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Original Article

Outcome of Paraumbilical Perforator Flap for Coverage of Soft Tissue Deficiency around the Forearm and Hand

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ABSTRACT

Introduction: *Soft tissue injury of the forearm with exposed bone, tendon, or hardware is a challenging reconstructive problem. The coverage choice varies from primary closure to microvascular free tissue transfer.* ***Objective:*** *This study was designed to know the complications and the outcome of paraumbilical perforator flap following coverage of soft tissue deficiency around the forearm and hand.* ***Methods & Materials:*** *A prospective observational study was conducted at NITOR from January 2020 to December 2021. Study population was patient with soft tissue defect around hand, wrist or forearm requiring flap coverage meeting the selection criteria.* ***Results:*** *The mean age was 29.1±10.7 with male (90%) predominance. Machinery injury was the main cause of injury (66.7%). The mean wound dimension was 64.6±41.8 cm² and flap dimension was 88±48.6 cm². The mean duration*

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of injury to reconstruction of defect was 22.5±7.1 days. In 7 (33.33%) cases, donor site could be primarily closed while in 14 (66.67%) cases, split thickness skin grafting was needed. The donor site complications were hypertrophic scar (9.5%, n=2), wound infection (4.8%), n=1) and loss of grafted skin (4.8%, n=1). Marginal necrosis, and partial necrosis occurred in 3 (14.3%) and 1 (4.8%) case respectively. In 17 (81%) cases there was complete flap survival. ***Conclusion:*** *Paraumbilical perforator flap is a reliable option for coverage of soft tissue deficiency of the hand, forearm and wrist having unique attributes including easy planning and quick harvesting, consistent perforators and negligible donor site morbidity.*

Key words: *Paraumbilical Perforator Flap (PUP), Soft Tissue Defect, Forearm Reconstruction, Hand Reconstruction, Donor Site Management*

INTRODUCTION

The upper extremities are the most frequently involved sites of injuries following trauma from motor vehicle accidents, assaults, infections and electrical burns[1]. Extensive damage to the deeper tissues such as muscles, blood vessels and nerves, etc takes place with exposure of tendons, vessels, nerves, bones and joints, which requires early soft tissue cover by flaps[2]. Soft tissue injury of the forearm with exposed bone, tendon, or hardware is a challenging reconstructive problem[3].

As the hands and forearms are generally exposed, they have a high probability of injury. Severe trauma to the hands or forearms, such as electrical injuries, hot-crush injuries, crush injuries, and deep burns often result in deep defects of the skin tissues and exposure of tendon or bone[4]. Such wounds are difficult to repair and severely impact the functions of the hand and forearm. Skin graft on such wounds can't survive well and achieve good appearance and function[5]. The abdominal pedicle flaps are often used in such cases, most of which are random flaps. However, the application of random flap is limited by the length/width ratio, swollen pedicle, and inconvenient[6].

The choice of flap coverage depends on the requirements of the patient, both from a coverage perspective as well as a functional perspective[3]. There are many treatment options. Coverage choices may include primary closure, skin grafting, local cutaneous flaps, fasciocutaneous transposition flaps, island fascial or fasciocutaneous flaps, local or distant one-stage muscle or myocutaneous transposition, distant pedicle flaps, and microvascular free tissue transfer. Appropriate management requires careful consideration of all alternatives among the reconstructive ladder[7].

The use of free tissue transfer (FTT) produces tissue that is an excellent cover for exposed soft tissue. But, life-threatening injuries or other medical illness may preclude immediate lengthy complex and technically demanding reconstruction[2]. Traditional pedicled flaps often fall short in length, making it difficult for them to cover more proximal

forearm defects, and are used less frequently due to issues like donor site complications and stiffness in the extremities. The introduction of the axial groin flap has transformed the approach to managing hand injuries. But this flap has some limitations; it is insufficient for the large defects of the hand, adjacent forearm, and the defects around elbow[8]. The limb edema is constantly noticed due to the dependent position of the limb. Single large raw area in the hand and forearm are difficult to cover with conventional groin or hypogastric flap[9].

