33 Preventing Cranial Wound Complications in Cancer Patients

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Introduction

Patients undergoing resection for intracranial neurosurgical tumors pose unique issues for the reconstructive team, and consideration needs to be given for not only the initial resection but also for possible future resections. A strong understanding of the anatomy of the overlying soft tissue is important to prevent ischemic complications. Patients undergoing re-operative cases are at higher risk for infections, wound dehiscence, and skin necrosis which all stem from decreased blood flow and tension in the scalp from prior scarring. The combination of poor nutrition, immunosuppressive agents, anti-angiogenic agents, and radiation all pose specific risks to the postoperative patient which needs to be considered during operative planning. In this chapter, we will discuss these issues and highlight how to minimize tissue ischemia with appropriate planning of incisions through assessment of scalp perfusion. We will also discuss the management of the patient in the immediate postoperative period.

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Anatomy

Anatomic Layers

The scalp consists of five anatomic layers which are often described by the mnemonic "SCALP" (Fig. 33.1). Starting from the most superficial layer to the deepest layer, the five layers consist of:

- Skin
- Connective tissue
- Galea aponeurotica
- Loose areolar tissue
- Pericranium

The skin is connected to the galea aponeurotica through a network of tight connective tissue bands, allowing the galea aponeurotica and skin to move as a single unit during surgical manipulation. This subcutaneous connective tissue layer also contains much of neurovascular structures, and dissection in this plane can result in significant bleeding. The galea aponeurotica is a fibrous layer continuous with the superficial musculo-aponeurotic system (SMAS) of the face and is controlled by the frontalis muscle anteriorly and the occipitalis posteriorly. Under the galea aponeurotica is the loose areolar tissue, which allows for movement of the galea over the pericranium. The loose areolar tissue is a relatively avascular plane that allows for easy dissection

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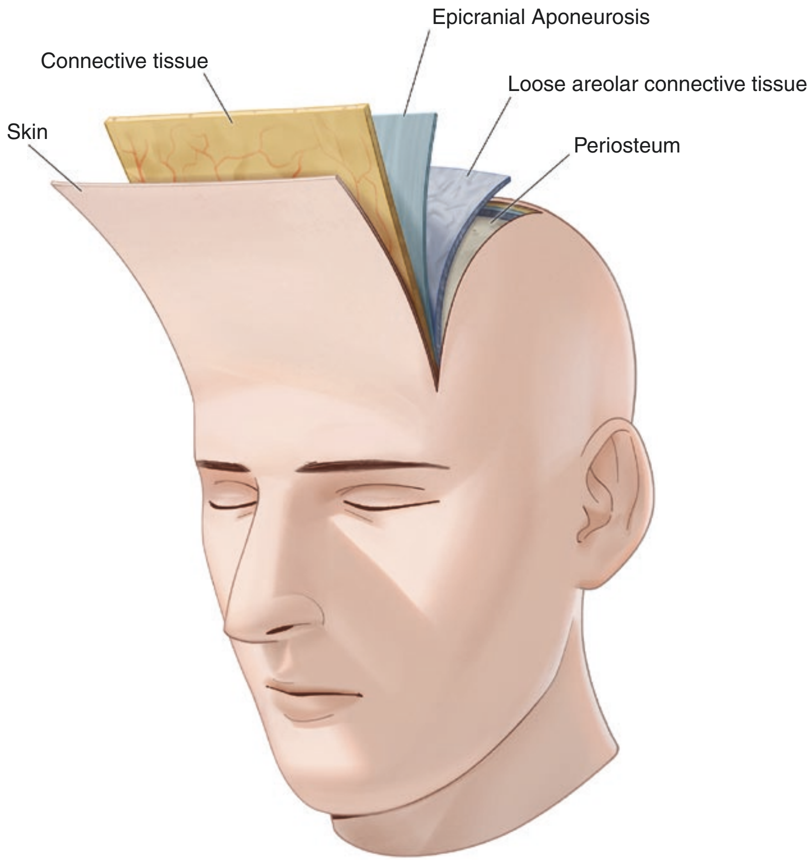

Fig. 33.1 The anatomical layers of the scalp

during surgical exposure of the pericranium with minimal bleeding. The pericranium is the periosteum of the skull that separates relatively easily from the underlying bone except at the cranial sutures. The pericranium provides nutrition to the skull and can be elevated as a flap for coverage and lining.

