

Review Article: Post-Trauma Scalp Reconstruction

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ABSTRACT

Traumatic scalp injuries represent a significant challenge in plastic and reconstructive surgery due to the anatomical complexity of the region and the need to restore both protective function and aesthetics. The scalp, composed of multiple layers (skin, subcutaneous tissue, galea aponeurotica, loose areolar tissue, and pericranium), is a richly vascularized structure that protects the skull and brain. Defects resulting from trauma can vary in size and depth, from small lacerations to extensive avulsions that expose the cranial bone, compromising structural and functional integrity, and severely affecting the patient's quality of life [1, 3, 9].

Successful post-trauma scalp reconstruction not only aims to close the defect but also to restore protective coverage, preserve hair function, and achieve an acceptable aesthetic outcome. Over the years, various surgical techniques have been developed, ranging from primary closure and skin grafts to the use of local, regional, and microvascularized flaps, as well as tissue expansion and the use of dermal substitutes [1, 4, 7, 8, 12]. The choice of the optimal reconstructive technique depends on multiple factors, including the size and location of the defect, the presence of healthy surrounding tissue, bone exposure, the patient's age and comorbidities, and the surgeon's experience [3, 10, 12].

This systematic review article aims to provide an updated overview of contemporary techniques in post-trauma scalp reconstruction. It focuses on the most recent and relevant medical literature published in plastic surgery journals over the last 5 to 8 years, in order to synthesize surgical innovations, treatment algorithms, and reported outcomes. This review seeks to be a comprehensive guide for medical professionals and researchers interested in the advanced management of traumatic scalp defects, contributing to the improvement of reconstructive strategies and, ultimately, to the optimization of patient outcomes.

KEYWORDS: Traumatic scalp injuries, scalp reconstruction, plastic and reconstructive surgery, local and regional flaps, microvascularized flaps, tissue expansion, dermal substitutes, skull protection, aesthetic outcomes, surgical techniques

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INTRODUCTION

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protective function and aesthetics. The scalp, composed of multiple layers (skin, subcutaneous tissue, galea aponeurotica, loose areolar tissue, and pericranium), is a richly vascularized structure that protects the skull and brain. Defects resulting from trauma can vary in size and depth, from small lacerations to extensive avulsions that expose the cranial bone, compromising structural and functional integrity, and severely affecting the patient's quality of life [1, 3, 9].

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For the elaboration of this systematic review, an exhaustive search of the medical literature was carried out in specialized electronic databases, including PubMed, Scopus, and Web of Science. The search strategy was designed to identify relevant articles published in the last 5 to 8 years (2017-2025) that addressed scalp reconstruction techniques specifically in the post-traumatic context. The keywords used, in both Spanish and English, included combinations of terms such as "scalp reconstruction," "trauma," "avulsion," "flaps," "tissue expansion," "grafts," "dermal matrix," "plastic surgery," and "complex wound management."

The inclusion criteria for article selection were: (1) publications in plastic surgery journals or related fields of reconstruction; (2) articles describing surgical techniques, treatment algorithms, clinical outcomes, or case reports in post-trauma scalp reconstruction; (3) studies published between January 2017 and September 2025; and (4) availability of the abstract and, preferably, the full text in Spanish or English. Articles that did not focus on post-traumatic scalp reconstruction, narrative reviews without

clear methodology, animal or in vitro studies, and publications with incomplete data or low methodological quality were excluded.

The selection of articles was carried out in two phases. Initially, a review of titles and abstracts was performed to identify potentially relevant publications. In the second phase, pre-selected articles were evaluated in full text to confirm their eligibility and extract pertinent information. Priority was given to studies that offered a detailed description of surgical techniques, functional and aesthetic outcomes, and associated complications. The information extracted from each article included the type of study, the number of patients, the etiology of the trauma, the reconstructive techniques used, the results obtained, and the main conclusions. A minimum of 15 bibliographic references that met the established criteria were collected.

The synthesis of the information was carried out critically and objectively, grouping the findings by type of reconstructive technique and analyzing current trends in the management of scalp defects caused by trauma. Special attention was paid to innovations and evidence supporting the efficacy and safety of different surgical approaches. Finally, all references were strictly formatted according to the Vancouver citation style.

RESULTS

Recent literature review reveals a continuous evolution in post-trauma scalp reconstruction techniques, with a focus on optimizing functional and aesthetic outcomes. The choice of technique depends on the complexity of the defect, the availability of healthy tissue, and patient characteristics. Key findings and the most relevant techniques identified in the reviewed articles are summarized below.

Reconstruction Techniques and Treatment Algorithms

The principles of the reconstructive ladder are fundamental in the management of scalp defects, ranging from simple options to complex procedures [3]. For small defects, primary closure remains the preferred option. However, for larger defects or those with significant tissue loss, more advanced techniques are employed. A working algorithm developed in a tertiary center in Spain, based on 108 cases, describes the application of all steps of the reconstructive ladder, adapting to the extent and depth of the defect [3].

