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Reverse Dorsal Metacarpal Artery Flap for Coverage of Soft Tissue Defects on Dorsal and Volar Aspects of Medial Four Finger Proximal to the DIP Joint

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Abstract

Background: The reverse dorsal metacarpal artery flap is a versatile solution for resurfacing soft-tissue defects of fingers. This is a widely used flap to cover finger defects. ***Materials and Methods:*** This prospective observational study was carried out at Dhaka Medical College Hospital, Dhaka from 1st July, 2018 to 30th June 2019. 30 patients were included in the study. Patient age, gender, defect type, defect location, donor site coverage, flap dimensions, range of motion of the meta-carpophalangeal joint and proximal interphalangeal joint, postoperative complications were evaluated. Follow up period was 3 months. ***Results:*** 30 patients underwent coverage of skin defects of the finger proximal to DIP joint with reverse dorsal metacarpal artery flap. All flaps survived completely. Flap size ranged from 2.5 cm 1.5 cm to 5.5cm 3.5 cm. 17 flaps were based on the second dorsal metacarpal artery. Skin paddle was taken from the dorsal aspect of the second, third, and fourth intermetacarpal area. All patients had full range of movement of the reconstructed and donor digits when followed at 3 months after surgery. ***Conclusions:*** The reverse dorsal metacarpal artery flap is a flap which is safe, easy to apply in the context of soft tissue coverage procedures and does not result in the loss of finger functions. It also confers excellent aesthetic skin suitability and does not require debulking procedures.

Key words: Reverse dorsal metacarpal artery flap, finger reconstruction, functional outcome.

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INTRODUCTION

The dorsal skin is very thin and it covers one of the nature's best-engineered creations, the extensor apparatus [1]. The soft tissue envelope of the hand is uniquely designed to provide tactile input from our environment and must also withstand substantial wear over a lifetime. There are many insults that can compromise the soft tissue of the hand including trauma, thermal injury, infection and malignancy [2]. Coverage requires a thoughtful approach that enables simultaneous restoration of the aesthetic appearance and the function of the hand [2]. There are many options for the reconstruction of soft-tissue defects of the fingers including homo-digital, hetero-digital, regional or distant flaps. Among the options reverse dorsal metacarpal artery (RDMA) flap is very widely used for covering significant skin and soft tissue defects of the finger.

Earley and Milner reported the use of skin island flaps from the dorsum of the finger and web spaces nourished by the 1st and 2nd dorsal metacarpal vessels [3]. Quaba and Maruyama first reported reverse dorsal metacarpal artery flap in 1990 in English literature.

RDMA is used as a cutaneous pedicle, subcutaneous tunnelled as well as propeller flap design for finger reconstruction. It also used as a bilobed second dorsal metacarpal artery – based island flap for reconstructing complex defects around the thumb metacarpophalangeal joint [4]. Dorsal metacarpal artery advancement flap, a variation can be used simple syndactyly reconstruction [5]. The reverse second dorsal metacarpal artery vascularized bone flap may be given to reconstruct bony loss in the distal phalanx [6].

The thin characteristic of the dorsal hand skin gives an extra edge for RDMA flap over other options of the finger dorsum and volar reconstruction. The vascular basis of the RDMA flap is well studied. RDMA flaps are arterialized flaps that are raised and transposed to provide coverage for a digit [7]. The reverse dorsal metacarpal artery flap is a good option for coverage of soft tissue defects on dorsal and volar aspects of medial four finger proximal to the DIP joint.

MATERIALS AND METHODS

This prospective, observational study was conducted in 30 patients using purposive sampling technique in Dhaka Medical College Hospital, Dhaka from 1st July, 2018 to 30th June 2019. Patients age was between 5 to 47 years, who came with skin and soft tissue defects over fingers proximal to DIP joints. Functional outcome was measured by Strickland's evaluation system, based on active flexion at PIP & DIP joints and extension lag at PIP & DIP joints, measured by goniometer.

Surgical Technique

Flap design:

The axis of the flap is in the middle between adjacent metacarpals. Pivot point is marked with hand held Doppler probe. A skin pinch test is used to confirm primary donor site closure.

