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Case Series

Surgical Reconstruction of Scalp Defects: A Case Series and Clinical Outcomes

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Abstract

Background: The scalp, a crucial protective barrier for intracranial structures, undergoes intricate reconstruction procedures, demanding detailed anatomical knowledge. Vascular considerations, orchestrated by branches from carotid arteries, sustain scalp health. The multifaceted nature of scalp defects, driven by diverse causes, underscores reconstruction complexity.

Aim and Objective: To evaluate the surgical reconstruction of scalp defects and the associated clinical outcomes.

Material and Method: This was an observational case series conducted over a 2-year period (2025–2026). The study evaluated the use of local flaps, Matriderm, and free flaps for scalp defect reconstruction, with the reconstructive technique selected according to the characteristics of the defect. A total of 18 patients underwent scalp reconstruction, with trauma being the most common etiology (50%). The study details flap nourishment, defect location descriptions, and surgical planning, meticulously assessing intrinsic and extrinsic factors.

Result: 18 patients underwent successful scalp reconstruction, primarily for traumatic (50%) . There was a male predominance (72.2%, and interventions varied across regions, with the parietal area being the most common (44%).

Conclusions: For the majority of scalp defects in this series, local flaps with or without skin grafting provided satisfactory coverage. The choice of reconstructive technique should be individualized according to the size, location, depth, wound-bed condition, and availability of local tissue.

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Introduction

The scalp, as a highly specialized organ, serves as an effective barrier to protect against physical injuries and also facilitates thermoregulation. This anatomical feature is crucial when assessing the well-vascularized flap. The superficial aponeurotic system, along with its vascular, neural, and lymphatic components, plays a crucial role in the flap dissection procedure.

The deeper portion of this anatomical structure contains loose connective tissue, which facilitates the movement of the tissues above it, thereby simplifying the dissection procedure. The easily dissected layer is routinely included in flap dissection, contributing to the overall efficacy of the procedure. In the end, the deep layer called the pericranium provides blood supply to the skull bone and can serve as a vascularized surface in grafts based on the reconstruction plan [1,2]. The scalp is irrigated through branches originating from the internal and external carotid arteries, with the anterior portion receiving blood supply from the supratrochlear and supraorbital arteries, thus preserving circulation to the frontal area. By contrast, the lateral portion gets blood supply from the superficial temporal and posterior auricular arteries. The posterior area receives blood supply from the occipital artery [1].

The complexity of scalp defects stemming from various factorsincluding trauma, tumors or benign lesions, burns, irradiation, infection, congenital anomalies, and cosmetic issuescombined with the scalp's distinctive characteristics, such as the galea's inability to stretch and the scarcity of tissues in this area, renders repair challenging [1,3-5].Effective surgical planning demands an assessment of internal as well as external factors. Surgeons must carefully review patients' health histories, encompassing any chronic conditions,

smoking habits, steroid treatments, radiation exposure, and social factors [1].

Materials and Methods

Study Design and Setting: This was an observational case series conducted in the Department of Plastic and Reconstructive Surgery, Patna Medical College and Hospital (PMCH), Patna. The study included patients presenting with scalp defects requiring surgical reconstruction during the study period. Various reconstructive techniques were selected according to the size, site, depth, and local tissue availability of the defect.

Study Population: A total of 18 patients with scalp defects who underwent surgical reconstruction during the study period were included in the study. The etiologies of scalp defects included trauma, electrical burns, and other causes.

Clinical Assesment: All patients underwent a detailed clinical assessment before reconstruction. Relevant demographic and clinical information was recorded, including age, sex, etiology, anatomical location, and characteristics of the scalp defect.

The size and extent of the defect, condition of the surrounding scalp, availability of local tissue, and suitability of the wound bed were assessed to determine the most appropriate reconstructive option.

Reconstructive Technique : The reconstructive method was selected according to the individual characteristics of the defect. The techniques used included local scalp flaps such as rotation, transposition, and advancement flaps, as well as dermal substitute-based reconstruction and free tissue transfer in selected cases. Full-thickness or split-thickness skin grafting was used when considered appropriate for wound coverage.

Local flaps were planned to provide adequate defect coverage while maintaining vascularity and minimizing wound tension. For larger or more complex defects in which local tissue was insufficient, alternative reconstructive methods, including dermal substitutes and free flaps, were considered.

Postoperative Assessment and Follow-up: Patients were monitored postoperatively for flap or graft viability and wound healing. Follow-up assessment included evaluation for complications such as flap tip necrosis, infection, wound dehiscence, and complete flap loss. The final clinical outcome was assessed on the basis of wound healing, adequacy of defect coverage, and overall aesthetic appearance.

