Scalp and Forehead Reconstruction

Barbara S. Lutz, M.D., Ph.D.¹

ABSTRACT

The treatment of scalp and forehead defects is challenging. There are few cases in which an untreated scalp defect can heal by secondary intention. However, lack of adequate treatment can also lead to fatal consequences. Adequate judgment and treatment of a defect on the scalp are therefore mandatory. There are many options to reconstruct a scalp defect. Each option has its role in the reconstruction repertoire. Various factors need to be considered when choosing the method to be used. These factors include etiology and the size of the defect, age and general health of the patient, as well as the situation at the hospital/unit where the treatment is performed. In this article, different reconstruction methods are presented, and guidelines for the selection of the various options are provided.

KEYWORDS: Forehead, scalp

The treatment of scalp and forehead defects can be challenging. On the one hand, there are a few cases in which an untreated scalp defect can heal by secondary intention. On the other hand, a lack of adequate treatment can lead to fatal consequences related to osteomyelitis of the skull bone. Adequate judgment and treatment of a defect on the scalp are therefore mandatory.

There are plenty of options to reconstruct a scalp defect. Each option has its role in the reconstruction repertoire and has its advantages and disadvantages. Whereas one option can be the best method for covering a particular scalp defect, the same option can be disadvantageous or even impossible for another type of scalp defect. Thus, different factors need to be considered when choosing the method to be used for covering a scalp defect. These factors include the size and etiology of the defect, the age and general health of the patient, as well as the local situation at the hospital/unit where the treatment is performed. Microvascular free flap transplantation demands a different local setup than, for example, the use of local flaps. In this article, different reconstruction methods are presented, and guidelines for the selection of the respective options are provided.

ETIOLOGY

Excision of malignant tumors such as squamous cell cancer, basal cell carcinoma, or angiosarcoma, and irradiation necrosis can cause large scalp or forehead defects. Elderly patients are involved in the majority of these cases, whereas the age range of patients suffering from scalp defects acquired by trauma or burns is usually younger. Other causes of scalp defects include congenital lesions and infections.

ANATOMY

The pericranium (skull bone) is covered by skin, subcutaneous tissue, partially diverse muscles, the galea, and loose connective tissue. These layers are consistent over the entire scalp except over the temporalis muscle. This muscle is enclosed by the superficial and the deep temporal fascia. Major blood vessels, hair follicles, and integumentary structures are located in the subcutaneous tissues.¹ Due to the tight galea aponeurosis, which forms a fibrous connection between the frontalis muscle anteriorly and the occipitalis muscle posteriorly, the scalp is relatively inelastic.²

¹Consultant Plastic Surgeon, London, United Kingdom.

Address for correspondence and reprint requests: Barbara S. Lutz, M.D., Ph.D., Consultant Plastic Surgeon, Abbey Riverside Hospital, Great West Road, London TW8 9HE, UK (e-mail: bslutz08@hotmail.com).

Advances in Head and Neck Reconstruction, Part I; Guest Editors, Samir Mardini, M.D., Christopher J. Salgado, M.D., and Hung-Chi

Chen, M.D., F.A.C.S.

Semin Plast Surg 2010;24:171–180. Copyright © 2010 by Thieme Medical Publishers, Inc., 333 Seventh Avenue, New York, NY 10001, USA. Tel: +1(212) 584-4662.

DOI: <http://dx.doi.org/10.1055/s-0030-1255334>.

ISSN 1535-2188.

Blood supply derives from five consistent arteries on each side: the superficial temporal artery with anterior and posterior branches, posterior auricular artery, occipital artery, supratrochlear artery, and supra-orbicular artery. These vessels are widely interconnected and are commonly used when local or pedicled flaps are elevated.

The temporal branch of the facial nerve, the supratrochlear nerve, and the supraorbicular nerve innervate muscles at the forehead and the temporalis muscle. Sensory innervation comes from branches of the greater and lesser occipital nerves, the auriculotemporal nerve, the greater auricular nerve, and branches of the first branch of the trigeminal nerve. Underneath the pericranium lies the dura mater with its venous sinus, which separates the brain from the bone.

