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Nerve Sparing Antegrade Homodigital Island Flap

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ABSTRACT

Background: Fingertip reconstruction requires stable, sensate, and painless padding. Digital defects proximal to the tip around distal interphalangeal joint or dorsal raw areas preclude these objectives except for preserving the sensation to the fingertip. Antegrade Homodigital island flap accomplishes these objectives for fingertip defect coverage.

Objective: In this case series, we modify this flap to cover different defects proximal to the fingertip while sparing the digital nerve to preserve fingertip sensation.

Material and Methods: Between March 2019 till June 2022 Fourteen patients (fifteen finger) with deformed distal phalanges, contracted distal interphalangeal joint, or defects sparing the finger tips were treated with a nerve sparing antegrade homodigital island flap. The mean age was 27±17 years old. The etiologies were post-traumatic, post-burn or firearm injury. Follow-up period ranged from 4-18 months.

Results: All flaps survived with delayed wound healing in two flaps and proximal interphalangeal joint 15 degrees' extension lag in one patient. Fingertip sensation was preserved in all patients with mean 2 point-discrimination (2PD) test 3±1mm. We evaluated patient satisfaction regarding cosmetic and functional outcomes.

Conclusion: Nerve sparing antegrade homodigital island flap is considered a reasonable choice for covering finger defects proximal to the fingertips. It provides durable, robust, and aesthetically accepted coverage.

Key Words: *Antegrade homodigital flaps – Neurovascular Island flaps – Contracted DIP joint and finger defects.*

Ethical Committee: Institutional Review Board (IRB) ethical approval and patient consents were obtained in Ain Shams University Faculty of Medicine.

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INTRODUCTION

Hand trauma is considered one of the most common pattern of injuries presented in the emergency department worldwide. They account for up to 30% of all received visits **[1]** and perhaps more in developing countries, where no protective equipment or safety are maintained among manual workers. The commonest type of hand trauma is fingertip injuries, with its different variant presentations. Soft tissue reconstruction with durable, glabrous, and sensate skin is required to achieve proper coverage. And avoid unwanted complications which may debilitate the function of the hand **[2]**. Antegrade homodigital island flap was described by Joshi in 1974. It is considered one of the options to resurface the fingertip defects **[3]**. In some situations, the defect is away from the fingertip, this necessitates preserving the sensation to the tip. Peacock 1960 described the preservation of the digital nerve during elevation of heterodigital island flap **[4]**, and Peacock modification on the homodigital island flap was adapted by Rose on six patients in 1983, he named it arterialized island flap **[5]**. In this study we presented a nerve sparing antegrade homodigital island flap for coverage of digital defects after release of deformed DIP joint or other defects away from the fingertip.

Aim of work:

Is to modify the antegrade homodigital island flap to cover defects proximal to the fingertip with sparing of the digital nerve to preserve fingertip sensation.

Anatomical background:

The arterial supply of the hand digits is predominantly palmar, with little contribution from the dorsal arterial system. Common digital arteries give rise to digital arteries at a level just distal to metacarpophalangeal joints. The artery to nerve relation changes along its course, where the artery is volar in the beginning then becomes dorsal to the nerve before the common digital artery divides into two digital arteries. The common digital nerve usually divides into digital nerves proximal to the arterial division **[6]**. The neuroarterial bundle in the digit is coursed in between Cleland and Grayson ligaments surrounded by fatty tissue, this fat con-

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tains multiple venous channels. Proper digital arteries end just distal to the level of distal interphalangeal joint (DIP joint) by dividing into three branches [7]. Through their course multiple branches from the digital arteries are identified, the most constant and important are the dorsal branches between proximal phalanx and middle phalanx, branches on the volar aspect proximal phalangeal neck and the proximal, middle and distal transverse arcades. Both digital arteries are connected via their branches, these connections where the arterial flow is reversed in case of reversed homodigital island flap. As regard the digital nerve, it follows the same course as the artery in a volar position in the digit, with three terminal branches. Its' branches follow the arterial one [8].

PATIENTS AND METHODS

Fourteen patients (15 fingers) presented in the outpatient or emergency departments with deformed distal phalanges, contracted distal interphalangeal joint, or defects sparing the fingertips from March 2019 to June 2022. Regarding patients' demography there were 12 males and 2 females, with age ranged from 8 to 57 years old. The etiology ranges from traumatic defects, post burn or traumatic deformed DIP joint and one case with firearm injury. Preoperative X-ray of the affected digit (PA, Oblique, and lateral views) in addition to the routine laboratory investigation were requested. All the patients underwent coverage of the present defects by nerve sparing homodigital island flap. The follow-up period ranged from 4 month to 18 month.

