Use of Precontoured Positioning Plates and Pericranial Flaps in Midfacial Reconstruction to Optimize Aesthetic and Functional Outcomes

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Objectives: To present our experience with reconstruction of midfacial defects using "precontoured positioning plates" with or without pericranial flaps and to describe our technique in detail.

Methods: Thirty-two consecutive patients with midfacial defects subsequent to oncologic resection that were reconstructed primarily with cranial bone grafts and precontoured positioning plates were reviewed for type of defect, functional outcome, complications, and postoperative appearance.

Results: Primary reconstruction of all defects in this series was performed. Defects involved the orbital rim, orbital floor, or both in 28 patients (88%), the body of the zygoma in 24 patients (75%), and extended to the skull base in 16 patients (50%). Pericranial flaps were used to cover the bone grafts in 22 patients (69%). Postoperative radiotherapy was performed in 22 patients (69%), preoperative radiotherapy in 5 (16%), and the other 5 (16%) had no radiotherapy. There were no intraoperative complications, and postoperative complications included plate exposure (n=2), ectropion (n=3), and partial bone graft loss or resorption subsequent to completion of radiotherapy (n=2). Postoperatively, appearance was excellent in 24 patients, fair in 6 patients, and poor in 2 patients. Secondary reconstructive procedures were performed in 4 patients (12%). Follow-up ranged from 12 months to 6 years (median, 4.2 years).

Conclusions: Precontoured positioning plates with or without pericranial flaps enable precise reconstruction of midfacial defects with precise incorporation of cranial bone grafts. In our series we routinely covered the bone grafts with well-vascularized tissues, leading to a low incidence of complications and excellent aesthetic results.

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MIDFACIAL DEFECTS most commonly result after trauma or resection of neoplasms involving the paranasal sinuses, the overlying facial skin, or both. Such defects may result in substantial functional and aesthetic morbidity. Reconstructive goals include obtaining a healed wound, separating the oral cavity from the defect to aid oral intake and speech, supporting orbital contents, and optimizing facial aesthetics. While prostheses are often successful with maxillectomy defects in obturating the palate, especially if sufficient dentition is preserved,[1] the resection of orbital bone and the zygoma compromises support for facial soft tissue and the globe. Reconstruction is more challenging after total maxillectomy if orbital contents are preserved.[2]

Numerous methods have been described for reconstructing maxillectomy and midfacial defects, including local or regional flaps,[3] prostheses, bone grafts, titanium mesh,[4,5] and free flaps.[1,6-10] Traditionally, reconstruction of maxillectomy defects involved a dental obturator and skin grafts to the internal mucosal defect. Such reconstruction has the advantage of enabling easy examination to detect tumor recurrence. However, the lack of bony support results in soft tissue contracture that is often exacerbated by postoperative radiotherapy. The advantage of being able to directly survey the defect has been minimized by the improved sensitivity of magnetic resonance imaging and positron emission tomography or computed tomography to detect tumor recurrence after maxillectomy reconstruction. A wide variety of free flaps have been recommended for reconstruction of maxillectomy defects. The rectus abdominis myocutaneous flap is easy to harvest and provides a large volume of tissue to obliterate large palate, orbital exenteration, and skull base defects.[8] However, it is difficult to precisely reconstruct the complex configuration of the malar eminence and orbital rim with soft tissue flaps. Cov-

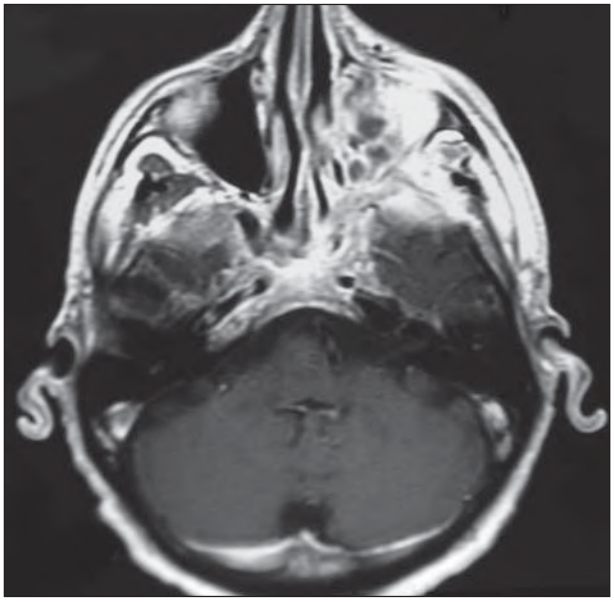

Figure 1. Preoperative axial magnetic resonance image demonstrates extensive squamous cell carcinoma of the left maxillary sinus with extension into the skull base.

