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*Case Report*

# Staged Pediatric Scalp Reconstruction for Extensive Lacerations with Necrosis Following Agricultural Machinery Injury: A Case Report

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**Abstract**

Pediatric scalp injuries caused by agricultural machinery are rare but potentially devastating with long-term implications on craniofacial growth and psychosocial development. These injuries present unique reconstructive challenges due to the scalp's limited elasticity, robust vascularity and the need to preserve both function and cosmesis in a developing child. This report describes the staged surgical management of a 1.5-year-old boy who sustained extensive scalp lacerations and calvarial fractures following entrapment of scalp hair in a rice-cutting machine. Initial wound closure was followed by partial flap necrosis. Then a secondary procedure involving transposition flap reconstruction and split-thickness skin grafting (STSG) was performed. This case underscores the importance of a systematic, adaptive reconstructive strategy, adherence to the principles of the reconstructive ladder and long-term multidisciplinary follow-up. Psychological support, parental counseling and vigilance for late sequelae were integral components of care.

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## Introduction:

Pediatric scalp trauma most commonly results from blunt force mechanisms such as falls or road traffic accidents. Agricultural machinery-related injuries are less common but tend to be more severe due to their high-energy mechanisms.[1] Rotatory blades of devices of agricultural devices can cause complex lacerations, avulsion injuries and comminuted calvarial fractures.[2] Pediatric patients are particularly susceptible to such trauma due to smaller cranial dimensions, thinner soft tissue envelopes and less developed musculocutaneous support.[3]

The scalp consists of five histological layers: skin, dense connective tissue, galea aponeurotica, loose areolar tissue and pericranium. The tightly adherent nature of the first three layers results in limited elasticity. While the subgaleal space allows for the propagation of hematoma and infection.[4] Pediatric scalp tissue demonstrates reduced thickness and redundancy compared to adults and increases the difficulty of tension-free closure. Reconstruction must accommodate future cranial growth and minimize long-term psychosocial morbidity.[5]

Management is guided by the reconstructive ladder—ranging from primary closure to local flaps, skin grafts, tissue expansion and microvascular free tissue transfer- depending on defect size and complexity. Local flaps are preferred for moderate defects due to their reliable vascularity and preservation of hair-bearing tissue. Successful outcomes depend on timing,

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infection control, adequate debridement and close postoperative surveillance.[6]

## Case Presentation

### Patient Demographics and Initial Trauma

A 1.5-year-old boy was brought to the emergency department following traumatic scalp avulsion caused by entanglement of scalp hair in the rotating blades of a rice-cutting machine two hours ago. The incident resulted in multiple deep scalp lacerations with partial avulsion and comminuted fracture of the underlying skull bone.

**Figure 1:** Initial Presentation

### Initial Clinical Assessment and Imaging

Initial assessment was performed following Advanced Trauma Life Support (ATLS) guidelines. Pediatric Glasgow Coma Scale (GCS) was used to evaluate of patient. The Pediatric GCS is a validated tool for assessing neurologic function in young children, accounting for age-adjusted verbal and motor responses.[7] No focal neurological deficits were noted.

Hemostasis in the emergency room was achieved with pressure dressing. Non-contrast cranial CT revealed multiple calvarial bone fractures with intact dura and without any intracranial hemorrhage. No cervical spine or systemic injuries were identified. Given the mechanism of injury and patient age, wound exploration was performed under general anesthesia.

### Initial Operative Management (Primary Closure)

Initial operative management was undertaken by combined approach of the neurosurgery and plastic surgery team. Neurosurgical team ruled out any need for neurosurgical intervention and the plastic surgery team did the initial wound management. Thorough irrigation with normal saline and sharp debridement of devitalized tissue were performed. Multiple linear viable scalp flaps found. Avulsed bone fragments were removed and intact dura mater was found. After primary evaluation of wound and considering patients massive haemorrhage proceeding to shock, the surgical team decided not to proceed for flap coverage and decided for primary closure. Primary closure was achieved using non-absorbable (Prolene) sutures. A closed-suction drain was placed to prevent seroma and hematoma formation and removed after 48 hours. The family was counseled regarding the provisional nature of the reconstruction and the potential need for secondary procedures due to risk of complications such as wound dehiscence or flap necrosis.[8]

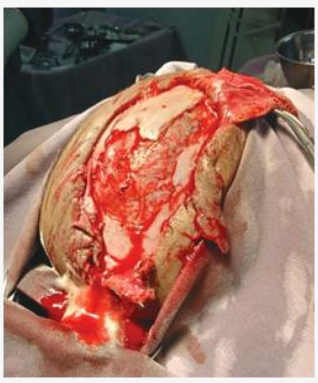

**Figure 2:** Intraoperative Findings

**Figure 3:** After first operation

### Early Postoperative Complication

On postoperative day 4, clinical signs of ischemia were noted in the distal portions of the scalp flaps. The area appeared dusky with patchy black discoloration and surrounding edema—features suggestive of partial flap necrosis.8 There was an absence of granulation tissue and a delayed healing response, indicating vascular compromise, likely secondary to excessive tension or insufficient perfusion.[9]

**Figure 4:** After partial flap necrosis after first operation

### Secondary Surgical Reconstruction

A second stage reconstruction was planned 3 weeks after initial injury. Under general anesthesia, necrotic tissue was excised and the wound bed was reassessed. A transposition flap was raised from an adjacent well-perfused scalp region and transposed to cover the defect. The donor site was resurfaced with a split-thickness skin graft harvested from the thigh. Flap design followed angiosomal principles to ensure adequate perfusion and flap survival.[10] The patient tolerated the procedure well and both flap and graft demonstrated complete take without complications.

