VERSATILITY OF PARAUMBILICAL PERFORATOR FLAP FOR UPPER LIMB RECONSTRUCTION

Plastic Surgery

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ABSTRACT

Background: Microvascular flap and groin flap are the most commonly used flaps for upper limb reconstruction. Microvascular flap can not be done in certain situations and groin flap is not convenient for coverage of forearm defect and elbow defect. Paraumbilical perforator (pup) flaps can provide a large amount of tissue for coverage of forearm, elbow defects and mitigates the side effects of groin flap.

Material and method: A retrospective study was conducted for reconstruction of soft tissue defects from finger tip to elbow between January 2016 to December 2019 with PUP flaps. Demographic data, size of the defect, etiology, flap design and flap complication were analysed.

Result: The age of the patients ranged from 12 years to 56 year with mean age of 29.85 years and SD = 11.073. Male to female ratio was 1.5 : 1 (M=12, F=8). Size of the defect varied between 20 cm² to 288 cm² with mean of 88.1 cm² and SD = 29.69. No. of cases with flap dimension < 100 cm² (n=13), and > 100 cm² (n=7). Aetiology of injury included vehicular accidents in 10 patients, machine injury in 2 patients, electrical burns in 6 patients post snake bite ulcer 2 patients. The location of the defect included hands, forearm and the elbow, and fingers. Flap was directed Superolaterally in 18 patients, inferolaterally in one case, and combined medially and laterally in one case. There was no case of complete flap failure.

Conclusion: Paraumbilical perforator flap can be a safe and reliable option for soft tissue reconstruction in varied areas of upper limb.

KEYWORDS

pedicle flap, forearm defect, hand defect, paraumbilical flap

INTRODUCTION

Upper limb soft tissue defect with exposed tendon, bone, implant and, neurovascular structure necessitates flap cover. Role of microvascular flap in coverage of such defects has been well established^[1]. But in emergency situation, in patients with high voltage electric burn and for old patients pedicle flap has proven its effectiveness. Pedicle flaps are also useful when a future toe transfer is planned. Random pattern abdominal flap leaves a large secondary defect. Its use is limited by fixed length to breadth ratio. Axial pattern groin flap^[2] although a versatile flap has some limitations. It is insufficient for the large defects of the hand, adjacent forearm, and the defects around elbow. The limb edema is constantly noticed due to the dependent position of the hand. Hypogastric flap^[3] is an alternative to groin flap. However it is not suitable for volar surface defect of forearm^[4]. To address these issues, the pedicled paraumbilical flap based on perforators from deep inferior epigastric artery has come in to clinical practice. Ian Taylor^[5] studied the course of deep inferior epigastric artery and musculocutaneous perforators arising from it. Flap based on perforator around umbilicus are given various names like wing flap^[6] thoraco umbilical flap^[7,8,9,10,11] and paraumbilical flap^[12,13,14,15,16]. While thoracolumbar flaps are directed upward and laterally paraumbilical flaps are directed both inferolaterally^[13] and superolaterally^[15]. The flap has been used for hand^[13], forearm^[14], finger^[16] and scrotal reconstruction^[17]. This flap has a consistent anatomy, can be harvested rapidly, has low donor site morbidity. In the post operative period upper limb is kept elevated higher up in the trunk which reduces the chance limb edema which is the main disadvantage of groin flap. It is comfortable to patient and allows greater range of movement of elbow and shoulder joint during the interval between flap transfer and pedicle division. Use of this flap has not been described for circumferential skin loss involving both flexor or extensor aspect of the distal forearm. Use of the flap has not been described in vertical direction either. This paper describes our experience with use of custom made design of paraumbilical perforator flap along with conventional design based on the course of paraumbilical perforator in the abdominal skin.

MATERIAL AND METHOD

A retrospective study was conducted in 20 patients between January 2016 to December 2019 who underwent reconstruction of finger, forearm and elbow using paraumbilical perforator flap. Apart from routine investigation in all patients paraumbilical perforator was identified by 8 Hz hand held Doppler. In no case Doppler ultrasound or CT angiography was done.