ering bone grafts with such bulky flaps makes ultimate contour results generally mediocre at best. Osteocutaneous free flaps may be used to reconstruct midfacial skeletal defects, but the use of multiple osteotomies to precisely contour the flap may compromise the bony or cutaneous portions of the flap.[2]

The use of cranial bone grafts is the traditional method for reconstructing orbital defects.[11] While reconstruction of the facial skeleton may appear straightforward, it is often difficult to recreate the complex 3-dimensional (3-D) anatomy of the zygoma[8] and orbit. What we term "precontoured positioning plates" are plates precisely contoured to the midfacial skeleton to allow 3-D reconstruction of bony defects with cranial bone grafts. In this article we review the experience of 1 of us (Y.D.) with this method of reconstruction of midfacial defects.

METHODS

All patients undergoing reconstruction of orbitozygomatic defects with cranial bone grafts and positioning plates were included in this review. A total of 32 patients treated by 1 of us (Y.D.) from September 1997 to September 2003 with this method were reviewed in detail. All patients were followed up for at least 12 months. Patients requiring substantial palatal resection who were thought to be good candidates for successful prosthetic dental obturation were evaluated preoperatively by a maxillofacial prosthodontist, and a surgical obturator was created preoperatively. Medical records were reviewed for location of defect, additional reconstructive procedures performed, and complications. Preoperative and postoperative photographs were reviewed to evaluate aesthetic results. Patients were interviewed and asked to rate their reconstructive result as excellent, fair, or poor.

In cases in which the outer frame or contour of the midfacial skeleton was not deformed by neoplasm, 1.3- and 1.7-mm titanium miniplates were bent to conform to the expected defect (**Figures 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12,** and **13**). Generally, at least 3 such plates were used. Each plate

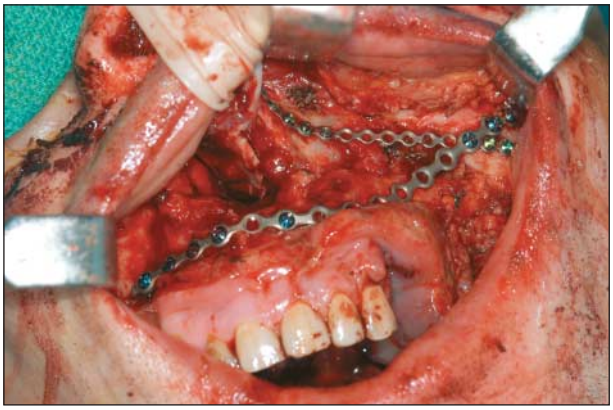

Figure 2. Positioning plates have been preadapted to span the proposed area of resection. Note placement of screws well away from the area that will be resected: left nasal bone, zygomatic arch, and right anterior maxilla.

spanned the defect and extended well medially, laterally, or superiorly away from the area of expected resection. A minimum of 3 screws were placed on each end of the plate. The goal was to overlap the areas beneath the precontoured positioning plates to provide a scaffoldlike fingerprint of the anticipated defect. The plates and screws were removed and labeled. With total maxillectomy defects, positioning plates were anchored medially at the superior remnant of the nasomaxillary buttress and over the radix and laterally at the remaining zygomatic arch. If the midfacial skeleton was deformed and unsuitable for use as a template for positioning plates, then plates were contoured on a human skull placed in a sterile plastic bag on a side table.[4] Alternatively, a 3-D acrylic model based on the patient's computed tomography scan is used. The model's contour deformity is corrected on a side table with a round burr, followed by placement of positioning plates as mentioned earlier. After resection of the osseous midface, the positioning plates are returned to the predrilled proximal and distal holes on the patient's remaining facial skeleton. Outer table calvarial bone grafts were harvested from the patient's nondominant parietal skull. In patients requiring a craniotomy, grafts were harvested from the inner cortex of the bone flap. The grafts were contoured and secured to the scaffolding provided by the positioning plates. If there was lack of mucosal coverage intraorally, vascularized tissue flaps, most commonly extended pericranial flaps,[12] were routinely used to cover the bone grafts and plates in an effort to decrease the risk of resorption and extrusion. Pericranial flaps were based anteriorly and passed via the nasofrontal region, or laterally and passed into the midface over the zygomatic arch remnant. Temporary dental obturators were secured to the remaining hard palate with titanium screws.