### Follow-Up and Outcomes

The patient was followed regularly for 12 months. Clinical assessments included evaluation of flap viability, scalp sensation and hair regrowth. Serial photographs and imaging studies were used to monitor cosmesis and cranial contour. The outcome was satisfactory from both functional and aesthetic standpoints. The patient exhibited normal developmental milestones and no signs of infection or alopecia at the reconstruction site. Cranioplasty for the underlying calvarial defect was scheduled for a later date to align with age-appropriate cranial growth.[11] Another additional observation in this case is that, over time the transposition flap donor site has reduced in dimension.

**Figure 5:** After 3 months follow up

## Discussion

### Unique Considerations in Pediatric Scalp Trauma

The pediatric scalp presents distinct challenges due to its anatomical and physiological characteristics. Compared to adults, children have a thinner dermis, reduced subcutaneous fat and tighter skin adherence to the pericranium, especially over the parietal and occipital regions. This results in limited mobility and tissue redundancy, making primary closure difficult, even in a relatively small defect. Scalp high vascularity is advantageous for healing but may predispose to significant hemorrhage. It can rapidly destabilize pediatric patients due to their smaller circulating blood volume.[4,5,6]

The preservation of hair-bearing tissue is crucial in pediatric patients to prevent long-term disfigurement and psychological distress.[12] A failure to consider these factors in primary reconstruction can result in poor cosmetic results, secondary alopecia and a need for future correction surgeries. Calvarial fractures with exposed dura increase the risk of a lot of complications, notably central nervous system infection, trauma to the brain and cerebrospinal fluid leakage.[13] This necessitates a multidisciplinary approach involving neurosurgery.

In this case, the presence of multiple lacerations, fractured calvarial bones, exposed dura and high blood loss made immediate hemostasis and stabilization the top priorities.

### Application of the Reconstructive Ladder

The reconstructive ladder offers a systematic approach to wound closure. Primary closure is ideal but often unachievable in large or complex scalp defects. Local flaps—such as rotation, advancement or transposition flaps—are frequently the next option. These flaps maintain the native skin quality, hair-bearing surface and provide robust perfusion. In pediatric cases, flap design must also accommodate ongoing craniofacial development.[5,10]

Tissue expansion may be useful for later staged corrections but is less applicable in the acute setting due to risk of infection and time constraints. Free tissue transfer is rarely required in pediatric scalp reconstruction but may be considered in cases with extensive avulsion or devascularization.[5]

In this case, the transition from primary closure to a transposition flap highlights the importance of intraoperative judgment and postoperative reassessment. The transposition flap provided robust vascularity, tension-free closure and excellent tissue matching—all critical elements for long-term functional and aesthetic success. Flap success was optimized by adherence to angiosomal territories, ensuring a vascular base and tension-free inset.[10]

### Management of Flap Necrosis

Flap necrosis is a feared complication after any flap surgery. Contributing factors for flap necrosis include poor flap design (e.g., length-to-base ratio), excessive tension, compromised vascular pedicle and patient-related factors such as infection or hypotension. Early

recognition is critical. Postoperative flap monitoring should include inspection for color change, temperature, turgor, capillary refill and bleeding on pinprick.8

Adjunct tools like handheld Doppler ultrasound or indocyanine green angiography can aid in perfusion assessment in high-risk cases. In this patient, timely debridement followed by well-vascularized flap coverage and STSG minimized further morbidity (for example- risk of infection) and preserved function and cosmesis.[9]

**Psychosocial and Developmental Implications**

The psychological impact of disfiguring scalp injuries in children is well documented. Visible alopecia or asymmetry can result in peer exclusion, bullying and long-term self-esteem issues. Parental anxiety is also a common occurrence following pediatric trauma.[12]

In this case, preoperative and postoperative counseling helped align expectations and fostered trust. Planning for future cranioplasty and psychological support ensured comprehensive care. Consideration of cranial growth patterns is essential, as improper timing or technique can lead to deformities requiring secondary correction.

**Public Health Relevance**

This case emphasizes the complex interplay of surgical planning, age-specific anatomy and psychological care in managing pediatric scalp trauma. It also reflects the need for community education and improved agricultural equipment safety in rural areas.[1,2] Preventive strategies, including mechanical guards, child supervision and public awareness, are crucial in reducing such injuries.

## Conclusion

This case report illustrates the staged surgical management of extensive pediatric scalp trauma following agricultural machinery injury. Early stabilization, staged reconstruction with a transposition flap and STSG and diligent postoperative monitoring resulted in a favorable functional and aesthetic outcome. The case highlights the importance of anticipating complications such as flap necrosis, adhering to reconstructive principles and addressing the broader psychological and developmental needs of the pediatric patient.

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