Scalp and Forehead Reconstruction

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Abstract

Reconstructing the scalp and forehead is a challenging endeavor frequently undertaken by facial plastic and reconstructive surgeons. There are many anatomical factors to be considered in this area, including multiple neurovascular structure present that should be identified and preserved. Hair morphology and physiology should be considered, and trichophytic techniques should be incorporated into incision planning and closure. The reconstructive ladder must be used when considering options in reconstructing scalps and forehead defects. This article reviews reconstructive options including secondary intention, primary closure, skin grafting, allografts, tissue expanders, and local, regional, and free tissue transfers, among others in the surgical management of forehead and scalp defects. The reconstructive surgeon should be familiar with these techniques and be able to use them when indicated, based on the size, shape, and location of defects.

Keywords
- scalp
- forehead
- defect
- reconstruction

The scalp is the soft tissue covering the bony calvarium. It is essential for the protection of intracranial contents and contributes to the external aesthetic appearance. Damage to the scalp often occurs from trauma, tumor excision, radiation, infection, burns, and alopecia. There are multiple factors that contribute to the complexity of reconstruction in this area. The thickness of skin and subcutaneous tissue, as well as the presence of a thick galea aponeurosis, combined with a convex cranial surface make reconstruction of the scalp especially challenging. Furthermore, the presence of neurovascular structures on the forehead, including the frontal branch of the facial nerve, and the supraorbital and supratrochlear neurovascular bundles, should be considered in any reconstruction of forehead defects. These factors, coupled with large sizes of defects, and radiation history often make primary closure of wounds impossible, necessitating the use of skin grafts, allografts, tissue expanders, and microvascular free tissue transfer. The surgeon should use the reconstructive ladder, employing the simplest form of reconstruction whenever possible. The reconstructive surgeon should also understand concepts of intrinsic skin elastic properties that control stress relaxation and creep. These factors control collagen bundle realignment, elastic fiber fragmentation, and mechanical stretch of skin when tissue expansion is used.[1]

Scalp and Forehead Anatomy

The mnemonic "SCALP" has been frequently used to describe the anatomy of the layers of the scalp. This represents (S)kin, sub(C)utaneous tissue, galea (A)poneurosis, (L)oose areolar tissue, and (P)ericranium (►**Fig. 1**). The scalp has been described as having the thickest layer of skin in the body, measuring between 3 and 8 mm.[2] The skin is supplied by blood vessels and nerves, which run in the subcutaneous tissue superficial to the galea in the scalp, and the frontalis muscle in the forehead. Knowledge of this anatomy is important in designing local flaps and elevating pericranial flaps.

Understanding areas of mobility is also important in scalp and forehead reconstruction. Areas of high mobility are

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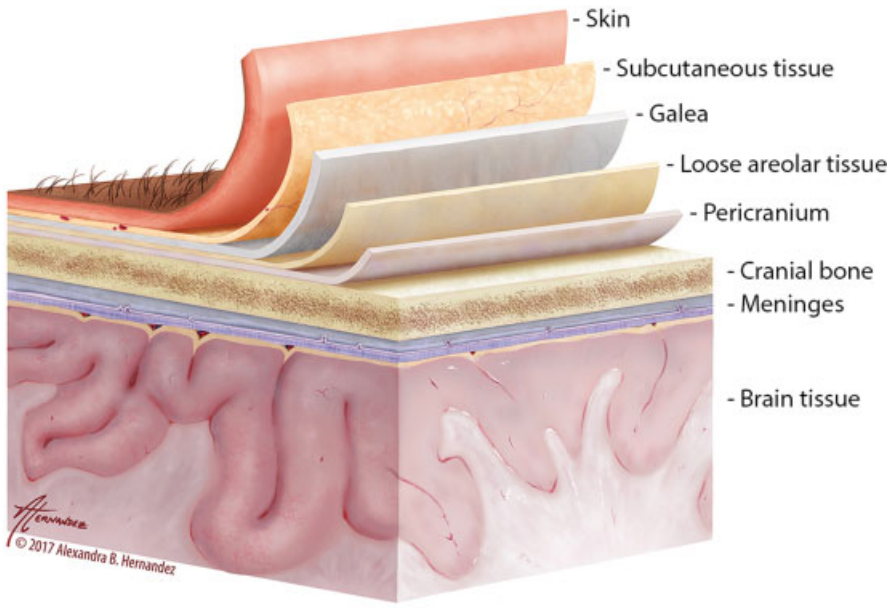