RESULTS

Our technique enabled primary reconstruction of all defects for which such reconstruction was attempted. Disease requiring resection of the midfacial segment included squamous cell carcinoma (n=19), sinonasal undifferentiated carcinoma (n=4), sarcoma (n=4), adenocarcinoma (n=3), and myxoma (n=2). Defects involved the orbital rim, floor, or both in 28 patients (88%), the body of the zygoma in 24 patients (75%), and extended to the skull base in 16 patients (50%). Pericranial flaps were used to envelop the bone grafts in 22 patients (69%). In addition, 14 temporalis muscle flaps were used. Postoperative radiotherapy was performed in 22 pa-

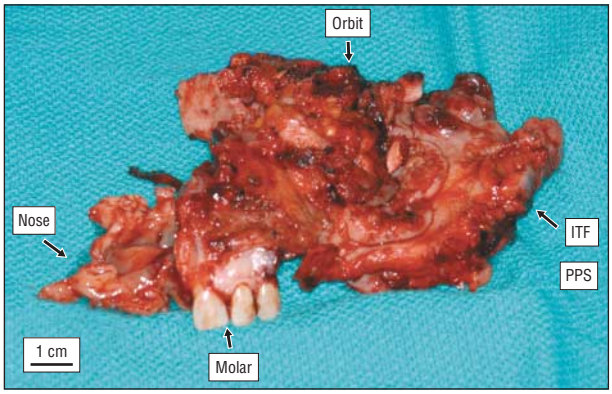

Figure 3. Left extended maxillectomy to include the left maxilla, infratemporal fossa (ITF), parapharyngeal space (PPS), orbit, and nasal cavity with attached septum.

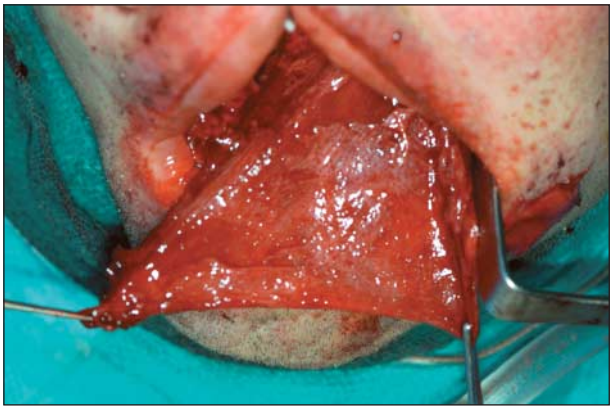

Figure 5. Pericranial flap has now been passed into the midface and is being retracted through the mouth to demonstrate length.

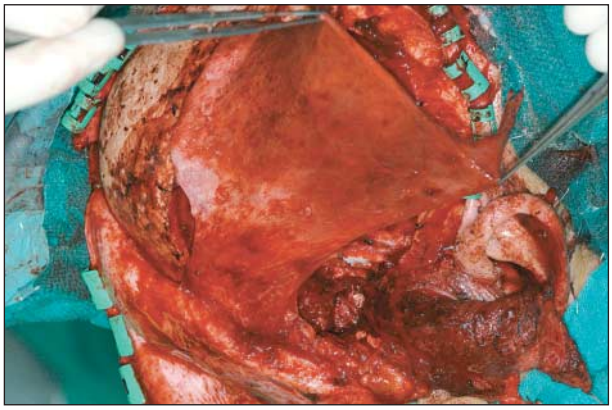

Figure 4. Left laterally based pericranial flap has been harvested (retracted with forceps); temporalis muscle flap is being reflected inferior to the visualized portion of the left auricle.