All the procedures were done under local anesthesia, supraclavicular block, local intravenous block or general anesthesia. Magnify loupe 3-3.5 X was used and under pneumatic tourniquet in most of the cases (digital tourniquet in only one case) proper wound preparation or release and correction of the deformity were done with carful protection of the neuroarterial bundle. The position of the DIP joint was maintained by K wire whenever needed. One female patient needed repair of the flexor digitorum profundus tendon and another male patient underwent simultaneous osteotomy and distraction to lengthen the digit. Flap marking was done according to the defect dimensions form the ipsilateral side with either volar or dorsal obliquity according to the defect position. In case of more dorsal defects, the choice of the flap was from the non-dominant sensory side of the finger. A mid lateral zig zag incision was done to identify the bundle and it was extended proximally whenever required. Meticulous separation of the nerve from the artery, after release of Grayson ligaments preserving an adequate fatty tissue around the artery to maintain flap venous outflow [9]. Subsequently, all the digital nerve branches were preserved while, the arterial branches are carefully dissected and coagulated using fine tip bipolar. Digital nerve is spared from the flap preserving the sensation to the fingertip. Flap elevation is followed based only on the artery with release of Cleland ligament dorsally its mobilization is achieved. In one male patient, who had presented with dorsal defects in two digits, the flap was oriented slightly dorsal and inclusion of the dorsal terminal branch of the digital nerve was done, which necessitate proximal intraneural dissection of this branch from the digital nerve under microscopic magnification. Flap inset was done and maintained by 5/0 or 6/0 sutures, followed by non-tight skin closure. Small raw area could be left proximal to the flap for secondary intention healing, provided the artery is properly covered under the skin. After Tourniquet release all the flaps showed good vascularity. PIP joint may be maintained in 15-20 degrees' flexion for skin closure and avoid compression or traction of the pedicle. Light dressing is applied, with limb elevation and oral medications the patients were discharged and followed up in outpatient department. Sutures were removed after 12-14 days postoperatively. During patients' follow up photographs were taken, patient satisfaction was measures using a scale of 5, wound was evaluated, and fingertip sensation was assessed by static two-point discrimination tests (2 PD test).

RESULTS

In this study fourteen patients with fifteen digits underwent reconstruction of digital defect (sensory non demanding defects). There were 12 males and 2 females. The age group ranges from 8-57 years old with the mean age of (27±17). Six patients with post burn deformed DIP joint (electric and flame burn), 4 patients with post traumatic deformed DIP joint, 3 patients with posttraumatic defects, and one patient with deviated distal phalanx after firearm injury. Eight patients were already presented with stiff DIP joint, however only one patient underwent joint fusion, the others remain with tolerated decreased range of motion. All the flaps survived, with proper wound healing except in two cases where delayed wound healing was observed, one of them ended by hypertrophic scar. Nine patients required postoperative physiotherapy with only one patient remains with Proximal interphalangeal joint (PIP joint) 15 degrees' extension lag. The static 2 PD test ranged from 2-4mm in all patients except one patient who reported 6mm in addition to prolonged paresthesia for 6 weeks.

Follow-up ranged from 4-18 months (average). Data were analyzed using the Statistical Package for Social Sciences (SPSS version 27). Middle finger was the most commonly affected finger. The most commonly associated condition was the stiffness of the DIP joint. One patient sought lengthening of the finger with correction of the deformity. When correlating the complication to the underlying cause of injury there was no significant difference between the causes, expect that the PB deformities showed better prognosis and less complication rate. Patient satisfaction was 4±1 on a 5 points rating scale (5=Very satisfied, 4=Fairly satisfied, 3=Uncertain, 2=Not very satisfied and 1 not satisfied at all).

As regard the age, 2 PD test and patient satisfaction there were no statistically significant difference in relation to the etiology of the defect /or the deformity whether post traumatic, post burn or after firearm injury.

Table (1): Patients demography and clinical data.