Fig. 1 Layers of the scalp at the vertex.

termed "loose areas," whereas areas of low mobility are referred to as "tight areas." The temporoparietal fascia overlying the temporalis fascia is the area with the greatest amount of mobility, and advantage should be taken of this anatomical feature when designing local flaps in this area. However, at the temporal line, there is adherence of the galea to the pericranium. This leads to decreased mobility of the scalp, and division of these attachments should be performed for improved mobility in this area.[3]

The internal and external carotid arteries both contribute to the vascularity of the scalp. There is extensive arborization of the terminal branches that directly supply the scalp. Formation of collaterals contributes to the redundant blood supply in this area (►**Fig. 2**). The forehead and the anterior scalp are supplied by the supraorbital (lateral) and supratrochlear (medial) arteries. The supraorbital artery exits from the supraorbital foramen, which is usually along a line perpendicular to the medial limbus. The supratrochlear artery usually travels in the subcutaneous plane 1.7 to 2.2 cm from midline.[4] The posterior scalp superior to the nuchal line is supplied by the occipital arteries. Inferior to the nuchal line, musculocutaneous branches perforating the trapezius and splenius capitis contribute to the blood supply.[1]

The trigeminal nerve and cervical spinal nerves contribute to the sensory innervation of the scalp. The superficial division of the supraorbital nerve innervates the skin of the forehead and anterior scalp. The deep division innervates the frontoparietal scalp.

The anatomy of the temporal region is also of clinical importance. There have been multiple anatomical studies performed to shed light on the intricate anatomy of this region.[5,6] The layers of the soft tissue covering of the temporal calvarium includes skin, subcutaneous tissue, superficial temporal fascia (temporoparietal fascia), superficial layer of the deep temporal fascia, temporal fat pad, deep layer of the temporal fascia, temporalis muscle, and periosteum. (►**Fig. 3**) The frontal branch of the facial nerve runs superficial to the superficial layer of the deep temporal fascia within the temporoparietal fascia. It can be located 1.5 to 2 cm above the lateral brow as it courses from the inferior edge of the tragus.[6]

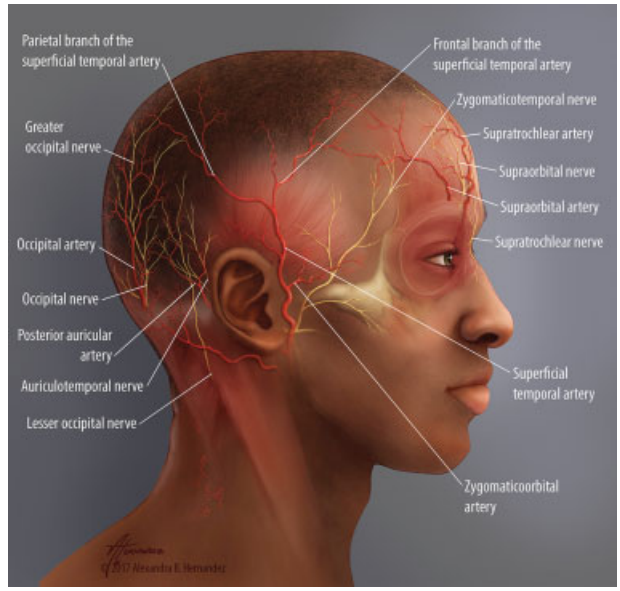

Fig. 2 Blood supply and innervation of the scalp and forehead.