Inclusion criteria

(1) Upper limb soft tissue defect with exposed bone, tendon, implant, neurovascular structure (2) soft tissue loss with presence of

granulation tissue as a prerequisite for future tendon reconstruction or nerve grafting

Exclusion criteria

- (1) Patients with recent MI (60 days) or unstable angina, decompensated heart failure, high-grade arrhythmias, or hemodynamically important valvular heart disease (aortic stenosis in particular) clusion criteria
- (2) Hemodynamically unstable patient
- (3) Grossly infected wound
- (4) Uncontrolled diabetes

Vascular Anatomy of the Flap

Deep inferior epigastric artery after its origin from external iliac artery just proximal to inguinal ligament runs superomedially in extraperitoneal tissue, pierces transversalis fascia and gives off two or three small peritoneal branches before supplying the abdominal skin. Superior epigastric artery a branch of internal mammary artery runs vertically downward from above and vascular arcade between these two system is completed in a watershed zone between xiphoid process and umbilicus. The abdominal skin is mainly supplied by branches from DIEA and SIEA. DIEA gives three type perforating branches. Musculocutaneous perforators supply mainly muscle with a little contribution to skin, cutaneous perforators supply mainly skin. A third type of perforators arises lateral to rectus sheath muscle and has very little contribution for supply of abdominal skin. More than 90% of the paraumbilical perforators are concentrated within 6 cm radius of umbilicus and mostly concentrated in inferolateral quadrant. Perforators run in three different directions vertical, horizontal and lateral. The perforators of DIEA after piercing the rectus sheath run in the subcutaneous fat in a suprafascial plane before joining subdermal plexus. In this subdermal plexus they are interconnected with small vessels from superior epigastric vessels and intercostal vessels.

Operative Technique

Patients were operated under general anaesthesia or combined brachial and spinal anaesthesia as decided by the anaesthetist of our hospital. Preoperative identification of the paraumbilical perforator was done. Base of the flap was always at the periumbilical region 6 cm away from umbilicus. Direction of the flap was chosen according to site of the defect and comfort of the patient. When the defect was on the volar aspect of the palm flap direction was inferolateral. When the defect was on the dorsum of the hand and dorsal aspect of the forearm flap direction was superolateral. For circumferential electric burn of wrist and palm custom made design was made as described in case report 2. For defect on the dorsum of hand and distal forearm involving both extensor and flexor aspect again a custom made design was made (described in case report 2)

Flap planning when the flap was designed with a superolateral direction. Base of the flap was positioned 6 cm away from the umbilicus at the inferolateral quadrant. A line extending superiorly and laterally from the umbilicus to the tip of the scapula form the axis of the flap. The flap is raised from distal (lateral) to proximal (medial). It is elevated just superficial to the underlying muscles' to include the subdermal plexus, fat and the thin layer of fascia overlying the abdominal muscles. The dissection stops at the lateral border of the rectus muscle or at any point of time if the flap is found to be adequate in length. In no case perforator was islanded completely. The surrounding tissues are undermined and the donor site is closed primarily without tension. Large secondary defects are skin grafted.

Table 1 Summarises flap details

Sl no	Age/sex	Defect location	Flap size	Total surface area	Comorbid condition	Flap direction	Donor site closure	Complication
1	26 / M	Distal forearm	11 cm x 6 cm	66		Sl	p	
2	18 / M	Hand and forearm	16 cm x8 cm flexor side ,7x7 on extensor aspect	177		Sl	ssg	
3	43 / F	Dorsum hand and distal forearm	18 cm x12 cm	216		Sl + sm	p	Edema
4	38 / M	Ring finger	8cmx 7 cm	56		Sl	p	
5	28 / M	Dorsum and first webspace	1c cm x 7 cm	70		Horizontal	p	Edema
6	34 /F	Dorsum hand	12 cm x 10 cm	120		Sl	ssg	
7	32 /M	Proximal forearm	14 cm x 10 cm	140		Sl	Ssg	
8	16 / F	Elbow	9 cm x7 cm	63		Sl	P	
9	26 / F	Elbow	10cm x7 cm	70		Sl	P	
10	34 / M	Proximal forearm	13cm x 9 cm	117		Sl	Ssg	
11	56/ M	Distal, middle and proximal forearm	22cm x 8 cm	176		sl	ssg	Flap dehiscence
12	19 / F/	Dorsum hand and distal forearm	12 cmx 8 cm	96		Sl	P	
13	42 / F	Hand	6 cm x5 cm	30		Il	P	
14	22 / M	Forearm	8cm x 6 cm	48		Sl	P	
15	39 /M	Extensor aspect of forearm and finger	8cm x 4 cm	32		sl	P	
16	18 /F	Thumb	8 cm x 6 cm	48		H	P	
17	23/M	Finger	5 cm x2 cm	10		Sl	P	
18	44/F	Multiple finger	13 cmx 3 cm	39		Sl	P	
19	12/M	Metacarpal hand	10 cm x8 cm	80		Sl	P	
20	27/m	Flexor aspect of distal forearm	12 cm x9 cm	108		sl	P	

