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Research Article

Outcomes of Loco-Regional Perforator Flaps in Upper Limb Soft Tissue Defect Management

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Abstract

Background: The reconstruction of soft tissue defects in the upper limb is a complex yet frequent challenge. Local flap solutions have proven dependable and standard for addressing significant soft-tissue abnormalities in the proximal and distal upper limb.

Objective: To determine the outcome of loco-regional perforator flaps in terms of post-operative flap survival in soft tissue defects of upper limb.

Methodology: This descriptive case study was carried out over a period of twelve months (January 2020 to December 2020) at the department of Plastic and reconstructive surgery, Dow University of Health Sciences, Civil Hospital, Karachi. Patients of both genders between 18-60 years of age, presenting with upper extremity defects of up to 8 cm length and 4 cm width, with exposed underlying structures thus requiring soft tissue reconstruction, were included. Pedicled, locoregional perforator flap reconstruction was done in all cases. Patients were observed for complications daily until the 7th post-operative day.

Results: 30 patients were included in this study. Mean age was 36.43 years. A male preponderance was observed [21(70%) males and 9(30%) females]. Types of flap shows that radial artery flaps were done in 7 (23.30%), ulnar artery flaps in 11 (36.70%), posterior interosseous artery flaps in 4 (13.30%), lateral arm flaps in 6 (20%) and medial arm flaps in 2 (6.70%) patients. Flap survival was found in 27 (90%) patients.

Conclusion: Perforator flaps are an important tool in small to medium soft tissue defects requiring flap coverage.

Received | 30-05-2025 **Revision** | 13-11-2025 **Accepted** | 01-01-2026

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Keywords | perforator flap, soft tissue defects, upper limb reconstruction

Introduction

Reconstruction of soft tissue defects in the upper limb is an intricate challenge due to its complex tissue anatomy and the dual need to restore both form and function.[1] Upper limb soft tissue trauma due to road traffic accidents may expose vital structures i.e nerves, tendons, joints or bones.[2] Other causes resulting in such defects are oncological resections, burn injuries, contracture releases, and soft tissue infections.

These complex defects are not suitable for merely skin grafting, and must be reconstructed with soft pliable tissue. Options for reconstruction include pedicled loco-regional flaps, pedicled distant flaps (such as abdominal and groin flaps) and free tissue transfer. All these modalities have their own merits and demerits.[3]

Perforator flaps, introduced in late 20th century have revolutionized upper limb tissue resurfacing by allowing defect reconstruction with flexible flap design and

minimal donor site morbidity.[4] A perforator flap is a faciocutaneous or adipocutaneous flap that is vascularized by a perforating vessel which arises from a deeper source axial artery. These vessels travel through or between muscles to supply the overlying subcutaneous tissue and skin.[3,5]

Utilization of perforator based flaps is a big paradigm shift in upper limb soft tissue defect management.[6] The pedicled perforator flaps harvest skin and subcutaneous tissue and conserve underlying muscle, resulting in functional preservation, decreased donor site morbidity and better cosmetic appearance. Also, perforator flaps often do not compromise the main vascular supply. Other benefits are reliable vascular source, improved contour, versatility in designing, short operative time and single stage reconstruction. Despite many advantages, outcome of perforator flaps depends on operative planning, defect size and location. Another very important point to consider is patient comorbid factors. A careful selection of patients and choice of flap will ensure overall better outcomes.

This study aims to evaluate clinical outcomes of perforator flaps in upper limb reconstruction in terms of flap survival and patient satisfaction. It also correlates outcomes with patient comorbid factors, i.e diabetes mellitus size of defect, and choice of flap. This will aid in improving outcomes and decreasing morbidity, as well as in clinical decision making.