It is obvious that the advent of microvascular free flaps has revolutionized the approach to the acute hand injuries with extensive soft-tissue loss. In the current era of microvascular surgery, pedicled distant flaps still play a valuable role in reconstructing soft tissue in the hand and forearm. Prompt coverage of open hand wounds is widely recognized as crucial for achieving better functional outcomes. However, in the immediate aftermath of trauma, especially in cases of severe hand injury, it is often challenging to reach a facility with a specialized team capable of performing free-flap surgery. For this reason, pedicled distant flaps should be performed as a salvage procedure in such cases[10]. Historically, pedicled flaps from the abdomen and chest have been utilized to provide regional coverage with reasonable success. Commonly, these are random pattern flaps with restricted length to width ratios. By incorporating perforators of an axial vessel, however, a traditional abdominal flap may have an extended length to width ratio[3].

The objective of this study was to evaluate the outcome of paraumbilical perforator flap for coverage of soft tissue deficiency around the forearm and hand.

METHODS & MATERIALS

This prospective observational study was conducted at the National Institute of Traumatology and Orthopedic Rehabilitation (NITOR), Dhaka, from January 2020 to December 2021. A total of 25 cases were initially included, but due to the COVID-19 pandemic, 4 cases were lost to follow-up, resulting in 21 patients. A purposive, non-randomized sampling technique was used, with inclusion criteria covering patients of all ages and genders who had soft tissue defects with exposed bones, tendons, vessels, or nerves on the forearm, wrist, or hand. Exclusion criteria included active infections, unstable fractures, potential vascular injury from prior surgery, psychiatric disorders, and superficial defects.

Data on demographic and clinical variables such as age, gender, injury mechanism, smoking history, comorbidities, wound and flap dimensions, and time to reconstruction were collected. The outcome variables included flap success and complications. The surgical procedure involved serial debridement, stabilization of fractures, and paraumbilical flap coverage. Flap division occurred after three weeks, and donor sites were closed or grafted as necessary. Postoperative monitoring focused on complications like infection,

necrosis, and hematoma. Patients were discharged on the 5th day, followed for 12 weeks, and advised on physiotherapy.

Data were collected using a structured questionnaire and analyzed with SPSS version 25.0. Categorical data were presented as frequencies, while quantitative data were expressed as means and standard deviations. Fisher's exact test, Chi-square tests, and independent t-tests were used, with a p-value <0.05 considered significant. Ethical approval was obtained, and all patients provided written informed consent following the Helsinki Declaration.

RESULTS

During this study, 25 cases with soft tissue deficiency around the forearm and hand who full-filled the inclusion criteria for this thesis were included. But due to COVID-19 pandemic situation, 4 cases were lost to follow up and a total 21 cases could be analyzed. Marginal necrosis, and partial necrosis occurred in 3 (14.3%) and 1 (4.8%) case respectively. In 17 (81%) cases there was complete flap survival. **Table I** showed the distribution of patients by age. In this study, the highest number of patients 12 (57.1 %) were 15 to 26 year age group followed by 5 (23.8%) cases in 39 to 50 year age group and lastly 4 (19%) cases in 27 to 38 year age group. The mean age was 29.1±10.7 years with range from 15 to 50 years.

Table – I: Distribution of Cases According to Age (*n*=21)

Age (In years)	Frequency	Percentage
15-26	12	57.1
27-38	4	19.0
39-50	5	23.8
Total	21	100.0
Mean±SD	29.1±10.7	

Figure 1 shows the gender distribution of the study patients. Male was 19 (90%) and female 2 (10%) with a male-female ratio of 9.5:1.

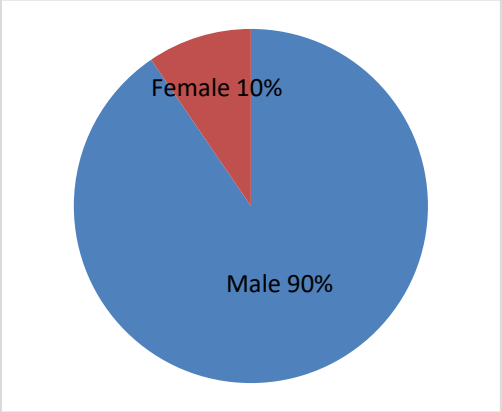

Figure – 1: Gender Distribution of the Study Patients (*n*=21)

Table II showed that the leading cause where 66.7% (n=14) cases were due to machinery injury while in 28.6% (n=6) cases were due to motor vehicle accident. The remaining 1 (4.8%) case was due to physical assault.