P=primary closure ssg= splitthickness skin graft sl= superolateral il = inferolateral H=horizontal

Sm = superomedial

In the first three weeks patients were followed up for immediate and early complications like partial necrosis, total necrosis, limb oedema, infection, superficial epidermolysis, wound dehiscence and minor venous congestion.

Patients were also followed up at monthly interval for a minimum of 6 month . During each visit delayed complications such as joint . stiffness, pressure ulcers, donor site infection, scar , scar hypertrophy ,scar ulceration, and donor site hernia were noted.

CASE SERIES

Case 1

A 26 year old male presented to the hospital with machine injury causing avulsion of extensor tendons from origin and skin loss at the extensor aspect of distal forearm (upper figure 1). Single setting repair of tendon and soft tissue coverage of the forearm was planned. Paraumbilical perforator flap was planned with superolateral direction (figure 1 ,middle). Donor site was primarily closed and flap inseting was done (figure 1 lower). Entire flap survived.

The arm is immobilized on the patient's side with the help of adhesives and a pillow is placed beneath the elbow. The flap division and final inset are performed 3 weeks later.

Flap planning when flap was designed in inferolateral direction

Axis of the flap is marked as a line extending from umbilicus towards the anterior superior iliac spine . The flap is raised from below upwards. The incision was made up to sub fascial level. The flap was raised and stopped at the lateral boarder of rectus abdominis muscle. The donor site is closed or skin grafted depending on the size of the flap harvested.

Case 2

An 18 year old boy presented with high voltage electric burn on the wrist and palm. After debridement the defect was found to be of 16 cm x 8 cm on flexor aspect and 7cm x 7cm on the extensor aspect (figure 2 upper , figure 2 middle). A free style paraumbilical flap was designed .Distal portion of the flap was planned for extensor surface coverage and proximal portion was designed for coverage of flexor aspect . The flap has less width in the distal portion and more width in the proximal portion . This was in contrast to the traditional superolateral paraumbilical perforator flap with similar width throughout the length. The flap design is shown in (figure 2, lower).

The flap was harvested from lateral to medial above the muscle of lateral chest wall and abdominal wall in a subfascial plane (figure 3 ,upper).The dissection stopped at lateral boarder of rectus muscle. No

attempt was made to visualise the perforator. The flap was inset as much as possible. After 21 days detachment and flap inseting was done. Entire flap survived (figure 3 middle and figure 3 lower) .

Case 3

A 43 year old female suffered road traffic accident resulting in soft tissue loss over dorsum of the hand, extensor aspect of the forearm and flexor aspect of the forearm. So analysing the defect location the defect is not in a single axis so a free style paraumbilical flap was designed. The dorsum and extensor aspect of forearm was considered as one axis and the flexor aspect was considered as another axis. Flap was designed accordingly. Direction of the flap was not typical of thoraco umbilical flap rather a combination of superolateral and super medial direction. The base of the flap was designed on inferolateral paraumbilical perforator. Flap was elevated from distal to proximal direction above the plane of the abdominal muscle. Flap inseting was done and divided after 21 days. The entire flap survived. Though it was a very large flap due to multi planar design donor site was closed primarily (figure 4).

