° restriction in 1 (5.0%), and no movement in 2 (10.0%). Shen et al reported 30–60° of DIP motion at final follow-up.[18]

Overall flap outcome was excellent in 14 (70.0%) cases, satisfactory in 4 (20.0%), and poor in 2 (10.0%), consistent with the studies of Shen et al and Kostopoulos et al.[17,18]

Limitations

The study had a few limitations such as microvascular expertise was required, and due to time constraints, a small sample size was included, the follow-up period was limited, this was a single-center study.

CONCLUSION

The use of the DAP flap for fingertip reconstruction provides excellent functional outcomes without sacrificing the digital artery. This reliable, free-style perforator flap can be used for the reconstruction of all types of distal interphalangeal finger defects.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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