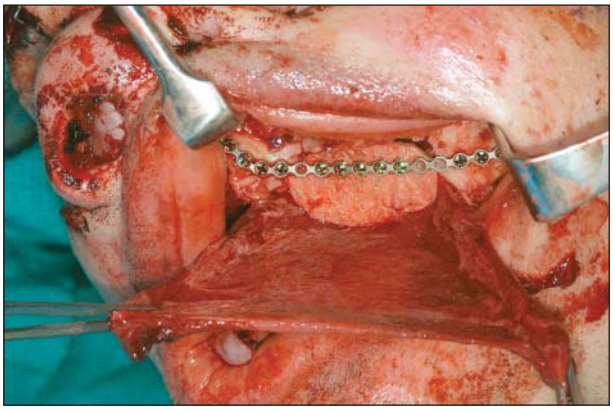

Figure 6. Positioning plates have been re-placed and bone grafts have been placed on the undersurface of the new scaffold. Pericranial flap will now wrap the bone grafts.

tients (69%) and was initiated within 8 weeks of resection and reconstruction. Doses in this group ranged from 5500 to 7000 rad (55-70 Gy). Preoperative radiotherapy was used in another 5 patients (16%). There were no intraoperative complications, and postoperative complications included plate exposure in 2 patients, ectropion in 3 patients, and partial bone graft loss or resorption subsequent to completion of radiotherapy in 1 patient each. There was no evidence of complete bone resorption or loss. Postoperative appearance was excellent in 24 patients, fair in 6 patients, and poor in 2 patients, as deemed by the patients themselves. Secondary reconstructive procedures were performed in 4 patients (12%). Follow-up ranged from 12 months to 6 years (median, 4.2 years).

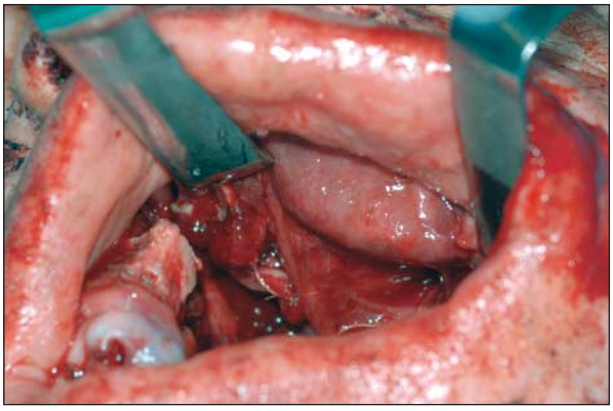

Figure 7. Pericranial flap has completely wrapped the bone grafts on the oral side.

COMMENT

Midfacial defects present a tremendous challenge for successful reconstruction. Numerous approaches have been described for reconstruction of midfacial and maxillectomy defects, including temporalis muscle flaps[3]; pectoralis major myocutaneous flaps[13]; latissimus dorsi,[7] scapular, or parascapular free flaps[9,10]; and rectus abdominis free flaps.[8]

Preoperative evaluation is critical in planning midfacial reconstruction. After maxillectomy, the status of the remaining dentition and expected size of the palatal defect determine the likely success of a palatal obturator. We routinely consult a maxillofacial prosthodontist preoperatively. In patients requiring extensive palatal resections who desire dental implants, osteocutaneous free flaps can provide successful dental rehabilitation. Futran et al[1] reported the use of fibula osteocutaneous free flaps in 27 patients with midfacial defects that involved greater than 50% of the maxillary dentition. Osseointegrated implants were placed in 18 patients, and 14 patients were able to tolerate

Figure 8. Patient in Figures 1 through 7. A, Preoperative basal view. B, Postoperative basal view demonstrates adequate maxillary contour.

