Reconstruction of Skull Base and Fronto-orbital Defects following Tumor Resection

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ABSTRACT

Reconstruction of the anterior skull base and fronto-orbital framework following extensive tumor resection is both challenging and controversial. Dural defects are covered with multiple sheets of fascia lata that provide sufficient support and avoid herniation. Plating along the skull base is contraindicated. After resection of orbital walls, grafting is necessary if the periosteum or parts of the periorbital tissue had to be removed, to avoid enophthalmus or strabism. Free bone grafts exposed to the sinonasal or pharyngeal cavity are vulnerable to infection or necrosis: therefore, covering the grafts with vascularized tissue, such as the Bichat fat-pad or pedicled temporalis flaps, should reduce these complications. Alloplastic materials are indispensable in cranial defects, whereas microsurgical free tissue transfer is indicated in cases of orbital exenteration and skin defects. The authors review their experience and follow-up of 122 skull base reconstructions following extensive subcranial tumor resection. Most significant complications were pneumocranium in 4.9%, CSF leaks in 3.2%, and partial bone resorption in 8.1%.

KEYWORDS: Skull base reconstruction, fascia lata, fleece-bounded tissue sealing, bone grafts, local flaps, free tissue transfer, alloplastic materials

Resection of extensive tumors involving the anterior skull base, including the parasellar, sphenoclivar, and fronto-orbital regions, often requires wide access and exposure so the anterior fossa and the tumor borders can be seen directly. This generally results in large hard- and soft-tissue defects with destruction of the anatomical barrier between

the sterile intracranial and the contaminated extracranial nasosphenoidal compartments. Partial dural resection following tumor ablation carries with it the potential risk of cerebrospinal fluid (CSF) leakage, tension pneumocephalus, and meningitis. Osteomyelitis and necrosis of osteotomized bone flaps or poorly vascularized bone transplants in

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Skull Base Reconstruction; Guest Editor, Dan M. Fliss, M.D.

Skull Base 2007;17:59–72. Copyright © 2007 by Thieme Medical Publishers, Inc., 333 Seventh Avenue, New York, NY 10001, USA. Tel: +1(212) 584-4662.

Published online: January 11, 2007.

DOI 10.1055/s-2006-959336. ISSN 1531-5010.

communication with the large dead-space cavity are well-known complications after radiotherapy and this ultimately results in collapse of the frontonasal skeleton. Proper reconstruction of the defect following extensive skull base tumor resection is essential so that optimal functional and cosmetic results and an acceptable quality of life for the patient can be achieved.

In this article we present our reconstruction methods for skull base and fronto-orbital defects following tumor resection using the subcranial/subfrontal and combined approaches. These were developed by Raveh in 1978 for the management of severe skull base injuries¹⁻³ and later adapted for the treatment of congenital anomalies^{4,5} and resection of anterior skull base tumors.⁶⁻⁸

METHODS AND TECHNIQUES

The surgical aspects and modifications of the subcranial extended approach have been well described in previous publications.⁹⁻¹¹ Briefly, a bicoronal flap is raised in a subperiosteal plane with preservation of the pericranium and the temporal vessels for possible later use. The outline of the nasofrontal segment and the possible cranial extensions are planned depending on the anatomy of the frontal sinus and the tumor size and location in regard to the subcranial and intracranial extension. *Type I osteotomy* leaves the frontal sinus posterior wall intact to be removed in a subsequent step. A *type II osteotomy* includes the posterior wall in a one-step procedure with meticulous protection of the underlying dura. If no anterior or nasal cavity involvement is apparent, special care is taken to preserve a small bridge over the anterior part of the nasal bone, which facilitates later reconstruction of the nasal dorsum. The osteotomies are performed using a thin blade of a powerful high-speed oscillating saw (TPS, Stryker SA, Montreux, Switzerland) under water irrigation in an oblique manner to ensure exact repositioning, thus providing sufficient bone contact for optimal healing. The frontonasal segment is then carefully raised and

stored in a wet saline towel. The frontal sinus is cranialized by total removal of the posterior wall. Further broad anterior and inferior exposure including the ethmoid and sphenoid roofs up to the clivus, across both orbits toward the temporal bone and maxilla, permits precise extradural and intradural en bloc tumor removal under direct vision and with minimal frontal lobe manipulation. No further facial incisions or damage to other intact structures are necessary, which in turn facilitates reconstruction. If additional exposure to the anterolateral, retro-orbital, or parasellar regions and the infratemporal fossa is needed, the subcranial approach can be combined with a classical pterional or an extended orbitozygomatic approach,¹² whereas an additional Le Fort I osteotomy gives a better opportunity to reach the retromaxillary area and the sphenopalatine fossa.

