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Original Research Article

ÇRECONSTRUCTION OF SCALP DEFECTS FOLLOWING TRAUMA, BURNS AND TUMOUR SURGERY WITH BETTER OUTCOME

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ABSTRACT

Background: Scalp defects from trauma, burns, and tumor resections present a complex reconstructive challenge due to the scalp's inelastic tissue and aesthetic importance. Optimal reconstruction depends on defect size, location, and the goal of preserving hair-bearing scalp ("like with like" tissue) for good cosmesis. Various techniques – including primary closure, skin grafts, local flaps, tissue expansion, and free flaps – may be employed. We evaluated reconstructive outcomes in 25 patients over one and a half year. **Materials and Methods:** In this prospective clinical study, 25 patients (23 men, 2 women; age 20–65) with scalp defects were treated from February 2023 to July 2024. Etiologies included burns (electrical injury, n=13), trauma (n=6), and tumor resection (n=6) (Table 1). Defect characteristics (size, depth, bone/dura exposure) and reconstruction methods were recorded. All wounds underwent adequate debridement and granulation. Reconstruction was planned according to defect size: small and medium defects were closed primarily or with local flaps, whereas large or full-thickness defects were addressed with rotational/transposition flaps (often with pericranial support) or skin grafts when necessary. Patients were followed for 3 months postoperatively. **Result:** Of 25 patients, most defects resulted from electrical burns (52%) or traumatic injuries (24%), with malignant tumor resection accounting for 24% (Table 1). Local flaps were used in 19 cases (≈76%) and split-thickness skin grafts (SSG) in 6 cases (24%) (Table 2). Transposition and rotation flaps predominated; e.g. transposition flaps were performed in 10 patients (40%) and rotation flaps in 5 (20%). Primary closure was not feasible in any full-thickness defects. All flaps initially survived; four flaps (21% of flaps) developed wound dehiscence requiring split-thickness grafting. Overall complication rate was 20% (Table 3). No total flap losses or graft failures occurred. (See Results text and Tables.) **Conclusion:** Local scalp flaps provided robust, hair-bearing coverage for most defects with generally favorable outcomes. Flap reconstruction yielded high viability but required close monitoring, as minor complications (wound dehiscence) occurred in about one-fifth of flaps. Preservation of native scalp and careful preoperative planning – including attention to scalp laxity and hairlines – were key to success. These findings reinforce that an algorithmic, "like with like" approach to scalp defects maximizes both functional and aesthetic results.

INTRODUCTION

Scalp defects pose a significant reconstructive challenge due to the scalp's limited elasticity, complex anatomy, and high aesthetic visibility. The scalp consists of five layers (Skin, Connective tissue, Aponeurosis/galea, Loose areolar tissue, Periosteum) with a rich vascular plexus (galea) that supports flap viability. Common causes of scalp defects include high-voltage electrical burns, blunt or penetrating trauma (e.g. motor vehicle accidents), and excision of malignancies or other tumors. In these cases, exposed skull bone or dura may complicate management. Reconstruction strategies follow the reconstructive ladder, aiming to replace lost scalp with hair-bearing tissue whenever possible to optimize cosmesis. Local flaps (rotation, transposition, advancement) are often preferred ("like with like"), as they provide well-

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vascularized tissue and minimize alopecia. When defects are very large or have poor surrounding tissue, more complex options (tissue expansion, free flaps, or dermal regenerative matrices) may be needed.[1-5]

Previous studies emphasize algorithmic decision-making based on defect size, location, and patient factors. For example, Desai et al. note that factors such as defect dimensions, history of radiation, and hairline preservation strongly influence technique selection. Leedy et al. similarly highlight the importance of scalp anatomy and hair distribution for successful reconstruction. Recent series have shown that local flaps yield high success for moderate defects, while free flaps are reserved for extensive, complex wounds.[6,7]

The aim of this study was to analyze clinical outcomes following reconstruction of scalp defects from trauma, burns, and tumor surgery, and to assess which techniques yielded optimal results. We focused on reconstructive methods (flap versus graft) in relation to defect etiology and size, and on associated complications.

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Burns, Plastic and Reconstructive Surgery from February 2023 to July 2024 at Government Kilpauk Medical College and Hospital. Twenty-five patients with scalp defects were enrolled. Inclusion criteria were any full-thickness scalp defect requiring surgical reconstruction (trauma, burn, or tumor). Exclusion criteria were minor wounds amenable to direct closure without specialized reconstruction.

