

29. Scalp and Calvarial Reconstruction

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APPLIED ANATOMY¹⁻⁶

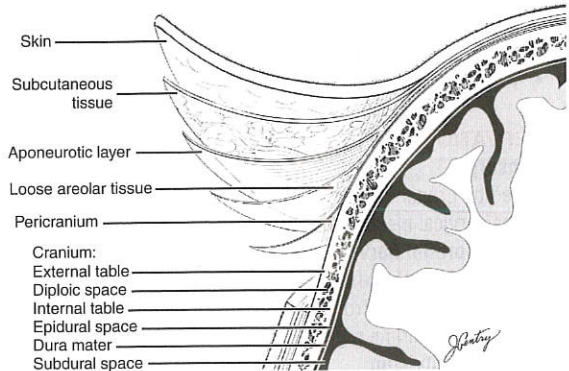
SCALP LAYERS (Fig. 29-1)

- Mnemonic: SCALP
 - **S** (*skin*): Measures 3-8 mm thick
 - **C** (*subcutaneous tissue*): Vessels, lymphatics, and nerves found in this layer
 - **A** (*aponeurotic layer*): Strength layer, continuous with frontalis and occipitalis muscles
 - **L** (*loose areolar tissue*): Also known as *subgaleal fascia* and *innominate fascia*; provides scalp mobility; contains emissary veins
 - **P** (*pericranium*): Tightly adherent to calvarium

CRANIUM LAYERS

- External table
- Diploic space
- Internal table
- Epidural space
- Dura mater
- Subdural space

Fig. 29-1 Layers of scalp and cranium.



VASCULARITY (Fig. 29-2)

Arterial branches and venae comitantes of the **internal and external carotid systems** are divided into **four distinct vascular territories**.

TIP: Extensive collateralization of these vascular territories allows total scalp replantation based on a single vascular anastomosis.

- **Anterior territory**
 - **Supraorbital and supratrochlear arteries** (terminal branches of the internal carotid system).
 - Supraorbital artery arises through supraorbital notch or groove, which is located in line with the medial limbus.
 - Supratrochlear arteries arise more medially, usually in plane with the medial canthus.
- **Lateral territory** (largest territory)
 - **Superficial temporal artery** (terminal branch of the external carotid system)
 - Bifurcates at the superior helix of the ear into **frontal** and **parietal** branches

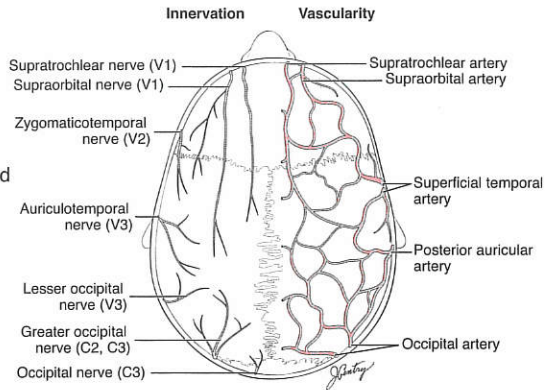


Fig. 29-2 Scalp innervation and vascularity.

■ **Posterior territory**

- Cephalad to the nuchal line: **Occipital arteries**
- Caudal to the nuchal line: Perforating branches of the trapezius and splenius capitis muscles

■ **Posterolateral territory** (smallest territory)

- **Posterior auricular artery:** A branch of the external carotid system

INNERVATION (see Fig. 29-2)

■ **Sensory**

Supplied by branches of the three divisions of the trigeminal nerve, cervical spinal nerves, and branches from the cervical plexus

- **Supraorbital nerve**
 - ▶ **Superficial division**
 - ♦ Pierces the frontalis muscle on the forehead and supplies the skin of the forehead and anterior hairline region
 - ▶ **Deep division**
 - ♦ Runs superficial to the periosteum up until the level of the coronal suture where it pierces the galeal aponeurosis, approximately 0.5-1.5 cm medial to the superior temporal line to innervate the frontoparietal scalp
- **Zygomaticotemporal nerve**
 - ▶ Branches from the maxillary division of the trigeminal nerve
 - ▶ Supplies a small region lateral to the brow up to the superficial temporal crest
- **Auriculotemporal nerve**
 - ▶ Branches from the mandibular division of the trigeminal nerve
 - ▶ Supplies the lateral scalp territory
- **Greater and lesser occipital nerves**
 - ▶ Branch from the dorsal rami of the cervical spinal nerves and the cervical plexus, respectively
 - ▶ Innervate the occipital territory
 - ▶ Greater occipital nerve shown to emerge from semispinalis muscle approximately 3 cm below occipital protuberance and 1.5 cm lateral to midline⁷