Data Collection and Analysis: Demographic, clinical, etiological, anatomical, reconstructive, and postoperative outcome data were recorded for all patients. The findings were summarized using descriptive statistics. Continuous variables were expressed as mean values, while categorical variables were presented as frequencies and percentages.

Ethical Considerations: The study was conducted after obtaining approval from the Institutional Ethics Committee of the institution. Patient confidentiality was maintained throughout the study. Written informed consent was obtained for the surgical procedure and for the use of anonymized clinical photographs for academic and publication purposes.

Results

"A total of 18 patients underwent scalp reconstruction using various reconstructive techniques." Of these, 13(72.2%) were male and five (27.7%) female, with a mean age of 59.6 years. The most frequent etiologies weretraumatic injuries (n-9), followed by electrical burns (n-6), followed by other causes (n-3).

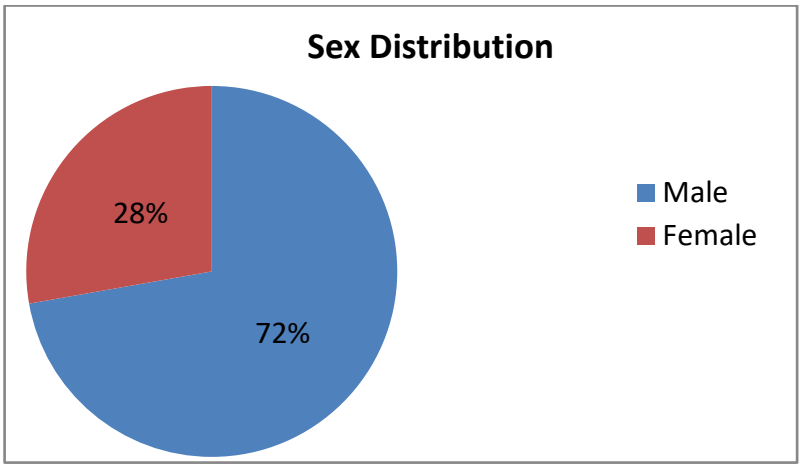

Figure 1: showing sex distribution among scalp defect cases

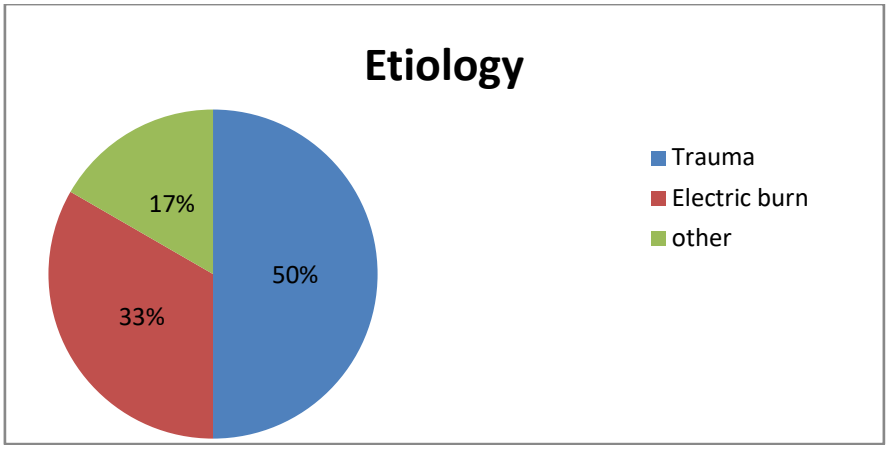

Figure 2: showing etiology of scalp defect

Defects were located in the parietal (8), frontoparietal (4), parietooccipital (4), occipital (1), and a single complex case involving the frontoparietotemporal region(1).