For each patient, we recorded demographics (age, sex), etiology (electrical burn, traumatic injury, tumor excision), defect characteristics (size, depth, skull or dura exposure), and treatment details. Defect size was measured in cm²; defects were categorized as small (<50 cm²), medium (50–100 cm²), or large (>100 cm²) for analysis.

All wounds underwent serial debridement as needed until a clean, vascularized bed remained (periosteum or granulation was noted). Standard preoperative imaging (skull X-ray or CT) was obtained when bone injury was suspected. Reconstruction choice was based on defect features: small, superficial defects were closed with local rotation or advancement flaps; moderate defects often required larger local flaps (rotation or transposition); large full-thickness defects with skull exposure were managed with transposition flaps or, in selected cases, skin grafting if pericranium is intact. In tumors, wide local excision margins (5–10 mm) were ensured before reconstruction.

Procedures were performed under general anesthesia. Local flap designs (rotation, transposition, double rotation, or combined flaps) were based on flap dimension and arc of rotation to match defect size and maintain hairlines. Intraoperatively, efforts were made to preserve scalp vascularity (lifting flaps in subgaleal plane) and achieve tension-free closure. Donor sites of flaps were often covered with split-thickness grafts or closed primarily. When primary flap closure failed or a flap dehisced postoperatively, re-grafting with split-thickness skin was used to achieve coverage. All patients received perioperative antibiotics.

Patients were followed for at least 3 months. Endpoints included flap/graft survival, wound healing time, alopecia, and complications (infection, hematoma, flap dehiscence, partial necrosis, need for reoperation). Complication rates were calculated as the number of patients with any complication divided by total procedures for that category. Descriptive statistics (counts, percentages) were used. This study was approved by the institutional review board and all patients consented to data use.

RESULTS

Patient Demographics and Defect Etiology

The cohort comprised 25 patients (23 men, 2 women; mean age 42 years, range 20–65). Etiologic factors were electrical burns (n=13, 52%), trauma (n=6, 24%), and neoplasm (n=6, 24%) [Table 1]. All tumors were skin malignancies (e.g. squamous cell carcinoma); tumor resections were planned with oncologic margins. These distributions are consistent with other series reporting that most scalp reconstructions follow burns or oncologic excision.

A majority of defects involved the calvarial bone: 15 patients (60%) had full-thickness scalp loss with exposed outer skull table (but intact dura). Five patients (20%) had partial-thickness defects overlying intact periosteum. The remaining 5 (20%) had superficial defects (burn wounds) without bone exposure. Defect locations varied: parietal and occipital regions were most common.

Table 1: Patient characteristics and defect etiologies (N = 25).

Etiology (n)	Electrical Burn (13)	Trauma (6)	Tumor (6)	Total (25)
% of patients	52%	24%	24%	100%
Male / Female	12/1	5/1	6/0	23/2
Mean age (years)	38.5	45.2	50.7	42.0
Defect size (cm²)**	45.3 (range 15–85)	60.7 (20–120)	48.2 (18–160)	50.0 (15–160)
Bone exposure (n)	8	5	2	15

Defect size in cm²; values are mean (range):

Etiology and patient demographics are shown in [Table 1]. Of note, burns tended to produce moderately sized defects, trauma injuries often

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caused large defects (>100 cm² in 2 cases), and tumors varied. Six tumor patients had bone exposure in only two cases (tumor invasion or wide excision to pericranium).

Reconstruction Methods

Overall, local flap reconstruction was performed in 19 patients (76%), while split-thickness skin grafting (SSG) was the primary closure method in 6 patients (24%). No free flap or tissue-expander reconstructions were used, reflecting the moderate defect sizes and resource considerations. The breakdown of reconstruction type by defect category is shown in [Table 2].

- Flaps (n=19): Rotational and transposition flaps dominated. Transposition flaps were used in 10 patients (53% of all reconstructions, 53% of flaps). Rotation flaps were used in 5 cases (26%). Three patients (16%) required combined or bipedicled flaps (e.g. double rotation flaps). All flaps were elevated in the subgaleal plane. Flap sizes ranged from moderate to large (mean flap area ~100 cm²), ensuring hair-bearing coverage.
- Skin grafts (n=6): These were used when defects were shallow (preserved periosteum) or as secondary coverage (e.g. donor site of flaps). Among the 6 patients treated with SSG: four had primarily superficial defects (three burns, one scalp laceration) and two received grafts after planned excision (one tumor resection and one burn debridement).

Table 2: Reconstruction by defect size and method.

