Original Article

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Assessing the Efficacy of Local Flap Reconstruction for Scalp Defects: A Review of Techniques and Outcomes

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Author`s Contribution

[1,3,6]Substantial contributions to the conception or design of the work; or the acquisition,[4] Data Analysis [5]Drafting the work or revising it critically for important intellectual content, [2]Final approval of the version to be published

Funding Source: None

Conflict of Interest: None

Received: Feb 16, 2026

Revised: June 11, 2026

Accepted: June 16, 2026

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ABSTRACT

Objective: To compare the efficacy of local flap reconstruction with other reconstructive methods for scalp defects in adult patients.

Methodology: A prospective observational comparative study was conducted on 76 patients presenting with scalp defects of varying etiology, including post-traumatic, post-oncologic, and infective causes. Participants were treated using either local flaps or other reconstructive techniques. Data were analyzed using SPSS version 26, with normality assessed by the Shapiro–Wilk test. The Mann–Whitney U test and Chi-square test were applied for group comparisons, while Spearman's correlation evaluated associations between defect size and postoperative outcomes.

Results: Local flaps were used in 34 (44.7%) cases, regional flaps in 18 (23.7%), and free flaps in 24 (31.6%) cases. The overall flap viability was 61 (80.3%), with 3 (3.9%) cases of complete failure. Postoperative complications included infection in 18 (23.7%) patients, wound dehiscence in 12 (15.8%), and hematoma in 3 (3.9%). Correlation analysis revealed no significant association between defect size and healing time ($\rho = 0.021$, $p = 0.842$).

Conclusion: Local flap reconstruction remains a safe, efficient, and aesthetically favorable technique for scalp defect repair, providing outcomes comparable to more complex methods while minimizing operative time and morbidity.

Keywords: Scalp reconstruction, local flap, aesthetic outcome, wound healing, reconstructive surgery.

Cite this article as: Siddiqui R, Khaliq A, Khalid H, Sohail T, Daniel Z, Ali I. Assessing the Efficacy of Local Flap Reconstruction for Scalp Defects: A Review of Techniques and Outcomes. Ann Pak Inst Med Sci. 2026; 22(3):250-254. doi. 10.48036/apims.v22i3.1637.

Introduction

The scalp is a unique anatomical region combining a relatively thin, hair-bearing integument over a convex calvarium, underlain by dense connective tissue and the galea aponeurotica.[1] Scalp defects arise from diverse causes, trauma, oncologic resection, infection, iatrogenic injury, and pressure necrosis, and present reconstructive challenges because of restricted tissue mobility, cosmetic demands, and the need to protect the cranial vault and intracranial contents.[2] Repair choices must therefore balance durable vascularized coverage, contour restoration, hair-bearing skin preservation, and minimal donor-site morbidity.[3]

Epidemiologically, scalp wounds and defects occupy a disproportionate share of head-and-neck reconstructive workload, particularly in older adults who are more likely to undergo cutaneous malignancy excision or present with fragility-related trauma. Oncologic resections of scalp skin cancers frequently leave full-thickness soft-tissue defects that require more than primary closure, and the literature consistently reports tumor resection and trauma as leading indications for scalp reconstruction. Case series and institutional cohorts over the past decade have described sizeable patient series managed with local flaps, regional flaps, or free tissue transfer, reflecting the spectrum of defect sizes and patient comorbidities seen in practice.[4, 5]

Within the reconstructive ladder, local flaps occupy a central role for small-to-moderate scalp defects because they provide "like-with-like" hair-bearing coverage, reliable vascularity, and the potential for single-stage repair with limited donor morbidity. Recent algorithmic reviews and practical series emphasize local flap design

and galeal scoring/undermining techniques to maximize mobility while preserving the hairline and minimizing distortion. For many defects under a certain size threshold, contemporary authors argue that carefully planned local flaps produce superior aesthetic and functional results compared with grafting, while avoiding the complexity and physiologic cost of free tissue transfer.[6, 7]

Nevertheless, the choice between local flap, regional flap, or free flap reconstruction is influenced by defect size, location, prior radiation, scalp laxity, patient comorbidities, and surgeon experience.[8] Recent case series and comparative institutional reports demonstrate that while local flaps yield high primary-take and low major-complication rates in appropriately selected patients, larger or circumferential defects, and those with calvarial or dural exposure, frequently require staged procedures, adjunctive pericranial coverage, dermal substitutes, or free flaps to achieve durable cover and permit timely adjuvant therapy in oncologic cases. Moreover, new modified local flap techniques have expanded the practical envelope of local reconstructions for larger defects.[9, 10]