Dural Repair

Dural defects must be closed in order to restore a watertight barrier between the intracranial contents and any communication with the sinonasal cavity or nasopharynx to avoid CSF leak, pneumocephalus, or infection. Solitary dural tears may be sutured, whereas larger defects require the interpositioning of a biologically reliable membrane. Local fascia grafts are available from the deep temporal fascia or pericranium and can be used successfully to patch smaller holes. For major defects resulting from intradural tumor involvement, sheets of fascia lata harvested from the lateral thigh are recommended. The first layer must be adapted subdurally between the remaining dura and the lateral resection borders of the planum sphenoidale, orbital roofs, and frontal cranial vault. Further overlapping layers are applied using fibrin glue to seal the entire anterior skull base defect, which reaches from the exposed frontal lobes up to the clivus. An additional absorbable gelatin sponge is glued over the superficial fascia layer toward the sinonasal cavity. However, no other rigid support such as bone grafts or metallic or resorbable implants is required to prevent brain herniation (Figs. 1A-C). In recent cases, "fleece-bounded tissue

Figure 1 Extensive esthesioneuroblastoma Hyams grade 4 with intra- and extracranial tumor extension. (A) Preoperative axial MRI, left, and the corresponding intraoperative view after tumor removal, right. S, sphenoid; B, resected dura with exposed brain tissue. (B) Dural repair with fascia lata. See text. S, sphenoid. (C) Postoperative sagittal MRI demonstrating absence of the tumor and presence of fascia lata layers with no brain herniation.

sealing” using a collagen sponge coated with fibrinogen and thrombin coagulation factors (Tacho-Sil[®], Nycomed Austria GmbH, Linz, Austria) has proven to be a cost-effective and timesaving surgical alternative,¹³ as illustrated in Figures 2A,B. Finally, a Vaseline-coated gauze is applied along the skull base planes to provide additional support against brain pulsation; this is removed transnasally after 8 to 10 days. In cases with large intracranial tumor involvement or if signs of early postoperative CSF leakages are apparent, lumbar CSF is drained for 5 days.

Reconstruction of the Orbit and Midface

Extensive skull base tumors often involve bone and soft tissue of the orbit, nose, maxilla, and zygoma.

To achieve oncologically tumor-free clear margins, massive excision, that might include the orbital walls, anterior maxillary sinus, and the palate, may be necessary. Significant osseous defects are likely to produce functional disturbances or aesthetic contour deformities if left unrepaired and should be reconstructed.¹⁴ Even an enophthalmus of more than 2 mm is usually noticeable and may be considered cosmetically disfiguring. It should be remembered that if primary reconstruction cannot be performed, rather difficult secondary defects would represent an even greater challenge to the surgeon at a later stage.¹⁵

The thin lamina papyracea and the orbital floor are rapidly eroded, bringing the tumor in contact with the orbital periosteum, which may resist tumor spread for some time. In the absence of macroscopic intraorbital tumor penetration,

Figure 2 Malignant embryonal tumor in a 10-year-old girl. (A) Subcranial exposure. D, dura opened; C, chiasm with bilateral optic nerves exposed. (B) Fleece-bounded tissue sealing using a collagen sponge coated with fibrinogen and thrombin coagulation factors (TachoSil®).

periosteal frozen sections and adequate excision are then undertaken.¹⁶ Small orbital wall defects do not necessarily result in enophthalmus or diplopia and do not have to be reconstructed in all

cases. In the intra- and early postoperative stages the patient may even have proptosis due to soft-tissue swelling. When near-total removal of the medial wall or orbital floor is necessary or if the

Figure 3 Reconstruction after resection of both medial orbital walls including the periosteum. (A) Intraoperative view. G, calvarial bone graft fixed with a microplate; S, sphenoid. (B) Postoperative coronal and axial CT scan showing accurate positioning of the grafts.