Innervation

Anteriorly, the scalp is innervated by the supratrochlear and supraorbital nerves, both of which are derived from the ophthalmic division of the trigeminal nerve. The supratrochlear nerve innervates the lower part of the forehead, traveling beneath the frontalis as it ascends. The supraorbital nerve originates from the supraorbital notch or foramen and terminates in medial and lateral branches. The medial branch of the supraorbital nerve enters the corrugator supercilii and frontalis muscles, while the lateral branch enters the galea aponeurotica. Posteriorly, the greater occipital nerve, originating from the C2 spinal nerve, provides innervation from the occiput to the vertex. The lesser occipital nerve originates from C2 and C3 spinal nerves and innervates the region of the scalp posterior to the ear. The auriculotemporal nerve, a branch of the mandibular division of the trigeminal nerve, innervates the tragus, the area anterior to the ear, and the posterior portion of the temple region. In the temporal scalp region, special attention should be paid to the frontal branch of the facial nerve as it passes cephalad over the zygomatic arch, running just deep to the superficial temporal fascia as it innervates the frontalis, orbicularis oculi, corrugator supercilii, and auriculares anterior and superior.

Blood Supply

Understanding the rich blood supply of the scalp is crucial to avoiding wound complications during cranial surgery. The five main paired arteries that supply the scalp come together in a rich arterial network that runs throughout the subcutaneous connective tissue layer (Fig. 33.2). From the ophthalmic branch of the internal carotid artery, the supratrochlear and supraorbital arteries arise from the superior orbital rim and supply much of the anterior scalp. The supratrochlear artery provides much of the blood supply to the midline forehead, while the supraorbital artery reaches as far up as the vertex of the scalp. Laterally, the superficial temporal artery arises from the external carotid artery and runs anterior to the ear before splitting into frontal and parietal branches. The superficial temporal artery is typically the largest of the scalp vessels, and it anastomoses with the supratrochlear and supraorbital vessels anteriorly and the posterior auricular and occipital vessels posteriorly. The occipital artery is the main blood supply of the posterior scalp, and it also arises from the external carotid artery system. It runs deep to the neck muscles posteriorly from the external carotid artery before turning cephalad from the posterior scalp up to the vertex. The posterior auricular artery, the smallest of the scalp arteries, branches off of the external carotid artery and provides bloody supply to the posterior ear and mastoid region.

The venous drainage pattern of the scalp follows veins that run with the arterial blood supply. Additionally, emissary veins on the cranium also contribute by draining blood into the dural sinuses. Lymphatic vessels also run in the subcutaneous connective tissue layer, draining into parotid, preauricular, postauricular, upper cervical, and occipital lymph node basins.

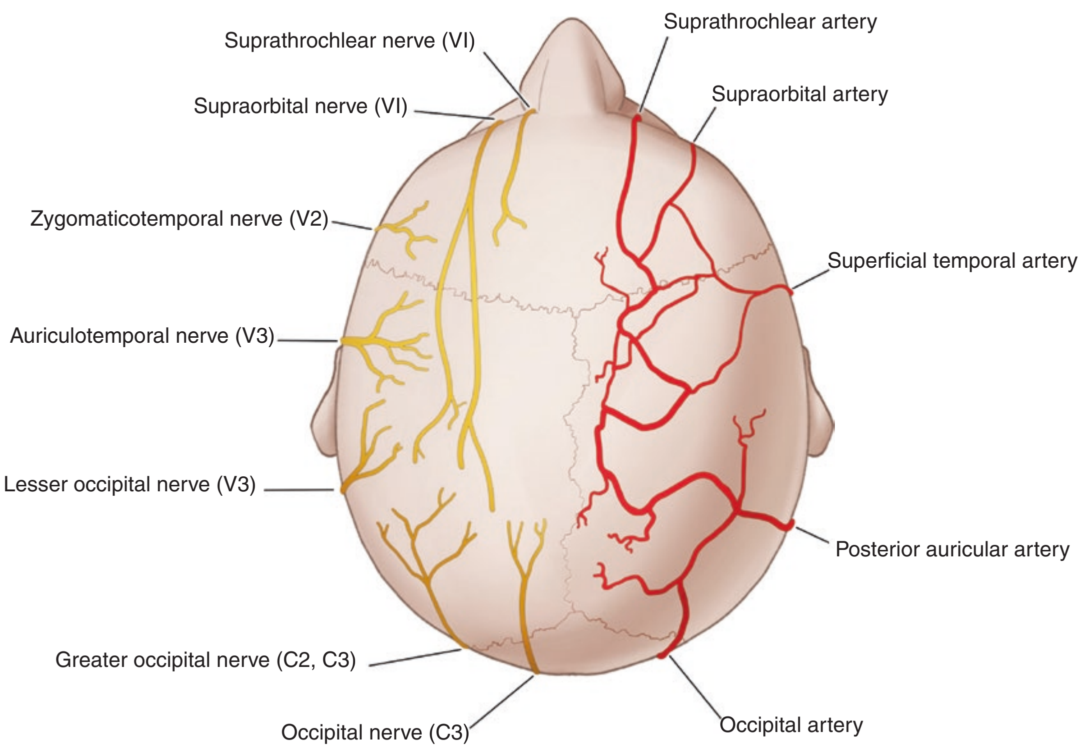

Fig. 33.2 The five main paired arteries of the scalp (right) and the neural innervation of the scalp (left)