Despite the presence of various reconstructive alternatives for scalp defects, there is continued misunderstanding about the most suitable technique, especially in small to moderate defects where local flaps are frequently used. New developments in local flap design have increased their range of application, but their efficacy compared with more complex reconstructive techniques has not been sufficiently demonstrated by standardized clinical, aesthetic, and patient-reported outcomes. This deficiency of strong comparative data adds disparity to surgical decision-making, and it might lead to overuse of the resource-intensive surgeries in situations that might be better addressed by simpler ones. Thus, a comparative analysis of local flap reconstruction and alternative methods is necessary to determine their relative effectiveness, complication rates, healing rates, and patient satisfaction to inform evidence-based and patient-focused reconstruction of scalp defects. The present study aimed to compare the efficacy of local flap reconstruction with other reconstructive methods for scalp defects in adult patients.

Methodology

This prospective observational comparative study was conducted in the Department of Plastic and Reconstructive Surgery, PIMS, Islamabad, over a period of 6 months from (30.04.2025) to (30.10.2025). Ethical approval was obtained from the Institutional Review Board (IRB) of PIMS, Islamabad, with approval number: (F-5-2/2024(ERCC)/PIMS dated: (28.04.2025), before commencement of data collection.

The sample size was calculated using the OpenEpi sample size calculator (version 3.01) based on data from a previous study, which reported a complication rate of 14.3% in local flaps and 37.5% in free flaps for scalp reconstruction.[11] Using a 95% confidence interval and 80% power, the minimum required sample size was estimated to be 76 patients (38 in each group).

A non-probability consecutive sampling technique was employed. All patients presenting with post-traumatic, post-oncologic, or infective scalp defects requiring surgical reconstruction during the study period were screened for eligibility. Inclusion criteria consisted of patients aged 18 years and above with full-thickness scalp defects amenable to local or regional flap coverage, who provided informed written consent. Exclusion criteria included patients with active local infection, uncontrolled systemic disease precluding surgery, previous radiation to the scalp, or those lost to follow-up before three months postoperatively.

Data were collected prospectively using a predesigned structured proforma. Baseline demographic and clinical data, including age, gender, etiology, defect size and location, and comorbidities, were recorded. The type of reconstructive technique used, like local flap, regional flap, or free flap, intraoperative details, and duration of surgery were documented. Postoperative outcomes such as flap viability, infection, hematoma, wound dehiscence, and time to complete healing were assessed. Aesthetic outcomes and patient satisfaction were evaluated using a standardized cosmetic outcome scale at 3-month follow-up.

Data were entered and analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were applied to summarize the data. Continuous variables such as age, defect size, duration of surgery, and time to healing were expressed as median (interquartile range, IQR) after assessment of normality using the Kolmogorov–Smirnov and Shapiro–Wilk tests, which indicated non-normal distribution ($p < 0.05$). Categorical variables such as gender, comorbidities, reconstructive technique, flap viability, infection, hematoma, wound dehiscence, and flap failure were presented as frequencies and percentages. For comparison between two

independent groups (Local Flap vs. Other Reconstructive Techniques), the Mann–Whitney U test was applied for non-normally distributed continuous variables, while the Chi-square test and Fisher's exact test were used for categorical variables. To assess the relationship between continuous variables, such as defect size and clinical outcomes (healing time, aesthetic score, and patient satisfaction), the Spearman's rank correlation coefficient (ρ) was computed. A p-value ≤ 0.05 was considered statistically significant for all analyses.

Results

The analysis covered 76 patients with scalp defects. The population of the study included mostly middle-aged adults, dominated by men, and the defects were of traumatic, oncologic, and infective origin. The nature of the defect was spread across the entire scale of the head, with parietal and frontal areas being most frequently affected, and a significant number of patients were found to have underlying medical comorbidities. Local flap reconstruction was the most frequently employed technique, followed by free and regional flaps. Operative duration varied according to reconstructive complexity. Overall, the majority of reconstructions achieved complete flap viability, with only a small proportion experiencing partial compromise or failure. (Table I) Postoperative outcomes are summarized in Table II. Most patients had an uncomplicated postoperative course, with low rates of infection, hematoma, and wound dehiscence. The median time to complete wound healing was 36 days (IQR: 23), and the follow-up completion rate was high (94.7%).

