Evaluation of Propeller Digital Artery Perforator Flap for Fingertip Reconstruction

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ABSTRACT:

BACKGROUND:

Fingertip injuries are among the most common injuries to upper extremities. Maintenance the functional length of the finger and reconstruction with a durable sensate coverage are among the primary goals in fingertip reconstruction. The aim of this study is to evaluate the use of Propeller digital artery perforator flap in covering traumatic fingertip defects.

PATIENTS AND METHODS:

A prospective study done between April 2019 and January 2020 for 11 patients suffering from traumatic fingertip amputations who underwent reconstruction with propeller digital artery perforator flap. The flap designed on the radial or ulnar aspect of the digit based on perforator closest to the defect which is detected intra-operatively without use of Doppler device. We cover the defect with this flap and evaluate its functional and aesthetic outcomes.

RESULT:

Patient's age ranged between 15 - 45 years. All flaps survived completely except one flap developed partial skin necrosis. The donor site closed primarily in six of patients and covered with full thickness skin graft in five of them. Temporary venous congestion observed in five cases. Static two-point discrimination test ranged between 3-6 mm. The flaps had good sensation and contour.

CONCLUSION:

Propeller digital artery perforator flap is a reliable one stage procedure, replace tissue of similar characteristics to the original defect with preservation of digital neurovascular bundle that can be used for all types of fingertip injury.

KEYWORDS: Fingertip defect, Digital artery perforator, Propeller flap.

INTRODUCTION:

Fingertip injuries are defined as those injuries occurring distal to the insertion of the flexor and extensor tendons. The primary goal of reconstruction is a painless fingertip with durable and sensate coverage. Considerable hand dysfunction results when a painful fingertip causes the patient to exclude the digit from use[1]. Fingertip amputations are treated in relation to the level of injury and the amount of viable tissue remaining. Options include healing by secondary intention, skin grafting, skin flaps and replantation of the amputated tip[2]. Microsurgical replantation is the gold standard for reconstruction of fingertip amputation in terms of preserving function and achieving best cosmetic result but it's is not always possible[3].

Koshima et al was first who described Digital artery perforator flap (DAP) in 2006. It is a perforator-based island flap elevated on either the radial or ulnar side of the finger and is based on the small perforators coming out of the proper digital artery at constant locations either proximal or distal to the joints[4].

Many small branches arise from proper digital arteries on both medial and lateral aspects of digits, they perforate the thin fascia and subcutaneous tissue to end into multiple arterioles in the sub dermal layer, they arose just proximal and distal to digital joints and are called digital artery perforators (Fig.1) [4, 5].

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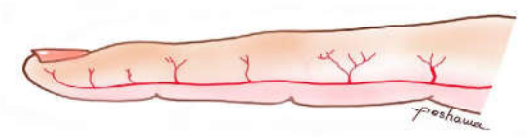

Figure 1: Perforator branches of proper digital artery.

A propeller flap is an island flap that reaches the recipient site through an axial rotation. A perforator propeller flap is most commonly used, it has a skin island made of two paddles, one larger and one smaller, separated by the perforating vessel and it represents the pivot point. The two portions of the skin island can rotate around the pedicle from 90 up to 180 degrees (Fig.2) [6].

Figure 2: Propeller flap for fingertip reconstruction
A: Design of the flap
B: Flap rotation and closure of the defect

PATIENTS AND METHODS:

Between April 2019 and January 2020, a total number of 11 patients who presented with fingertip injury with bone exposure underwent a randomized study for fingertip reconstruction with propeller DAP flap in West Erbil Emergency Hospital. In all cases, defects caused by traumatic amputation in Ishikawa subzone I, II or III, nine of them were due to industrial accidents and two of them were due to domestic accidents. The mechanism of injury included sharp, crush and avulsion injuries.

Excluding criteria were defect less than 1 cm with no bone exposure**,** associated soft tissue injury to the digit other than tip, associated phalangeal fracture, concomitant injury to other digits i.e. multiple digit involvement, thumb tip injury, children and adolescents below 14 years old and lastly previous trauma to the injured finger. The consent obtained from patients, all data were collected and analyzed using contingency Tables and Chi Square statistics.

The procedure performed under digital nerve block, digital tourniquet and 3.5x loupe magnification. The perforator detected intra-operatively, no Doppler device was used to detect it.