Reconstructive Techniques

Secondary Intention

Secondary intention can be used as a definitive or temporizing surgical treatment of scalp and forehead defects. Healing

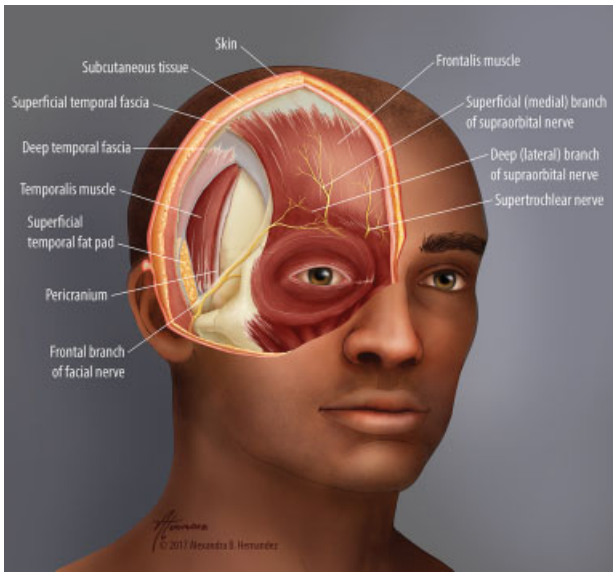

Fig. 3 Layers of the temporal scalp.

by secondary intention allows granulation tissue formation and epithelialization regardless of the presence a pericranial layer. However, it is associated with telangiectasia, alopecia, atrophic scars, and color and profile mismatch. Longer healing times may also delay adjuvant therapy in the case of cancer reconstruction. This technique can be combined with a purse string closure to diminish the size of large scalp defects. Once the size and depth of the defect become more manageable, and adequate granulation tissue develops, skin grafting, allografting, or local flap reconstruction can be performed. It is usually reserved for patients with multiple comorbidities who cannot tolerate general anesthesia for more definitive procedures. This option should be considered, even in the absence of a pericranial layer. Becker et al reported a series of 205 patients with full-thickness defects of the scalp and forehead after Mohs surgery. In 38 patients with bone exposure, there was 100% healing without infection. However, time to epithelialize was 7 weeks for wounds without bone exposure, and 13 weeks when the bone was exposed.[7]

Allografts

Allografts are decellularized matrices comprising a structurally integrated basement membrane complex and an extracellular matrix. They are commonly used in head and neck surgery in oral cavity reconstruction in the form of an acellular dermal matrix (AlloDerm, Lifecell Corporation). Newer materials available to promote granulation tissue formation and healing for cutaneous defects include BioFix Amniotic Allograft (Integra LifeSciences) and MatriStem Wound Matrix (ACell). These materials are available in various forms, including sheets and powder matrices, that can be applied to a defect to promote granulation tissue formation and healing by secondary intention. This technique can be used as a definitive treatment or as a bridge to further procedures such as split-thickness skin grafts or local tissue flaps, as deemed necessary by the reconstructive surgeon.

Skin Grafts

When primary closure local flap closure is impossible and a suitable wound bed is available, split- or full-thickness skin grafts are viable options. Split-thickness skin grafts are commonly harvested from the anterior thigh, when used for major head and neck reconstruction. In our practice, we use a Zimmer dermatome set to 0.014-inch thickness. The length and width of the skin graft are determined by the size of the defect. Once the skin graft is brought in contact with the wound bed, it begins to undergo a series of changes. During the first 48 hours, the skin graft absorbs plasma wound fluid through a process called plasmatic imbibition. Subsequently, vascular ingrowth occurs between days 4 and 7 through the process of inosculation. These small blood vessels eventually grow into the skin graft through preexisting endothelial channels and contribute to a rich vascular network. Full-thickness skin grafts have also been described as a technique of reconstructing scalp defects. Worlicek and Kaufmann described a method of harvesting full-thickness skin grafts from the upper arm, which was used to reconstruct a full-thickness scalp defect with good results.[8]

Local Flaps

Local flaps are advantageous in reconstructing scalp and forehead defects because of the ability to replace the defect with similarly appearing tissue. Local flaps are associated with very low complication rates of 3.4%.[9] Options for local flap closure include rotation, advancement, and transposition flaps. In designing local flaps in the forehead, it is important to follow certain tenets, which include using wide bases and wide undermining, as well as minimal use of cautery.

