Surgical Management of the Anophthalmic Orbit, Part 2: Post-Tumoral

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Ablative surgery for tumors of the globe and its adnexal structures is frequently the cause of major orbitofacial deformity. Radiotherapy compounds the problem because it suppresses skeletal growth in the growing patient and induces a contraction of the remaining soft tissues in the orbit. Goals for reconstruction in these patients include the restoration of orbital structures to allow the fitting of an ocular prosthesis and the correction of distorted orbitofacial relationships. The authors present a series of 53 patients (mean age, 29 years; 28 male) who were treated over the past 18 years by composite reconstruction of the post-tumoral anophthalmic orbit. The follow-up ranged from 5 months to 18 years (mean, 7.75 years). Four patients were treated primarily (immediate reconstruction after tumor ablation), and 49 were treated secondarily (mean oncological follow-up since ablative surgery, 14.8 years). Twenty-eight patients underwent orbital enucleation (including three bilateral cases), 23 underwent orbital exenteration, and two underwent evisceration. Forty-two patients received radiotherapy, including 20 enucleation patients, 15 exenteration patients, and seven others in whom details of primary therapy were incomplete. A staged reconstruction was undertaken in each case; it considered, in turn, the bony orbital volume (orbital remodeling and cranial bone grafts), orbital contents (implant, temporalis muscle transposition, cranial bone grafts, and dermafat grafts), conjunctival sac (mucosal and skin grafts), ocular prosthesis, eyelids (local flaps and skin grafts), and additional procedures to restore orbitofacial symmetry. The authors conclude that the long-term results of post-tumoral orbital reconstruction are favorable, and they particularly recommend the use of autogenous tissues in irradiated orbits. (*Plast. Reconstr. Surg.* 108: 827, 2001.)

Tumors of the eye and its adjacent structures often require the removal of the globe (enucleation) or the entire orbital contents (exenteration). Surgery and radiotherapy have mutilating consequences in the orbit,[1] the impact of which differs as a function of the age of the patient. In a child, bony growth retardation[2] and soft-tissue retraction are often the cause of severe hemifacial deformities. In the adult, the asymmetry remains mostly at the orbital level.

The absence of an eye and facial disharmony are important psychological and physical handicaps to the patient. The management of a post-tumoral anophthalmic orbit requires an intimate knowledge of orbital anatomy, combined with specifically adapted surgical techniques. It should have two objectives: (1) to enable the fitting of an ocular prosthesis and (2) to treat the consequences of the anophthalmic orbit by restoring equilibrium to the face.[3,4] To this aim, techniques developed in craniofacial surgery have contributed to achieving a permanent reconstruction of the orbitopalpebral region, avoiding the use of external facial prostheses.

The eye is a natural inducer of facial expansion in the child, and its removal in infancy is the cause of important orbitopalpebral deformities.[5] The radiotherapy that is frequently required to control orbital tumors causes further tissue injury.[2] The delay in the growth of the bone and the soft tissues of the face extends beyond the confines of the orbit, causing hemifacial hypoplasia, which is manifested by retromaxillism and nasal, maxillary, and mandibular deviation. In time, the normal hemiface seems to "wrap itself" around its injured counterpart. In addition, soft tissues within the irradiated orbit become scarred and poorly vascularized. As a result, characteristic features at presentation include blunted, eroded orbital rims (Fig. 1, *above*), a contracted conjunctival sac, and atrophic eyelids (Fig. 2, *left*). The latter are tethered and drawn into the cavity, which

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FIG. 1. A 22-year-old woman who underwent enucleation and radiotherapy of the right orbit at 5 years of age for retinoblastoma. (*Above*) The reconstruction first addressed orbital volume with a transposition of the temporalis muscle and cranial bone grafts placed within the orbit, around the orbital frame, and to augment the malar area. (*Below, left*) Two years later, the conjunctival sac was created using a graft of buccal mucosa, followed by eyelid reconstruction using a nasolabial flap and eyelash and full-thickness skin grafts. (*Below, right*) Ten years later, the conjunctival sac had significantly contracted and had to be restored using a full-thickness skin graft.