No.	Age	Sex	Etiology	Affected finger	2PD test	Patient satisfaction (1-5)	Associated Problem	Complication	Follow-up
1	18	M	Traumatic defect	Middle	2mm	5	–	–	7
2	21	M	Post burn contracted DIP joint	Ring	3mm	5	Stiff DIP joint	–	12
3	30	M	Post traumatic deformed DIP joint	Little	6mm	3	Stiff DIP joint	Prolonged paresthesia and 2 PD 6 mm	15
4	17	M	Post traumatic deviated DIP joint	Right Ring	4mm	4	Stiff DIP joint + Short Digit	–	5
5	8	F	Post burn contracted DIP joint	Middle	3mm	4	Stiff DIP joint + Short digit	–	10
6	28	M	Post firearm injury and deviated DIP joint	Index	3mm	3	–	Arthrodesis DIP joint	4
7	57	M	Post traumatic defect	Left Middle and Ring	3mm	5	Stiff DIP joint	–	4
8	45	M	Post traumatic deformed DIP joint	Index	3mm	3	Cut FDP tendon	PIP joint extension lag and delayed wound healing	6
9	11	F	Post traumatic defect	Middle	2mm	3	Stiff DIP joint	Delayed wound healing followed by hypertrophic scar	11
10	8	M	Post burn contracted DIP joint	Middle	3mm	4	–	–	18
11	15	M	Post burn contracted DIP joint	Little	3mm	4	–	–	8
12	43	M	Post traumatic defect	Ring	3mm	5	Stiff DIP joint	–	6
13	31	M	Post burn deformed DIP joint	Middle	3mm	4	Stiff DIP Joint	–	9
14	21	M	Post burn contracted DIP joint	Index	4mm	4		–	6

Case presentations:

Case (1) (Fig. 1):

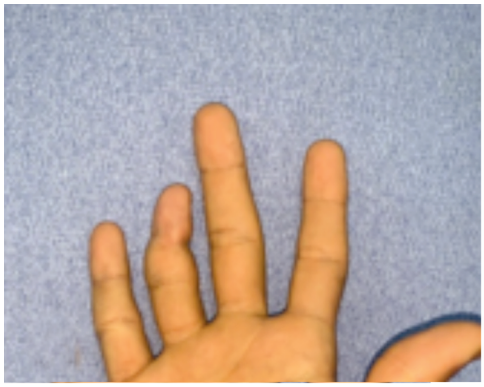
17 years old male patient presented with radial deviation of distal phalanx of the right ring finger of 2 years duration after traumatic injury by an electric saw, his initial management in a primary care hospital was fixation of the joint and repair of the soft tissue. He was asking for correction of the deviation in addition to lengthening of the digit. Release of soft tissue on the radial side and the resultant defect covered by antegrade homodigital island flap with nerve preservation. Osteotomy of the middle phalanx with application of finger distractor was followed. After achievement of the desired lengthening, distractor left in place for bony consolidation, and removed under local anesthesia in outpatient department.

Case (2) (Fig. 2):

11 years old girl presented with traumatic injury to her right middle and index finger by broken glass. Index finger showed area of just skin loss, while the middle showed cut Flexor digitorum profundus tendon zone I in addition to lacerated overlying skin with partial loss. Decision was to use the avulsed skin in the middle finger as a full thickness graft to the index finger and after repair of the FDP tendon an antegrade homodigital island flap was dissected to provide stable and reliable coverage for the repaired tendon.

Case (3) (Fig. 3):

57 years old male with post traumatic dorsally oriented defects after fingertips avulsion in both middle and ring fingers with complete loss of the nail and exposed underlying bone. Homodigital island flap was planned for coverage, isolation of one of the digital nerve terminal branch was done and incorporated in the flap. In order to mobilize the flap with this digital nerve branch, retrograde inter-fascicular dissection was required. The main digital nerve and its other branches was persevered.



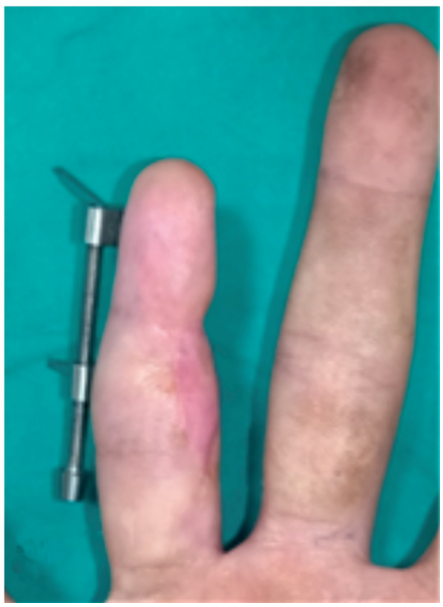
(A)

(B)

(C)

(D)

(E)



(F)

Fig. (1): (A,B): Radial deviation with shortening of the distal phalanx of the right ring finger volar aspect and dorsal aspect respectively, (C): Marked flap and digit length, (D): X-ray PA view with fused DIP joint and short middle phalanx, (E): During distraction, (F): After 5 weeks post operatively.