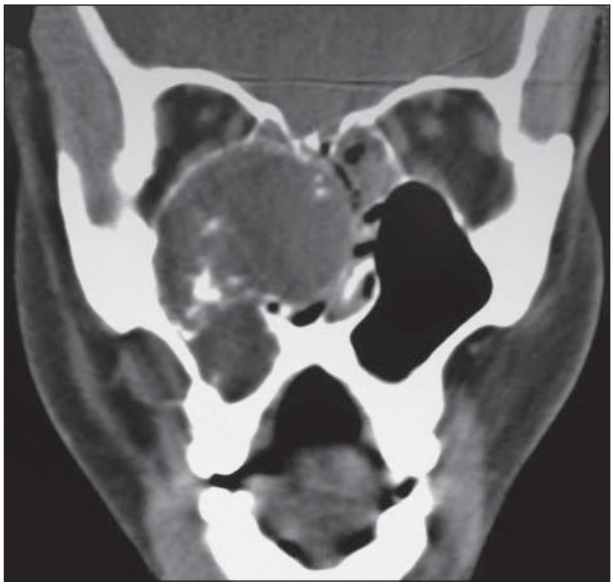

Figure 9. Preoperative coronal computed tomographic scan in a patient with massive odontogenic neoplasm of the right maxilla with involvement of the orbital floor.

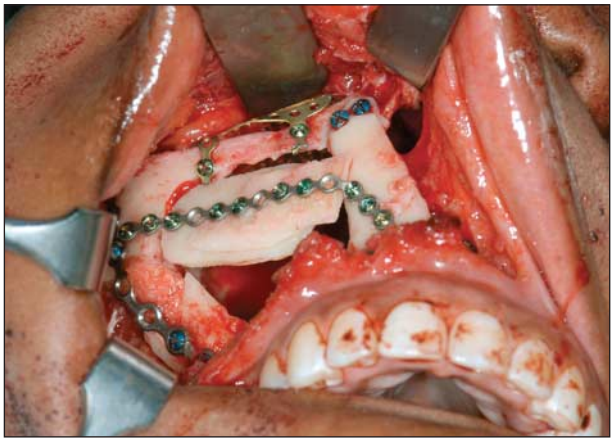

Figure 10. After resection of tumor and replacement of positioning plates, bone grafts have been brought into position. They will be covered.

a regular diet. Cosmetic results were excellent in patients with inferior maxillary defects. In patients with loss of the orbital rim, the malar prominence, or both, the aesthetic

Figure 11. Postoperative 3-dimensional computed tomographic scan demonstrates adequate restoration of the right midface with positioning plates and bone grafts.

results were "fair" secondary to flattening of these regions. Secondary procedures to correct ectropion were required in 3 patients.[1]

In patients with large midfacial defects the rectus abdominis myocutaneous free flap is a reasonable alternative. Advantages of this flap include ease of harvest with the patient in the supine position, a long pedicle, and a large volume for potentially obliterating orbital exenteration or skull base defects. Browne and Burke[8] reported a series of 12 patients with maxillectomy defects reconstructed with the rectus abdominis free flap. Reconstruction allowed all 9 patients with palatal defects to resume their preoperative diet. When total maxillectomy is combined with orbital exenteration, Cordeiro and Santamaria[14] recommend a rectus myocutaneous free flap with 3 skin islands, for the orbit, lateral nasal wall, and hemipalate. A disadvantage of the flap is the expected atrophy of one third of the flap volume and the inability of this flap to duplicate the patient's premorbid skeletal form.[8]