Risk Factors for Complications

Medical History

Several patient-specific factors can put a patient at elevated risk for scalp complications postoperatively. A comprehensive preoperative history and physical is essential to note and control for these relevant factors. Factors such as smoking history and diabetes mellitus can affect the vascularity of the scalp and increase the risk of wound complications. Nicotine in smoke acts as a vasoconstrictor while also increasing platelet adhesiveness [1]. Carbon monoxide reduces oxygen transport and hydrogen cyanide impairs oxidative metabolism. These substances in cigarette smoke can lead to tissue ischemia, thrombotic microvascular occlusion, and impaired healing [1]. Similarly, diabetes mellitus contributes to poor wound healing in multiple ways, including microvascular ischemia, impaired immune function, decreased growth factor production, and reduced fibroblast proliferation.

Nutrition is also important to take into consideration, especially in cancer patients who may be cachectic or have poor oral intake. Malnutrition has been well-documented as a risk factor for poor wound healing, infectious complications, and other sources of operative morbidity and mortality. In critically ill patients or patients under stress, basal energy expenditures and caloric requirements are increased, necessitating a more aggressive approach to maintaining proper nutrition. Proper nutrition includes not only adequate intake of all macronutrients such as carbohydrates, fats, proteins, and fluids but also a sufficient supply of micronutrients [2]. These micronutrients include amino acids; vitamins A, C, D, and E; and minerals such as zinc, selenium, and iron. Vitamin C is well-known for its role in collagen polymerization and cross-linking. Vitamin A is an important cofactor in the inflammatory phase of wound healing, promoting phagocytic activity and immunologic function. Although the mechanisms of vitamin E and zinc are not as well-defined in the literature, there are data that support their importance in collagen production [2]. It is also recommended that albumin and prealbumin levels are within normal levels prior to surgical intervention, and supplemental nutrition should be provided as needed to help patients reach their nutritional goals. Enteral nutrition is preferred over parenteral nutrition, as enteral nutrition is more efficient, has fewer metabolic complications, costs less, and helps promote the growth and development of gastrointestinal mucosal tissue. When enteral nutrition is not possible, parenteral nutrition should be considered in malnourished patients. Regardless of nutritional route, all patients should be offered adequate nutritional support prior to surgical intervention in order to avoid wound complications in this high-risk population.

Perfusion

Tissue perfusion is essential to wound healing, and any conditions that may impair adequate perfusion of the scalp can increase the risk of cranial wound complications. During incision planning, previous scars should be taken into consideration, and adequate inflow from at least one of the five major blood supplies should be preserved. The vascular network of the scalp runs in the subcutaneous connective tissue layer superficial to the galea aponeurotica so great care should be taken when performing galeal scoring maneuvers. Adequate blood pressure and hemoglobin should be maintained in the perioperative period to ensure sufficient perfusion and oxygenation for wound healing. Postoperative dressings should allow for expected edema and not be tight enough to restrict blood flow to the surgical site.

Tension

Care should be taken to avoid tension over the scalp closure in order to prevent wound complications such as dehiscence, skin necrosis, and infection. Experimental studies have also demonstrated increased incidence of hypertrophic scarring and scar widening when wounds are subjected to excessive tension during the early wound healing period [3]. Techniques to avoid tension during incision closure include wide undermining of the scalp in the loose areolar tissue layer, performing galeal scoring maneuvers, and utilizing local flaps as needed. Scalp tissue should be closed in a layered fashion with sutures in the galea aponeurotica offloading most of the tension from the cutaneous closure [4]. Tissue expansion can sometimes be used prior to oncologic resection if there is an anticipated deficit of scalp tissue and sufficient lead time prior to surgery.

Radiation

The negative effects of radiation on wound healing have been well-documented in the literature. The inflammatory phase of wound healing, characterized by the infiltration of macrophages and neutrophils, is delayed and inhibited in irradiated tissues. The formation of granulation tissue is also slowed as fibroblast activity and collagen formation are reduced. Lastly, epithelialization in irradiated tissue is delayed and the overall healing time of wounds is prolonged. The effect of external beam radiation on the scalp is characterized by early skin changes followed by chronic damage long after radiation therapy has been completed. Acute findings include skin erythema, tenderness, warmth, epidermolysis, and ulceration. These effects are often dose-dependent and reversible. Long-term effects of radiation can include tissue fibrosis, sebaceous gland dysfunction, loss of hair follicles, microvascular compromise, skin necrosis, and secondary carcinogenesis. These effects are often irreversible and result in a higher risk of delayed wound healing, infection, hardware exposure, skin necrosis, and flap failure [5].