AIMS OF RECONSTRUCTION

The goal of reconstruction for scalp and forehead defects is to achieve a stable coverage with acceptable aesthetic results. Donor site morbidity should be minimal. A stable coverage of the bone, or the brain in case of bone loss, is of utmost importance. Cosmetic considerations at the scalp include an adequate contour and hair growth. The latter cannot be achieved with free or distant pedicled flaps. However, secondary employment of tissue expanders³⁻⁵ to the remaining hair-bearing scalp or micrografting of hair transplants² can solve this aspect after an adequate time interval, if wished by the patient.

At the forehead region, acceptable cosmetic results include color match, maintenance of the frontal and temporal hairlines, and brow symmetry. Sensory and motor nerves should be preserved whenever possible.

Straight rehabilitation is important, especially in elderly patients to avoid systemic complications such as pneumonia. Furthermore, a one-stage operation with one donor site is of high benefit to the patient as it reduces morbidity, pain, and overall costs compared with either one operation with two or more donor sites, or staged operations for cosmetic reasons.

OPTIONS AND GENERAL CONSIDERATIONS OF RECONSTRUCTION

Healing by Secondary Intention

As mentioned above, healing by secondary intention can achieve acceptable results for small and superficial wounds after trauma or tumor excision. However, this option is time consuming and demands regular wound care to avoid a secondary infection.² There is no hair growth in the developing scar tissue, which can be a disadvantage in hair-bearing areas.

Direct Wound Closure

Due to the inelasticity of the scalp, only small defects can be closed directly. Usually a wide subgaleal undermining is necessary to avoid wound tension. Additional multiple galeal incisions placed parallel to the incision line can enhance stretch of the wound edges during closure. Keeping in mind not to injure larger subgaleal vessels, this procedure eases wound closure. In the case of high wound tension, healing problems or secondary alopecia can occur.²

Skin Graft

When the pericranium is intact, the defect at the scalp or forehead can simply be covered with skin grafts. At the forehead region, the use of Integra (Integra Life Sciences, Plainsboro, NJ) was reported to improve the aesthetic outcome.⁶

Denuded bone can be covered with split-thickness skin graft after a healthy foundation of granulation tissue has been established²; this usually demands burring of the bone. However, the healing process is time consuming, and usually no stable coverage is achieved. The main domain of skin grafting at the scalp is either a temporary coverage until a stable reconstruction can be performed or a salvage procedure in a patient with otherwise bad general health. At the forehead region, however, a full-thickness skin graft can produce good aesthetic results in certain superficial defects.

Tissue Expander

In some congenital lesions^{7,8} or in lower-grade malignant tumors,⁹ preoperative tissue expansion provides a good option to cover the (planned) defects with exactly matching tissue. A Silastic balloon is placed under the galea and inflated with saline until the desired volume is obtained. To account for tissue recoil during advancement, the volume of the expanded flap should be 20% larger than the size of the planned defect.¹⁰ To reduce the risk of infection, a single large expander is preferred over multiple small expanders, although in scalp expansion multiple expanders are frequently used to gain the greatest amount of tissue.¹¹ Tissue expansion takes several weeks and is therefore not a treatment modality for malignant tumors such as squamous cell carcinoma or for traumatic and infected defects. In such conditions, the main role of tissue expanders is in secondary treatment for cosmetic improvement after a stable reconstruction of the scalp defect.

Autologous Full-Thickness Tissue

In all other cases, which present denuded periosteum combined with trauma, consistent infection, bone loss, or after resection of a malignant tumor, autologous

full-thickness tissue is required for an adequate one-stage reconstruction.

Various local flaps,^{12–15} distant pedicled flaps,^{16,17} and free flaps^{18–24} have been suggested for scalp reconstructions. Although local flaps containing hair can be used successfully for scalp reconstructions,^{12–15,25–27} they have limitations²¹ in dimension or location and often create a split-thickness skin-grafted area at their donor sites.