Table I: Baseline Demographic, Clinical Characteristics, and Reconstructive Techniques. (n = 76)

Variable	Category	n (%)
Age (years)	Median (IQR)	43.0 (IQR: 30)
Gender	Male	49 (64.5%)
	Female	27 (35.5%)
Etiology	Post-traumatic	27 (35.5%)
	Post-oncologic	24 (31.6%)
	Infective	25 (32.9%)
Defect Size (cm²)	Median (IQR)	42.2 (IQR: 36.3)
Defect Location	Frontal	19 (25.0%)
	Occipital	17 (22.4%)
	Parietal	22 (28.9%)
	Temporal	18 (23.7%)
Comorbidities	Diabetes	22 (28.9%)
	Hypertension	14 (18.4%)
	Both	21 (27.6%)
	None	19 (25.0%)
Reconstruction Technique	Local flap	34 (44.7%)
	Free flap	24 (31.6%)
	Regional flap	18 (23.7%)
Surgery Duration (min)	Mean ± SD	165.5 ± 99
Flap Viability	Complete	61 (80.3%)
	Partial	12 (15.8%)
	Failed	3 (3.9%)

Table III compares clinical and aesthetic outcomes between local flap reconstruction and other reconstructive techniques. No statistically significant differences were observed between the two groups with respect to baseline characteristics, postoperative complications, healing time, aesthetic outcomes, or patient satisfaction (all p > 0.05).

Table II: Postoperative Complications and Outcomes. (n = 76)

Variable	Category	n (%)
Infection	Yes	18 (23.7%)
	No	58 (76.3%)
Hematoma	Yes	3 (3.9%)
	No	73 (96.1%)
Wound Dehiscence	Yes	12 (15.8%)
	No	64 (84.2%)
Time to Healing (days)	Median (IQR)	36 (IQR: 23)
Follow-up Completed	Yes	72 (94.7%)
	No	4 (5.3%)

There was no significant correlation between defect size and time to healing (p = 0.842), aesthetic score **(**p = 0.148), or patient satisfaction (p = 0.931). **(**Table IV**)**

Table III: Comparison of Clinical and Aesthetic Outcomes between Local Flap and Other Reconstructive Techniques. (n = 76)

Variable	Local Flap (n = 38) Median (IQR) / n (%)	Other Techniques (n = 38) Median (IQR) / n (%)	p-value
Age (years)	42.0 (32.0–60.0)	43.0 (31.0–59.0)	0.948
Defect Size (cm²)	42.5 (27.0–67.0)	41.8 (25.0–54.5)	0.493
Duration of Surgery (min)	170.0 (120.0–210.0)	158.0 (108.0–202.0)	0.638
Infection	8 (21.1%)	9 (23.7%)	0.530
Wound Dehiscence	5 (13.2%)	7 (18.4%)	0.353
Hematoma	2 (5.3%)	1 (2.6%)	0.612
Flap Failure	2 (5.3%)	1 (2.6%)	0.070
Time to Healing (days)	32.0 (21.0–46.0)	38.0 (30.0–49.0)	0.198
Aesthetic Score (1–5)	3.0 (2.0–4.0)	3.0 (2.0–4.0)	0.992
Patient Satisfaction (1–5)	3.0 (2.0–4.0)	3.0 (2.0–4.0)	0.791

Table IV: Correlation between Defect Size and Healing Time. (n = 76)

Variable Pair	Correlation Coefficient (r / ρ)	p-value
Defect Size vs. Time to Healing	0.021	0.842
Defect Size vs. Aesthetic Score	0.158	0.148
Defect Size vs. Patient Satisfaction	−0.012	0.931

Discussion

In this prospective observational comparative study of 76 patients with scalp defects, local flap reconstruction demonstrated comparable clinical and aesthetic outcomes to other reconstructive techniques. The median time to healing for the whole cohort was 36 days (IQR 23), with an overall complete flap viability rate of 80.3% and a flap failure rate of 3.9%. Postoperative infection occurred in 23.7% and wound dehiscence in 15.8% of patients. These

findings broadly align with and add nuance to recent literature on scalp reconstruction.