Preoperative radiation, when indicated, should be performed at least 3–6 weeks prior to surgery in order to avoid wound complications. This is especially important when doses larger than 50 Gy are administered. Postoperative radiation therapy is often preferred to allow for a period of healing prior to initiating the negative effects of radiation therapy on wound healing [6]. Clinical studies have demonstrated lower rates of wound complications when postoperative radiotherapy is used, and this may be an important consideration when recurrence rates are similar with preoperative and postoperative radiation therapy [5, 6]. Some of these concerns can be mitigated with radiosurgical techniques either in the pre- or postoperative setting. Given the high conformality and ability to limit scalp dose, the concerns related to wound healing are minimized. In our practice, we are comfortable with either preoperative or rapid postoperative radiosurgery given the advantages conferred by this radiation technique.

Chemotherapy

Similar to radiation therapy, chemotherapy is an important component of cancer treatment but can negatively impact wound healing via several mechanisms. The effects of chemotherapeutic agents are linked to their ability to impair DNA replication, interfere with metabolic processes, and prevent cell division. While these effects disproportionately impact rapidly growing tissues such as cancer cells, they can also impact immune cells, epithelial tissue, neovascularization, and fibroblasts that are important in the wound healing process.

Alkylating agents such as cyclophosphamide at high doses have been shown to increase wound complications by impairing neovascularization during the proliferative phase of wound healing. Thiotepa and mechlorethamine have also been demonstrated to impair wound healing in animal models by inhibiting fibroblast function and collagen production. Cisplatin has also been proven in multiple animal studies to decrease wound healing by impairing fibroblast proliferation, inhibiting neovascularization, and reducing connective tissue proliferation [6].

Chemotherapeutic antibiotics such as bleomycin, doxorubicin, and mitomycin C have also been found to have an impact on wound healing in animal models. Bleomycin inhibits the production of collagen by fibroblasts, thus decreasing wound tensile strength postoperatively. Doxorubicin also interferes with DNA transcription and has been found to decrease wound tensile strength in animal models. Mitomycin C, though most often used topically, has also been demonstrated to have a negative impact on wound healing in rat models [6].

The use of antimetabolites such as methotrexate and 5-fluorouracil at higher doses has also demonstrated some decreased wound tensile strength in animal models. The effects of azathioprine and 6-mercaptopurine on wound healing are still unclear and require further study. Similarly, plant alkaloids such as vincristine and vinblastine have shown mixed results on wound tensile strength in animal studies [6].

Anti-angiogenesis agents such as bevacizumab provide a unique challenge to the healing wound. Bevacizumab is a monoclonal antibody which targets VEGF, preventing neovascularization. It has been widely used in multiple cancers, including neurological cancers. It has a more direct effect on the healing wound than any other agent currently in use and has been shown to cause wound dehiscence, hematomas, and wound infection. As the half-life is 20 days, recommendations in the literature include waiting 6 weeks after the last therapy prior to surgical intervention [7]. Patients should be counseled that the rate of wound complications following bevacizumab therapy is considerable, particularly if the wound has been previously irradiated.

Corticosteroids, while not necessarily considered a chemotherapeutic agent, are also often used in cancer patients to alleviate pain and inflammation. Steroids are well-known for having deleterious effects on wound healing, and studies have shown increased rates of wound complications and dehiscence in patients on corticosteroid therapy in the perioperative period. The administration of vitamin A has been shown to mitigate some of the negative effects on wound healing, although further studies are needed to better define the impact of vitamin A co-administration [6].

Given the variability of chemotherapeutic agents and their effect on wound healing, it is important to keep the timing and dosing of chemotherapy in mind when considering surgical intervention. If possible, delaying the initiation of chemotherapy in surgical patients for 7–10 days may decrease the risk of wound complications in this population. Furthermore, it is important to ensure patients are not neutropenic prior to surgery. Careful consideration should be taken to control for other wound healing risk factors before surgical intervention.

Incision Planning

Careful consideration should be taken when planning cranial incisions in order to minimize the risk of postoperative wound complications. Incisions should be selected in a fashion that would allow for wide exposure of the target surgical site as well as flexibility to extend the incision for subsequent surgeries if needed. With cranial surgery, the incision choice should reflect the goals of surgery and potential for future surgeries in that patient. For example, patients with gliomas often recur within 2 cm of a previous resection cavity. As such, incisions should reflect an understanding of possible future recurrence such that the same incision can be used or easily modified in the future without causing vascular compromise to the scalp. When cranial hardware is used, we try to limit the amount of hardware directly underneath the incision. We have found this technique helps avoid delayed hardware exposure, particularly in patients with atrophic scalp tissue or those that subsequently undergo scalp irradiation.