Free flaps can safely cover large defects and tolerate postoperative irradiation in the case of tumor treatment.^{20–22} They can include bone^{28,29} or fascia to reconstruct skull or dura defects.^{21,30} Good results have been described when a free soft-tissue flap is combined with titanium mesh or methylmethacrylate.³¹

Local and Pedicled Flaps

Scalp flaps have the advantage of technical simplicity and, if needed, two or three local flaps can be used for coverage of a large scalp defect.^{15,27} Usually elevated in the subgaleal plane, they are used as local rotational or advancement flaps. Flaps such as V-Y flaps²⁷ offer a stable coverage in defects with a diameter up to 4 to 5 cm. Following the common rules for local random pattern flaps as elsewhere, it is important to note that, due to the inelasticity of the scalp, a larger flap size is required than in the face, for example. As in direct wound closure, galeal incisions can be used to ease wound closure. The flap design should take into account the hairline: incisions should be parallel to the hair follicles to avoid local hair loss.

Pedicled flaps are based on a vascular pedicle such as the superficial temporal artery and vein, the occipital artery and vein, or the postauricular artery and vein. This has the advantage that their width/length ratio does not need to follow the guidelines of local (random pattern) rotation flaps, thus providing more length. One example is the temporoparieto-occipital flap (Juri flap³²), which can have a safe length of 20 cm supported by a width of 4 cm. This flap is based on the posterior branch of the superficial temporal vessels. Preoperative marking of the respective vessels using a Doppler probe is recommended.

In general, all scalp flaps have the advantage of being able to reconstruct the existing defect with hair-bearing tissue. However, often the donor sites need to be covered with split-thickness skin grafts, which impairs the aesthetic result and requires a second donor site. Another disadvantage is the unreliability of local flaps in cases of trauma or after irradiation.²¹ Traumatized or vascular compromised irradiated tissue close to the respective defect imposes a high risk of local flap failure.

Propagated as a reliable distant pedicled flap for coverage of the occipital and lateral areas of the scalp is the lower trapezius musculocutaneous flap,^{16,17} which is

based either on the deep branch of the transverse cervical artery¹⁶ or on the dorsal scapular artery.¹⁷ Using only the lower part of the trapezius muscle should preserve shoulder function.

The main disadvantage of distant pedicled flaps such as the lower trapezius flap or the latissimus dorsi flap (see later) is due to the individual pedicle length and the restricted range of mobilization, which limits extension to the lateral or occipital areas of the scalp. Other disadvantages include lack of hair growth, and, because of the proximity of the flap and the defect, the simultaneous operation of two teams is not possible.

Free Flaps

Free flaps provide large and various tissues for scalp defects. As mentioned above, these flaps can include bone or fascia to reconstruct skull or dura defects. They can be thin skin flaps or thicker muscle and musculocutaneous flaps.

However, free flaps need vascular anastomoses to provide blood supply to the transplanted tissue at the new recipient site. Thus, microvascular free tissue transplantation demands a setup that includes specific equipment (e.g., microscope, instruments, etc.) and microvascular trained surgeons, anesthetists, and nurses.

Free flaps are reliable, highly successful, and, in many cases, the best option for covering scalp defects.^{18–24,30}

FREE FLAP SELECTION

As previously pointed out by Disa et al³³ and Lutz and Wei,³⁴ the use of a few but well-established flaps leads to reliable surgical results with few postoperative complications. Concentrating on selected flaps instead of using a wide range of flaps allows the reconstructive surgeon to master particular flaps early and safely. Ideal flaps for scalp and forehead reconstruction should fulfill the following criteria³⁵:

- adequate flap size
- superior texture
- large and long pedicle with consistent anatomy
- easy and safe flap dissection
- feasibility of a two-team approach
- negligible donor site morbidity.

As shown in two earlier publications,^{21,30} three free flaps clearly dominate the author's approach in scalp and forehead reconstruction:

1. The latissimus dorsi (LD) muscle flap with split-thickness skin graft.
2. The anterolateral thigh (ALT) flap in various designs.
3. The radial forearm (RF) flap.

The LD flap has its main usefulness in very large defects. The ALT flap is particularly useful due to its versatility,³⁵ including the possibility of simultaneous harvest, and its negligible donor site morbidity.^{30,36} The RF flap is mainly used for covering defects at the forehead because of its thin skin texture.

Other soft tissue flaps, such as the lateral arm flap and scapula flap, usually belong to the repertoire of a reconstructive microsurgeon and are needed in exceptional cases only.