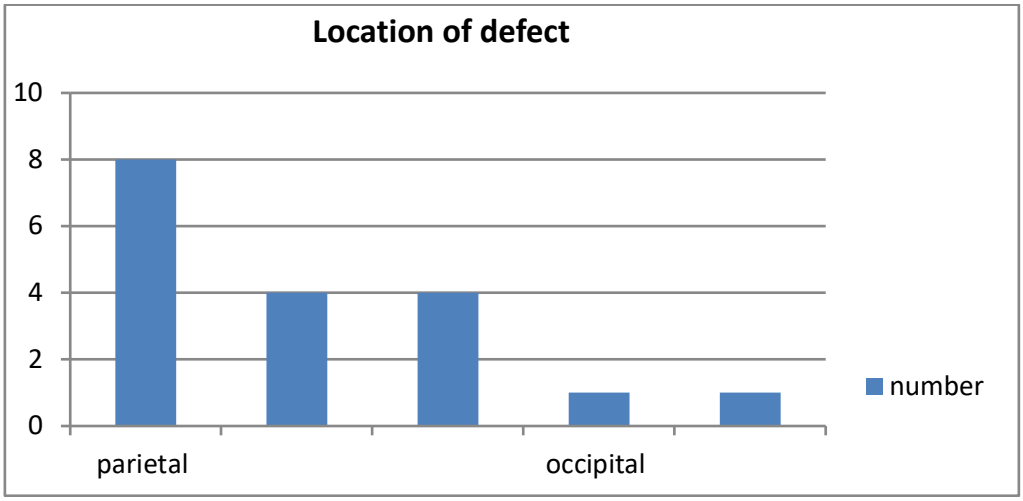

Figure 3: showing location of scalp defect

The most commonly used techniques included Rotation flaps (n=5), transposition flaps (n=3), advancement flap (n=2), BTM (2), Matriderm (1) and free flap (n=2). In three cases, local flap coverage was complemented with skin grafts due to extensive or full-thickness defects.

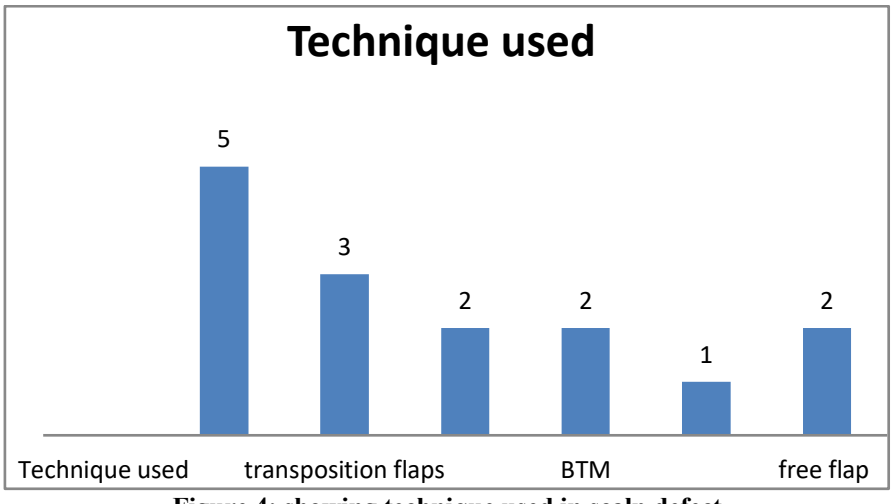

Figure 4: showing technique used in scalp defect

Distal tip necrosis occurred in 2 patients (11.1%), while postoperative infection occurred in 2 patients (11.1%). No cases of complete flap loss or wound dehiscence were observed."

Discussion

The reconstruction of defects in the scalp should include restoration of the hair using tissues from the scalp region as well as maintaining hairlines in a typical pattern [1,10]. The tissues used in the reconstructive procedure in this area will be similar to the lost ones regarding color, hairiness, and thickness, providing a better cosmetic appearance [1,13]. Based on the size, location of scalp and forehead defects, and patients' status, among other factors, various reconstruction techniques can be selected for covering the best results [4,10,11,14,15]. The proposed algorithm describes a selection of different reconstruction options for various scalps and foreheads defects.

Primary wound closure of the defect following undermining or advancement flaps of the margin of the edges gives the best cosmetic result. Primary wound closure, which may require extensive undermining even if the defect is less than 3 cm in diameter, results from the immobility of the scalp [16]. Healing by secondary intention may serve as an effective technique, although it is not preferred by most reconstructive surgeons due to the formation of scars that lack hair. This may be considered for hairless areas [16].

Figure 5: showing rotation flap done for temporal defect

Figure 6: showing rotation flap done for Electric burn defect

Lateral forehead defect management may either be a skin graft procedure on top of the intact pericranium or a temporoparietal fascial flap along with the skin graft, and the rotation flap procedure is preferred when there is no pericranium.

Defects measuring up to 50 cm^2 in the vertex were closed using the double opposing rotation flap procedure. They were also closed in the peripheral area using the rotation flap, and there was no distortion in the hairline. Primary closure of the donor area in the rotation flap procedure gave an excellent aesthetic result. Scalp defects larger than 50 and 200 cm^2 in size were repaired using the transposition flap procedure where the scalp tissue is transferred from a less cosmetically pleasing area to a more attractive area.