periosteum has to be resected, reconstruction is indispensable. Lyophilized cartilage grafts are only used for small defects, whereas for larger defects we favor autologous materials, as they reduce late problems with extrusion or infection in the hypovascular recipient bed. Calvarial bone has an excellent shape for the reconstruction of bony orbital and maxillary defects including the orbital floor.¹⁷ The outer table of the skull is the most common donor site, as the bone from this region undergoes less resorption compared with free grafts from other locations, such as the iliac crest.¹⁸ The partial-thickness grafts are harvested in the parietal region with curved chisels no closer than 1 cm from the suture lines because of the fusion of the inner and outer table and the danger of damaging the sagittal sinus. Potentially the more dangerous full-thickness osteotomy can occur as the curvature of the skull is convex. Donor site bleeding is controlled and the defect restored with Bone-Source[®] hydroxyapatite cement (Stryker Leibinger, Kalamazoo, IL) (see properties below), otherwise a gap will usually be palpable. The bone transplants are then drilled to the desired shape to fit into the defect and are placed correctly (Fig. 3). Three-dimensional CT programs or navigation systems allow the surgeon to visualize and plan the accurate positioning of the floating grafts within a few millimeters.¹⁹ Enough stability is obtained with the use of titanium microplates (Stryker Leibinger GmbH & Co. KG, Freiburg, Germany) and two to three screws on each side. Resorbable bone plates and screws would be indicated in this location, but—due to the better pliability of the titanium microimplants compared with the available resorbable implant technology—the small titanium microplates can still be more easily shaped to the contour of the bone grafts. If possible, we apply a pedicled buccal fat-pad from the outer side of the buccinator muscle, aligning the nonvascularized graft's inner surface toward the ventilated nasosethmoidal cavity or maxillary sinus (Fig. 4). This ensures a certain coverage and sufficient blood supply to keep the anticipated resorption or potential necrosis at a

Figure 4 Schematic drawing of the midface reconstruction with bone grafts aligned toward the maxillary sinus by the pedicled buccal fat-pad.

minimum. As an alternative, temporoparietal fascia independently or in combination with calvarial bone²⁰ supplied by the superficial temporal artery are used for coverage of bone grafts or cartilage. Further, either the entire temporalis muscle flap or only a part of it, supplied by the anterior and posterior deep temporal arteries, can also serve as a vascular surface for free grafting or as a protection of the exposed carotid artery. The length of the muscle in the middle third makes this portion ideal for use in the orbitozygomatic region, palate, and maxilla, including the orbital floor. For the muscle transfer a tunnel is created and the zygomatic arch osteotomized. However, when transposition of a temporalis muscle or temporoparietal fascia flap is planned, the temporal vessels must already be preserved during scalp flap elevation (Fig. 5). The most common donor site complication in this area is secondary alopecia.^{21,22}

Figures 6A–D illustrates the reconstruction of the medial orbital wall and floor in a case of extensive leiomyosarcoma invading the left orbital cone, effacing the optic nerve, infiltrating the dura,

Figure 5 Temporoparietal fascia flap in combination with full thickness calvarial bone graft, supplied by the superficial temporal artery.

and extending intracranially. Nevertheless, this patient rejected orbital exenteration.

Orbital Exenteration

Extensive primary paranasal and skull base malignancies can infiltrate the orbital content. In cases of obvious intraperiosteal or bony orbital tumor involvement, the orbit with the adjacent bone and sinuses should be removed. Yet, because of the disfiguring nature of this procedure, exenteration may only be performed with curative intention and preoperative agreement with the patient. Restoration of an orbital defect always represents a challenge and the surgeon can enhance the later prosthetic rehabilitation by planning and preparing the defect during the primary intervention. Isolated exenterated sockets without major involvement of adjacent structures may be left to heal by granulation or draping with a split-thickness skin graft as an orbital lining. Small fistulas into the paranasal sinuses or the brain are obliterated by performing locoregional flaps, such as the temporoparietal fascia flap or temporalis muscle, transpositioned through the lateral orbital wall. In more extensive cases the boundaries between the empty orbit and adjacent cavities must be re-established with free tissue transfer. Despite

the wide selection of free flaps and their versatility in reconstruction, our cases with orbital exenteration or extensive skin resections mainly include fasciocutaneous scapular, latissimus dorsi, and radial forearm flaps (Figs. 7A–C). However, one should never forget that voluminous pedicled or revascularized flaps limit the clinical and radiological ability to visualize recurrent disease adequately at the primary site.