Serious donor site complications such as ileus or intra-abdominal bleeding are reported after harvest of free omental flaps.³⁷ A prolonged recovery time, including weakness of the abdominal wall and risk of hernias, is recognized after rectus abdominis muscle or transverse rectus abdominis muscle (TRAM) harvest.^{38,39}

SHORT INTRODUCTION TO SELECTED FREE FLAPS

Latissimus Dorsi Flap

The free LD flap was first published by Maxwell et al in 1978.⁴⁰ The LD muscle is the largest single vascularized

transplant. Hence, this flap is ideal for reconstruction of large defects (see Fig. 1). Its anatomy is consistent, receiving its main blood supply from the thoracodorsal artery and vein. Tailored to the respective needs, the LD flap can be used as a myocutaneous flap, a muscle flap with split-thickness skin graft, a functioning muscle flap, or a flow-through flap.⁴¹ In the mid-1990s, the perforator fasciocutaneous LD flap became popular, leaving the muscle including its motor nerve in situ.^{42,43} A two-team approach is possible when the patient is in a lateral position, which is frequently the case in scalp and forehead reconstructions. Donor site morbidity is low.⁴⁴ A postoperative seroma is rather common, but mostly temporary.

Anterolateral Thigh Flap

Song et al first described the ALT flap in 1984.⁴⁵ The recently evolved perforator flaps with intramuscular dissection of the skin-feeding vessels provide safe flap elevation regardless of vascular pedicle variations. The ALT flap can be customized to individual needs and harvested as a cutaneous flap, myocutaneous flap, vastus lateralis muscle flap, or "chimeric" flap. It can be employed as a

Figure 1 (A) A 61-year-old man reconstructed with an LD flap plus split-thickness skin graft (600 cm²) for coverage of a recurrent angiosarcoma after irradiation therapy. Frontal view 3 months postoperatively while the patient underwent a second irradiation due to a new recurrence. (B) Same patient: view from the left side where the anastomoses were performed using the superficial temporal vessels. (C) Same patient: view from the right side.

sensate flap, flow-through flap, or as a functioning muscle flap as mentioned previously.³⁰ Usually musculocutaneous perforators from the descending or transverse branch of the lateral circumflex femoral artery, or from this artery directly,^{46,47} supply the overlying skin. In only 13 to 18% is the skin island based on septocutaneous vessels.^{46,47} Owing to the variability in the vascular anatomy, dissection of the ALT flap can be technically demanding. A safe dissection is based mainly on a retrograde fashion of dissection of the skin vessels toward the main pedicle.^{23,33,48} Fascia lata for dura repair or for a sling procedure and nerve grafts can be harvested simultaneously.³⁰ If the skin vessels are injured during dissection or the main pedicle is absent, the surgeon can convert the ALT flap into an anteromedial thigh flap or a tensor fascia lata flap.³⁴

Direct wound closure can be performed up to 8 cm in width, or even up to 13 cm in elderly patients. Full mobilization can start at the first postoperative day.³⁰ Skin grafting to the ALT flap donor site can impair the range of motion at the hip and knee joint owing to adhesions between the meshed skin graft and the underlying tissue.⁴⁹ However, further donor site investigations did not find significant morbidity, even after harvest of the vastus lateralis muscle.^{34,36,49}

Radial Forearm Flap

Since the introduction of the RF flap by Yang et al in 1981,⁵⁰ it has become a favorite free flap in head and neck reconstructions. Indications for the forearm flap include small and thin defects at the forehead or situations where the ALT flap is not available or not suitable.

The RF flap is a type II fasciocutaneous flap,⁵¹ which receives its blood supply from multiple small branches of the radial artery in the lateral intermuscular septum. These branches are systematically distributed into distinct proximal and distal subgroups⁵² and are found in the septum between the brachioradialis and flexor carpi radialis tendons. This allows the septocutaneous harvest of the RF flap, leaving the fascia in situ.^{53,54}

Donor site morbidity is low after suprafascial flap elevation.⁵⁵ The preserved fascia provides a good bed for the take of a full-thickness skin graft and thus contributes to a good appearance. The intact conjoin of the two layers of the deep fascia also prevents tenting and adhesions of the underlying flexor musculotendinous structures.³⁴ Thus, the range of motion and strength of the hand is maintained.⁵⁵

RECIPIENT VESSELS FOR MICROANASTOMOSIS

Commonly, the superficial temporal artery and vein are used for microvascular anastomoses. Other vessels are the facial artery and vein or the occipital artery and vein.

