Original Article

Restoration of Sensibility Following Reconstruction of Soft Tissue Defect of Thumb with the First Dorsal Metacarpal Artery Island Flap

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Abstract

Introduction: Thumb injuries constitute a challenge for the plastic surgeon because the loss of its function compromises the function of the entire upper limb. If there is a soft tissue defect in thumb where tendons, joints, or bones is exposed, it requires stable vascularized flap reconstruction preferably with a local or regional flap. The First Dorsal Metacarpal Artery (FDMA) island flap from the dorsum of the index finger is an option for reconstructing such thumb defect.

Objectives: To assess the quality of sensitivity at flap site following reconstruction of soft tissue defect in thumb with the FDMA island flap.

Materials and Methods: A prospective observational study was conducted from July 2012 to June 2013 among 31 patients admitted with soft tissue defect of thumb with exposure of tendon, bone, joint or loss of pulp and were treated with innervated FDMA island flap. Recovery of sensation was evaluated by static-2PD test.

Results: Out of 31 patients 28 were male and 3 were female with male to female ratio is 9:1. The mean age was 26.2±8.8 years. A large number of patient was manual worker (construction worker, mechanic). Most of them sustained injury in their dominant thumb (61%). Most common cause of injury was electric burn (78%) rest were due to machinery injury. Average s-2PD over the flap area 9.1 mm (range, 8-12 mm) compared with 7.4 mm (range, 7-11 mm) over the donor site of opposite index finger and 5.5 mm (range, 3-9 mm) over corresponding site of opposite thumb. Average loss of s-2PD over the flap area compared with the donor area was 1.4 mm (19.2%). Every patient was satisfied with the outcome.

Conclusion: Restoration of sensibility is quite satisfactory after reconstruction of soft tissue defect of thumb by first dorsal metacarpal artery island flap.

Key word: FDMA flap, Thumb defect, Static 2-PD, Sensibility.

Introduction

Thumb injuries constitute a challenge for the plastic surgeon because the loss of its function compromises the function of the entire upper limb[1]. In fact, the thumb itself is responsible for 40% to 50% of the overall function of the hand[2]. It enables activities like pinch, grasp, and fine manipulation which are essential for daily life[3]. A functional thumb depends on four aspects of prehension to provide strong and fine manipulation of objects: opposition, three-point pinch, adduction or key pinch, and cylinder grasp. Provision of these functions depends on a number of factors. Intact sensibility of the palmar skin of the thumb is an important factor and for this reason, reconstructive techniques that preserve or restore sensibility are favored over those that do not. Finally, hand function depends on a thumb that has durable skin coverage[4]. As role of thumb is crucial for hand function, maximum efforts must be taken to salvage severely injured thumbs[5]. Soft tissue injury of thumb with exposed tendons, joints, or bones require stable vascularized flap reconstruction preferably with a local or regional flap.

The FDMA island flap from the dorsum of the index finger is an option for reconstructing of such thumb defect. The advantages of this flap are its variable size, stability, pliability, wide arc of rotation that can easily reaches the palmar or radial aspect of thumb and the pulp of distal thumb defect of thumb with no major donor site morbidity[5,6]. Its sensibility is not well studied particularly in restoration of sensibility at flap site in reconstruction of soft tissue defect of thumb except in study with pulp reconstruction[7]. The aim of this study is to see the sensibility of first dorsal metacarpal artery island flap site in reconstruction of soft tissue defect of thumb as the restoration of sensibility of thumb is of utmost important in thumb functions as well as in hand functions.

Materials and Methods

A prospective observational study was conducted from July 2012 to June 2013 among the patients admitted in the Department of Plastic Surgery, Dhaka medical college hospital with the complaints of soft tissue defect of thumb with exposed bone, tendon, joint, or pulp. Total 31 patients were selected basing on the inclusion and exclusion criteria. Inclusion criteria was loss of soft tissue of thumb of at least 1.5 cm in greater dimension and soft tissue loss of thumb causing exposure of bone, tendon, joint or pulp. Exclusion criteria was (1) injury on the dorsum of the proximal part of the index finger, (2) injury on the course of FDMA, a thumb soft tissue defect less than 1.5 cm in greater dimension,

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children less than 12 years of age and presence of comorbid disease-causing impairment of sensation like diabetes with neuropathy. Sensory recovery was assessed by measuring static two-point tactile discrimination testing carried out according to the "Moberg Method" as described by the American Society for Surgery of the Hand (ASSH)[8].