If pre-existing surgical scars are present, an attempt should be made to incorporate those scars in the new incision to avoid leaving bridges of devascularized scalp tissue. Regardless of incision design, all remaining segments of scalp tissue once old scars and new incisions are taken into account must be contiguous with at least one of the five main paired arteries (supratrochlear, supraorbital, superficial temporal, posterior auricular, and occipital) in order to survive. All attempts should be made to avoid acute angles between incisions as that often leads to devascularized distal segments of the scalp. New incisions can either be an extension of an old incision or take off at a 90° angle from an existing scar (Fig. 33.3).

Traditional incisions such as the coronal or bitemporal incision allow for wide access to the anterior cranial vault, forehead, and facial skeleton. The coronal incision can be reopened multiple times to allow for repeated exposure in the case of recurrent disease or complication. In the coronal approach, the anterior flap is vascularized by the supraorbital, supratrochlear, and superficial temporal arteries, while the posterior flap is supplied by the posterior auricular and occipital arteries. If access to the posterior cranium is needed, the coronal incision can be extended with a midline sagittal incision oriented perpendicular to the coronal incision.

The lateral skull base approach with the Al Kayat and Bramley modification of the preauricular incision, often referred to as the "question mark" incision, is often used to access the lateral anterior skull base and middle cranial fossa, although it can be modified to reach the posterior cranium, as well. The anterior flap is most often supplied by the superficial temporal artery although the ipsilateral supraorbital or supratrochlear arteries may contribute depending on the design of the incision. The posterior flap remains vascularized on the posterior auricular and occipital arteries. The "question mark" incision limits access to the contralateral hemisphere and posterior cranium. If exposure of the contralateral anterior cranial vault is needed, a contralateral "question mark" incision can be made with the midline scalp preserved as a bipedicle flap. If access to the posterior cranium is needed, a sagittal incision can be made perpendicular to the curve of the "question mark" and extended posteriorly, similar to Kempke's "T-bar" incision.

The midline posterior skull base approach allows access to the posterior cranium and exposure for the classical suboccipital craniotomy. In this incision, all major scalp arteries are preserved; however, blood flow across the midline is disrupted in the posterior scalp. The midline posterior scalp incision allows for much flexibility in extending the incision anteriorly as needed to gain further exposure. This incision can also be

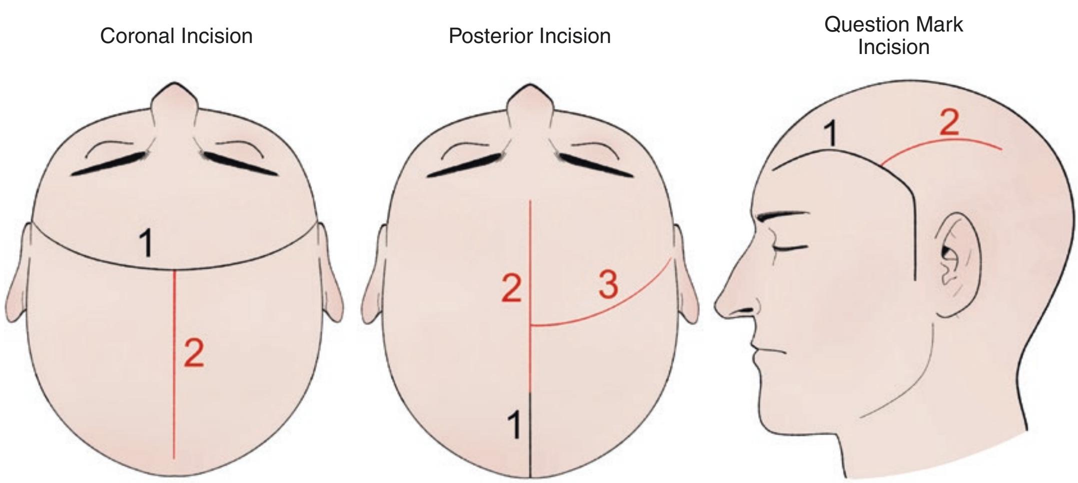

Fig. 33.3 Common neurosurgical incisions (1) and example extensions to avoid wound complications (2 and 3)

converted to a “T-bar” incision if needed. Access to the anterior cranial vault can also be achieved through separate incisions using the traditional approaches described above.