Following a disease-free interval, the empty orbital cavity can be covered by means of an ocular prosthesis or episthesis, as shown in Figures 8A–C. Implants anchored to the supraorbital or infraorbital rims provide support and retention that are superior to those achieved with silicone skin adhesives, but radiation therapy may compromise osteointegration. Orbital prostheses never appear completely lifelike, because the vital eye moves constantly, whereas the artificial eye is fixed. Eyeglasses can camouflage this aesthetic deficiency and protect the uninvolved eye at the same time.²³

Frontonasal Reconstruction

In cases without direct tumor involvement of the frontal bone or nasal skeleton, the previously osteotomized nasofrontal segment is exactly repositioned following tumor extirpation and subsequent dural repair. All of the mucosa from the undersurface must be removed with a diamond drill to prevent mucocoele formation. The original preoperative anatomical configuration of the frontonasal region is restored by using previously adapted microplates and a meticulously thin osteotomy, providing sufficient bone contact for optimal healing. Fliss and Gil introduced the technique of additional wrapping of the frontal bone segment by a vascularized pericranial flap.^{24,25} Using this technical innovation, their rate of osteonecrosis or osteomyelitis following radiation was decreased significantly.

The detached medial canthal ligaments are refixed with sutures, guided centripetally underneath

Figure 6 Representative case for the reconstruction of the orbital wall and floor in a leiomyosarcoma. (A) Preoperative coronal MRI showing tumor extensions toward the orbital cone, nasal cavity, maxillary sinus, and resorption of the palate. (B) Corresponding postoperative MRI. Absence of the tumor, contrast-enhanced layers of fascia lata and orbital walls. The eye was preserved. (C) Intraoral view showing the reconstructed orbital floor with a pedicled calvarial bone graft. O, orbit; S, sphenoid. (D) Subcranial view of the medial wall fixed with microplates. F, fascia lata; O, orbit; S, sphenoid.

the frontonasal segment to the contralateral supra-orbital rims to reduce postoperative telecanthus. The correct symmetrical positioning is achieved by bilateral tightening of the sutures with medial, inward, and downward pull. Today we are using resorbable sutures for this procedure and no polyethylene drainage tubes are inserted into the subcranial compartment.

If an anterior bridge of nasal bone and septum is left intact, contouring of the nasal dorsum is uncomplicated. Yet, when the dorsal osseocartilaginous junction is detached, a gap will develop over

the nasal dorsum. In those cases a thin dorsal cartilaginous graft or AlloDerm[®] (LifeCell Corporation, Branchburg, NJ), a dermal replacement derived from cadaveric skin, is inserted to achieve a smooth and natural contour. An even more difficult situation occurs when the frontonasal frame including the nasal septum must be rejected due to tumor involvement. In this case external table grafts and a preadapted Y-shaped miniplate for graft fixation provide enough rigid support in total nasal reconstruction. Lyophilized cartilage grafts are used for the alar region and columella.

Figure 6 (con't.) (E) Postoperative coronal CT scan demonstrating the accurate reconstruction of the orbit and maxilla. (F) Postoperative view of the patient following reconstruction. Normal vision. Photo reproduced with permission.

Figure 7 Recurrent irradiated basalioma involving the skull base, the orbit, and surrounding skin. (A) Preoperative illustration showing the extensive ulceration. (B) Intraoperative situation following radical tumor resection and orbital exenteration. A latissimus dorsi musculocutaneous free flap is already anastomosed to the superior thyroid artery. Microsurgery performed by A. Banic, Plastic & Reconstructive Surgery. (C) The patient's postoperative appearance with no further prosthetic rehabilitation. Photo reproduced with permission.

Figure 8 Patient with adenocarcinoma involving the right eye and skull base. (A) Preoperative view. (B) One year after orbital exenteration and reconstruction. The scapular fasciocutaneous flap is completely healed. Microsurgery performed by A. Banic, Plastic & Reconstructive Surgery. (C) Situation following flap debulking and epithetic rehabilitation by means of a silicone skin adhesive (Felber MA, Lucerne, Switzerland). Photos reproduced with permission.

Calvarial Reconstruction

Loss of calvarial segments by tumor involvement or full-thickness craniectomy defects require immediate reconstruction to protect the underlying brain and to correct major aesthetic deformities. Autologous bone, harvested from the parietal cranium as described earlier in this article, is an ideal material for this purpose. In patients with large defects, various sizes of external table grafts may be necessary for appropriate contouring. However, due to the resorption rate of the bone transplants, the donor site morbidity, and the time-consuming harvesting procedure, there are multiple disadvantageous factors.