Surgical technique: This operation is done by placing the patient in a supine position and the arm of operating hand is kept on the arm table. Either general anesthesia or brachial plexus block was used for anesthesia purpose. Painting and draping done in whole upper limb. For hemostatic purpose a sterile rubber tourniquet was applied at upper arm. Sharp debridement done on the thumb defect. The skin flap was outlined on dorsal aspect of the index finger, 1 mm larger than the defect in all diameter. The flap was harvested including the FDMA and a branch of the superficial radial nerve as a pedicle flap. Skin island included from dorsal skin of proximal phalange of index finger within the line of mid-radial and mid-ulnar axis of the finger. Dorsal skin overlying the metacarpophalangeal joint and proximal interphalangeal joint was preserved to reduce donor site morbidity. Most proximal point of pedicle dissection is determined by tip of triangular first web space which is palpated between the bases of first and second metacarpal bone and this is the pivot point of our flap. Skin incision continued along the radial side of the second metacarpal bone to include a large subcutaneous vein with the pedicle. Flap dissection started from distally and radially and paratenon was preserved over the extensor apparatus. Pedicle dissection was carried towards origin of the FDMA. Ulnar branch of the FDMA is tiny and it courses deeply in the musculo-osseous groove so no attempt was made to visualize the artery. We included the radial shaft periosteum of second metacarpal bone and ulnar head fascia of the first dorsal interosseus muscle with the pedicle to achieve safe dissection. We ligated or coagulated any tiny arterial branches penetrating the aponeurosis of FDMA. By this way we achieved maximum flap pedicle length. So, this pedicle includes (1) fascia of the FDMA (2) dorsal veins and (3) sensory branch of the radial nerve. Tourniquet was released after raising the flap and vascular flow was ascertained. Either through a subcutaneous tunnel or by opening the skin bridge, the flap was transferred to the defect. The donor site was covered with full thickness skin graft. By visual inspection of tissue color and capillary refilling, flap circulation was monitored. The hand was splinted for 7 to 10 days above heart level to reduce venous congestion and to protect skin graft. Stiches was removed on 10th to 12th post-operative day. Active range-of-motion exercises was started thereafter. Patients were then discharged with advise to revisit on 6th week after operation.

Defect

Flap design

Flap harvesting

Flap insert

Donor site

Recipient site

Donor site(7th POD)

Recipient site(7th POD)

Results

Out of 31 patients 28 were male, rest 3 were female within the age range of 14-47 years where maximum 14(45.2%) was in the age group of (21-30) years. Most common cause of injury was electric burn, 24 (77.4%), next was due to machinery injury 6 (19.4%), only one case was due to wax burn. Most of the injury occurred on thumb of dominant hand, 19(61.3%) compared to not non-dominant hand, 12 (38.7%) and most of the patient was right hand dominant, 27(87.1%). Distribution of location of injury over thumb are volar (proximal) 10(32.3%), pulp 7(22.6%), Ulnar (proximal) surface 5(16.1%), Dorsum(proximal) 4(12.9%), Dorsum (IP joint) 1(3.2%), Stump 2(6.5%), Radial(proximal) 2(6.5%). Most common indication for flap cover was exposed bone 12(38.7%), then exposed tendon 9(29%), pulp cover 7(22.6%), stump cover 2(6.5%), exposed joint 1(3.2%). Mean wound length was 34 mm and breadth 26.96mm. Mean flap length was 35.25 mm and breadth were 28.21mm. Mean flap pedicle length was 6.02 cm with a range from 5-8 cm. Of our 31 patients, 9(29%) patient encountered complication and while 22(71%) patient recovered uneventfully. Most common complication was loss of epidermis (n=6), partial flap necrosis of less than 2 cm size (n=3). We do not encounter any total flap loss or flap necrosis more than 2 mm size. All our complication was managed conservatively with dressing and healed without any intervention.

