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# Management of Scalp Substance Loss: Surgical Techniques and Clinical Outcomes Based on an Anatomoclinical Framework

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## Article History

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**Abstract:** Original Research

***Background***: Scalp substance loss (SSL) poses a complex surgical challenge due to the anatomical rigidity and aesthetic importance of the region. Rich vascularization and anatomical peculiarities allow diverse reconstructive options, ranging from primary closure to complex vascularized and free flaps. ***Methods:*** This retrospective study evaluates surgical techniques for SSL reconstruction over 36 months in a single center. Patients were stratified based on defect size, depth, location, and etiology. Outcomes, complications, and patient satisfaction were analyzed. ***Results:*** A total of 48 patients (mean age 42.7 years) were treated. Lesions ranged from 2 to 20 cm. Reconstruction techniques included direct sutures (22.9%), skin grafts (18.7%), local flaps (35.4%), tissue expansion (14.6%), and free flaps (8.3%). Flap survival was 95.8%. Minor complications occurred in 27.1% (mainly flap edge necrosis and delayed healing). Aesthetic satisfaction was high in 89.5% of cases. ***Conclusion:*** The choice of technique depends on an individualized anatomical and etiological analysis. Vascularized flaps and tissue expansion offer reliable and aesthetically pleasing results for moderate to large SSL.

**Keywords:** Scalp reconstruction, Substance loss, Vascularized flaps, Surgical techniques, Aesthetic outcomes.



## 1. INTRODUCTION

Scalp substance loss (SSL) refers to the exposure of the cranial vault following trauma, tumor excision, burns, or infection. Unlike other body areas, the scalp is characterized by low elasticity, a convex surface, and hair-bearing skin, all of which influence reconstructive planning.

Recent advancements, particularly in the use of axial vascularized flaps and skin expansion, have enhanced the possibilities of achieving both functional and aesthetic outcomes. This article aims to provide a comprehensive clinical analysis of various techniques based on a prospective classification of scalp defects.

## 2. Materials and Methods

### 2.1 Study Design

A retrospective study was conducted in the Department of Plastic Surgery at CHU Marrakech between January 2021 and December 2023. Included patients had full-thickness SSL requiring surgical reconstruction.

### 2.2 Classification of Defects

Defects were stratified according to:
- Size:
- Group I: <3 cm
- Group II: 3–7 cm
- Group III: 7–15 cm
- Group IV: >15 cm
- Depth: With or without periosteum exposure
- Etiology: Trauma, tumor resection, infection, burns, others

- Location: Frontal, parietal, occipital, temporal, or vertex

### 2.3 Surgical Techniques

**Reconstructive methods included:**

- Direct primary closure
- Directed secondary healing ± grafting
- Split- or full-thickness skin grafts
- Local advancement/rotation/transposition flaps
- Axial vascular flaps (temporal, occipital, frontal)
- Tissue expansion with subgaleal expanders
- Distant pedicled flaps (latissimus dorsi, trapezius)
- Free flaps (parieto-temporo-occipital, radial forearm, ALT flap)

### 2.4 Outcome Measures

- Flap/graft viability
- Healing time
- Complications (hematoma, necrosis, infection, alopecia)
- Aesthetic outcome: Patient-rated (0–10 scale)
- Need for secondary revision

## 3. RESULTS

3.1 Demographics and Defect Characteristics

- Total patients: 48
- Age: Mean 42.7 years (range 7–74)
- Sex ratio: 1.2 (26 men, 22 women)
- Etiologies:
- Trauma: 41.6% (n=20)
- Tumor excision: 31.2% (n=15)
- Infection: 12.5% (n=6)
- Burns: 8.3% (n=4)
- Other: 6.2% (n=3)
- Defect size distribution:
- Group I (<3 cm): 11 cases (22.9%)
- Group II (3–7 cm): 14 cases (29.1%)
- Group III (7–15 cm): 16 cases (33.3%)
- Group IV (>15 cm): 7 cases (14.5%)

### 3.2 Surgical Technique Breakdown

| Technique | Number of Cases | % |
|---|---|---|
| Direct suture | 11 | 22.9% |
| Skin graft (STSG/FTSG) | 9 | 18.7% |
| Local rotation/advancement flaps | 17 | 35.4% |
| Tissue expansion | 7 | 14.6% |
| Free flaps | 4 | 8.3% |

- Local flaps included:
- Rotation flaps (Imre, S-plasty): 11
- Transposition flaps (Juri, Orticochea): 6
- Expanders were hemispheric (mean volume 450 cc), used mostly for delayed alopecia correction.
- Free flaps included 2 parieto-temporo-occipital and 2 latissimus dorsi flaps.