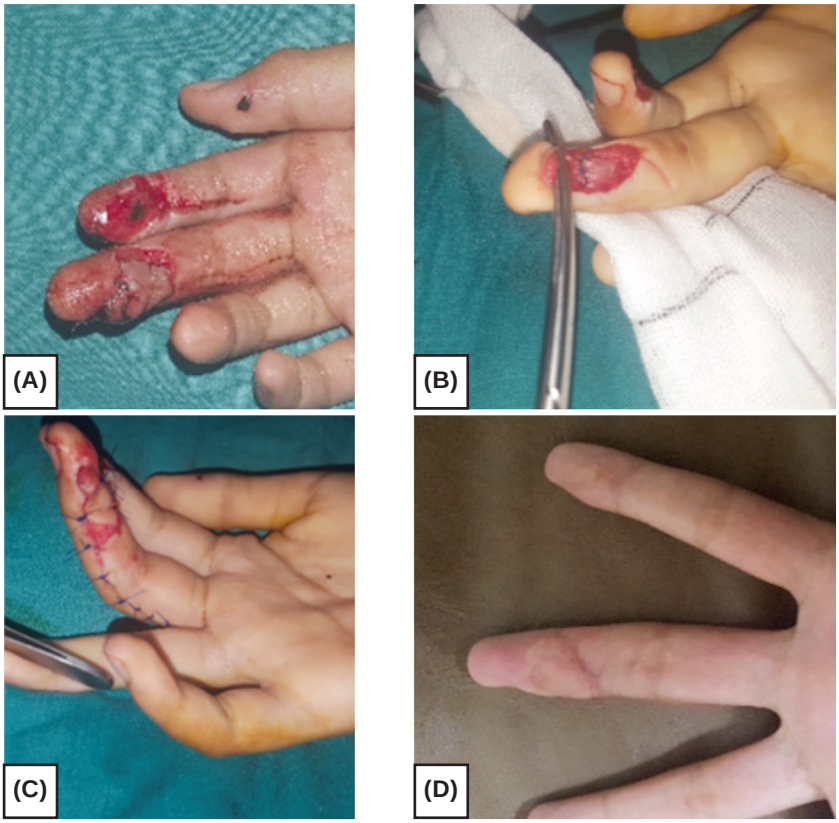


Fig. (2): Right middle and index fingers defects. (A): Lacerated devitalized volar skin over the DIP joint of the middle fingers with cut FDP tendon and skin loss of the index finger pulp, (B): Repair of FDP tendon and oblique triangular design of homodigital island flap, (C): After flap in setting and closure of the donor, (D): After 11 months, still hypertrophic scar in noticed.

Fig. (3): (A): Post traumatic machine injury of both left middle and ring fingers with dorsally oriented tissue and nail loss with exposed distal phalanx. (B): Marking of the flap from the non-dominant sensory side. (C): Dissection of the artery from the nerve with inclusion of most dorsal branch of the nerve trifurcation in the flap and preservation of the two other branches for fingertip sensation. (D): Immediate post-operative after flap suturing. (E,F): After 4 months post operatively.

Case (4) (Fig. 4):

28 years old military officer male patient with history of firearm injury to his left index finger of 6 months ago. He underwent wound debridement and bone fixation by k wires in another hospital. Followed by wound care for 2.5 months until complete healing. He presented to us with ulnar deviation of his index finger distal phalanx. Release of soft tissue and correction of the deformity with arthrodesis of the DIP joint remaining articular surface.