Table – II: Mechanism of Injury of the Study Patients (*n*=21)

Cause of Injury	Frequency	Percentage
Machinery Injury	14	66.7
Road Traffic Accident	6	28.6
Physical Assault	1	4.8
Total	21	100.0

Most of the primary wound size was in between 31 cm^2 to 60 cm^2 which was in 9 (42.9%) cases. In 5 (23.8%) cases, it was <30 cm^2 and the rest 7 (33.33%) cases, the wound size were ≥60 cm^2. The mean wound size was 64.6±41.8 cm^2, ranging from 24 cm^2 to 162 cm^2 (**Table III**).

Table – III: Primary Wound Dimension of the Cases (*n*=21)

Wound Size	Frequency	Percentage
≤30 cm^2	5	23.81
31-60 cm2	9	42.86
>60 cm^2	7	33.33
Total	21	100.00
Mean±SD	64.6±41.8	

In 6 (28.6%) cases, the flap size was ≤50 cm^2. In most of the cases e.g. 10 (47.6%), the flap size was in between 51 cm^2 to 100 cm^2. The mean flap size was 88±48.6 cm^2, ranging from 35 cm^2 to 200 cm^2 (**Table IV**).

Table – IV: Distribution of Cases According to Flap Dimension (*n*=21)

Flap Size	Frequency	Percentage
≤50 cm^2	6	28.57
51-100 cm^2	10	47.62
>100 cm^2	5	23.81
Total	21	100.00
Mean±SD	88±48.6	

Table V showed that 8 (38.13%) cases were operated within 12 to 19 days and 20 to 27 days each. The average duration of injury to reconstruction of defect were 22.5±7.1 days ranging from 13 days to 34 days.

Table – V: Duration of Injury to Reconstruction of Defect (days) (*n*=21)

Duration of injury to reconstruction of defect (days)	Frequency	Percentage
12-19	8	38.10
20-27	8	38.10
28-35	5	23.81
Total	21	100.00
Mean±SD	22.5±7.1	

In 7 (33.33%) cases, donor site could be primarily closed while in 14 (66.67%) cases, split thickness skin grafting was needed (**Table VI**).

Table VI: Donor Site Management (*n*=21)

Donor Site Management	Frequency	Percentage
Primary Closure	7	33.33
Split thickness skin grafting	14	66.67

Out of 21 cases, in 17 (81%) cases flap has survived completely. Marginal necrosis, and partial necrosis occurred in 3 (14.3%) and 1 (4.8%) case respectively. There was no instance of either subtotal loss to complete flap loss (**Table VII**).

Table – VII: Distribution of Cases According to Flap Outcome (*n*=21)

Flap Outcome	Frequency	Percentage
Completely Survived	17	80.95
Marginal Necrosis	3	14.29
Partial Necrosis	1	4.76

Out of 21 cases, complication occurred in 5 (23.8%) cases. Among them, 4 (19%) were at donor site and 1 (4.8%) occurred in flap area. The donor site complications were Hypertrophic scar (9.5%, n=2), wound infection (4.8%), n=1) and loss of grafted skin (4.8%, n=1). In 1 (4.8%) case, there was flap site complication which was venous congestion (**Table VIII**).

Table – VIII: Distribution of Cases According to Complication (*n*=21)

Complication	Frequency	Percentage
No complication	16	76.2
Donor site complication	4	19.0
Hypertrophic scar	2	9.5
Skin loss	1	4.8
Infection	1	4.8
Flap complication	1	4.8
Venous congestion	1	4.8

The significance between flap size and flap outcome was calculated. The calculated *p*-value was <0.05 which was significant. The higher the flap size, the lower the chance of flap survivability.