FIG. 2. (*Above, left*) A 26-year-old woman presented with the sequelae of left enucleation after undergoing radiotherapy at 2 years of age for retinoblastoma. The orbital reconstruction consisted of the placement of an implant wrapped in allograft sclera in Tenon's capsule, orbital remodeling associated with transposition of the temporalis muscle into both eyelids (which were severely atrophic), a subperiosteal mask lift to restore symmetry to the orbital level of the face, and reconstruction of the conjunctival sac with a graft of buccal mucosa. (*Above, right*) Follow-up at 7 years. (*Below*) Profile of the patient wearing an ocular prosthesis before and after reconstruction, demonstrating the correction of the volume deficit in the anophthalmic orbit, the projection of the lateral orbital rim, and the improvement in the structure and appearance of the eyelids.

restrict their excursion and motility. Enucleation performed when the patient's orbital growth is complete carries a lesser morbidity. A redistribution of tissue volumes occurs within the orbit, including contraction of the conjunctival sac. After an exenteration, however (Fig. 3, *above*), in which the entire orbital contents are resected with or without the eyelids, the vascularity of the orbital bone is greatly diminished.

PATIENTS AND METHODS

We use a stepwise, anatomical approach to reconstructing the post-tumoral anophthalmic orbit that separately addresses the container (bony orbit) from its contents (orbital vol-

FIG. 3. (*Above*) A 40-year-old man was referred for reconstruction after a complete right orbital exenteration for carcinoma of the lacrimal gland. (*Below, left* and *center*) A complete orbital reconstruction was undertaken. This included, in separate stages, reconstruction of orbital volume with cranial bone grafts and transposition of the temporalis muscle. The temporalis muscle was resurfaced with a full-thickness skin graft, a conjunctival sac was created with a buccal mucosa graft, and eyelids were reconstructed using the divided full-thickness skin graft and eyelash grafts, followed by the fitting of a definitive, removable ocular prosthesis. (*Below, right*) Result at 3 years.

ume). Access to the orbitofacial region is obtained through bicoronal and lid incisions, which allow for the simultaneous remodeling of the upper facial skeleton and the harvesting of cranial bone grafts.

Bony Orbit (Container)

Onlay bone grafts are a versatile tool for reconstructing the post-tumoral anophthalmic orbit and modifying the balance between container and contents. When required, the entire bony orbit (four walls and superior and inferior orbital rims) and the malar bone are refashioned with bone grafts placed directly in contact with bone[6] (Fig. 1, *below, left* and Fig. 3, *below, left* and *center*). The infraorbital rim is fashioned slightly higher than on the healthy side to support the prosthesis and ensure its centric position within the orbital frame. Our choice is virtually always cranial bone,[7] which is closest to the recipient tissue both embryologically and morphologically. Resorption of onlay bone grafts is greater in the postirradiated orbit,[8] and an overcorrection is necessary to achieve the desired volume. The grafts are harvested from the outer table of the parieto-occipital skull as unicortical grafts or are split from a bicortical parietal bone flap for more substantial reconstructions. Osteosynthesis is used, except for the orbital floor and some malar grafts.

When indicated by a severely devitalized bed, the cranial bone grafts are complemented with cancellous bone taken from either tibial or iliac donor sites. Rib grafts are only occasionally used because of their potential morbidity. Synthetic materials are avoided, especially in irradiated orbits, because we judge the risk of their eventual extrusion to be too high, either acutely or after chronic, low-grade infections. The use of autologous tissue is perfectly tolerated by the patient in both the short and long term, and it imports healthy tissue into the orbit.[6] Advancing the orbital framework using osteotomies in these patients is usually considered unsafe, because a segment of irradiated, poorly vascularized bone runs a high risk of sequestrum formation.

Orbital Volume (Contents)

Enucleation (removal of the globe) is followed by the placement of an adequate spherical implant (polymethylmethacrylate or silicone), which replaces the volume of the globe.[9,10] The implant is wrapped in autologous fascia (lata or deep temporal) to reduce its risk of expulsion. The motility of the stump and, thus, of the ocular prosthesis is maximal when the implant is placed within Tenon's capsule[1] (Fig. 4). If the implant sits too low in the orbit, a subperiosteal cranial bone graft placed on the orbital floor through a subtarsal incision may be used to lift it into place or simply to add to the orbital volume. In the postirradiated socket or after the expulsion of an implant, we use a dermafat graft harvested from the buttock because of the high risk of alloplastic rejection.