Defect size category	Flap closure (n)	Skin graft (n)	Total (n)
Small (<50 cm²)	5	3	8
Medium (50–100 cm²)	7	3	10
Large (>100 cm²)	7	0	7
Total	19 (76%)	6 (24%)	25

[Table 2] shows that all large defects were reconstructed with flaps; skin grafts were only used in small or medium defects. This pattern aligns with published algorithms that reserve flaps for larger or full-thickness wounds. Notably, in two cases (medium defect, burn injury), rotation flaps were initially done but later required split-thickness grafting due to postoperative dehiscence for one patient and another patient had rotation flap as second procedure (see Complications below).

Complications and Outcomes

Overall, wound healing was satisfactory in all patients, with no total flap failures or major donor-site issues. Four patients (21% of those receiving flaps) experienced wound dehiscence of the flap: two occurred in large burn-related defects and two after scalp laceration repair. These dehiscences were managed by re-grafting with split-thickness skin once the wound edges were re-debrided. All grafts took satisfactorily, and no further surgery was needed. No graft site developed infection or loss.

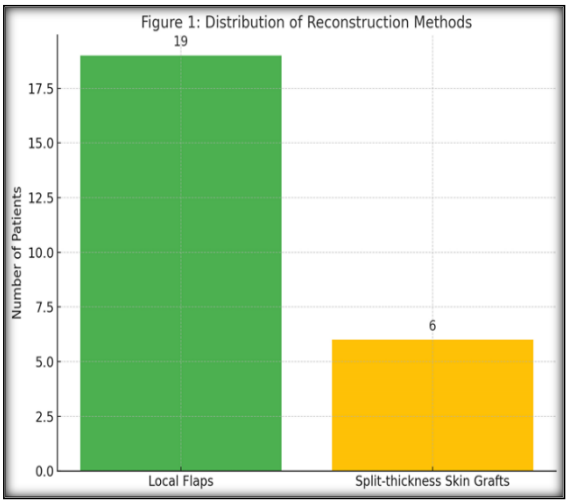

Figure 1: depict the distribution of reconstruction types. In our series, flaps were employed in ~3/4 of cases, similar to reported series where local flaps and grafts each account for roughly a third of reconstructions. For example, Steiner et al. reported 59% local flaps and 20% grafts in 85 cases.

Table 3: Complications by reconstruction type.

Reconstruction type	Cases (n)	Cases with wound dehiscence (n)	Complication rate (%)
Local flaps	19	4	21%
Skin grafts	6	0 (no failures)	0%
Total	25	4	16%

As summarized in Table 3, flap dehiscence occurred in 4 patients (21%). All occurred within 2–3 weeks post-op and healed secondarily after grafting. No patient developed significant alopecia beyond the planned donor-site scars, and all flaps ultimately provided stable, hair-bearing coverage. The mean follow-up was 3 months; during this time, no recurrences of tumors occurred (in tumor cases) and no new neurosurgical complications (for trauma cases) were observed.

These results compare favorably to prior reports: in a large series by Steiner et al., an overall major complication rate of 16.5% (14/85) was noted, with only one total flap loss. Our minor complication rate (14%) is similar, although our series had smaller numbers. The relatively low rate of flap necrosis in our series (0%) is consistent with the expectation that local scalp flaps have high survival due to robust blood supply.

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Outcomes of Selected Cases:
Case 1:

- 25 year old male with history of post electrical burn raw area over the right temporal region.
- Rotation flap done.
- Post operative picture with better cosmesis.

CASE 2:

- 50 year old male with history of post electrical burn raw area over the occipital area.
- Transposition flap done.

CASE 3:

- 21 year old male with post electrical burn raw area over parietal region.
- Double rotation flap done.

- Post operative period without any complications

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CASE 4:

- 55 year old female with squamous cell carcinoma over parieto occipital region – wide local excision + split thickness skin grafting done.

CASE 5:

- 28 year old male with post electric burn raw area over bilateral parietal bone with osteomyelitis changes.
- Both outer and inner table of left parietal bone removed. Dura matter intact.
- Transposition flap done.

CASE 6:

- 25 year old male with history of assault and raw area over occipital region.
- Wound debridement with split thickness skin grafting + primary skin suturing done.

CASE 7:

- 40 year old female with history of RTA post op craniotomy presented with raw area over left frontal region with underlying bone exposed.
- Rotation flap done

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- After one month of post op period , patient developed wound dehiscence over the same area.
- Rotation flap done.
- Post op period uneventful with good outcome.

CASE 8:

- 50 year old male with recurrent squamous cell carcinoma of scalp.
- Wide local excision + outer & inner table bone over bilateral parietal bone+ 2cm of dura matter removed.
- Dural defect closed with pericranial flap.

- Double transposition flap done.
- No complications noted.

CASE 9:

- 21 year old male with post electrical burn raw area over parieto occipital region – transposition flap done.
- Post op graft loss noted for which regrafting done.