Table – IX: Significance Between Flap Size and Flap Outcome (*n*=21)

Outcome	Mean	SD	p value
Complete flap survival	81.88	47.41	0.039
Some percentage of flap loss	107.60	52.47	

p-value was calculated with two sample t test with unequal variance

DISCUSSION

The PUP flap is a safe and consistent flap in terms of Rich blood supply due to presence of multiple perforators around

the umbilicus. The other advantages of this flap include easy harvesting, no need for microsurgical setup, needs less expertise and fast learning curve. Furthermore, the positioning of the hand with abdomen is comfortable and amiable to the patients, especially in paediatric patients[11]. On the other hand, axial abdominal skin flaps such as groin flap or superficial inferior epigastric artery flap have the advantage of narrower pedicles, usually enabling primary closure of the donor site. The groin flap based on the superficial circumflex iliac artery was popularized by McGregor and Jackson. It is a very useful flap for hand defects, but it is difficult to use this flap for extensive forearm defects because of the inferior and uncomfortable position of the flap. Another useful flap for hand reconstruction is the superficial inferior epigastric artery flap described by Shaw and Payne. Although this flap has a potential to cover larger areas, it also inconvenient for extensive volar forearm defects because of uncomfortable upper-extremity position[10].

Due to the consistent presence of large number of perforators around umbilicus, Doppler examination of the perforator needs not to be routinely done[12]. The mean age of the present study was 29.1±10.7 years with range from 15 to 50 years. This age group is the active group who has to work at outside and potential health hazard. This is also evident in other studies. In the study of Chikte & Goud, mean age of their cases was 28.83 years and Demirseren, et al., also observed the involvement of age group between 12 and 54 years with mean age of 36.2 years. Both of the results are in concordance with our study[2,13].

Male was 19 (90%) and female 2 (10%) with a male-female ratio of 9.5:1. Male preponderance (70/83) and (21/23) has also been observed by Mishra and Sharma and Demirseren, et al., respectively[13,14]. However, our observation of 90% male preponderance may be attributed to social composition of our population where more often men is performing outdoor work and hence is more prone to the trauma. In 66.7% (n=14) cases, injuries were due to machinery injury while in 28.6% (n=6) cases it was due to motor vehicle accident. The remaining 1 (4.8%) case was due to physical assault. In the study of Mishra and Sharma vehicular accident was the most common cause of injury while ***Mir, et al.***, found fall from heght was the most common cause of injury[7,13].

Most of the primary wound size was in between 31 cm^2 to 60 cm^2 which was in 9 (42.9%) cases. In 5 (23.8%) cases, it was <30 cm^2 and the rest 7 (33.33%) cases, the wound size were ≥60 cm^2. The mean wound size was 64.6±41.8 cm^2, ranging from 24 cm^2 to 162 cm^2. The flap dimension was taken according to the primary wound size. In every case, the flap size was about 20 cm^2 greater than wound size. The mean flap size was 88±48.6 cm^2, ranging from 35 cm^2 to 200 cm^2. In 6 (28.6%) cases, the flap size was ≤50 cm^2. In most of the cases e.g. 10 (47.6%), the flap size was in between 51

cm^2 to 100 cm^2. The flap size vary from 101 to 400 cm^2 in cases of Mishra and Sharma, 6 cm–14 cm × 34 cm in study cases of Demirseren et al. and 10 × 14 cm^2 in cases of ***Zang et al.***[13,14,15]. In the study of Lankaram & Karthikeyan all cases the length-breadth ratio is >1:1 and it ranges from 1:1.3 to 1:2.2. This is one of the principle advantages of para umbilical perforator flap where longer flap can be taken with a narrow base[11]. Similar result is seen in the present study. In all cases the length to breath ratio is >1.1 and it ranges from 1:1.17 to 1:2.8. The significance between flap size and flap outcome was calculated. The calculated p value was <0.05 which was significant. The higher the flap size, the lower the chance of flap survivability.