■ **Motor**

- **Frontal branch of facial nerve**
 - ▶ Supplies the frontalis
 - ▶ See Chapters 37 and 80 for anatomic location

- **Posterior auricular branch of facial nerve**
 - ▶ Supplies the anterior and posterior auricular muscles, occipitalis muscle

SKIN BIOMECHANICS⁸

Skin biomechanics is important for understanding tissue expansion reconstruction of the scalp.

- **Stress relaxation:** Property of the skin that decreases the amount of force necessary to maintain a fixed amount of skin stretch over time.
- **Creep:** Skin property that gives a gain in skin surface area when a constant load is applied.
 - As force is applied to a leading skin edge, tissue thickness decreases from extrusion of fluid and mucopolysaccharides, realignment of dermal collagen bundles, elastic fiber microfragmentation, and mechanical stretching of the skin.

PRINCIPLES OF SCALP RECONSTRUCTION

- **Replace tissue with like tissue.**
 - Use adjacent scalp for reconstruction if possible.
 - Incorporate at least one main-named scalp vessel into flaps.
 - Consider using scalp tissue from the **parietal region** where scalp mobility is the greatest.
 - Only debride devitalized tissue in acute repair of traumatic defects, because robust vascularity of the scalp may allow recovery of marginal tissues.
 - Employ hair micrografting to improve incision lines and subsequent alopecia secondarily.
- **Consider tissue expansion.⁹**
 - It is useful if local tissue rearrangements are inadequate for reconstruction because of the size of the defect, traumatized local tissue, unacceptable rearrangement of hair patterns, or distortion of the hairline.
 - During the expansion process, exposed bone can be covered temporarily with split-thickness skin grafts either after burring of the outer table or coverage with pericranial flaps.
 - Approximately **50%** of the scalp can be reconstructed with tissue expansion before alopecia becomes a significant issue.

TIP: Local anaesthetic with dilute epinephrine decreases intraoperative skin edge bleeding and can be used to hydrodissect the subgaleal plane.

Minimize the use of hemostatic clips and electrocautery on cut edges of the scalp to prevent potential follicular damage and subsequent iatrogenic alopecia.

Score the galea perpendicular to the direction of desired tissue gain, avoiding inadvertent injury to the scalp arteries that lie superficial to the galea.

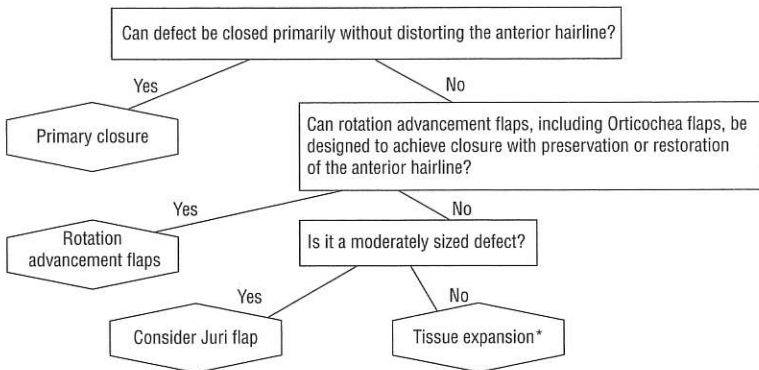
Closure requires approximation of the galea because it is the strength layer.

GUIDELINES FOR RECONSTRUCTION

Reconstructive options vary depending on the defect's cause, location, and size. An algorithmic approach is useful.