Methodology

This was a descriptive study carried out at the department of Plastic and Reconstructive Surgery, Dow University of Health Sciences & Civil Hospital, Karachi over a duration of 12 months w.e.f January 2020 to December 2020. After obtaining IRB approval, a non-probability consecutive sampling was used. All patients of either gender, aged between 18-60 years, presenting to the plastic surgery clinic, or referred from other departments, with upper limb soft tissue defects of upto 8 cm in length and 4 cm in width, requiring flap reconstruction due to underlying exposed structures, were included in the study. Patients with concomitant fractures, segmental bone defects or osteomyelitis were excluded.

Patients with defect size more than 8 cm, and previous surgical scars around the soft tissue defects were also excluded.

After taking informed written consent, a detailed history and examination was carried out and data recorded on a proforma. After standard pre-operative preparation, perforator flap based reconstruction was performed in each case. Standard post-operative care was given to all the patients. Flap parameters were assessed on daily basis until the 7th post-operative day, at which time the patients were discharged unless otherwise indicated. All peri and post-operative data was also recorded on the same proforma.

The data were entered and analyzed with SPSS-22 software. The mean and standard deviation were computed for quantitative characteristics such as age, wound size, and duration of surgery. Frequencies and percentages were computed for qualitative characteristics such as gender, flap type, diabetes mellitus, and flap survival. Relationship between flap survival and factors such as choice of flap, defect size, and diabetes mellitus was assessed using chi-square test. A P-value of $p \leq 0.05$ was considered significant.

Results

There were 30 patients included in this study. Mean age of the patients was 36.43±15.81 years, with a minimum age of 19 and a maximum age of 56 years. There was a male preponderance in this study population, with there being 21(70%) males as compared to 9 (30%) females. Table 1 further elaborates on the demographic and clinical details of the patients population.

Table 1: *Demographic and clinical characteristics of the patients*

Variable	Frequency (n)	Percentage (%)
Age		
≤35years	19	63.3
>35 years	11	36.7
Gender		
Male	21	70.0
Female	9	30.0
Diabetes mellitus		
Present	8	26.7
absent	22	73.3
Defect size		
<6 cm	16	53.3
>6 cm	14	46.7

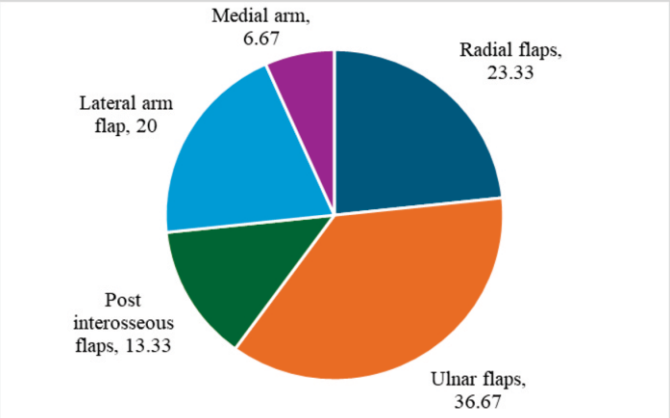

Figure 1: *Types of perforator flaps*

Various perforator flaps were used for soft tissue reconstruction in this study. The most frequently used were ulnar based perforator flaps (n=11, 36.67%), followed by radial artery based perforator flaps (n=7, 23.33%). Figure 1 represents the frequencies of types of perforator flaps used.

Complications were encountered in 3 (10%) of the patients and they all were diabetics.. One patient had complete flap loss, that was debrided and eventually resurfaced with pedicled groin flap. One patient had partial flap necrosis necessitating debridement and repeated dressings until granulation tissue was achieved and the wound was skin-grafted. The third patient had delayed wound healing due to wound infection which was managed conservatively with local wound care and culture specific antibiotics.

Table 2 represents the association between various variables (diabetic status, defect size, and type of flap) and the outcome of the flap procedure. Out of 8 diabetic patients in this study, 3(37.5%) had flap loss/ complications. According to the chi-square value (9.17, p = .01), diabetes is significantly linked to an increased risk of flap loss or complications.