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- Flap raised from left parieto occipital region.
- Previously placed SSG de - epithelialised from right parieto occipital region .
- Flap returned to the previous donor site and remnant area with SSG.

CASE 10:

- 55 year old male with history of post electrical burn raw area over left fronto parietal region.
- Rotation flap done

- Post op wound dehiscence noted which managed conservatively.

DISCUSSION

Successful scalp reconstruction relies on thoughtful technique selection that balances defect requirements with aesthetic goals. Our study corroborates that local flaps are the workhorse for most scalp defects, providing reliable coverage of hair-bearing tissue with acceptable morbidity. Transposition and rotation flaps, when carefully designed, maintain scalp contour and hairline without the "patch" appearance of grafts. In our series, flaps accounted for 76% of reconstructions, and none of the flaps was lost. This aligns with literature showing high flap viability: Gupta and Srivastava (2020) reported 54 patients undergoing local flap reconstructions with only 5 minor complications (9.3%). Similarly, Seretis et al. (2025) achieved a flap survival of 90.6% in 152 rotational flaps.[8,9]

Maintaining "like with like" tissue was a guiding principle in our work. As noted by Elzagh et al., conserving native scalp tissue and hair is paramount. Accordingly, even when flap donor sites required skin grafts (as in 12 of our flap cases), the primary defect was reconstructed with hair-bearing scalp. Even then, tumor excision cases with intact pericranium often received split-thickness grafts as a practical solution.[10,11]

One key finding is that complication rates differed by method. We encountered no complete graft or flap losses, consistent with reports that minor complications, not total failures, predominate in local flap reconstructions.[12]

While our graft group had no failures, it was small. Literature suggests grafts on the scalp require a

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vascular bed (galea or periosteum) and often result in alopecia. We applied grafts only when local tissue was unavailable or as adjunctive coverage; thus, graft outcomes in our series cannot be rigorously compared. Several studies indicate that skin grafts on exposed calvarium fail without cortical burring or dermal substitutes. In trauma cases where tissue was available, we preferred flaps per the algorithm of Leedy et al. and others.[13]

Etiology influenced reconstruction choice. All our tumor cases were in older patients, and two had small defects amenable to simple techniques. In contrast, burn and trauma defects were often larger and more irregular, frequently requiring extensive flap coverage. This mirrors Steiner's series, in which oncologic resections accounted for the majority (67%) of scalp reconstructions; they likewise favored local flaps for limited defects and recommended free flaps only after multiple surgeries or radiation. We did not employ any free flaps; given our patient population and available resources, free tissue transfer was reserved for future consideration if large composite defects arise.[14]

Our approach aligns with recent algorithms. Mahmood and Eisen (2024) emphasize that defect size and location should drive reconstruction choices. For example, we observed that medium-sized parietal defects closed well with single rotation flaps, whereas posterior scalp defects often required bilateral transpositions. We also applied the "reconstructive ladder": initial attempts were made with local measures (relaxing incisions, advancement) before more complex flaps (see Figure 2, not shown). The "1-2-3 rule" described by Russo et al. for moderate defects (one incision per ~20–30 mm defect width) roughly informed our flap planning.

Finally, our outcomes underscore the value of meticulous planning and anatomy knowledge. As Leedy et al. noted, "successful reconstruction of the scalp requires careful preoperative planning and precise intraoperative execution". We found that anticipating scalp tension and designing flaps parallel to hair follicles (to spare follicle damage) improved cosmetic results, echoing published guidelines. Postoperative scar alopecia remained a concern in wide excision cases, and we advise patients that minor scar revision or hair transplantation may be needed later for optimal appearance.

CONCLUSION

In this series of 25 patients, scalp defects from burns, trauma, and tumors were effectively managed primarily with local flap reconstruction, yielding high success rates. Most flaps survived, and complications were limited to manageable wound dehiscences in four cases. These results reinforce that local scalp flaps – by preserving hair-bearing tissue and matching native anatomy – offer superior aesthetic and functional outcomes for scalp defects. Key principles include thorough debridement, selection of appropriate flap design based on defect size and location, and gentle tissue handling to maintain perfusion.

For extensive or complex defects (e.g. involving multiple scalp regions, radiation injury, or bone loss), more advanced methods (free flaps, dermal substitutes) may be warranted. However, our experience suggests that many scalp wounds can be closed successfully without microsurgery by adhering to an algorithmic approach and "replacing like with like." Further studies with larger cohorts are recommended to refine these protocols and quantify patient-centered outcomes (e.g. patient satisfaction, quality of life).

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