Due to the thick and inelastic nature of the scalp, advancement flaps are typically not used in isolation. They are combined with a myriad of rotational flaps. The combination of rotation and advancement flaps allows for the distribution of tension over multiple incision lines. The O-to-Z flap and the Orticochea flap have been classically described in closing large scalp defects.[10,11]

Regional Flaps

The temporoparietal fascia flap is a fasciocutaneous flap based on the frontal and/or parietal branches of the superficial temporal artery. It can be used as a regional flap or in free tissue transfer. Other regional flaps that have been described in scalp and forehead reconstruction include trapezius flaps[12] and latissimus dorsi myocutaneous flap.[13] In general, regional flaps are limited in their use because of the versatility of microvascular free flaps. They are commonly used as salvage flaps in patients with poor healing because of radiation history, among other causes.

Tissue Expanders

Where local flaps alone are not sufficient to close a defect, it might become necessary to expand the tissue surrounding the defect by inserting tissue expanders. Tissue expansion is governed by the concepts of biological and mechanical creep. Biological creep refers to increased mitotic activity associated with sustained stretch applied to issue, whereas

Fig. 4 Treatment of patient with a scalp defect using a tissue expander.

mechanical creep is defined as the elongation of skin with a constant load over time beyond intrinsic extensibility.[14] The skin undergoes epidermal thickness, temporary dermal thinning, and increased blood flow during the expansion period. In patients with a history of previous radiation and infection, tissue expansion is associated with high complication rates. This technique should be used in stable, nonradiated wounds. Excellent results can be obtained with detailed patient counseling regarding the transient deformity that will be experienced (►**Fig. 4**). Very large scalp defects can be closed by combining this method with local rotational advancement flaps. It is ideal to place the tissue expanders remote from the defect in the subgaleal plane to avoid extrusion into the wound. Up to 10% of the expander capacity may be added per week. More aggressive expansion in a single session is often limited by patient discomfort or tissue perfusion.

Free Tissue Transfer

Free tissue transfers are typically reserved for very large defects, previously radiated patients, exposed cranial contents, or chronic infection. Advantages of free tissue transfer include bulk of vascularized tissue, and healthy recipient site for skin grafts. The superficial temporal artery and vein are commonly used recipient vessels for anastomoses. The facial vessels and external jugular vein can be used as interposition grafts if the vascular pedicle is short. Alopecia and color and contour mismatch are disadvantages of microvascular free flaps in scalp and forehead reconstruction.

Common free tissue options for reconstructing scalp defects include the latissimus dorsi flap, serratus anterior, radial forearm free flap, anterolateral thigh, rectus abdominis, and omental flaps. Latissimus dorsi and rectus abdominis flaps are usually harvested as muscular flaps only because of the bulk of subcutaneous fat. A split-thickness skin graft is subsequently placed over the muscle. Microvascular free tissue transfer is associated with high success rates in scalp and forehead reconstruction.[15–17] The choice of free flap is typically dictated by the size of the defect and the surgeon's familiarity and comfort level.

Trichophytic Techniques

When reconstructing scalp and forehead defects, it is important to consider the pattern and direction of growth of overlying hair. Avoidance of alopecia begins with meticulous planning of incisions. This involves beveling the blade in the direction of hair follicles. A study by Kadakia et al showed that alopecia can be avoided by using a cold steel scalpel for skin and subcutaneous incision and avoiding cautery and Raney clips.[18] Trichophytic wound closure, commonly used in hair transplant surgery, involves the tangential excision of the upper or lower wound margin to approximately 1 mm. After this is performed, the wound edges are approximated, and hair grows through the incision line. This results in an effective camouflage of the incision.[19]

Conclusion

Scalp and forehead reconstruction requires a detailed understanding of anatomy and familiarity with the myriad of options available for reconstruction. The reconstructive surgeon should consider several factors including size, depth, location, and local tissue quality in choosing a reconstructive option. The reconstructive ladder should be used employing the simplest option possible for wound closure.

Conflict of Interest
None.

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