After an exenteration or an extended enucleation with radiotherapy, one must recreate the entire orbital volume using bony and soft tissues. The soft-tissue component is required to be (1) supple, to conform to and fill any bony irregularities and deficits of the orbital walls and to eliminate any potential dead space; (2) well vascularized, to allow for the creation of a conjunctival sac by grafting and to improve the potential for growth of the bone and eyelids; (3) of sufficient volume to fill the apex of the orbit; and (4) resistant, to support the conjunctival sac, the prosthesis, and the eyelids. The temporalis muscle[11,12] satisfies all of these criteria, and it is our first choice when it is available. Transposition of its anterior portion (Fig. 5, *above*) is sufficient to fill the orbit (Fig. 1, *below, left*) and create a vascularized basis for the overlying grafts that will form the eyelids and the conjunctival sac. Excessive filling risks the forward propulsion of the future prosthesis, whereas transposition of insufficient muscle gives a final appearance of enophthalmos. When the temporalis muscle is unavailable, numerous other options for

FIG. 4. Placing an implant wrapped in temporalis fascia inside Tenon's capsule (hooks). The suture line faces inside the orbit to minimize the risk of implant extrusion.

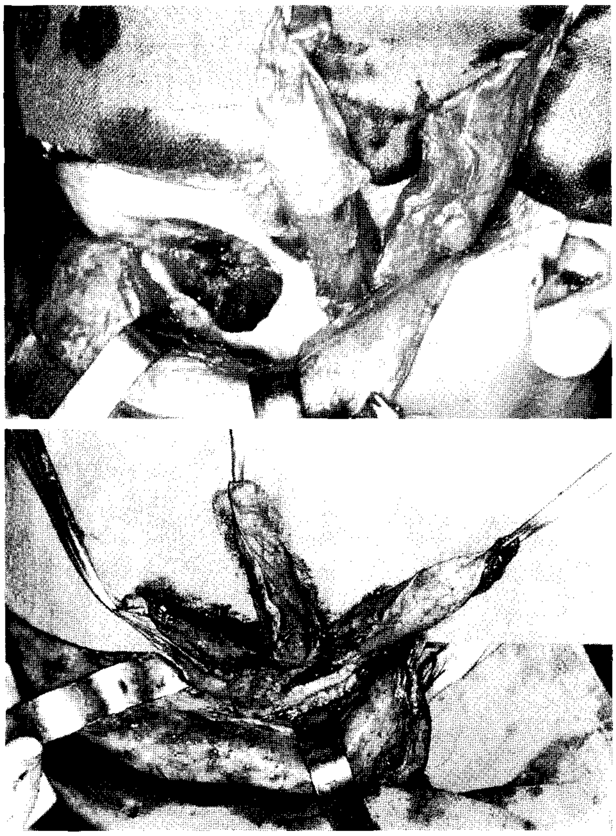

FIG. 5. Transposition of the temporalis muscle, shown (*above*) divided into two parts for adding volume to the orbit and (*below*) divided into three parts for reconstructing the eyelids.

restoring orbital volume have been proposed using microsurgical transfer.[13-15]

Conjunctival Sac

In the anophthalmic socket, the conjunctival sac and its fornices serve to maintain, humidify, and articulate the ocular prosthesis (Fig. 1, *above*). Adequate configuration of the fornices is the key[1,4,16] to success with the fitting of a light and well-positioned prosthesis. A contracted sac fails to contain the prosthesis and should be reconstructed using mucosal or skin grafts.[10,17,18] Buccal mucosa is the graft tissue of choice, because it is more durable and contracts less than a skin graft, but it has the disadvantage of being in short supply and carrying a certain morbidity. It is taken from the buccal vestibule in full thickness (3 × 4 cm, preserving the vestibule and Stensen's duct), and any part of the donor site that cannot be closed is reepithelialized. The patient is encouraged to massage the intraoral scar several times a day and to chew gum to reduce the risk of contractures. Skin grafts are taken full-thickness from glabrous areas that are easily concealed (inguinal fold, forearm). Their surface area is not a concern, but they contract more than mucosal grafts and are often the source of other problems, such as desquamations, hair growth, and malodorous secretions.

The conjunctival sac reconstruction is either partial (individual fornices) or complete after high-dose radiation or orbital exenteration. Partial sac reconstruction involves the inferior and medial fornices most frequently and, rarely, the superior fornix. The dissection of the recipient site is continued deep to the orbicularis muscle until the periosteum of the orbital rims is encountered. The graft is sutured to the existing conjunctiva. Bolster sutures and an annular conformer placed within the cavity are used to maintain the shape and depth of the fornices. A two-layered median tarsorrhaphy[17] is completed and kept in place for 4 to 6 months.