Alloplastic materials have revolutionized craniofacial reconstruction over the last few years. Polymethylmethacrylate (PMMA) is a common inexpensive material for cranioplasty, but is also subject to major disadvantages: hardening is associated with an exothermic reaction and excess liquid monomer leading to irritation of the adjacent soft tissue. Furthermore, the acrylic material is incorporated in a fibrous capsule and is potentially at risk of infection or extrusion. The achievement of a proper adherence to the surrounding bone in complex

cranial defects may be difficult, especially in those involving the fronto-orbitotemporal region. Therefore PMMA is in the author's hands replaced by more biocompatible bone substitutes, allowing easy contouring and avoiding donor site morbidity. BoneSource[®] hydroxyapatite cement is an osseointegrative bone substitute composed of dicalcium and tetracalcium phosphate salts that isothermally forms a putty-like paste when mixed with water.²⁶ It can be shaped easily and applied within 20 minutes; it converts to a hard, strong implant composed of pure hydroxyapatite within 4 to 6 hours, which adheres to the surrounding bone. BoneSource[®] is an ideal bone graft substitute for non-stress-bearing applications such as cranial defects.^{27–30} For proper contouring of the orbital roof, silastic sheets are temporarily placed against the periorbital area to prevent adhesion. BoneSource[®] maintains its shape and volume with progressive osseointegration. Figures 9A–D illustrates the fronto-orbital reconstruction following resection of a growing fibrous dysplasia by means of a preshaped hydroxyapatite cement template.

For cranial defects with a surface larger than approximately 25 cm², more mechanical stability

Figure 9 Young woman with active fronto-orbital fibrous dysplasia and consecutive visual disturbance. (A) Intraoperative view of the fronto-pterional craniectomy defect. O, orbital content; C, craniotomy defects with exposed dura. (B) On the basis of a stereolithographic model, a hydroxyapatite cement (BoneSource[®]) template was preshaped, exactly placed, and fixed with a titanium mesh. (C) Preoperative CT scan illustrates the orbital restriction, left. Postoperative CT scan shows accuracy of the hydroxyapatite template, right. (D) Preoperative view with orbital depression, left. Same patient 1 year later with orbital symmetry and normal vision, right. Photos reproduced with permission.

and protection of the cement against repetitive trauma from dural pulsations are provided by the application of an additional titanium Dynamic Mesh[™] (Stryker Leibinger GmbH & Co. KG, Freiburg, Germany). Its low profile thickness, either 0.3 or 0.6 mm, can be cut easily with scissors to conform to the size and shape of the defect. Special bulged bending pliers allow precise bending action to the desired anatomical contour. The mesh is then placed just over the craniectomy edges and fixed with self-tapping screws. The procedure is shown in Figures 10A–F, a recurrent transitional meningioma along with extensive involvement of the frontal bone. If no hydroxyapatite is available, the space between the dura and the titanium can also be filled

with autologous fat. The detached temporalis muscle is then reapproximated and sutured to the mesh or microscrews, to prevent postoperative contracture resulting in masticatory dysfunction and temporal hollowing.

RESULTS

The data of 122 extensive reconstructive cases, surgically treated by the extended subcranial approach including combinations between 1990 and 2005, have been reviewed. There were 75 male and 47 female patients with a mean age of 51.5 years;

Figure 10 Representative case with recurrent meningioma of the transitorial type. (A) Axial and sagittal MRI depict tumor involvement of the frontal sinus and frontal bone. (B) Intraoperative view of the craniectomy defect and resected dura. FS, frontal sinus. (C) Dural repair with fascia lata and fleece-bound tissue sealing (TachoSil®). Frontonasal duct closed with muscle and fascia. (D) Following obliteration of the frontal sinus with hydroxyapatite cement (BoneSource®), a titanium mesh is adapted (see text). (E) Hydroxyapatite cement allows easy contouring of the supraorbital region and orbital roof. (F) Frontal and lateral 3-D CT scans show the exact shape of the reconstructed fronto-orbital region, left. Patient's postoperative appearance, right. Photo reproduced with permission.

malignant tumors were present in 60 cases and benign tumors in 62 cases. In accordance with both the AJCC (American Joint Committee on Cancer) and TNM staging systems, 16.8% of the malignant tumors were classified as T3, 29.0% as T4a, and 54.2% as T4b. The references to the state of disease and overall survival rate are beyond the scope of this article and are stated elsewhere.