Distribution of static two-point tactile distance over flap area in 27(87.1%) patient is within (6-10) mm. Rest 4(12.9%) patient having s-2 PD between (11-15) mm. Minimum 8 mm and maximum 12 mm s-2 PD was found on flap site with a mean of 9.1±1.1 mm. Mean of two-point discrimination distance at flap site was 9.1±1.1 mm, dorsum of opposite index finger was 7.4±1.0 and corresponding site of opposite thumb was 5.6±1.4 and this difference is statistically significant (p<0.001). Mean s2-PD on flap was 9.3 mm and dorsum of opposite index finger was 7.84 mm with mean change 1.44 mm and percent change 19.2%. We measured outcome of patient on three variables; flap survivability, static two-point discrimination distance at flap area and patients own satisfaction. 22(71%) patient had excellent outcome and 09(29%) patients had good outcome regarding flap survival. There was no poor outcome. 27(87.1%) patient had good static two-point discrimination distances and 4(12.9%) patient had fair static two-point discrimination distance. No patient had excellent or poor outcome regarding flap sensation. Patients own appraisal of sensory recovery judged on a scale of 1 to 10, where the patients were asked to score by their own and the data was recorded by a non-biased third person not related to this study; regarding the sensory recovery of their reconstructed thumb. A large number of patients marked the recovery as very good 24 (77.4%), good 5 (16.1%) and satisfactory 2(6.5%). No patient responded the result as poor or very poor.

Table-I: Distribution of post-operative complication (n=9)

Complication	Frequency	Percentage
Loss of epidermis	6	66.7
Flap necrosis <2mm	3	33.3
Flap necrosis >2mm or total loss	0	0
Total	9	100

Table-II: Two-point discrimination distance in different site

Site	Range	Mean± SD	p value
Flap	8.0-12.0	9.1±1.1	< .001
Dorsum of opposite index finger	7.0-11.0	7.4±1.0	
Corresponding site of opposite thumb	3.0-9.0	5.6±1.5	

Table-III: Outcome of patient by flap survivability, s-2PD flap area and patients' satisfaction

Characteristics	Outcome	Frequency (%)
Flap survivability	Excellent	22(71%)
	Good	09(29%)
	Poor	0
s-2PD at flap area	Excellent(<6mm)	0
	Good(6-10mm)	27(87.1%)
	Fair(11-15mm)	04(12.9%)
	Poor(>15mm)	0
Patients' satisfaction	Very good (9-10)	24(77.4%)
	Good (7-8)	5(16.1%)
	Satisfactory (5-6)	2(6.5%)
	Poor (3-4)	0
	Very poor (0-2)	0

Discussion

Soft tissue defect of thumb with exposure of bone, tendon, joint or pulp are challenging reconstructive problem. Challenge becomes more so as reconstruction needed to be sensate without compromising hand functions. The clinical study comprised of 31 patients with soft tissue loss of thumb with either exposure of bone, tendon, joint or pulp defect. All patients were treated with first dorsal metacarpal artery island flap. Their age varied from 14 years to 47 years, with mean age of 26.2±8.8 years. Majority of the sufferers are from 21-30 age groups which indicates that active age group of people were the most sufferers. It may be due to involvement of this age group in different occupation related activities which exposes them to this sort of injury. Chen et al[9] found similar observation in their study in China. Among their 11 patients of thumb tip degloving injury mean age was 30.3 (range 17-48) years. But different observation is seen in study of Trankle et al[5]. In their study mean age was 48.3 years with range from 6-71 years. Major cause of injury among this study population

were electric burn 24(77.4%) next were machinery injury 6(19.4%) and one patient was due to wax burn. Zhang et al[10] showed a distribution of cause of injury among their 42 patients machinery injury was 31 patients and one was due to deep burn. The most common cause due to electric burn among this study population indicates their unprotected nature in their working environment and as electric burn causes deep burn with exposure of tendon or bone so they needed flap cover for their reconstruction and was included in this study.