Complete sac reconstruction is used in cases of exenteration or extreme soft-tissue contraction in the orbit. The temporalis muscle, which has already been transposed into the orbit, serves as a vascularized graft bed. The entire sac is refashioned with a large mucosal or skin graft (Fig. 6). A median incision is made to preserve what remains of the conjunctiva and line with it the posterior surface of both eyelids. The cavity dissection then continues to the bony margins of the orbit, and the mucosal or skin graft is sutured around a conformer (Fig. 8, *below*) and inserted in the space created. In the case of an exenteration, where the temporalis muscle has been transposed, the conformer bearing the skin graft is placed in a pocket dissected within the muscle, deep to the temporalis aponeurosis, which is useful for providing support for the reconstructed eyelids. A tarsorrhaphy is kept for a minimum of 6 months (1 year during puberty), with medial and lateral openings to allow for cavity lavages and the placement of topical medications. After an adequate reconstruction, the sac generally does not lose its shape and it permits the long-term contention and mobility of the prosthesis. The tarsorrhaphy is often released under local anesthesia, with removal of the conformer and exploration of the cavity. The mucosal edges are sutured to the skin. A temporary prosthesis is fitted within 10 days.

Eyelids

The eyelids of an anophthalmic socket conform to and maintain the ocular prosthesis,

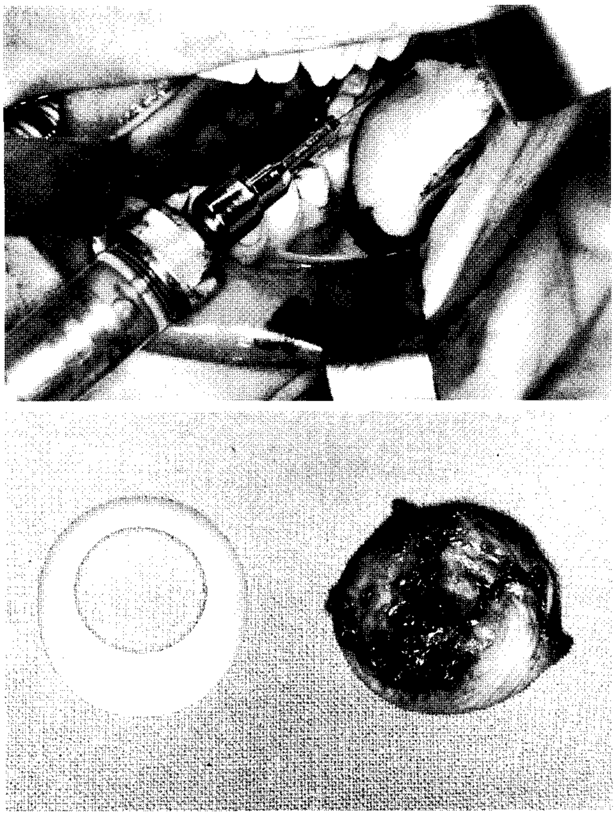

FIG. 6. Reconstruction of the conjunctival sac with a graft of buccal mucosa. (*Above*) Harvest of a wide area of jugal mucosa, taking care to avoid the parotid papilla. (*Below*) An annular conformer, after it is wrapped with a graft of buccal mucosa, is ready for insertion.

and they play an important aesthetic role in maintaining the symmetry of the orbital level of the face. They may be distended, atrophic, short, or immobile, any of which warrant surgical intervention. The upper eyelid almost always requires elevation with ptosis surgery and the creation of a palpebral fold. The lower lid usually requires ectropion surgery because it supports the ocular prosthesis and becomes distended over time.

Lax, distended lower eyelids are stretched and elevated by a lateral canthopexy (Fig. 7, *center*),[19] whereas the palpebral fissure is shortened by a lateral tarsorrhaphy (which may be made asymmetric to tighten the lower lid if necessary). Atrophic lids are deficient in support and vascularity, both of which are provided by a transposition of the temporalis muscle into the eyelids (Fig. 5, *below*). The anterior two-fifths of the muscle, divided into two parts, is tunneled into a suborbicularis pocket and sutured over bolsters at the medial canthus. Two paths exist for the transposition, either through a large fenestration of the lateral orbital wall or anterior to it when it is blunted and atrophic. The import of healthy muscle into the eyelids also improves their volume and appearance (Fig. 2). The posterior three-fifths of the temporalis muscle is brought forward to