The early and late complications related to the reconstruction are listed in Table 1. Pneumo-cranium (4.9%) or immediate CSF leakage (3.2%) mostly developed after accidental removal of the nasal packing in the early postoperative stage. These leaks were successfully controlled by a lumbar drain. In three patients with inadequate primary fascia lata alignment, revision surgery was necessary. Enophthalmus (11.4%) was most probably caused by secondary orbital fat resorption, whereas telecanthus (6.5%) developed after collapse of the nasal frame. Both were more aesthetic than functional problems. Two of three cases with mucocoele formation (2.4%) needed revision surgery several years later. In contrast to earlier reports,⁹ partial resorption of orbitomaxillary bone grafts (8.1%) and necrosis of the nasofrontal segment (2.4%) were observed in a total of 13 cases. With one exception, all of these patients underwent postoperative radiotherapy. Two patients with near total segment necrosis developed an additional nasofrontal fistula, which made a local repair necessary. The

collapsed frontonasal segments were successfully reconstructed in two cases (see Figs. 11A–D)—the revision in one patient with major cosmetic disfiguring was considered to be too risky.

DISCUSSION

Anterior skull base tumors can be surgically approached in various ways. The major advantages of the extended subcranial approach with temporary osteotomy of the nasofrontal segment are the broad exposure to the anterior skull base plane including the sphenoclival region as well as the nasal and paranasal cavities with direct visualization of the tumor margins and the adjacent vital structures. Additional disfiguring transfacial incisions such as the lateral rhinotomy are not necessary. However, the satisfying functional and cosmetic outcome always depends as much on the reconstruction as it does on the tumor resection. Ablation of voluminous tumor masses creates large dead-space defects with free communication between the paranasal sinuses and the intracranial space. The formation of a water- and airtight barrier between these compartments is technically challenging and may be complicated further by several factors. In our series, large fascia lata grafts, tacked in several sheets underneath and above the edges of the remaining dura or bone using fibrin glue or TachoSil[®] (Nycomed Austria GmbH, Linz, Austria), provide sufficient support to seal the entire anterior skull base defects and is confirmed by the low rate of postoperative CSF leakages of 3.2%. If no preoperative radiotherapy has been given and the recipient bed provides sufficient vascularity, free bone grafts in combination with local flaps such as temporoparietal fascia or temporalis muscle are valuable for bony defects of the naso-orbital and mid-face region. The application of an additional pedicled pericranial flap guided underneath the frontonasal segment decreases osteonecrosis or osteomyelitis, but may interfere with further cranial reconstruction and reduce sufficient bone contact between the segment and the cranium for optimal healing.

Table 1 Early and Late Complications Associated with Skull Base and Fronto-orbital Reconstruction in 122 Extensive Cases

Complications	Number of Cases	Percentage
Pneumocranium	6	4.9%
CSF leak	4	3.2%
Meningitis	2	0.8%
Significant brain edema	1	0.8%
Temporary seizures	3	2.4%
Enophthalmus	14	11.3%
Diplopia	9	7.3%
Telecanthus	8	6.5%
Mucocoele	4	2.4%
Partial bone resorption	10	8.1%
Total segment necrosis	3	2.4%

Figure 11 Necrosis and resorption of the frontonasal segment 1 year after successful removal of a juvenile ossifying fibroma of the skull base. (A) Collapse of the nasal dorsum. G, glabella. (B) Reconstruction with calvarial bone grafts, long miniplate, and nasal dorsum onlay graft. (C) Frontal pre- and postoperative appearance. (D) Same patient's lateral pre- and postoperative appearance. Photos reproduced with permission.

Although alloplastic materials are becoming increasingly popular in craniofacial reconstruction, their cost-effectiveness must be kept in mind. The extensive use of these expensive materials is only justified if the donor site morbidity as well as the operation time are significantly reduced and relevant complications with related revision surgeries can be avoided.

Progress in microvascular techniques today allows more radical tumor resection and effective reconstruction of extensive defects.³¹ A large volume of well-vascularized and nonirradiated tissue can be inserted into the defect area, but the bulky mass of tissue may also mask local recurrence, making radiological and clinical follow-up more difficult. Free tissue transfer represents a complex surgical procedure requiring the considerable expertise of a

multidisciplinary team and is therefore only indicated in those cases with large skin defects and orbital exenteration.

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