Case 4

A 38 year old male with circumferential injury to right little finger presented to our hospital 48 hour after injury. Paraumbilical perforator flap was planned. Initially flaps was elevates at sub fascial level. Then flap was thinned primarily. Flap Insetting was done and flap divided after 3 weeks. The entire flap survived. 3 month post operative finger has good consistency comparable to other finger. (figure 5)

RESULTS

The age of the patients ranged from 12 years to 56 year with mean age of 29.85 years and SD = 11.073 Common age group was between 20-40 year (55%). Male to female ratio was 1.5 : 1 (M=12, F= 8) [Figure 6]. Size of the defect varied between 20 cm² to 288 cm² with mean of -88.1 cm² and SD = 29.69. No of cases with flap dimension < 100 cm² (n= 13), and > 100 cm² (n= 7) [Figure 7]. Aetiology of injury included vehicular accidents in 10 patients, machine injury in 2 patients, electrical burns in 6 patients post snake bite ulcer 2 patients. [Figure 8]. The location of the defect included hands, forearm and the elbow, and fingers. [Figure 9]. Flap was directed Superolaterally in 18 patients, inferolaterally in one case, and combined medially and laterally in one case. There was no case of complete flap failure. None of the flaps showed signs of venous congestion. One case had partial flap detachment which was managed by resuturing. two cases had edema which were managed conservatively. Joint stiffness occurred in all cases but resolved with post-operative physiotherapy. Abdominal wall hernia was not seen in any patient. Donor site closure was achieve in 15 cases and skin grafted in 5 cases. All the defects less than 100 cm² were primary closed. One large defect of 216 cm² was also primary closed. 6 month follow up of donor site showed no deformity and most patients were satisfied.

Figure 7 Flap size distribution

Figure No 8 : etiology of defects

FIGURE 9 Distribution Of Defects

DISCUSSION

Free flaps are option of choice for a large complex defect of upper limb^[1]. They provide better aesthetic outcome and functional outcome. But it requires microvascular expertise, team work, dedicated staffs for post operative care for flap success. In the current era of microsurgery, pedicled flaps still have a role selected clinical scenarios. Use of pedicled flaps in reconstruction of electrical burn injuries is well described. They are suitable

alternative to free flaps as the recipient blood vessels may be thrombosed or extensive dissection may damage the established collateral blood flow^[19]. Pedicled flaps are preferred over the free flaps in frail elderly patients with multiple life-threatening comorbid illnesses. Free flaps are associated with more number of postoperative complications in spite of their success in these particular patients^[20,21,22]. Coverage of amputated stump of the thumb or multiple fingers by pedicled flap is a well-established entity^[23,24]. The pedicled flap preserves the recipient vessels for second-stage to transfer besides providing stable soft tissue cover and preventing contractures of fingers. Complex circumferential degloving injury to the multiple digits almost always requires a pedicled flap^[25,26].

Though this flap is well known, we want to emphasize the safety and reliability of pedicled paraumbilical perforator flap in this era of microsurgery^[18]. Primary thinning of flaps can prevent flap bulkiness and provide better contour to the affected part. Primary thinning is possible due to unique vascular pattern of the flap. Paraumbilical perforator vessels run in the deep subcutaneous fat and then superficial to the Scarpa fascia until their final destination^[12].

Superficial to the Scarpa fascia the direct perforators turn to have a course parallel to the skin, where they started to divide for forming subdermal plexus^[12]. These perforators were also found to be anastomosing with the superficial vessels in the abdominal wall. This