Prevention of Complications

Tissue Expansion

In patients who are high risk for postoperative cranial wound complications, several techniques can be used to maximize the chance of a successful reconstruction. When there is an existing skin deficit or resection of large portions of scalp tissue is anticipated, preoperative tissue expansion can be utilized to increase the surface area of scalp tissue available and reduce tension on the closure. Up to 50% of the scalp can be reconstructed with expanded scalp tissue, providing stable, potentially hair-bearing soft tissue coverage over cranial hardware or compromised bone. Tissue expansion, however, requires that there is adequate lead time prior to the procedure to place tissue expander devices and inflate them. Furthermore, tissue expansion requires an experienced surgeon as it can be associated with complication rates as high as 25% [8].

Laser Angiography

Intraoperatively, laser angiography can be utilized to assess the viability of scalp tissue and prevent potential wound complications. Modern laser angiography technology uses indocyanine green as a fluorescence agent to provide real-time assessment of tissue perfusion. Indocyanine green binds to plasma proteins and has a half-life of 3–5 minutes. It is administered intravenously and excreted by the liver into the bile so there is no risk for nephrotoxicity. Furthermore, indocyanine green fluorescence is viewed using a laser diode array emitting light in the near-infrared wavelength so no protective eyewear is needed and no harmful radiation is produced. Areas of scalp demonstrating poor tissue perfusion on laser angiography should be excised and replaced with well-vascularized adjacent tissue or soft tissue flaps as needed [9].

Delayed Flaps

When only a few weeks of lead time are available, flap delay is a technique that can be used to maximize the survival of anticipated scalp flaps. The delay phenomenon, also known as ischemic preconditioning, involves partially disrupting the vascular supply to a flap at the anticipated incision sites a few days or weeks prior to transfer of the flap. This allows for the opening of choke vessels in the remaining flap pedicle, propagation of collateral circulation, and increased tolerance to ischemia that can improve the survivability of the flap after transfer. This technique is useful in patients with a history of multiple cranial operations with high-risk incisions that may benefit from concomitant scalp flap reconstruction after intracranial surgery [8].

Other Therapies

Other modalities have also been described in the literature to salvage compromised scalp tissue. Hyperbaric oxygen therapy is a treatment that utilizes 100% oxygen at pressures greater than atmospheric pressure in order to raise tissue oxygenation levels. Some studies have suggested that elevated tissue oxygen levels may improve the healing and oxygen-dependent antibiosis of certain wounds such as delayed radiation injuries, burns, compromised flaps, diabetic ulcers, and soft tissue infections. The efficacy of hyperbaric oxygen therapy in salvaging ischemic scalp flaps, however, is still unproven in the literature as the evidence consists of mostly case reports [10].

Nitroglycerin ointment has also been described as a therapy to help salvage ischemic skin flaps. Topical application of nitroglycerin has been shown to increase local blood flow to the skin by acting as a vasodilator for both arteries and veins. Early studies have demonstrated benefits of 2% nitroglycerin ointment in the healing of anal fissures, pressure sores, and peripheral tissue ischemia in neonates. In the plastic surgical literature, nitroglycerin paste has been shown to decrease mastectomy skin flap necrosis in prospective and randomized controlled trials with no increase in complication rates [11]. Although not specifically studied in ischemic scalp tissue, nitroglycerin ointment can be considered as a therapeutic option to help salvage or limit skin necrosis in compromised cranial closures [12].

Management of Complications

Scalp Reconstruction Algorithm

When cranial wound complications do occur, reconstruction is often indicated to prevent desiccation of the bone, osteomyelitis, hardware exposure, and infection of the underlying contents. An important principle of cranial wound reconstruction is that nothing replaces scalp tissue as well as scalp tissue. When possible, reconstruction should strive for a cosmetically appealing result in addition to achieving coverage by restoring normal anatomy and paying close attention to hair growth patterns and hairlines. Small deficits of scalp tissue can potentially be addressed through undermining of adjacent scalp in the loose areolar plane and performing galeal scoring techniques. When larger skin deficits are present, scalp rotation flaps or transposition flaps can be utilized to recruit tissue from areas of laxity (Fig. 33.4). When needed, large rotation flaps can be transferred to the area of concern, and skin grafting can be performed over the donor site to achieve greater coverage (Fig. 33.5). Skin graft-