Selection of the recipient vessels depends on the localization of the defect and on the quality of the respective vessels. At any time, the spur of the artery should be tested before starting the anastomosis.⁵⁶ When the superficial temporal vessels are not suitable, the facial vessels or other vessels in the neck may be considered. Vein grafts are rarely needed.

POSTOPERATIVE TREATMENT OF THE COVERED DEFECT AT THE SCALP OR FOREHEAD

After free flap transplantation, the circulation in the flap should be monitored with clinical observations (color and turgor of the flap) and Doppler control during the first five postoperative days. The author does not use a Doppler probe after pedicled or local flap transfer but uses clinical monitoring. To ease this, usually no tight bandage is used, but a sponge is loosely fixed with tape at the wound edges. Skin-grafted muscle flaps are covered with a loose, moist sponge dressing during the first postoperative days. If there are any indications of an arterial or venous problem, adequate steps should be undertaken immediately. This is usually done under sterile conditions in the operating room (control and/or revision of anastomoses in free flaps or hematoma drainage/flap release in all types of flaps).

Adequate positioning of the head to avoid pressure to the flap is of great importance, particularly when the flap is located at the back of the scalp. External cranial fixation can prevent compression to the anastomoses and/or to the flap.⁵⁷

GENERAL DONOR SITE CONSIDERATIONS

Donor site morbidity ideally should be negligible after harvest of any autologous tissue. This includes functional maintenance, good aesthetic outcome, and easy donor site handling that does not prolong rehabilitation time. A good reconstruction but leaving an ugly donor site or even functional problems is not satisfactory for any patient. After having recovered from trauma or disease, significant donor site morbidity may become a major concern to the patient, with social impact.

Donor sites after the use of local scalp flaps often need to be skin grafted. This creates a second donor site. Both donor sites will be visible and, especially at the head, patients may ask for secondary procedures to improve the aesthetic appearance. Also, free muscle flaps need split-thickness or full-thickness skin grafting. Whenever skin grafts are needed, full-thickness grafts are recommended because of their better appearance and their minor donor site, which will be a small scar at the groin or in the neck.

The three proposed free flaps are known for their low donor site morbidity.^{36,44,49,55} However, depending

on the size of the elevated RF or ALT flap, donor site morbidity may increase.

TREATMENT RECOMMENDATIONS FOR SCALP DEFECTS

Stable coverage and adequate contour are primary goals in scalp reconstruction. The first choice of treatment is a direct suture whenever possible (clean, nontraumatized, and well-vascularized wound edges are mandatory). However, more extensive defects need autologous tissue for achieving these goals (Table 1). Complex and large defects can be reconstructed by using either free flaps or local or distant pedicled flaps depending on the size, location, and etiology of the defect.²¹ Meticulous analysis of the respective defect is recommended.⁵⁸ Bearing this in mind, local or pedicled flaps can be used for reconstruction as long as they are not situated close to traumatized or irradiated tissue, which increases the risk of flap failure.²¹ Distant pedicled flaps such as the lower trapezius musculocutaneous flap or the pedicled LD flap provide another option for coverage in certain scalp regions if a free flap is not chosen.

However, due to their reliability and high success rate, the author prefers free flaps for coverage of defects

such as the (partial) vastus lateralis (VL) muscle flap covered with skin grafts or the (ultrathin) ALT perforator skin flap for thin and small soft tissue defects. Although the RF flap also adequately covers such defects, the flaps from the thigh are preferred at the scalp due to the minor donor site morbidity in terms of aesthetic outcome compared with that of the RF flap.

Medium-sized defects are also regarded as the domain of the various flaps from the anterior thigh (see earlier), whenever the donor site can be closed directly. However, in all cases, if direct closure is not possible after ALT flap harvest, the LD flap plus split-thickness skin graft is regarded as a good alternative for three reasons: a skin-grafted thigh looks ugly; knee flexion might be impaired^{36,49} and the immobilization period is prolonged after skin grafting at the thigh. Thus, very large defects are a domain for the LD flap plus split-thickness skin grafts (Fig. 1).