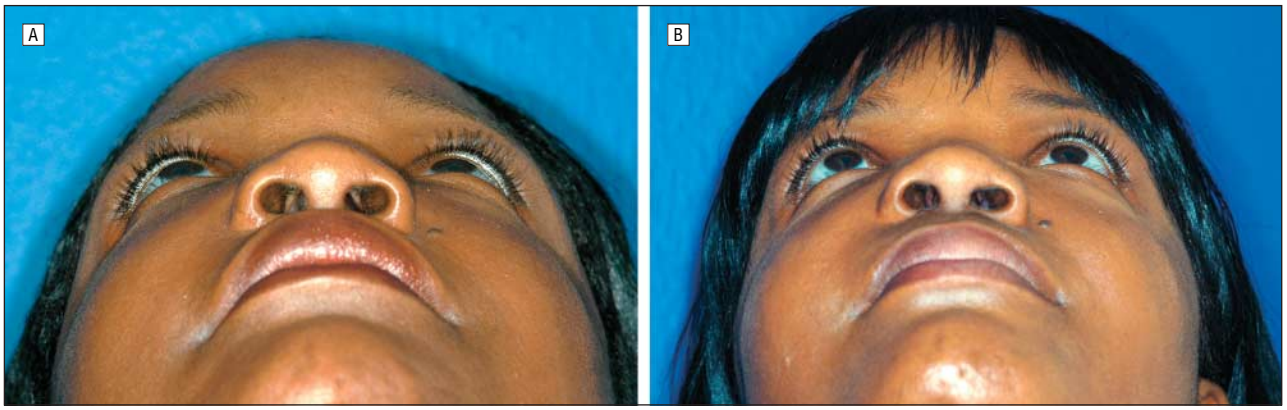

Figure 12. Patient in Figures 9 through 11. A, Preoperative basal view. B, Postoperative basal view demonstrates adequate midface projection.

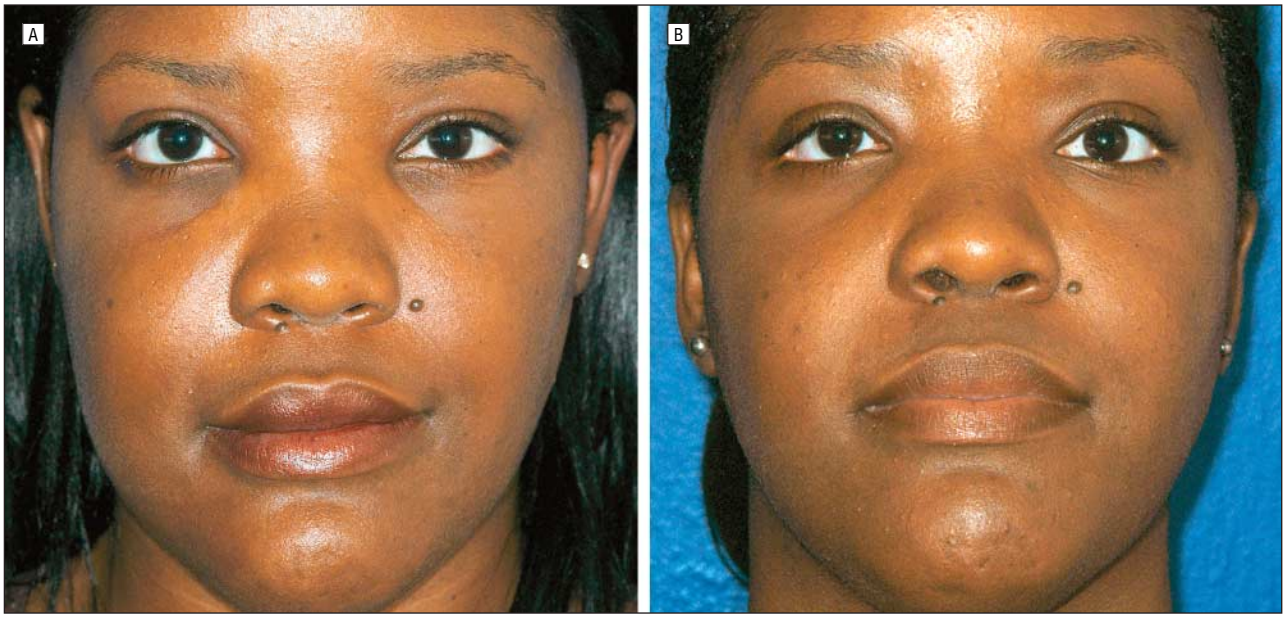

Figure 13. Patient in Figures 9 through 12. A, Preoperative frontal view. B, Postoperative frontal view demonstrates adequate midfacial width and symmetry.