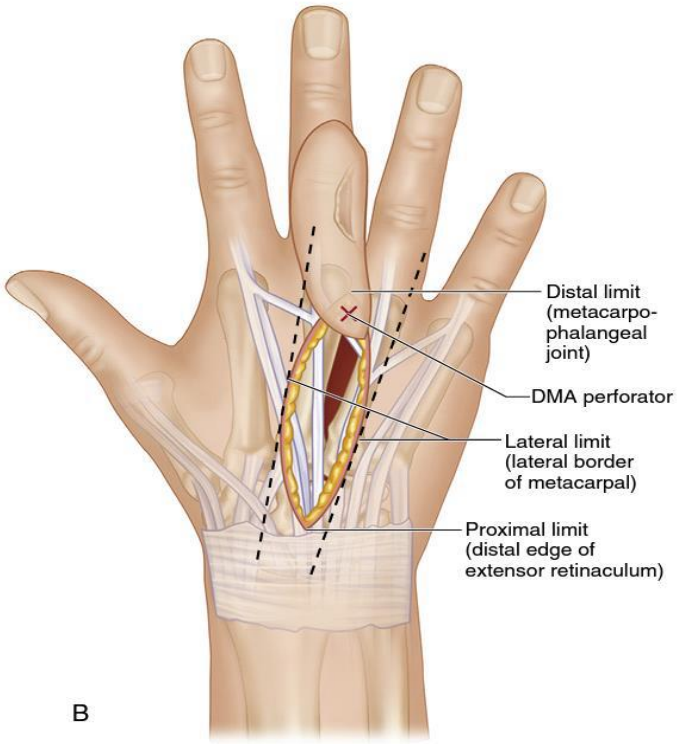

Figure 1: Reverse dorsal metacarpal artery flap [8]

Flap elevation - The reverse dorsal metacarpal artery flap was first reported in 1990 by Lu and Wan in China and by Quaba and Maruyama in English literature [9]. The dissection plane is above the epimysium of the dorsal interosseous muscle. Flap dissection starts from proximal to distal. The main trunk of dorsal metacarpal artery is not included within the flap. This flap is elevated until the pivot point is reached which is approximately 1.5 cm proximal to the leading edge of the web space. This point is determined by the presence of juntura tendinum. The juntura tendinum is transected, then dissection can continue up to the communicating branch between the dorsal metacarpal artery and the palmar metacarpal artery. The pedicle should be surrounded by the portion of subcutaneous tissue and a superficial vein can be included within the flap to preserve and potentially improve the venous drainage.

Flap rotation and inset:

The flap reach on the dorsum and volar aspect of medial four finger proximal to DIP joint. Tunnelling the flap through the soft tissue of the web compromise the venous return. Tourniquet is released after the flap rotated 180 degrees into the defect to ensure there is no kinking or twisting of the pedicle. The flap is inset with minimum number of sutures to avoid ischemia or compression.

The skin defect of less than 3.5 cm over the donor site can be closed directly [10]. If the defect is more than 3.5 cm, then skin graft is needed. A volar splint is used for 1 week to keep the fingers extended and maintain the wrist in extension. The patients were started on range-of-motion exercises at 2week. The sutures were removed at 2 weeks.

Figure 2: Pre operative picture

Figure 3: Per operative picture

Figure 4: Immediate post operative picture

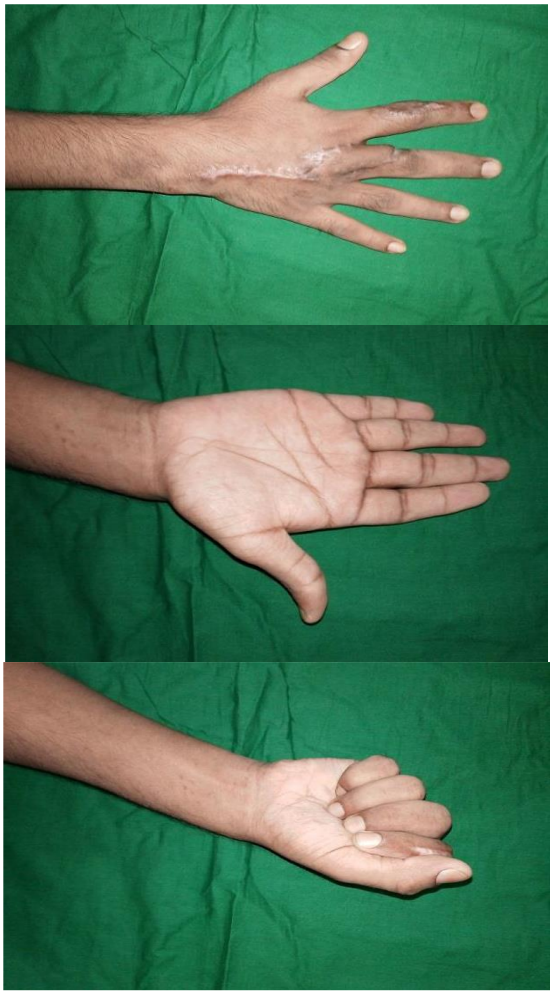

Figure 5: 3 months post operative follow-up

RESULTS

Among the respondents the mean age was 28.73 (± 8.19) years where minimum age was 5 years and maximum 47 years. 90% were male. 15(50%) respondents were factory workers. Electric injury occurred in 53.33% cases. Right hand (53.34) and index and middle fingers (36.67) were mostly affected (Table I).