Deeper defects, such as at the temporal region, often need both thick and thin parts for achieving a good contour. This is a domain for the myocutaneous ALT flap, which can be individually designed for the respective needs as shown in Fig. 2.

In all cases that might benefit from a secondary Branemark epithesis (Fig. 3), the Branemark screws

Table 1 Treatment Modalities for Scalp and Forehead Defects with Denuded Bone or Bone Loss (See Text for Specific Indications)

Etiology of Scalp Defect	Scalp Reconstruction	Forehead Reconstruction
After malignant tumor resection	<ul style="list-style-type: none"> • Direct suture • Local scalp flap(s) • Distant pedicled flap • Free VL flap + FTSG or STSG • Free ALT flap • Free LD flap + STSG 	<ul style="list-style-type: none"> • Direct suture • RF flap • Thin ALT perforator flap • Pedicled temporoparietal fascia flap + STSG
<i>Associated with bone defect</i>	<ul style="list-style-type: none"> • Secondary bone reconstruction • Vascularized bone–soft tissue flap (see below) 	<ul style="list-style-type: none"> • Secondary bone reconstruction • Vascularized bone–soft tissue flap (see below)
Involvement of adjacent tissue suspected (trauma, postirradiation)	<ul style="list-style-type: none"> • (Direct suture) • Distant pedicled flap • Free VL flap + FTSG or STSG • Free ALT flap • Free LD flap + STSG 	<ul style="list-style-type: none"> • (Direct suture) • RF flap • Thin ALT perforator flap
<i>Associated with bone defect</i>	<ul style="list-style-type: none"> • Rib or calvarial bone graft • Synthetic material 	<ul style="list-style-type: none"> • Rib or calvarial bone graft • Synthetic material
Chronic infection (osteomyelitis)	<ul style="list-style-type: none"> • VL flap + FTSG or STSG • Free ALT flap • Free LD flap + STSG 	<ul style="list-style-type: none"> • Pedicled temporalis muscle flap + FTSG • Free VL flap + FTSG • Free fasciocutaneous ALT perforator flap
<i>Associated with bone defect</i>	<ul style="list-style-type: none"> • Scapula flap + bone • Serratus anterior flap + bone • LD serratus anterior flap + bone • Secondary bone reconstruction 	<ul style="list-style-type: none"> • Scapula flap + bone • Serratus anterior flap + bone • Secondary bone reconstruction

RF, radial forearm; ALT, anterolateral thigh; VL, vastus lateralis; LD, latissimus dorsi; STSG, split-thickness skin graft; FTSG, full-thickness skin graft.

Figure 2 (A) A 72-year-old patient with recurrent squamous cell carcinoma at the right temporal/parotic region. The defect consisted of deep and superficial areas and included dura mater at the skull base. (B) Same patient: lateral view 8 months postoperatively after reconstruction with a myocutaneous ALT flap and fascia strip from the fascia lata at the same donor site. Arrow indicates tumor recurrence.

should be fixed in place before the flap is inset to avoid secondary late complications.

In cases of osteomyelitis, flaps such as the LD flap plus split-thickness skin grafts, the myocutaneous ALT flap, or a VL flap plus split-thickness or full-thickness skin grafts are proposed as a good option, supplying the respective area with excellent vascularity. The ALT flap harvested as a fasciocutaneous flap has also proved to be a good alternative in covering radiation defects.²¹