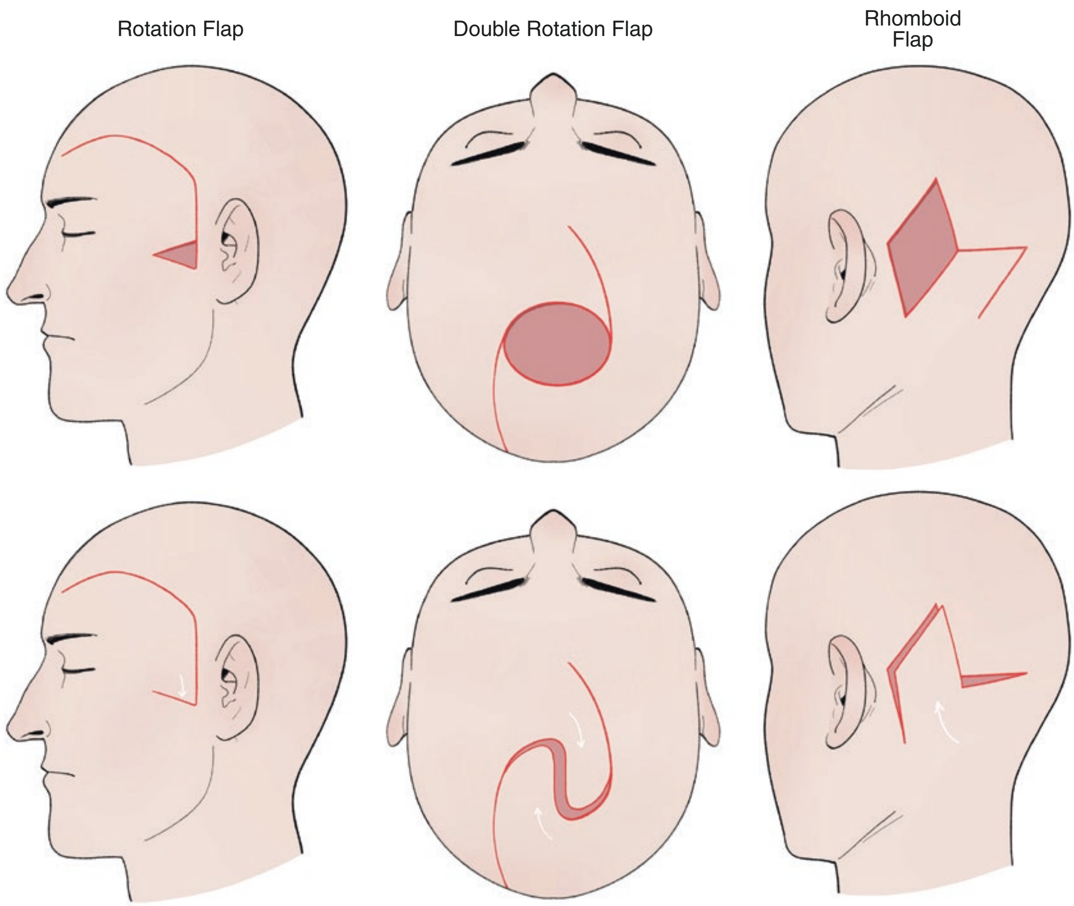

Fig. 33.4 Common local scalp flaps used to reconstruct cranial soft tissue defects

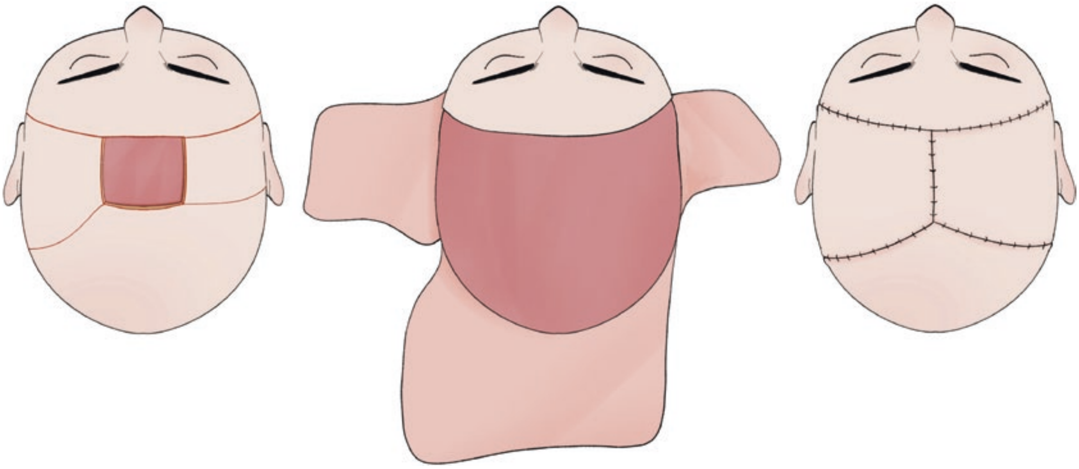

Fig. 33.5 Large scalp flaps can be designed to reconstruct bigger cranial soft tissue defects