allows maintaining axially of the flap. This allows harvest of large flaps beyond definite length breadth ratio. Wide range of design of paraumbilical perforator flap for coverage of varied anatomical locations extending from the elbow to fingers is also possible due to its axially. Yilmaz et al^[13] had used the flap in 11 patients for acute hand and forearm injuries with a considerably narrower pedicle containing at least 1 perforator vessel. The narrow pedicled allows primary closure of the donor site, provides a significant comfort and freedom for the limb movement. This is particularly useful for linear defects in forearm having more length and less width. Additionally, before flap detachment the hand and forearm are in a better physiologic condition than with the groin flap which reduces hand edema. Early mobilization of the hand is possible with the use of this flap. Since the extremities are short relative to torso in young children, this flap would be easier to use than the groin flap because the pedicle is superior. Moreover, it allows flap design in any direction according to the defect location. Maximum size of the flap in our series was 216 cm² which was more than the flap described by Yilmaz et al^[3] but less than flap described by Sarad et al^[28]. Flap as large as 420 cm² has been described by Sarad et al^[28]. Such a large flap can be harvested based on the perforators of paraumbilical region because deep inferior epigastric artery has a very large calibre of around 3 mm at its origin and on average 4 to 5 perforators of size more than 0.5 mm are concentrated around umbilicus. Perforators of 1 cm size has also been documented. This allows adequate blood flow in the flap. Since skin bridge is preserved at the base of the flap it provides additional pathway of venous drainage. Extensive intercommunication between posterior intercostal vessel and paraumbilical perforators at the subdermal level allows harvest of a very large flap. Even when flap is raised on a single perforator the vascularity is well maintained. It has been proven that when other muscular branches of a source vessel is divided and single perforator is preserved hyper perfusion of single perforator maintains the blood supply and allows harvest of a large flap. Opening of choke vessels also allows to harvest flap beyond its angiosome territory.

Rate of flap necrosis varies from (8.64%)^[28], (0%)^[13] [27][15]. Higher percentage of flap necrosis by Sarad et al^[28] was due to presence of infection in the wound bed, extension of the flap beyond posterior midline and use in hypotensive condition. Flap necrosis in our series was 0%. This was because of careful selection of case and avoidance of the risk factors which can lead to flap necrosis. In 75% of our cases, the donor site was closed primarily and in 25% cases donor site was closed with a skin graft. All the cases with flap size less than 100 cm² were primarily closed. Even we were able to close the abdomen primarily for a flap of size 216 cm². It was possible because patient was old with lax abdominal wall and the flap was designed in multiple direction one limb in vertical and one limb in oblique direction with wide angle in between them. It allowed undermining and primary closure. However when the width of secondary defects are very large it may not be possible to achieve tension free closure in all cases. In those cases skin graft was necessary for the closure of secondary defects. However the donor site defect was acceptable by all patients.

All the authors have designed the flap only in one direction either in superolateral or inferolateral direction. But one of our flap was designed in two direction (case no 3) which was not reported previously. However more and more cases are to be done to prove the safety of this flap design. In one of our cases (case no 2) flap was used for circumferential skin loss on both the flexor and extensor aspect of forearm. Use of PUP flap in this conditions has not been reported previously.

Limitations of this study are less sample size and lack of comparative group.

CONCLUSION

Paraumbilical perforator flap is a very safe and reliable option for coverage of soft tissue defect of upper limb from finger tip to elbow region. With proper planning and execution it can be a suitable alternative to free flap and groin flap for coverage of large and complex defect of upper limb.

Legends for figure

1. Complex wound on extensor aspect of right forearm with avulsion of tendons from its origin (upper). Tendon repaired (middle) and wound covered with paraumbilical flap (lower).

2. High voltage electric burn involving both flexor (upper)and extensor aspect (middle figure) of the distal forearm. Paraumbilical flap was planned based on inferolateral side of umbilicus 6 cm away from it. Flap designed to cover both extensor and flexor aspect of forearm in same setting (lower) . Flap extends well beyond mid axillary line.
3. Wound after debridement (upper left , lower left). Intra operative picture of flap harvest with donor site covered with skin graft prior to flap inseting (upper right) .post operative picture 1 week after flap detachment . Well settled flap on flexor aspect (middle right) and extensor surface (lower right)
4. Patient with wound on the dorsum of hand, extensor aspect of forearm extending to some portion of flexor aspect. Flap was designed with base at the inferolateral portion of umbilicus and flap was raised with one limb in the vertical direction and other in the oblique direction according to the requirement (upper) . Flap raised in subfascial level above the muscle layer (middle) . Donor side was primarily closed even after harvest of such a large flap and flap is well settled (lower) .
5. Total degloving of right ring finger and paraumbilical flap designed (upper left) . Identification of perforator (lower left) . Primary thinning of the flap done at distal portion (upper right) . Flap in situ (middle right) . Well settled flap 3 month after repair (lower right).

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