In 56.67% cases 2nd dorsal metacarpal artery flap were used (Table II) Dimension of wound range in length range 1.5 to 3.5 is 86.66% and width range 1 to 2 cm is 70 %. (Table III) and Dimension of flap range in length range 2.5 to 3.5 is 46.66% and width range 1 to 2 cm is 70 % (Table IV). Complete flap survival in 80 % cases (Table V). Donor site morbidity was uneventful in 90 % cases (Table VI). Full range of movement in MCP joint 93.4% cases (Table VII) and in PIP joint 90% cases (Table VIII). 25 (61.7%) respondents had excellent outcome (Table IX).

Table I: Multi-variate table showing demographic & injury characteristics of cases

Parameters	Frequency	Ratio (%)
Cases	30	100
Age		
5-15 years	2	3.3
16-30years	23	76.67
31-45years	17	16.67
46 -60 years	1	3.34
Gender		
Male/ Female	27/ 3	90/10
Occupation		
Factory worker	15	50
Garments worker	6	21.7

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Parameters	Frequency	Ratio (%)
Student	5	8.3
Housewife	2	15.0
Service holder	2	15.0
Type of injury		
Electric burn	16	53.33
Machinery injury	9	30
Trauma	2	6.67
Flame burn	2	6.67
PBSC	1	3.33
Affected hand		
Right/ Left	16/14	53.34/46.66
Affected fingers		
Index/ Middle/ Ring/ Little	11/ 11/ 4/ 4	36.67/36.67/13.34/13.34

Table-II: Use of reverse dorsal metacarpal artery in the flap (n=30)

Position of metacarpal space	Frequency (n)	Percentage (%)
2nd	17	56.7
3rd	12	40
4th	1	3.3

Table-III: Dimension of wound (n=30)

Wound length(cm)	Frequency	Percentage (%)	Wound Width	Frequency	Percentage (%)
1.5-2.5	13	43.33	1-2	21	70
2.51-3.5	13	43.33	2.1-3	6	20
3.51-4.5	4	13.33	>3	3	10
Total					
Mean		3.93		2.39	
SD(±)		.8363		.6244	

Table-IV: Dimension of flap (n=30)

Flap length	Frequency	Percentage (%)	Flap width	Frequency	Percentage (%)
2.5-3.5	14	46.66	1.5-2.5	18	60
3.51-4.5	9	30	2.51-3.5	12	40
4.51-5.5		7			23.33
Total					
Mean		3.93		2.6	
SD(±)		.8		.7874	

Table-V: Flap survival (n=30)

Outcome	Case	Percentage
Complete flap survival	27	80.00
Marginal flap necrosis	1	6.67
Partial flap necrosis	1	6.67
Total flap loss	1	6.67

Table-VI: Donor site morbidity (n=30)

Donor site morbidity	Frequency (n)	Percentage (%)
Uneventful	27	90
Scar	3	10

Table-VII: Functional outcome of MCP joint (n=30)

Movement of joint	Frequency (n)	Percentage (%)
Full range of movement	28	93.4
Restricted 10-15 degree	1	3.3
No movement	1	3.3

Table-VIII: Functional outcome of PIP joint (n=30)

Movement of joint	Frequency (n)	Percentage (%)
Full range of movement	27	90
Restricted 10-15 degree	2	6.7
No movement	1	3.3

Table-IX: Final outcome (n=30)

Final outcome	Frequency (n)	Percentage (%)
Excellent	25	83.4
Good	2	6.7
Poor	3	10

DISCUSSION

The reverse dorsal metacarpal artery flap is a reliable and excellent method to cover the skin defect over the injured finger, which has the advantage of a good quality skin paddle matched up with the skin over the fingers color, texture, and thickness [11]. The range of coverage includes the palmar and dorsal sides from the base to DIP joint of the finger. In most cases, there is sufficient laxity of the dorsal skin to permit linear closure of the donor defect.

If the flap is used to cover the skin defect over the middle phalanx with intact skin over the proximal phalanx, partial skin over the proximal phalanx must be sacrificed and covered by the flap. Even though there is sacrifice of the proximal skin in this situation, the therapeutic result is better than other methods, such as the cross-finger flap, which needs a secondary procedure [12].