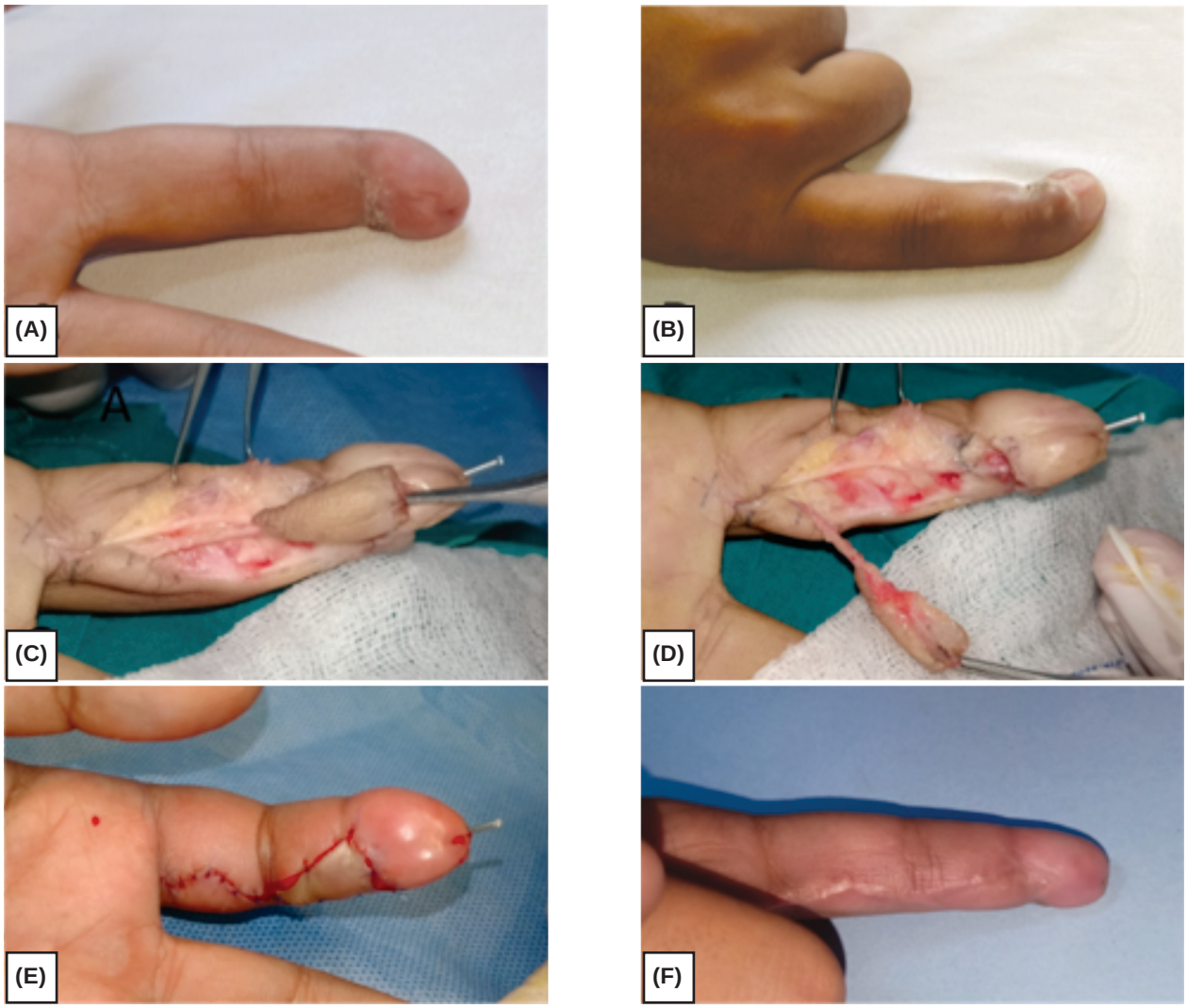


Fig. (4): (A,B): Ulnar deviation of distal phalanx of the left Index finger. (C,D): Flap dissection with carful separation of the artery and leaving the nerve in the bed. (E): After fusion of the DIP joint and flap suturing. (F): Post-operative follow-up after 4 months.

DISCUSSION

Fingertip and distal interphalangeal joint (DIP) are commonly exposed to injury. Etiologies including trauma, burn or firearm injuries. Many options had been described to reconstruct fingertip soft tissue loss. Ranging from healing by secondary intention to free tissue transfer (as long as the fingertip requirements are achieved) could be used **[10]**. Heterodigital Island flap was described by Moberg and Littler, with incorporation of the neuroarterial bundle **[11,12]**. The disadvantage is the use of a non-injured digit in addition to loss of sensation in the donor site. The preservation of sensation in heterodigital flap was advocated by Peacock in 19604. Joshi and Pho are the pioneers to describe the homodigital island flap **[3,13]**. In 1983 Rose adopted Peacock **[4]** modification on the homodigital flap in six cases, he named it arterialized island flap. He used the flap to reconstruct important structures in less critically sensate areas in the hand or digits **[5]**.