It was observed that defect size was also associated with the outcome of the flap procedure (chi- square = 3.81, p = .05). All 16 patients with flap size less than 6 cm had complete flap survival. Conversely, among the 14 patients with flap size above 6 cm, 3 (21.4%) had flap loss or complication. This outcome is marginally statistically significant, suggesting that bigger defect sizes (>6 cm) may elevate the chance of complications.

The chi-square value (9.63, p = 0.05) showed a there was also a statistically significant relationship seen between flap type and outcome; the posterior interosseus flaps had the highest complication rate (50%).

Figure 2: *defect on extensor surface with exposed ulna, (b) flap elevated on perforator from ulnar artery, (c) 7th post-operative day*

The results show that flap outcomes are influenced by flap type, diabetes, and defect size. Patients with diabetes and those with bigger defects (>6 cm) are more likely to have problems. Flaps that demonstrated 100% survival were radial and ulnar perforator flaps, and medial arm flaps. Posterior interosseous artery perforator flaps had the highest incidence of complications. A few representative patients are shown in Figures 2-4.

Figure 3: *(a) post-burn contracture left elbow, (b) ulnar perforator based flap used to cover elbow region, remaining wound and donor site skin-grafted, (c) 2 weeks post-op*

Figure 4: *(a) post-electric burn defect of 1st webspace, (b) PIA flap raised, (c) PIA flap inset into defect*

Discussion

The upper limb has intricate anatomy and delicate functions. Defects of the upper limb requiring reconstructions are a fairly common occurrence in the field of plastic surgery. These result from high-energy trauma, tumor resections, burns, infections or congenital abnormalities. In a lower- income country like Pakistan, lack of safe

Table 2: *Relationship between patients' diabetic history, defect size and type of flaps with the outcomes of flap procedure (*p≤0.05 was considered significant).*

Variables	Categories	The outcome of Flap Procedures		Total	Chi-square value
		Flap-loss/ complication	Complete survival flap		
Proportion of non-diabetic and diabetic patients	Non-diabetic	0	22	22	9.17 P = .01*
		0.0%	100.0%	100.0%	
	Diabetic	3	5	8	
		37.5%	62.5%	100.0%	
	Total	3	27	30	
		10.0%	90.0%	100.0%	
Defect size	<6 cm	0	16	16	3.81 P = .05*
		0.0%	100.0%	100.0%	
	>6 cm	3	11	14	
		21.4%	78.6%	100.0%	
	Total	3	27	30	
		10.0%	90.0%	100.0%	
Type of flaps	Radial artery perforator flap	0	7	7	9.63 P = .05*
		0.0%	100.0%	100.0%	
	Ulnar artery perforator flap	0	11	11	
		0.0%	100.0%	100.0%	
	Post interosseous artery perforator flap	2	2	4	
		50.0%	50.0%	100.0%	
	Lateral arm perforator flap	1	5	6	
		16.7%	83.3%	100.0%	
	Medial arm perforator flap	0	2	2	
		0.0%	100.0%	100.0%	
	Total	3	27	30	
		10.0%	90.0%	100.0%	

work-place practices add to this burden. Traumatic injuries from traffic accidents and industrial events are the most common causes of soft tissue defects, frequently leading to exposure of neurovascular bundles, tendons, joints and bones that require timely and effective coverage.[8]

Perforator-based flaps have become increasingly favored in upper limb reconstruction because they allow for the transfer of well-vascularized skin and subcutaneous tissue while preserving the underlying muscle,[6] thus maintaining donor site function.