The flap designed on the mid-lateral side of the digit with its pivot point either 2-3 mm proximal or distal to distal interphalangeal joint with its long axis parallel to the finger. Avoiding the functional border of the digit wherever possible. The flap size planned to be few mm larger in length than tissue defect. The distal part of the flap (distal to perforator) represented the short blade of the propeller flap and it's nearby the defect. The proximal part of the flap (proximal to the perforator) extends to middle phalanx or up to proximal phalanx (Figure 3 A). We begin incising the palmar aspect of the flap, dissection is done toward the perforator in subfascial plane and after that the dorsal incision is done proceeding toward the perforator and plane of dissection is above the extensor tendon paratenon. The perforator closest to the defect is chosen as a pedicle. The incision around the flap is then completed and the flap is raised from proximal to distal above the neurovascular bundle (Figure 3 B).Then the tourniquet is opened and the vascularity of the flap is checked, we wait for about 15 minutes then the flap is rotated either clockwise or counterclockwise to select the direction of the rotation (Figure 3 C).

The flap rotated 90 to 180 degrees and the long blade of the propeller flap is inset on the defect site and the short blade is inset to cover the donor site (Figure 3 D). The donor site closed primarily for flap width up to 1 cm, for flaps more than 1 cm the donor site is closed by full thickness skin graft harvested either from amputated part or from hypothenar area. The graft is fixed to its bed without tie over dressing to avoid compression of the neurovascular bundle (Figure 3 E). Bulky antibiotic dressing applied to the wound with no splint.

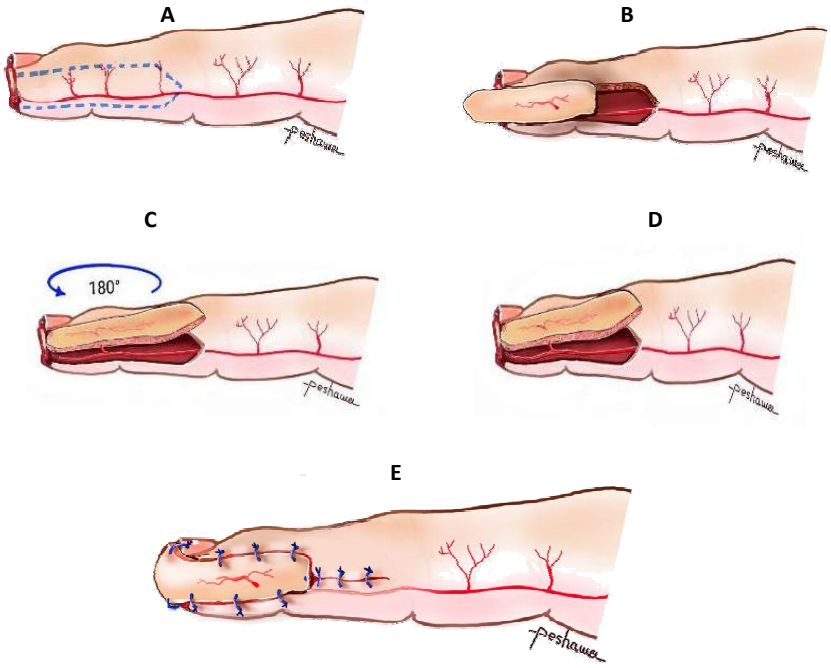

Figure 3: Propeller flap harvesting
A: Flap design **B: Flap elevation**
C: Flap rotation **D: Flap inset**
E: Closure of the wound

RESULTS:

Patient's data are shown in Table.1. Different defect type and level of injury were reconstructed with this flap with different mechanism of injury.

Table 1:Patient`s data.

Case	Age (yr.)	Gender	Defect type	Ishikawa subzone
1	40	Male	Lateral oblique	III
2	19	Male	Transverse	I
3	15	Male	Dorsal oblique	II
4	34	Male	Transverse	I
5	37	Male	Transverse	II
6	20	Male	Volar oblique	II
7	45	Male	Transverse	II
8	44	Female	Volar oblique	II
9	18	Male	Transverse	I
10	15	Female	Transverse	III
11	33	Male	Transverse	III

Among the involved sample; we found no significant differences in regard to their age but male's gender were more significantly involved than females. Table 2, 3 and Figure 4, 5.