The "1-2-3 Rule" is a stepped algorithm proposed for the reconstruction of medium sized scalp defects, guiding the choice of technique from direct suture to the use of rotation or transposition flaps, depending on the approximation distance of the defect and the need for release incisions [10]. This approach seeks the simplest and most effective technique, minimizing morbidity. Similarly, for extensive defects, a simplified therapeutic algorithm for free flap donor site selection has been proposed, considering factors such as defect size, tissue availability, and patient comorbidities [12].

LOCAL AND REGIONAL FLAPS



Figure1.- Occipito-frontal wound.



Figure 2.- Ying Yang flap marking.

Local and regional flaps are cornerstones in scalp defect reconstruction, especially when tissue with similar characteristics to the recipient area is required, including the presence of hair follicles [1, 4]. It has been shown that defects as large as 33% of the scalp can be successfully reconstructed using local flaps in a single surgical stage [4].



Figure 3.- Rotacion flap.



Figure 4.- Post surgical Ying Yang Flap



Figure 5.- ALT flap

Innovations in local flaps include the "bishop flap" and the "sigma flap," which have proven to be safe and viable for surgical defects in high-tension areas, such as the scalp. These flaps allow for low-tension closure and less undermining of surrounding tissue, resulting in smaller scars [16].

TISSUE EXPANSION

Tissue expansion is a valuable technique for the reconstruction of extensive defects, especially in cases of complex scalp avulsion [1]. It allows for the generation of additional autologous tissue with identical characteristics to the surrounding scalp, which is crucial for achieving optimal aesthetic and functional results, including hairline restoration. A case of complex avulsion in a pediatric patient was successfully reconstructed with a split-thickness skin graft and tissue expander [1].

MICROVASCULARIZED FREE FLAPS

For very large, complex defects or those with bone exposure, microvascularized free flaps represent the most reliable option [12]. These flaps allow for the transfer of large volumes of vascularized tissue from distant donor sites, ensuring robust coverage and tissue viability. Microsurgery is also fundamental in the management of severe burns, especially high-voltage electrical burns, where early free tissue transfer may be necessary [17].

DERMAL SUBSTITUTES AND BILAYER DERMAL MATRIX

The use of dermal substitutes, such as the bilayer dermal matrix Integra®, has gained ground as an effective alternative, especially in large defects or those with a non vascularized bed [7, 8]. This technique allows for two-stage reconstruction, offering a solution for patients with comorbidities or in situations where traditional flaps are not viable. A case of severe electrical burn with bone exposure was successfully reconstructed using the Orticochea technique, which can be complemented with the use of dermal substitutes [9].

MANAGEMENT OF COMPLEX WOUNDS AND OTHER TECHNIQUES

The closure of complex scalp wounds is a constant challenge. Dynamic systems with elastic bands have emerged as a promising alternative, adapting to each wound to optimize healing and achieve favorable aesthetic and functional results [2]. These systems are useful in cases with primary closure deficits.

Furthermore, hair transplantation has been consolidated as a reconstructive technique in post-traumatic cicatricial alopecia, offering significant improvement in the appearance of patients [16]. Hair restoration through follicular unit grafts is a gratifying procedure that has advanced notably, reducing

operative time and improving results.

Finally, the management of complex wounds with autologous fat grafting and NANO FAT has proven effective in tissue regeneration, improving revascularization and graft survival, which can be relevant in scalp reconstruction [15]. Although not exclusively focused on trauma, post-traumatic craniofacial reconstruction, which includes the scalp, presents significant challenges in the management of hard tissues and nerve regeneration [6].

In summary, post-trauma scalp reconstruction is a dynamic field that integrates a variety of surgical techniques, from local flaps and tissue expansion to microvascularized free flaps and the use of dermal substitutes. The selection of the most appropriate technique is based on an algorithmic and multidisciplinary approach, always seeking the best functional and aesthetic restoration for the patient.

CONCLUSION

Post-trauma scalp reconstruction is a complex and constantly evolving field within plastic surgery, demanding a deep understanding of regional anatomy and diverse surgical skills. Recent literature, published in the last 5 to 8 years, underscores the importance of a staged and algorithmic approach to selecting the most appropriate reconstructive technique, adapting to the specific characteristics of each defect and patient.

Techniques ranging from primary closure and skin grafts to local, regional, and microvascularized flaps, along with tissue expansion and the use of dermal substitutes like Integra®, offer a robust therapeutic arsenal. Local and regional flaps remain fundamental for moderate-sized defects, while tissue expansion is invaluable for extensive defects requiring autologous tissue with identical characteristics to the surrounding scalp. For the most complex defects, with bone exposure or significant tissue loss, microvascularized free flaps and dermal substitutes have proven to be reliable and effective solutions.

Innovations such as dynamic systems with elastic bands for wound closure and the application of hair transplants for post-traumatic cicatricial alopecia expand reconstructive options, improving both functionality and aesthetics. The incorporation

of autologous fat grafting and NANO FAT also shows promising potential in tissue regeneration and complex wound management.

Ultimately, success in post-trauma scalp reconstruction lies in meticulous defect evaluation, careful surgical planning, and the application of a multidisciplinary approach. Continuous research and the development of new techniques and materials will continue to improve patient outcomes, restoring not only physical integrity but also quality of life and psychological well-being.

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