The selection of an appropriate perforator flap depends on several factors, including the defect's size, location, and depth, as well as the availability and reliability of perforators that commonly arise from radial, ulnar, posterior interosseous, and brachial artery. Furthermore these flaps can be thinned to better match the desired contour making it highly suitable for complex defects in upper limb.[10]

In our series of 30 patients, we utilized various flap types. Agarwal et al.[11] reported complete flap survival in 34 paraumbilical perforator flaps used for upper limb defects, with only two instances of minor distal necrosis resolving conservatively. In contrast, Teo et al. reported a 12.7% failure rate in a cohort of 63 freestyle propeller flaps, with most failures occurring early in their experience, suggesting a significant learning curve.[12]

All three flap complications that were seen in this study occurred in diabetic patients. These findings coincide with existing literature that suggests that diabetes notably affects vascular health and impairs wound healing. Diabetic patients may have microvascular dysfunction that results in reduced tissue perfusion, delayed angiogenesis, and impaired response to ischemia.[13,14] Similar findings were seen by Smith et al[15] who suggested that diabetics undergoing free or pedicled perforator based flap reconstruction had higher flap failure rates. Likewise, Lee noted a 20% higher rate of complications involving primarily skin flap necrosis and delayed wound healing in diabetics.[16]

In our study, all complications occurred in patients with defects > 6cm, highlighting that the size of the

defect may indeed be a limiting factor when considering perforator-based flap reconstructions in the upper limb. The is due to the increased metabolic demand placed on the small perforator. Moreover, insetting of large flap onto a concave arm/forearm may increase the likelihood of kinking of the vascular pedicle. This has been demonstrated by Huang et al and Zhao et al,[9] that larger defects are at higher risk of complications and flap loss.[9,17]

Radial[18] and ulnar artery perforators are found proximal to the wrist; the lateral and medial arm flaps are based on perforators of the posterior radial collateral and brachial artery, respectively,[19] and the PIA flap is based on a perforator in the midforearm on extensor surface. Although these perforators are anatomically consistent, the use of a hand-held doppler is an important tool in planning, especially for propellar and islanded design flaps.

The complications seen in our study may reflect technical factors such as kinking due to inadequate perforator dissection, greater arc of rotation, vessel strain particularly in the context of larger defects, and impaired microvascular circulation seen in diabetic patients. These observations are supported by existing literature highlighting diabetes mellitus as a key risk factor for impaired healing and flap failure due to microvascular dysfunction and delayed neovascularization.[13] Despite these complications, almost all flaps healed uneventfully, and patients experienced good functional and aesthetic outcomes, particularly when rehabilitation was initiated early. The color and texture match from local perforator flaps was satisfactory, and donor site morbidity was minimal, especially in cases where primary closure was possible.

Limitations of our study include a small sample size and a relatively short follow-up period, which may restrict long-term evaluation of functional recovery and sensory integration. A steep learning curve and the need for specialized training are important considerations. Furthermore, other comorbid factors such as smoking, COPD, hypertension, and immunosuppression should also be considered.

Conclusion

Perforator-based flaps are a reliable and versatile reconstructive option in upper limb defects, provided that due consideration is given to planning of flap design and the health and comorbid status of the patient, so as to improve the outcomes.

Ethical Approval:

The Institutional Review Board (IRB), Bolan medical complex hospital, Quetta, approved this study vide letter No. IRB-1086/BMCH/Approval/2020/401 dated 01-01-2020.

Conflict of interest: None

Source of funding: None

Author's contribution

Masroor Ahmad: Conception and design of the study, analysis & interpretation of data , drafting of article, critical revision and Final approval of the version to be published and accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Irfan Ishaq: Acquisition of data, Data Collection and analysis and interpretation

Asadullah Awan: Study design, Data collection and Manu-script Revision

Romaisa Shamim Khan: critical revision of the article, manuscript revision and final approval of the article to be published

Abdul Waheed: Acquisition of data , Manuscript Revision, analysis and interpretation of data

Afzal Bashir: Article Editing, Manuscript Revision analysis and interpretation of data

All authors meet the ICMJE authorship criteria and agree to be accountable for all aspects of the work, ensuring the accuracy and integrity of the research.

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