In present study 30 reverse dorsal metacarpal artery flap were done in 30 patients where age range was 5 years to 47 years. Lu Lai-Jin *et al.,* performed a study of 153 cases and age distribution ranged from 6 years to 69 years. Young adults were prone to finger injury [13].

In Sandeep J. Sebastin [12] et. al. in a study showed that, 58 dorsal metacarpal artery perforator flaps were performed to resurface soft tissue defects proximal to the fingertip in 56 patients. Among them 52 were male patients (93%) and 4 female patients. In this study, among 30 patients 27 were male (90%) and 3 were female (10%). Sex distribution is similar to the study of other studies.

In Sandeep J. Sebastin *et al.,* study 79% patients were manual workers who sustained injury at work. Most of the patients in this study also manual worker (n=23) [12].

In most of the study post traumatic wound was the most common cause. But in this study electric burn was most common cause (n = 16), second common cause was machinery injury (n = 09).

In Lu Lai-jin, MD and Gong Xu, MD[13] series, sites of skin defects included the index finger (n = 74), middle finger (n =45), ring finger (n = 25), little finger (n = 7) and finger stump (n = 2). In this study index finger involved in 11 cases, middle finger in 11 cases, ring finger in 4 cases and little finger in 4 cases.

The second, third and fourth dorsal metacarpal artery can be chosen as the pedicle of the flap. The second and third dorsal metacarpal artery are the largest and most reliable. The fourth dorsal metacarpal artery is smaller, which is not reliable for the flap. In the present study 2nd dorsal metacarpal artery was used in 17 cases, 3rd in 12 cases, 4th in 1 case. In Lu Lai-jin *et al.,* study 2nd dorsal metacarpal artery used in 117 cases, 3rd dorsal metacarpal artery in 29 cases, and 4th dorsal metacarpal artery in 7 cases. 2nd dorsal metacarpal artery was most commonly used in all studies. This finding was similar with the other studies.

In Sandeep J. Sebastin *et al.,* study the defect size range was 1.5 x 1.0 cm to 6.0 x 2.0 cm [12]. The smallest flap measured 2.0 x 1.5 cm and the largest flap measured 6.0 x 4.0 cm. In this study size of the defect ranged from 1.5 x 1.0 cm to 4.5 x 3.0 cm. Size of the flap ranged from 2.5 x 1.5 cm to 5.5 x 3.5 cm. This data was almost similar to other studies. In each case flap dimension was 5 mm more both in length and width than that of the wound in this study.

G. Dautel *et al.,* study [14] showed that, in seven patients, all the flaps survived fully. In Lu Lai-jin, MD, and Gong Xu, MD1 series, 143 cases survived uneventfully within 153 cases. Venous congestion occurred in 8 cases, which led to partial epidermal necrosis, 2 cases failed completely due to injury of the pedicle [13]. Among 30 patients in this series 27 flaps survived completely, 5 to 10% loss occurred in 1 case, 40 to 50% loss occurred in 1 case and 100% flap loss occurred in 1 case. The post operative outcome of flap of this study had no gross dissimilarity compared to other studies.

In this study functional outcome of metecarpophalangeal joint and proximal interphalangeal joint was measured by Goniometer. At metecarpophalangeal joint 28 patients had full range of movement, 10 to15 degree restricted in 1 patient and 1 patient had no movement. At proximal interphalangeal joint 27 patients had full range of movement, 10 to 15 degrees restricted in 2 patients and 1 patient had no

movement. In other studies, authors did not mention the functional outcome of the fingers except tendon repair or tendon graft was done along with this flap.

C. Can Cedidi and *et al.*, [15]., in a study showed that tendon reconstruction was done along with DMA flap but in present study bony and tendon injury was not reconstructed.

In present study, excellent outcome found in 25 cases (83.4%) which is similar to other study.

The findings of this study reaffirm that the reverse dorsal metacarpal artery flap is a dependable and versatile option for reconstruction of soft-tissue defects of the fingers proximal to the DIP joint. Its ease of elevation, reliable vascularity, and minimal donor site morbidity make it a preferred choice for small to moderate digital defects. The flap provides durable coverage with excellent color and texture match while preserving finger mobility [16,17].

Limitations of the study

The sample size was small for representative data; study was single center based and period of follow up was limited.

Recommendations

A multi-center-based study with a larger sample size with long term follow up is needed.

CONCLUSION

The reverse dorsal metacarpal artery flap is a reasonable and reliable option in skin and soft tissue reconstruction in digits. It is a thin flap, easy to elevate and a wide range of flap transposition for defects at various levels of the digits in both the volar and dorsal sites is possible.

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