### 3.3 Complications

- Overall complication rate: 27.1% (13/48)
- Flap edge necrosis (n=4): Managed with conservative debridement
- Partial graft loss (n=3): Successfully regrafted
- Hematoma (n=2): Required drainage
- Infection (n=2): Treated with antibiotics
- Temporary alopecia (n=2): Resolved spontaneously

### 3.4 Healing and Outcomes

- Healing time (mean):
- Direct suture: 12 ± 3 days
- Graft: 16 ± 5 days
- Flaps: 20 ± 6 days
- Expanded scalp: 42 ± 8 days post-expansion
- Flap survival rate: 95.8%
- Reoperation rate: 10.4%
- Aesthetic satisfaction (patient-reported):
- Excellent (8–10/10): 43.7%
- Good (6–7/10): 45.8%
- Moderate (4–5/10): 10.5%
- Poor (<4/10): 0%

## 4. DISCUSSION

Scalp substance loss (SSL) presents a unique challenge in reconstructive surgery due to its complex anatomy, aesthetic significance, and limited elasticity. The convexity of the skull, the presence of hair-bearing skin, and the relatively poor elasticity of the scalp require specific and sometimes advanced techniques. Nevertheless, the rich vascularity and the presence of an expandable subgaleal plane offer reconstructive advantages.

### 4.1. Anatomoclinical Considerations

An anatomoclinical analysis is essential in determining the appropriate surgical approach. The nature, size, depth, location, and etiology of the defect, along with patient factors (age, comorbidities, smoking, previous radiation) guide the reconstructive plan. Small

defects (<3 cm) can often be managed with primary closure, provided that tension is minimized to preserve flap perfusion and avoid follicular distortion or ischemia.

Defects between 3 and 7 cm are typically ideal for local flap reconstruction. Rotation flaps such as the Imre flap or S-plasty offer good coverage with robust vascularity, particularly in the temporal and occipital regions. These areas offer more elasticity due to subcutaneous laxity, especially in younger patients.

For defects between 7 and 15 cm, the options expand to include axial flaps based on specific vascular pedicles (temporal, occipital, frontal). The work of Real *et al*., has shown that the superficial temporal artery can perfuse large areas of the scalp, permitting transposition or advancement of large flaps. In our series, axial flaps were reliable, particularly when designed with a broad base to ensure venous return and minimize distal ischemia.

### 4.2. Role of Tissue Expansion

Tissue expansion has revolutionized reconstructive scalp surgery, particularly in planned cases such as cicatricial alopecia or congenital nevus. The subgaleal plane, known as the Merkel space, allows for the placement of hemispheric or rectangular expanders, supported by the cranial vault. Expansion enables the production of hair-bearing skin that matches color, texture, and thickness, offering superior aesthetic outcomes compared to grafts.

In our study, tissue expansion was successful in 7 patients. The average expansion duration was 6–10 weeks. The process is best suited for elective cases and contraindicated in oncologic, infected, or irradiated fields. Nevertheless, in young, motivated patients, it remains one of the most effective strategies for achieving full aesthetic restoration.

### 4.3. Skin Grafting: Pros and Limitations

Skin grafting remains a cornerstone for SSL when local tissue is unavailable or the defect lies on a vascularized bed such as periosteum, granulation tissue, or subgaleal fascia. Split-thickness skin grafts (STSG) are preferred for larger defects; however, they result in non-hair-bearing skin, which may be aesthetically displeasing, particularly in the frontal region.

In our series, grafts were employed primarily in oncologic resections and infected wounds. Three cases required regrafting due to hematoma or partial loss. While grafts offer a rapid solution, they are best suited as a secondary option when flap reconstruction is not possible.

### 4.4. Distant and Free Flaps for Complex Defects

Defects >15 cm, especially with exposed dura, irradiated tissue, or multiple prior surgeries, often necessitate advanced techniques. Distant pedicled flaps (latissimus dorsi, trapezius) or free flaps (e.g., parieto-temporo-occipital, radial forearm, ALT) provide viable solutions. In our practice, four patients underwent free flap reconstruction with excellent results and low morbidity.

Microvascular reconstruction allows large surface coverage and is often the only option when local tissues are depleted. The latissimus dorsi remains the most versatile flap, while the Juri and Orticochea designs allow complex multi-flap planning using residual scalp.

### 4.5. Complication Management and Prevention

Complication rates in our cohort were 27.1%, which aligns with global reports (20–35%). Most were minor and managed conservatively. Flap edge necrosis occurred in four cases and was addressed by debridement. Flap design must prioritize wide pedicles, minimal tension, and delayed closure if necessary.

Proper preoperative planning, meticulous hemostasis, and postoperative monitoring are essential. In our series, flap viability was verified intraoperatively via color assessment and capillary refill tests. Drain placement and non-compressive dressings were also critical in flap survival.

### 4.6. Aesthetic Outcomes and Patient Satisfaction

Aesthetic restoration plays a pivotal role in patient satisfaction, especially for defects in the frontal or vertex region. Hair direction, scar placement, and contour restoration influence the final appearance. In our study, 89.5% of patients rated their result as good to excellent. Patient education, staged procedures, and secondary revisions (e.g., hair transplant, dermopigmentation) are essential parts of the reconstructive journey.

Overall, the data support an algorithmic approach to SSL based on defect characteristics and patient context. The integration of vascular anatomy, reconstructive ladder principles, and patient-centered care leads to optimal outcomes.

## 5. CONCLUSION

A structured, anatomically-based approach to scalp reconstruction ensures optimal functional and cosmetic outcomes. Local flaps remain the first-line choice, supported by vascular anatomy. Expansion and free flaps are reserved for specific complex cases. Long-term planning and attention to hair direction and scar placement are key to restoring patient identity and quality of life.

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