Table 2: Chi-square for the Age variable sample.

Age	Observed N	Expected N	Df	Chi -Square	p-value
15-24	5	3.7	2	1.273	0.529
25-34	2	3.7			
35-45	4	3.7			
Total	11				

Table 3: Chi-square for the Gender variable sample.

Gender	Observed N	Expected N	Df	Chi -Square	p-value
Male	9	5.5	١	4.455	0.035
Female	2	5.5			
Total	11				

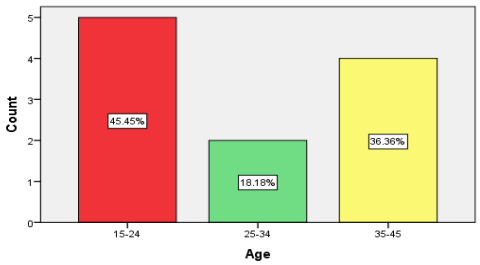

Figure 4:The Age variable sample

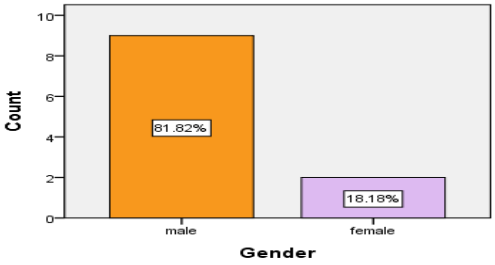

Figure 5:The Gender variable sample

There is no significant difference at 0.05: P-Value > 0.05 regarding the injured finger of our sample. Table 4 and figure 6.

There is a significant difference at 0.05: P-Value < 0.05 regarding the defect type of our sample .Table 5 and figure7.

Table 4: Chi-square for Defect type variable sample.

Defect type	Observed N	Expected N	Df	Chi -Square	p-value
Lateral oblique	1	3.7	3	9.000	0.029
Transverse	7	3.7			
Dorsal oblique	1	3.7			
Volar oblique	2				
Total	11				

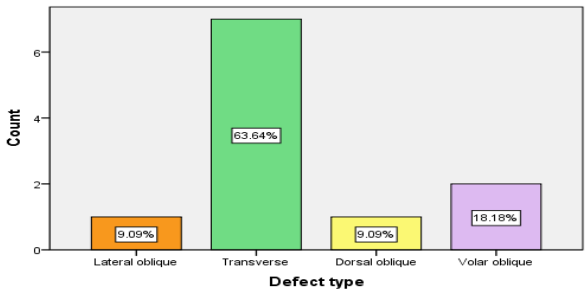

Figure 6: Defect type variable sample

There is no significant difference at 0.05: P-Value > 0.05 regarding Ishikawa subzone of our sample. Table 6 and figure 8.

Table 5: Chi-square for the Ishikawa subzone variable sample.

Ishikawa subzone	Observed N	Expected N	Df	Chi -Square	p-value
I	3	3.7	2	0.727	0.695
II	5	3.7			
III	3	3.7			
Total	11				

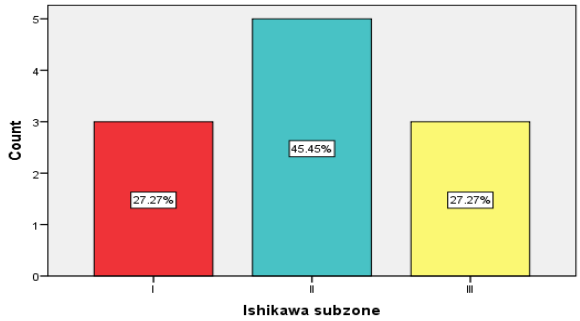

Figure 7: The Ishikawa subzone variable sample

There is no significant difference at 0.05: P-Value > 0.05 regarding cause of injury of our sample. Table 7 and figure 9.