Distribution of location of wound in this study population, highest number of wounds were on volar aspect over the proximal phalanx of thumb, 10(32.3%), next were pulp of thumb, 7(22.6%). These two areas comprise 55% of the total patients. It may correlate as most of our patients were due to electric burn injury in thumb which occurs during electrocution of thumb while holding electric wire or metallic object in hand grip and come in contact with either volar surface or pulp of thumb. Other studies[1,11] also have similar distribution of injury site of thumb injury. The main aim of this study was to see the sensibility at flap site after reconstruction of soft tissue defect of thumb. In this study, we used static two-point discrimination test to quantify the sensibility. The range s-2PD over flap was (8-12) mm with a mean of 9.1 mm (SD±1.1). 27(87.1%) patients had s-2PD between (6-10) mm rest 4(12.9%) had s-2PD between (11-15) mm. In contrast s-2PD on the dorsum of opposite index finger was within the range of (7.0-11) mm with mean sTPD of 7.9±1.0 mm. Paired 't' test which was significant ($p < .001$). So the flap remained sensate but there is significant difference of sensation after transfer from its donor site to recipient site and the flap lost definitely some sensation after its transfer. Opposite thumb s-2PD at the same site of injured thumb ranges from (3.0-9.0) mm with a mean value of 5.6±1.5 mm. So, the flap sensation is significantly ($p < .001$) different in comparison to non-injured thumb. Mean s-2PD is 10.8 mm (range 8-20) mm in an Egyptian work by Ege et al[12]. Chang et al also have similar finding of s-2PD ranges from 6-14 mm in their work with resurfacing of pulp defect in thumb injury in 8 patients[6]. The average sTPD of 10.6 mm in 7 patients with resurfacing of soft tissue defect of thumb by the work Muyldermans and Heiner's work Belgium[7]. Wound repaired by FDMA flap in Portugal mean sTPD was 11.2 mm (range 6-17)1 in the work described Horta et al[1].

To see the final outcome regarding sensibility, the result of static two-point discrimination were rated using the 'Modified American Society for Surgery of the Hand Guidelines for Stratification of s-2PD' (excellent, <6 mm; good, 6–10 mm; fair, 11–15 mm; poor, >15 mm)[10,11]. Out of 31 patients 27 (87.1%) patients were in the group of 'good outcome', rest 4(12.9%) were in the group of 'fair outcome'. None was in 'excellent' or 'poor' outcome group. Zhang et all have observation of 26 patients in fair group and 6 patients in poor group in their study of 32 patient of reconstruction of thumb pulp defect with first dorsal metacarpal artery flap[10]. There is little information regarding reconstruction of defect at different site of thumb with first dorsal metacarpal artery island flap and their sensory outcome. Flap survival was also evaluated. Out of 31 patients, 22(71.0%) were in the excellent group where there was no flap loss. Nine flaps have minor complication with six flap had epidermis loss and rest 3 had marginal tip necrosis of about 1 mm which healed secondarily and did not required any further intervention. They were in 'Good' outcome group. None was in poor outcome group. Rest 22 patients having no complication regarding flap survivability and were in excellent outcome group. Zhang et al[10] had observation of 42 cases where 40 flaps have no complication and two flaps had distal flap necrosis which were healed without surgical intervention. They had no wound infection; we also had no wound infection which is similar to this study.

Regarding the sensory recovery of their reconstructed thumb with FDMA flap. Twenty four (77.4%) patient opted for 'very good' rest 5(16.1%) in 'good' group and 2(6.5%) in 'satisfied' group. None was in poor or very poor group. Trankle et al[5] had observation with 25 patients where 22 patients were satisfied rest 3 were not satisfied. The observation is similar to this study. For reconstruction of soft tissue defect of thumb with sensate flap numerous flap have been used. Each has their own merits and demerits. In this study of 31 patients, 87.1% patient had good outcome regarding sensation rest 12.9% had fair out come and none had poor outcome. Again, regarding patient own appraisal for sensory recovery 77.4% patient responded as very good, rest 16.1% good and only 6.5% are satisfied. Flap survivability is also excellent in 71% patient without any complication of flap. So, this flap is a very good option for reconstruction of soft tissue defect of thumb with restoration of sensation which is very important for thumb function.

Conclusion

First dorsal metacarpal artery island flap is versatile and reliable method of reconstruction of soft tissue defect of thumb for its simplicity in design, an easy technique regarding its elevation and inset into the defect. The advantage of this flap were observed are; safe and single stage procedure, gives sensory coverage to thumb which is one of the prime requirement of thumb reconstruction, almost all area of thumb can be covered with this flap, easy to harvest and minimum donor site morbidity. So this flap can be one of the options for reconstruction of thumb for sensory recovery.

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