ANTERIOR DEFECTS (Fig. 29-3)

- **Location:** The area posterior to the anterior hairline and anterior to the plane of the superficial temporal vessels that lie in front of the root of the helix
- **Principles:** Recreation of the anterior hairline without derangement of native hairline or creation of dog ears in cosmetically sensitive areas; undermining of forehead for greater tissue gain
- **Small defects (<2 cm²)**
 - Primary closure after undermining
 - Advancement flaps based on subcutaneous pedicles
 - Small rotation advancement flaps
- **Moderate defects (2-25 cm²)**
 - V-Y flaps, V-Y-S flaps, subcutaneous pedicled flaps, rotation advancement flaps
 - Anterior hairline reconstruction: Temporoparietaloccipital flaps or the lateral scalp flap, as described for correction of male pattern baldness
- **Large defects (>25 cm²)**
 - Temporoparietaloccipital flaps
 - Large rotation advancement flaps with back-grafting of the donor site to restore anterior hair and move the defect
 - **Orticochea flaps**
 - ▶ Two flaps for reconstructing the defect, each based off the superficial temporal vessels, and one large flap based off the occipitals to fill the donor defect
 - ▶ Can result in significant alopecia and unnatural hair orientation



*Rotation advancement flaps can be used to move the defect to a less cosmetically sensitive area, such as the posterior vertex or occiput, with back-grafting and subsequent tissue expansion.

Fig. 29-3 Reconstruction algorithm: Anterior defects.

TIP: Consider tissue expansion in lieu of Orticochea flaps.

PARIETAL DEFECTS (Fig. 29-4)

- **Location:** The parietal scalp territory is supplied by superficial temporal vessels.
- **Principles:** Defects in the parietal scalp are amenable to local tissue rearrangement as a result of high scalp mobility in this region. They are less likely to have exposed bone because of the underlying temporalis muscle. Avoid sideburn displacement.
- **Small defects (<2 cm²)**
 - Primary closure
 - V-Y flaps, subcutaneous pedicled flaps, and rhomboid flaps possible for temporal sideburn reconstruction
- **Medium defects (2-25 cm²).**
 - Rotation advancement flaps
 - Bilobed flaps
- **Large defects (>25 cm²)**
 - Tissue expansion is often the only technique available for satisfactory reconstruction
 - Large bipedicled frontooccipital flaps with large areas of back-grafting have been described but are best reserved for single-stage reconstruction when excellent cosmesis is not required.

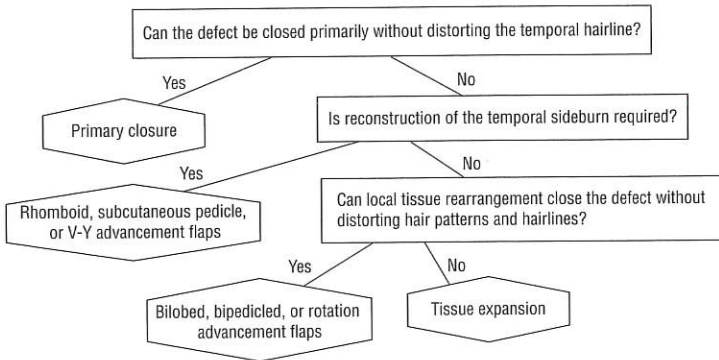


Fig. 29-4 Reconstruction algorithm: Parietal defects.

OCCIPITAL DEFECTS (Fig. 29-5)

- **Location:** Posterior scalp
- **Principles:** Region of moderate scalp mobility amenable to local tissue transfer; may require restoration or preservation of the occipital hairline
- **Small defects (<2 cm²)**
 - Primary closure
- **Medium defects (2-25 cm²)**
 - Rotation advancement flaps: Dissection carried over the trapezius and splenius capitis muscles to provide increased tissue gain

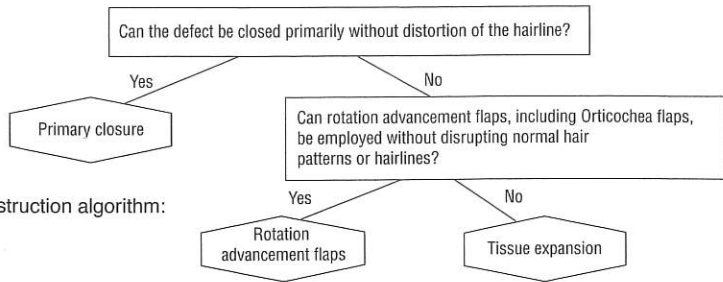


Fig. 29-5 Reconstruction algorithm: Occipital defects.