In this study, propeller digital artery perforator flap had being used for reconstruction of 11 cases of fingertip injury. Most common digit seen in this study presented in Table 4. The orientation of injury as shown in Table 6. The average size of the flap was 3.5 cm in length and 1 cm in width. The donor site closed primarily in 6 cases and covered with full thickness skin graft in 5 cases, the graft harvested from the hypothenar area in 4 cases and in 1 case was taken from the amputated part. The minimum time of follow up was 2 months. The primary parameter of our assessment was flap survival. In all of our cases, no total flap loss observed, only partial flap necrosis seen in one patient which was treated conservatively and healed by secondary intention. Temporary venous congestion was seen in 5 flaps and resolved spontaneously with conservative treatment over one week. No wound dehiscence or infection was encountered. Graft donor site shows complete graft with no scar contracture. No postoperative neuropathic pain seen in our patients. None of the patients had cold intolerance nor hypersensitivity. No obvious nail deformity observed in those with remaining nail bed. The flap had good color and texture match. Functional assessment was evaluated depending on postoperative range of movement and recovered sensation. All of our patients had full range of movement without stiffness or extensor lag. Sensation of the flap was evaluated by assessing pain, temperature and touch sensation which has adequate recovery and by assessing static 2-point discrimination test which ranged between 3-6 mm. All of the patients showed complete satisfaction regarding the appearance of their reconstructed fingertip and regarding function and sensation.

Case no.1

Figure 8: A 45 year old male with transverse defect of Rt. middle finger Ishikawa zone II. A and B: Defect with flap design on the radial border of the digit. C: Pedicle of the flap. D: Flap inset. E & F: Postoperative results after 8 months with full range of movement.

Case no.2

Figure 9: A 44 year old female with volar oblique defect of Lt. Index finger due to domestic accident Ishikawa zone II. A and B: defect with flap design on the ulnar border. C and D: flap incision and inset to the defect. E and F: postoperative results after 3 months.

DISCUSSION:

There are various flaps available for reconstruction of fingertip injuries such as V-Y advancement flap; however, V-Y advancement flap had limited length for closure of large defect. Both cross-finger, thenar and hypothenar flaps can be used, but these flaps need two stage operation with risk of joint stiffness. Reverse flow neurovascular island flap also can be used for fingertip reconstruction and had good result in term of sensitivity and contour. However, it required transection of major digital artery and had high rate of venous congestion. Kim's volar flap that based on transverse branch of the digital artery can be a good option for fingertip reconstruction with preservation of digital artery and no need for 180 degrees of rotation. However, it needs to use skin graft on the volar aspect of the donor site with increased incidence of flexion contracture. Lastly, free flaps are another available option like free hemi-pulp and venous flap. However, these methods need long operation time, experienced microsurgery skill for surgeon and steep learning curve[5, 7]. Propeller flap in the last years had gained much of the popularity between plastic surgeons for treatment of soft tissue defect in different parts of the body. Early described propeller flap was designed on thick subcutaneous pedicle which limited its movement. It is now possible to design propeller flap to be based on single perforator. This refinement in the propeller flap make its rotation up to 180 degree safe and this type of propeller flap is the most commonly used [7, 8, 9]. We elevated the flap from the less injured sites of the finger whether lateral or medial site of the finger avoiding the functional border of the digit where possible. Some authors preferred to elevate the flap from ulnar side with fingertip injury of the index and from the radial side with little fingertip amputation[10]. When we rotated our flap to the recipient site, we release the tourniquet. After we release the tourniquet, we rotated the flap whether clockwise or counterclockwise with couple of minutes between each rotation to avoid spasm to the perforator; we usually chose the direction that lead to least torsional effect[11, 12]. In this series, we encounter 5 cases of temporary venous congestion (45%) that resolved within 1 week with hand elevation and daily dressing, the cause mainly thought to be due to improper postoperative hand elevation in these patients.

The venous drainage of the digital artery perforator flap is mainly through small venules within the subcutaneous tissue around the pedicle. Harvesting the flap with adequate cuff of subcutaneous tissue around the pedicle will enhance its venous flow and reduce the chance of venous congestion which can be seen in reverse flow flaps. In addition, when we sutured the flap to its recipient site, we try to use limited number of sutures without tension which reduced the chance of venous congestion[9, 13].

CONCLUSION:

Propeller digital artery perforator flap for fingertip injury is a reliable one stage procedure that can be used for all type of fingertip injuries. It preserves digital neurovascular bundle with short operating time. Its circulation is robust and provides adequate padding of fingertip with satisfactory sensation.

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