FIG. 7. A 43-year-old woman who underwent enucleation and radiotherapy for retinoblastoma of the right eye as a 1-year-old. The left eye was also treated for retinoblastoma with radiotherapy. She was referred for treatment at 33 years (*left*) and underwent a three-stage reconstruction, including orbital implant wrapped in a scleral allograft, reconstruction of the conjunctival sac with mucosal grafts, and restoration of orbitofacial harmony with a subperiosteal mask lift, malar bone grafts, and lateral canthopexies. (*Center*) Ten days after mask lift. (*Right*) Follow-up 10 years later.

fill the temporal hollow, and the posterior defect is packed with fine Mersilene mesh.

Eyelids that have retracted within the orbit are fixed (Fig. 2, *left*). It is only by freeing them from adhesions in the socket that they regain a degree of mobility. Short or heavily scarred lids are an indication for either partial or total reconstruction using full-thickness skin grafts or local flaps. Lid reconstruction is frequently made easier by keeping the ocular prosthesis in place.

The ocular prosthesis must be light and take its support not from the lids but the infraorbital rim, which must be given sufficient projection for this purpose.

After a total exenteration (Fig. 3, *below, left* and *center*) with lid resection, one must undertake a complete reconstruction of both eyelids. The method we use has two stages: full-thickness skin grafting of the temporalis muscle transposed into the orbit, followed 1 year later by a horizontal incision to create a new palpebral fissure and dissect a pocket within the muscle. The eyelids obtain structural support from the temporalis muscle aponeurosis but lack any intrinsic movement and should initially be made short to control the palpebral fissure from becoming too wide. A nominal vertical movement of the upper lid can later be obtained using a frontalis muscle suspension (Fig. 3, *below, right*). Eyelash grafts are performed 1 month before the creation of the palpebral fissure. The creation of a palpebral fold and the use of tattoos contribute to the