The donor area for transposition flaps should always be situated in a less aesthetically pleasing area so that the long hair from the neighboring areas may cover the grafted skin area. When designing these flaps, one must ensure to include a major artery at their base area.

Figure 7: showing Transposition flap done for frontoperiatel defect

Defects in areas like the occipital and temporal regions, which remain cosmetically unnoticeable due to being hidden by long hair, were treated using a skin graft. The temporal area consists of the deep temporal fascia and temporal muscle, which can be grafted using a skin graft. Bone lesions in the temporal area typically occur following oncological surgery or avulsion injuries and require a free-flap reconstruction procedure. For bone-deep lesions, Matriderm or BTM can be utilized. A free split-thickness skin graft can be tried when the bone has been drilled to the diploic level, which improves the granulation process for wounds that cover large areas exceeding 100 cm^2, particularly after the loss of pericranium and when other treatment options have failed. This treatment approach can be taken into account for cases involving intolerance to anesthesia and the existence of other medical issues, such as heart disease. A vacuum-assisted closure device aids in enhancing the wound bed using a dermal regenerative template. [24].

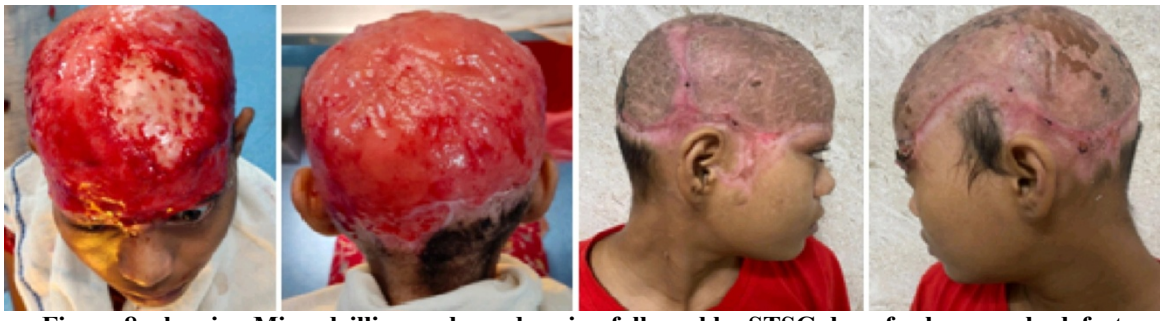

Figure 8: showing Microdrilling and vac dressing fallowed by STSG done for large scalp defect

Figure 9: showing LD free flap done for large scalp defect

In Complications, Distal Tip Necrosis of the Local Flap might result from an inadequately wide pedicle or excessive strain on the wound margins as a result of an insufficient arc of rotation. The triangular burrow at the base should not be removed during the same operation since it is essential for supplying blood to the flap. The frequent reasons for graft rejection in the donor region include damage to the pericranium caused by inappropriate dissection planes or scar tissue in the donor region. [13,23-25].

Table 1: Surgical outcome after scalp reconstruction compared with previous studies

Parameter	Lesavoy et al., 1993	Nagasao et al., 2011	Denewer et al., 2011	Cherubino et al., 2013	Zayakova et al., 2013	Zhou et al., 2020	Present study
Reported cases	10	20	42	86	13	173	18
Procedure used	LF	LF, FF	SG, LF, DF, FF	LF, SG, FF	LF	PC, LF, SG, DF, FF	LF, SG, FF
Immediate complications	None	Minor (3)	Major (12), minor (13)	NM	Minor (4)	Minor (8), complex (5)	Minor (4)
Most common etiology	Skin tumor (60%)	ICH (50%)	Skin tumor (100%)	Skin tumor (85%)	Skin tumor (38%)	Skin tumor (100%)	Trauma (50%)
Most common procedure	LF (100%)	FF (75%)	DF (57%)	LF (37.5%)	LF (100%)	SG (43%)	RF (55%)

NM: Not mentioned; LF: Local flap; FF: Free flap; SG: Skin grafting; DF: Distant flap, PC: Primary closure; ICH: Intracranial hemorrhage.

Conclusions

For majority of the scalp defects, local flap with or without skin grafts from the donor site are sufficient treatment modality. In comparison with local flaps, free flap is more time consuming and has higher morbidity at the donor site that makes the process not feasible for comorbid patients. Selection of a single and double rotation flap depends on the location of the defect and not necessarily its size. The transposition of the scalp flaps offers broader coverages with lesser time consumption and would be more suitable in high risk patients. The debridement of the external surface of the skull is essential in delayed presentation of the electrical contact burn of the scalp area.

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