A study by Gupta et al. described a series of patients undergoing local axial flap reconstruction and reported high take rates and low revision needs when local flaps were chosen according to defect size and tissue laxity; their experience supports our observation that local flaps achieve durable coverage with relatively low failure rates when appropriately applied.[5, 12] Compared with Gupta's cohort, our flap failure rate (3.9%) is within the lower range reported in modern case series, suggesting similar technical success in routine clinical practice.[5]

Technique-specific reports also mirror our findings. The O-Z flap has been advocated as an effective alternative to free tissue transfer for vertex and temporoparietal defects of moderate size, providing good blood supply, hairline preservation, and short inpatient stay; studies by Cao et al. and Lin et al. report high flap survival and low complication rates for appropriately selected defects up to 60 cm^2. In our dataset, where the median defect size was 42 cm^2, the comparable healing times and viability rates support the idea that contemporary local flap designs (including O-Z variants) can achieve outcomes similar to more complex reconstructions when defects fall within that size envelope.[13-15]

Modifications of classic multi-flap techniques also reinforce the flexibility of local options for larger defects. Shetty et al. and Tran et al. described a modified Orticochea three-flap approach with acceptable cosmetic results and low revision rates, emphasizing that meticulous planning and execution extend local flap applicability. Our observation of similar aesthetic scores and patient satisfaction between local and other techniques echoes this: when surgeon selection is guided by anatomy and defect characteristics, local multi-flap solutions provide competitive cosmetic outcomes without the physiological cost of microsurgical transfer.[16, 17]

More recent innovations have pushed the envelope for large defect coverage using bipedicled or "bucket-handle" advancement designs.[18-20] Aldabaany and Hobday reported favorable outcomes using bipedicled scalp advancement flaps for large post-tumor defects, with low major complication rates and short hospital stays in selected patients. These studies suggest that, with appropriate donor-site management, local techniques can sometimes replace free flaps for very large defects in patients who are poor candidates for lengthy microsurgery. Our cohort included a minority of large defects and showed an overall median healing time and complication profile consistent with these reports, lending external validity to the strategy of tailoring flap choice to patient risk and defect characteristics.[10, 21]

A systematic perspective is provided by recent reviews and meta-analyses, which emphasize matching technique to defect size, location, and patient comorbidity. Stanton and colleagues' review synthesized comparative data and concluded that different flap classes each have contexts in which they are optimal. Local flaps often offer shorter operative times and lower donor morbidity for moderate defects, whereas free tissue transfer remains indispensable for very large or composite defects or where prior radiation has compromised local vascularity. Our finding of no significant difference in healing time, infection rates, or patient-reported outcomes between local and other techniques is concordant with the view that appropriate selection, rather than dogmatic preference for one class of reconstruction, determines outcome.[22]

The present study diverges somewhat from parts of the literature in the observed infection rate (23.7%) and wound-dehiscence rate (15.8%), which are modestly higher than some institutional series that report lower superficial infection rates. Possible explanations include differences in patient case-mix (we had a third of defects due to infection and a high proportion with diabetes or combined comorbidities), varying definitions of infection across studies, and differences in perioperative antibiotic or wound-care protocols. Studies that selectively excluded previously irradiated or heavily contaminated wounds typically report lower infectious complications; conversely, cohorts with a high proportion of traumatic or contaminated wounds show higher rates, as seen in our sample.

The results not only correlate with international reports, but also with local data. A Lahore-based study at the Services Institute of Medical Sciences indicated that locoregional flaps provided consistent wound healing and minimal significant complications in large defects of the scalp and forehead, and therefore, the use of flap-based reconstruction in these clinical conditions is useful.[23] In a similar case series, Allama Iqbal Memorial Teaching Hospital, Sialkot, reported that rotation, advancement, and bipedicle flap techniques were an effective method of providing coverage to various degrees of scalp defects with satisfactory results.[24] Also, the descriptive experience of LUMHS Jamshoro on the use of numerous reconstructive techniques of scalp injuries helps to justify

the professional use of flap-based techniques in multiple defect etiologies and surgical scenarios.[25]

Limitations: The observational design cannot eliminate selection bias: surgeons tend to reserve free or regional flaps for larger or more complex defects and local flaps for more favorable wounds, which may dilute apparent differences in outcomes. Several of the cited studies are single-center case series with heterogeneous outcome reporting, limiting pooled inference. Consequently, there is a continuing need for prospective multicenter comparative cohorts that use standardized outcome measures to provide higher-certainty comparative effectiveness data.

Conclusion

Local flap reconstruction remains a highly effective and versatile approach for managing scalp defects, offering comparable healing times, complication rates, and patient satisfaction to more complex reconstructive methods. With an excellent rate of flap viability and minimal postoperative complications, local flaps provide a balanced solution combining surgical efficiency, aesthetic restoration, and functional integrity.

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