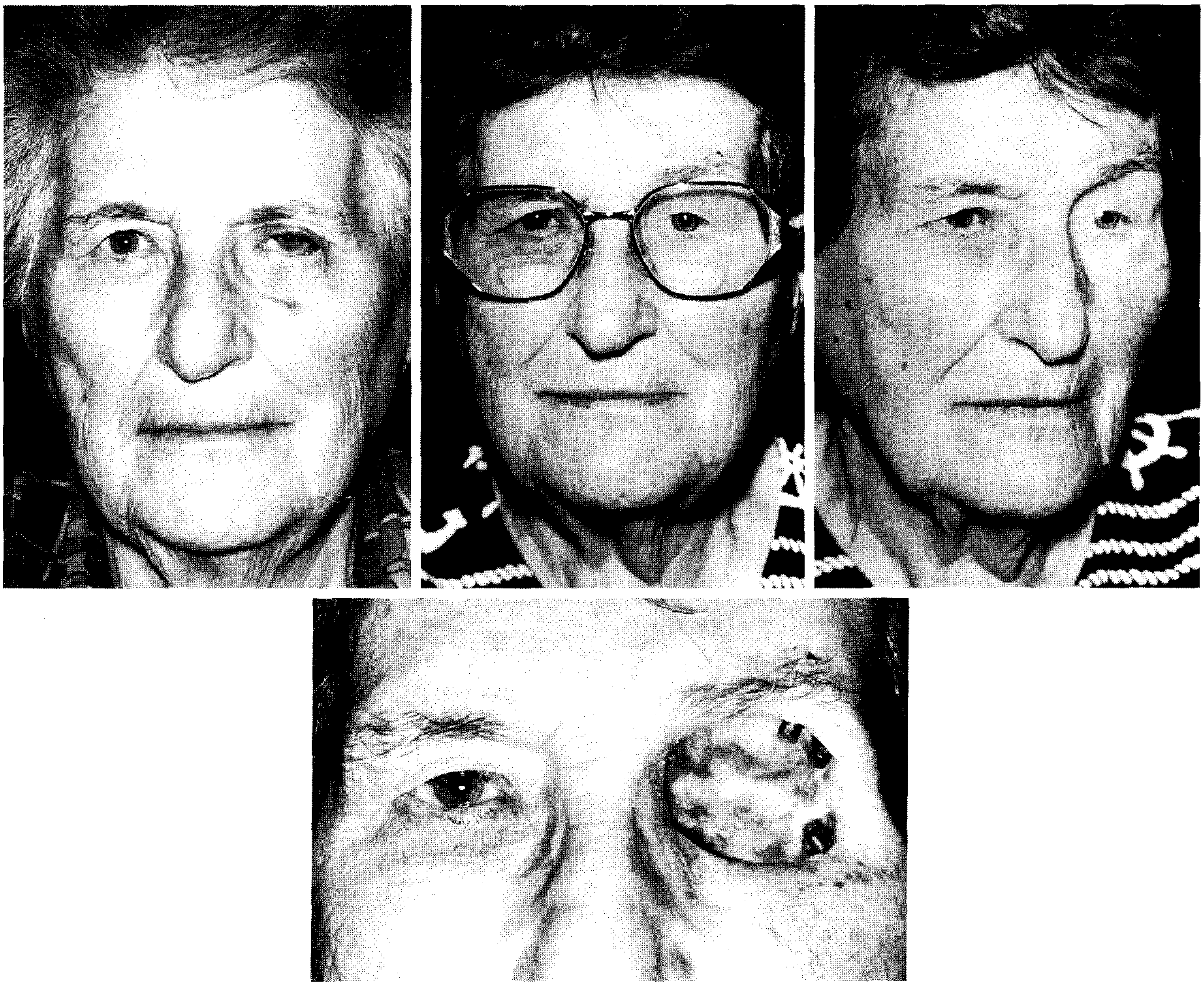

FIG. 8. (*Above, left*) A 75-year-old patient presented with recurrent adenocarcinoma of the left lower eyelid. (*Below*) She underwent a total left orbital exenteration with radiotherapy and immediate reconstruction. An implant was placed in the apex of the orbit, followed by a transposition of the temporalis muscle covered with a full-thickness skin graft. Three osseointegrated implants were placed in the orbital frame, and 6 months later, a definitive external prosthesis was fitted. (*Above, center* and *right*) Follow-up at 3 years.

final aesthetic appearance of the eyelids, and it is only then that the definitive ocular prosthesis is manufactured and fitted to the patient.

Finally, eyebrow grafts are performed using the contralateral eyebrow if it is sufficiently thick. Attention must be paid to the correct alignment of the hairs, which fall during the postoperative period but grow again after 6 months (Fig. 3, *below, left* and *center*). If the contralateral eyebrow is too fair or too fine, eyebrow tattoos or occipital micrografts give a good result.

Facial Harmony

In the adult, the facial disharmony that follows enucleation is minimal, and reconstruction remains primarily within the orbit. In the child, however, the correction of significant secondary facial deformities requires other techniques, such as maxillary osteotomies, genioplasty, rhinoplasty, bone grafts, or transposition muscle flaps to improve facial symmetry.

The reconstructed orbit can be brought further into harmony with the rest of the face using various aesthetic procedures, such as rhytidectomy and blepharoplasty (Fig. 2). In particular, the mask lift[19] has an unparalleled potential (Fig. 7) for correcting bony asymmetry within the orbitopalpebral region.

Alternative Techniques

Osseointegrated titanium implants may be used to support an external prosthesis[20] (Fig. 8). This technique has indications in the elderly and whenever tumor recurrence remains a significant risk. It is also an option when an autologous reconstruction is not feasible (e.g., when a communication exists between the orbit and the intracranial contents). Thanks to an external prosthesis, patients may regain an acceptable aesthetic appearance within 3 to 6 months. Their socket requires minimal care, and it presents an easy site for oncological surveillance. Although the temporalis muscle proves useful for lining the socket before inserting the implants, the orbital cavity must remain hollow enough to accept the prosthesis. Another method for restoring the exenterated orbit allies autologous reconstruction with the principle of an external prosthesis: it enables the patient to exchange, at will, ocular prosthesis and magnetic external prosthesis, supported by a magnet placed within the conjunctival sac.