■ **Large defects (>25 cm²).**

- Larger rotation flaps
- **Orticochea flaps** (Fig. 29-6)
 - ▶ Classically described for reconstruction of the occipital scalp
 - ▶ Three-flap technique improves flap vascularity over the four-flap technique and decreases post-operative alopecia and wound complications

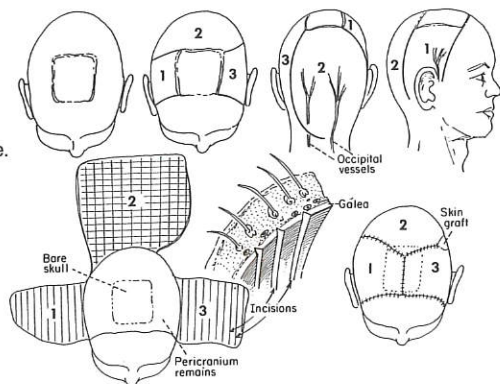


Fig. 29-6 Orticochea three-flap technique. (From Arnold PG, Rangarathnam CS. Multiple-flap scalp reconstruction: Orticochea revisited. *Plast Reconstr Surg* 69:607, 1982.)

TIP: Tissue expansion routinely gives a superior result.

VERTEX DEFECTS (Fig. 29-7)

- **Location:** Central scalp
- **Principles:** Area of limited scalp mobility; requires extensive undermining and recruitment of tissue from the more mobile regions; characteristic whorl pattern of hair growth should be preserved
- **Small defects (<2 cm²)**
 - Primary closure after subgaleal dissection; up to 4 cm wide described
 - Pinwheel flaps and adjacent rhomboid flaps particularly suited to reconstructing whorl pattern
- **Medium defects (2-25 cm²)**
 - Pinwheel and rhomboid flaps less useful but possible alternatives

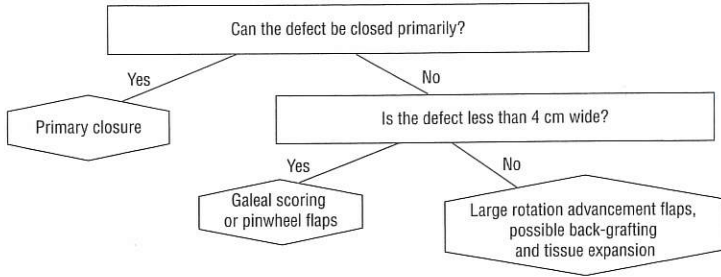


Fig. 29-7 Reconstruction algorithm: Vertex defects.

- Double-opposing rotation advancement flaps with incisions parallel to the hairline to prevent distortion
- Rotation advancement from the occiput with back-grafting of the donor site
- **Large defects (>25 cm²)**
 - Large rotation flaps that require almost complete scalp undermining and galeal scoring and possible back-grafting
 - Orticochea flaps **not** well suited for these defects because location does not allow a large third flap to cover donor site defect
 - Best results with tissue expansion

NEAR TOTAL DEFECTS¹⁰⁻¹²

- **Free tissue transfer:** Latissimus dorsi muscle, omentum, radial forearm fasciocutaneous, anterolateral thigh
 - Muscle flaps atrophy and contour well to skull over time; however, they can thin excessively and may result in exposed bone.
- **Integra** followed by skin grafting
- **Serial tissue expansion**

CALVARIAL RECONSTRUCTION¹³⁻¹⁷

- Goal is to provide protection for the brain and maintain normal calvarial shape

SURGICAL OPTIONS

- **Autogenous tissues**
 - **Split calvarial bone graft:** Parietal bone preferred because of increased thickness and absence of underlying venous sinuses
 - **Split rib graft:** If periosteum left intact the rib should regenerate
- **Alloplastic materials**
 - Methylmethacrylate over titanium mesh

KEY POINTS

- ✓ Scalp avulsions usually occur in the subgaleal plane.
- ✓ The scalp is highly vascularized and can be replanted from a single artery.
- ✓ Most scalp mobility occurs over the parietal region because of the temporoparietal fascia.
- ✓ Consider tissue expansion to achieve coverage with like tissue with acceptable scar placement.

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