In certain situations, injury may spare the fingertip. This injury is challenging because sensation has to be preserved to the fingertips during reconstruction of any proximal defects. Sequel of these injuries commonly lead to stiffness of the DIP joint, deviation of the distal phalanx or shortening of the affected digit. In addition to the previously mentioned causes, traumatic injury with tissue loss exposing vital structures away from the fingertip e.g., dorsal defects are approached with the same concept.

In this case series fourteen patient with fifteen digits were included, with different etiologies. These defects require reliable, durable and pliable coverage, as in most of these defects a vital structure is exposed. The application of a flap restores the tissue balance along the DIP joint and prevent recurrence of contracture or deviation. In addition to the previously mentioned prerequisites, preserving fingertip sensation is mandatory and it is critically important particularly for the dominant side (e.g., radial side of the index finger) **[14]**.

For this purpose, antegrade homodigital island flap with sparing of the digital nerve was used. In most of the cases we were obliged to use the flap from the same side, whatever it is the dominant sensory side or not. In few cases when both sides of the digit are available, we used the non-dominant sensory side. Although it is not the rule and depends on the size and geometry of the defects, a branch of the digital nerve trifurcation could be included in the flap without affection of the fingertip sensation. In such situation we recommend retrograde inter-fascicular dissection of the digital nerve under the microscope to facilitate sensate flap mobilization. In spite this study includes only three children, this flap is widely and easily used in pediatric age group.

Distant flaps can be used in hand and finger defects; however, it is two stages surgeries and requires prolonged period of immobilization. It is not recommended in children as well. Cross finger also requires second stage, using healthy neighbor digit and full thickness skin graft to resurface the donor. Digital artery perforator flap with its different modification is another option, although the injured digit is the donor, it still needs grafting of the dorsal surface **[15,16,17]**. Reversed homodigital is a non-sensate flap that could be used as well but antegrade design sounds more logic and omit the need for skin graft and it is liable to venous congestion **[18]**.

In this work zig zag incision for exposure of the neurovascular pedicle was adopted to minimize the risk of scar contracture and flexion deformity of the digit. This is constant with other studies as Adani et al., **[19]** and Katz **[20]** have advocated the use of Bruner or hemi Bruner incisions. In contrary to Lin-Wing Lok, et al., **[21]** who had used mid axial incision to expose the neurovascular bundle. The result of 2 PD test was 3mm as a mean with range (2-6mm), which is comparable to other studies as one reported by Varitimidis et al., **[22]** showed 4mm static 2 PD with range (3-6mm).

Early post-operative mobilization minimizes PIP joint flexion contracture. However previous studies of homodigital island flap were concerned with DIP joint range of motion (ROM), in this study due to the cause of injury this joint has already limited ROM. In concordance with Arsalan-Werner et al., **[23]** the need for splinting is not required, however we do not encourage the patient to do hyperextension of the PIP joint for 2-3 weeks postoperatively. We recommend doing physiotherapy after that to avoid extension lag of the PIP joint.

Disadvantage of this flap is sacrificing the main digital artery. This may lead to cold intolerance, nail and trophic changes **[24]**. Few complications we reported as delayed wound healing, extension lag of the PIP joint, prolonged paresthesia and hypertrophic scarring.

There are some limitations in this study. Small number of patients with wide range of age group. Although all the defects are covered easily with uneventful healing except in one case, flap advancement was not measured. It is reported in the literature that the longest advancement was 3 cm, however 1-1.5cm is sufficient in most of the defects **[25]**. Static 2 PD test was implemented on the fingertips only, it has to applied also on the flap, but this will need longer period of follow-up and it is expected to be more than 6mm.

Conclusion:

Nerve sparing antegrade homodigital island flap provide a stable, glabrous and reliable coverage for finger defects. Could be used in multiple digits and pediatrics. It is a one-stage procedure which does not need microvascular anastomosis. However, it requires more meticulous neuro-arterial bundle dissection to separate the nerve from the pedicle than the classic homodigital island flap.

Conflict of interest:

All named authors hereby declare that they have no conflicts of interest to disclose.

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