With midfacial defects involving the body of the zygoma and the orbital rim, it can be challenging to obtain excellent aesthetic outcomes. In a series of 14 patients with primary reconstruction of total maxillectomy defects with preservation of orbital contents, Cordeiro and Santamaria[14] reported that the malar eminence can never be reconstructed well with soft tissue flaps alone. Nonvascularized bone grafts from the calvarium, ribs, and iliac crest were used for orbital floor reconstruction. Reconstruction of the malar eminence was performed secondarily with a free bone graft from the zygomatic remnant to the maxilla adjacent to the nasal spine. Soft tissue reconstruction to obturate the palatal defect was performed with a myocutaneous rectus abdominis free flap in 12 patients and with a pedicled temporalis muscle flap in 2 patients. They did not experience any infections or resorption of the free bone grafts. The most common complication was lower eyelid ectropion in 76.9% of patients.[2]

Lee et al[15] also believe that cranial bone grafts provide superior reconstruction of the orbital rim and floor compared with free soft tissue flaps. They reported reconstruction of the orbital rim and floor after maxillectomy with a vascularized outer calvarial bone pedicled on the superficial temporal artery. They think that the natural curvature of outer calvarial bone is well suited for reconstruction of orbital bony defects. Ectropion occurred in 1 patient, and enophthalmos in 2 patients.[15]

Successful reconstruction of orbital rim defects after orbital exenteration with free flaps was reported by Chepeha et al.[6] For defects involving less than 30% of the bony orbital rim, reconstruction was performed with osseocutaneous radial forearm free flaps. With more extensive orbital rim defects and defects involving cheek skin or the bony malar eminence, scapular free flaps were used.[6] Cordeiro et al[2] have cautioned that using an osteocutaneous free flap to reconstruct both the orbital floor and maxillary buttress may lead to compromise of the bony and cutaneous portions of a flap.

In our series, we were able to obtain excellent aesthetic outcomes using positioning plates with cranial bone grafts for primary reconstruction of the zygoma and orbital rims. Fashioning the plates on the midface before resection allows accurate 3-D reconstruction of these complex regions. Precise reconstruction of the

orbitozygomatic regions is critical for providing support for facial and orbital soft tissues. We believe that the use of precontoured positioning plates is invaluable in this regard and will naturally lead to improved outcomes compared with simple "eyeballing." The scaffold they provide will ensure restoration of the premorbid osseous skeleton.

Cranial bone grafts are a well-accepted method for reconstruction of facial bony defects. Free membranous calvarial bone has been shown to have lower rates of resorption compared with endochondral bone grafts from the ilium or ribs.[16] We agree with Pollice and Frodel[17] that covering bone grafts with well-vascularized tissue may decrease the risks for resorption and extrusion. In their series of 6 patients with secondary reconstruction of maxillectomy defects, a pedicled temporoparietal flap was routinely used with cranial bone grafts.[17] Covering the bone grafts with a vascularized radial forearm free flap is another option. Our preference is to use extended pericranial flaps to envelop free bone grafts and positioning plates. Pericranial flaps provide supple, thin tissue that may be pedicled centrally or laterally to reach midfacial reconstructions.[12] Pedicled temporalis muscle flaps are also useful with maxillectomy reconstruction to provide well-vascularized tissue on the internal surface of the bone grafts, specifically in orbital floor graft coverage. The donor site aesthetic morbidity may be well managed with primary hydroxyapatite cranioplasty and secondary lipotransfer to the temporal fossa. The temporalis muscle is useful for obliterating the maxillectomy defect, and it may be primarily skin grafted or allowed to mucosalize.

We found a low incidence of complications with our technique of orbitozygomatic reconstruction. The most common complication was ectropion, which was similarly found in other series of midfacial reconstructions and occurred in as many as 79% of patients in 1 review.[2,15,17] Although most of our patients received external beam radiotherapy, the incidence of resorption or extrusion was low. We attribute this to good soft tissue coverage of all grafts. In fact, none of our patients experienced intraoral or mucosal extrusion. Both incidences of extrusion and partial resorption occurred underneath the nasal dorsal skin portion of the reconstruction on average 3.5 years after radiotherapy and were repaired with simple local soft tissue flaps.

CONCLUSIONS

The use of precontoured positioning plates with cranial bone grafts to repair orbitozygomatic defects is a reliable technique for precise reconstruction of the midfacial skeleton. This technique allows restoration of the 3-D structural support for facial and orbital soft tissues. We recommend enveloping the bone grafts with vascularized tissue such as pericranial flaps, which may be brought into the midface to promote graft viability and decrease resorption and extrusion.

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