TREATMENT RECOMMENDATIONS FOR DEFECTS AT THE FOREHEAD

Color match, adequate contour, and hairlessness are the most important considerations in forehead reconstruction. A direct suture for closing the defect is preferable, provided this does not distort brow symmetry. In certain superficial defects at the forehead, coverage with full-thickness skin grafts (aesthetically best in one piece considering the aesthetic units⁵⁸) can achieve good results. However, as above, more extensive defects need autologous tissue to achieve the desired result (Table 1). These criteria make the radial forearm flap ideal for forehead reconstruction. The epidermis of the radial forearm flap is thin, and the color of flaps from the upper extremity often adapts over time. Prefabricated flaps using, for example, supraclavicular skin at the neck area have the advantage of replacing tissue with (almost) like tissue⁵⁹ and are therefore a good option for forehead reconstruction. However, this approach is not an alternative when immediate reconstruction is needed after trauma or in cases of malignancy. The ultrathin ALT flap may be a good alternative to the RF flap, but the epidermis at the thigh is thicker than in the forehead

and, especially in Caucasians, there is often hair growth at the thigh. As shown in Table 1, the pedicled temporoparietal fascia flap or the pedicled temporalis muscle flap with ideally one piece of split/full-thickness skin graft, respectively, can also be employed if the pedicle and flap area are not involved in any damage (infection, trauma, irradiation).

Osteomyelitis and radiation damage at the forehead are treated in the same way as at the scalp. However, muscle flaps with full-thickness skin grafts provide better aesthetic results than musculocutaneous or fasciocutaneous flaps and are recommended whenever possible.⁶⁰

As local flaps at the scalp include hair growth, they are usually not recommended for coverage of the forehead.

TREATMENT RECOMMENDATIONS FOR BONE DEFECTS AT THE SCALP AND FOREHEAD

In all cases that need bone reconstruction, either one of the previously discussed flaps can be employed using rib, split calvarian bone, or synthetic material underneath the flaps (Table 1). These avascular bone grafts or synthetic material can be used primarily for skull reconstruction after trauma. In cases of an acute infection or chronic osteomyelitis, however, either vascularized bone such as vascularized rib or scapula bone,^{28,29} or preferably a secondary bone reconstruction, are regarded as standard treatment.²¹ Immediate bone reconstruction after tumor excision is not routine because of the risk of complications after postoperative radiotherapy and possible recurrence,²⁰ although vascularized bone grafts

Figure 3 (A) A 61-year-old man with squamous cell carcinoma at the right eyebrow. Preoperative view. (B) Same patient: intraoperative view after tumor resection. Reconstruction was performed with RF flap, split-thickness skin graft for eye socket, and Branemark screws for secondary epithesis. (C) Same patient: 2 years postoperatively with Branemark screws in the eye socket for the eye epithesis. (D) Same patient: 2 years postoperatively with stable fixed Branemark system.

are the material of choice because they tolerate radiation therapy.

SECONDARY COSMETIC PROCEDURES

Secondary procedures for cosmetic improvement include sequential scar resection after direct suture or skin grafting and tissue expanders. Expanders help to replace scar tissue or free flaps at the scalp with hair-bearing tissue and are a reliable secondary procedure if no previous radiation therapy was given to the patient. The complication rate is low when healthy tissue is used for expansion.⁵

Debulking procedures are relatively common after use of musculocutaneous or fasciocutaneous flaps, whereas they are not needed after employment of skin-grafted muscle flaps.⁶⁰

Cranioplasties for cosmetic reasons, if not performed initially, can be performed at a later stage.^{20,21}

Epitheses securely fixed with Branemark screws markedly improve the aesthetic outcome in cases of ear or eye loss (Fig. 3).

CONCLUSION

Scalp and forehead defects, if treated adequately, can heal with stable and aesthetically acceptable results. In all cases in which direct closure is not possible, the local, pedicled, and free flaps discussed above provide a good option for coverage.

Personally, the author prefers free flaps to pedicled flaps or local flaps whenever skin grafts are needed for coverage of the donor sites. The combination of a scalp defect covered with a local flap and a skin-grafted area directly adjacent (see figures in Ref. 58) looks ugly and does not meet the aesthetic goals, which can be achieved by using a free flap, for example from the thigh, with direct suture of its donor site. The author

now particularly favors the VL muscle flap with split/full-thickness skin grafts because of the better aesthetic result compared with that for free skin flaps, which are prone to edema in the head region.⁶⁰ In general, however, the latissimus dorsi flap, flaps from the anterolateral thigh, and the radial forearm flap are the three free flaps of choice for scalp and forehead reconstruction. Secondary soft tissue revisions and bone reconstruction may be necessary for cosmetic improvement.

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