Regarding duration of injury to flap reconstruction, the average duration was 22.5±7.1 days ranging from 13 days to 34 days. Eight (38.13%) cases were operated within 12 to 19 days and 20 to 27 days each. The average duration of injury to reconstruction of defect was 22.5±7.1 days ranging from 13 days to 34 days. In the series of Chikte & Goud, the mean duration was 3 to 6 weeks[2]. In the present study, this duration was shorter than Chikte & Goud,. This may be due to meticulous debridement of the primary wound during admission and re-debridement after 3 to 4 days which has enabled the primary wound to be prepared for flap coverage. But this duration could be even more be minimized. COVID 19 pandemic, requirement of RT PCR report for COVID 19 and optimization of comorbidities of patients renders some delay.

In 7 (33.33%) cases, donor site could be primarily closed while in 14 (66.67%) cases, split thickness skin grafting was needed. The mean flap size where donor site could be primarily closed was 51.6±18.4 cm2 while the mean flap size where STSG needed was 106.2±49.1 cm2. Even when skin grafting was required, the donor area was managed by reducing the raw area by advancing and suturing the margins of the donor defect. This is one of the durability of PUP flap. In other studies like Lankaram & Karthikeyan, most of the cases, the donor site was closed primarily and in some cases where large dimensions of the flap were taken, donor site was closed with a skin graft[11].

Out of 21 cases, in 17 (81%) cases flap has survived completely. Marginal necrosis, and partial necrosis occurred in 3 (14.3%) and 1 (4.8%) case respectively. There was no instance of either subtotal loss to complete flap loss. In the study of Chikte & Goud, there was marginal flap necrosis in 40% cases and total flap necrosis in 20% cases[2]. In the present study, to prevent flap necrosis meticulous attention was given to prevent pedicle torsion by proper positioning of the extremity in the postoperative dressing. Excessive flap tension at inset was avoided as it can also cause necrosis at the periphery[3].

Out of 21 cases, complication occurred in 5 (23.8%) cases. Among them, 4 (19%) were at donor site and 1 (4.8%) occurred in flap area. Most of the donor areas healed very well without any

complications with minimal scarring. The donor site complications were (9.5%, n=2), wound infection (4.8%), n=1) and loss of grafted skin (4.8%, n=1). Hypertrophic scar was treated with intralesional steroid injection. In case of wound hypertrophic scar infection wound swab was sent for culture and sensitivity. Regular dressing was done by appropriate precaution and antibiotic was given according to culture and sensitivity report. Inflammatory markers and protein level checked regularly. In 1 (4.8%) case, there was flap site complication which was venous congestion which was due to failure to maintain position of limb. Position was corrected and careful frequent follow up given to the patient and gradually congestion subsided. The postoperative upper limb venous congestion was found to be less, when compared to the edema observed in groin and hypogastric flaps. This could be because of the immobilization of upper limb at a higher and in an elevated position[2].

Limitations of the study

The limitations of this study include the fact that it did not focus on further reconstructive surgeries that might be required after the initial flap coverage. Additionally, the sample size was relatively small, which may limit the generalizability of the findings to a broader population.

Recommendations

Based on the findings of this study, it is recommended that the Paraumbilical Perforator (PUP) flap be utilized for covering soft tissue defects on both the volar and extensor surfaces of the hand, wrist, and forearm. The results of this study offer valuable insights and can serve as a foundation for future larger studies to further validate the efficacy and outcomes of the PUP flap in soft tissue reconstruction. Additionally, a comparative study could be designed to evaluate different flap techniques, allowing for the identification of the most effective option for soft tissue coverage in similar cases. Furthermore, conducting a multicenter study would provide a broader perspective and a more comprehensive understanding of outcomes across diverse patient populations and clinical settings.

Conclusion

Paraumbilical perforator flap is a suitable option for coverage of soft tissue deficiency around the forearm and hand. It has several unique attributes including consistent perforators ensuring robust blood supply, easy planning and quick harvesting, increased flap length to width ratio and negligible donor site morbidity. This flap is a good armamentarium for coverage of upper limb defect with satisfactory flap survival rate.

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Conflict of Interest

The authors declare no conflict of interest.

Ethical approval

The study was approved by the Institutional Ethics Committee.

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