Results

A consecutive series of 53 patients (28 males) were treated over the past 18 years in our unit for surgical reconstruction of the post-tumoral anophthalmic orbit. Ages ranged from 5 to 78 years (mean, 29.0 years). The follow-up ranged from 5 months to 18 years (mean, 7.75 years). Four patients were treated primarily (immediate reconstruction after tumor ablation), and 49 were treated secondarily (mean oncologic follow-up since ablative surgery, 14.8 years). Twenty-eight patients underwent orbital enucleation (including three bilateral cases), 23 underwent orbital exenteration, and two underwent evisceration. Forty-two patients received radiotherapy, including 20 enucleation patients, 15 exenteration patients, and seven others in whom details of primary therapy were incomplete. The most common tumor histology was retinoblastoma; this was followed by a mixture of pathologies (detailed in Table I). Because of differences in their surgical management, both meningiomas and neurofibromas were excluded from this study. The same surgeon (D.K.) operated on all cases. A breakdown of the reconstructive procedures used in this series is detailed in Table II.

Contraction of the soft tissues within the orbit was observed in the majority of patients who had received radiotherapy, sometimes occurring many years after treatment. We observed that this phenomenon was more common during puberty (of nine severe orbital retractions, all occurred in patients who had multiple operations and previous irradiation, which included four adolescents). Radiation injury was associated in several cases with a partial resorption of cranial bone grafts placed around the orbital rims; a further bone graft-

TABLE I
Pathology of Orbital Tumors

Tumor Type	Number
Retinoblastoma	22 (19 unilateral, three bilateral)
Rhabdomyosarcoma	8
Osteosarcoma	2
Fibrosarcoma	1
Carcinoma	8 (six basal cell, one adeno, one squamous cell)
Malignant melanoma	2
Rhinoscleroma	1
Vascular malformation	2
Glioma	2
Unknown	5

TABLE II
Procedures Used in Orbital Reconstruction

	Enucleation	Exenteration	Evisceration
Container			
Onlay bone graft	19	14	1
Burring/remodelling	15	13	—
Contents			
Temporalis muscle transposition	11	20	—
Frontalis flap	2	1	—
Implant	16	2	2
Sac			
Mucosal grafts	16	8	
Skin grafts	4	4	
Ocular prosthesis	25	11	2
No ocular prosthesis	2	5	—
Implant-maintained prosthesis	2	5	1
Other procedures	7	5	—
Still undergoing treatment	6	1	—

ing procedure was required in five patients (all adults) to restore orbital bony symmetry.

One patient developed tumor recurrence 5 years after surgery for a fronto-orbital osteosarcoma after an immediate reconstruction for exenteration.

Discussion

The reconstruction of an anophthalmic orbit is a complex undertaking. It should follow a satisfactory period of oncological surveillance, and it is essential for the surgeon to have a good knowledge of both reconstructive and aesthetic orbitopalpebral and facial surgery before embarking on this lengthy endeavor. The treatment plan is conceived both in space and in time and should be carefully adapted to the fragile and evolutive psychology of the post-tumoral anophthalmic patient. In our unit, the reconstruction of an anophthalmic orbit follows a definite sequence that is individually tailored to the oncological, radiological, ophthalmological, and psychological circumstances of each patient. The proposed surgical plan is designed around computed tomography scans and premorbid and contemporary photographs, and the patients' wishes are given careful consideration by the multidisciplinary team.

Most of the patients in this series presented late, and the risk of masking local tumor recurrence with a composite reconstruction was correctly judged to be low (one local recurrence in 53 patients). This low incidence of tumor recurrence probably reflects the small number of immediate reconstructions in this series and the relatively long period elapsed since primary surgery in the delayed cases. A long interval period between extirpative surgery and a orbital reconstruction not only validates the safety of this surgery in an oncological sense, but it also reaffirms our observation that many patients with acquired anophthalmia wish for a more definitive reconstruction, which can be provided by an external prosthesis or an eyepatch. In this respect, one might argue that this series selects a psychologically favorable patient population by which to judge the outcome of this surgery. Certainly the repeated operations of a staged approach test the patient's confidence and cooperation.

The dynamic interrelationships between autologous tissues, which are often radiation-injured, and the alloplastic components of a composite orbital reconstruction (implant or ocular prosthesis), also mean that long-term follow-up and the provision for minor adjustments, such as sac regrafting, must be available. Despite these, it is ultimately rewarding to witness the impact of a successful orbital reconstruction on the lifestyle and psyche of a post-tumoral anophthalmic patient. Finally, we recommend that surgical interventions be planned outside of any "growth spurt" period in the patient to avoid a predictable deterioration in results. Considerate management of available autologous donor sites is mandatory, because repeated episodes of grafting are likely to become necessary. One would expect that advances in prosthetic technology will contribute toward further improving the quality of these results, such that synchronous prosthetic movement may one day be achieved.

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