ing can also provide permanent or temporary coverage over areas of the scalp with intact periosteum. If no periosteum is present and a pericranial flap is not available, the outer table of the cranium can be burred down to the diploic space in order to accept a skin graft. This serves as a viable option for immediate coverage of a scalp defect. In the long run, hair-bearing coverage of up to 50% of the scalp can be achieved with tissue expansion in the subgaleal plane. Tissue expansion requires staged operations with lengthy interval periods and complication rates varying from 6% to 25%. However, oftentimes the best aesthetic results can only be achieved with this technique. When even larger defects are present or if local tissue quality is poor due to radiation therapy, strong consideration should be given to free tissue transfer as a reconstructive option [8].

Cranioplasty Materials

In some circumstances, patients may require a cranioplasty either due to decompressive craniectomy, resection of cranial bone, trauma, or prior surgical complication. Cranioplasty may be performed with autologous bone graft, synthetic material, or biosynthetic material. The cranioplasty material of choice is somewhat controversial given the paucity of quality randomized, controlled trials, but some studies have suggested that the risk of postoperative infection is lower with autologous bone reconstructions [13]. Autologous bone, however, is subject to bone resorption and is not immune to infection of the devitalized bone segment. Methyl methacrylate is a popular synthetic material used in cranioplasty as it is malleable, lightweight, and radiolucent. It is often in conjunction with titanium mesh to provide enhanced structural support. Hydroxyapatite, a form of calcium phosphorus naturally present in bone tissue, is also frequently used in cranioplasty. The advantage of hydroxyapatite is its strong osteointegrative ability, minimal tissue reaction, and enhanced bone healing. Its biggest disadvantage, however, is its propensity to break under mechanical stress. As a result, hydroxyapatite is also often used in conjunction with titanium mesh reconstruction. More recently, polyetheretherketone (PEEK) has become a popular material used in cranioplasty, especially as a computer-designed implant requiring little to no intraoperative molding [14].

Timing of Cranioplasty

Regardless of material used, achieving stable soft tissue coverage over the cranioplasty implant is of utmost importance. When there is concern regarding the quality of soft tissue coverage or potential contamination of the field, it is often best to delay the cranioplasty procedure and allow for complete healing of the surgical site before introducing devitalized or synthetic material. Various interval periods have been advocated for in the literature, but no definitive period has been proven to be superior. Most studies recommend waiting anywhere from 6 weeks to 3 months and as long as 6 months to 1 year if there is any evidence of infection. Ultimately, timing of cranioplasty is an individualized physician choice that must account for infection risk and wound healing capability.

Use of Drains

Little reliable evidence exists in the literature regarding the use of subgaleal drains to prevent cranial wound complications. Some retrospective studies have suggested that the use of scalp drains significantly reduces the seroma rate in patients undergoing craniofacial surgery. Other studies have noted subjective improvement in facial swelling and decreased length of stay with the use of subgaleal drains, but those findings have not been corroborated in the literature [15]. Most studies on drain use have not shown a statistically significant effect on infection rate, hematoma formation, transfusion requirement, or other postoperative complications [16]. Although some have questioned whether there is an association between drain use and infection risk, there is minimal supporting evidence that closed-suction drain use increases the risk of surgical site infection [17]. As a result, we recommend the judicious use of closed-suction drains in cases with an elevated risk of postoperative seroma and timely removal of drains once no longer needed. In cases where drains are aspirating the cerebrospinal fluid (CSF) because of a defect in a dural repair, it is important that these drains be removed to prevent intracranial hypotension and subsequent subdural hematomas. Should a CSF collection develop under the scalp, these can be percutaneously tapped and often they are self-limiting. In cases of recalcitrant CSF collections, lumbar drains combined with percutaneous aspiration can be used for several days which often allows dural defects to seal and thus obliterate the CSF leak. Finally, if a CSF collection persists despite these maneuvers, the patient should be evaluated for either hydrocephalus or a meningitis (possible aseptic). It is vitally important to ensure that scalp collections do not cause tension on the wound as leaks through the wound will increase the rate of postoperative infections.

Conclusion

The soft tissue concerns for patients undergoing cranial extirpative surgeries can be complex and layered. Appropriate preoperative planning, intraoperative decision-making, and postoperative care can decrease perioperative morbidity. Appropriate soft tissue coverage is necessary to allow for appropriate timing of radiation therapy and adjuvant chemotherapy. In our practice, neurosurgeons routinely involve plastic surgeons preoperatively in patients with high-risk wounds both for incisional planning and intraoperative closure. This team approach has been highly effective at preventing postoperative wound complications.

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