Reconstruction After Resection of Sphenoid Wing Meningiomas

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Objective: To review our experience of reconstructing the lateral and superior orbital walls after resection of sphenoid wing meningiomas. We will review the presentation and complications, examine the aesthetic results postoperatively, and compare preoperative and postoperative computed tomographic scans. To our knowledge, a comparative analysis of preoperative defect and postoperative reconstruction has not been performed.

Methods: We conducted a retrospective analysis, with a minimum of 5 months and a maximum of 9 years of follow-up in an academic multidisciplinary skull base center. Twenty-two patients were treated for sphenoid wing meningiomas by resection and reconstruction with split calvarial bone graft and, for more than half of the patients, also with free abdominal fat graft. The main outcome measures were aesthetic evaluation of patients and analysis of tumor control using computed tomographic scans, survival, and complications.

Results: A total of 24 resections were performed on 22 patients. The average follow-up was 14.6 months. All patients had meningiomas with similar preoperative presentations, and for 21 of the 22 patients aesthetic reconstruction resulted in the near symmetry of the 2 sides. All patients are currently alive, those who underwent complete resection are without recurrence, and 15 (68.2%) did not incur complications. One patient experienced a worsening of temporal wasting following radiation therapy.

Conclusion: Reconstruction of the defect with split calvarial bone and free abdominal fat grafts affords the patient excellent aesthetic results as well as good symmetry, as demonstrated by a postoperative computed tomographic scan.

Arch Facial Plast Surg. 2005;7:99-103

Meningiomas are slow-growing, expansile benign tumors that can involve the bone and dura. These tumors arise from arachnoid cells of the perineurial sheaths or the arachnoid layer of the meninges. The incidence of hyperostosis in sphenoid wing meningiomas approaches 90%, and histopathologic studies have revealed that the hyperostosis is due to meningiomatous infiltration of the bone. Terstegge et al also showed by means of magnetic resonance imaging with gadolinium enhancement in the area of the hyperostosis that this condition may be related to meningiomatous bone infiltration. Predisposing factors to the development of sphenoid wing meningiomas include female sex, previous ionizing radiation, and type 2 neurofibromatosis. To our knowledge, a comparative analysis of preoperative defect with postoperative reconstruction has not been performed. We will review our experience with resection of sphenoid wing meningiomas and reconstruction at the University of Michigan. Our main outcome measures were aesthetic evaluation by physicians as well as analysis of tumor control using computed tomographic (CT) scans, survival time, and complications.

METHODS

OPERATIVE TECHNIQUE

A bicoronal or hemicoronal flap and orbital/pterional craniotomy were performed by the neurosurgical team in the usual fashion. A fronto-orbital, zygomatic temporal craniotomy was then performed, followed by the removal of the posterolateral wall of the orbital bone and the major sphenoid wing lateral to the foramen spinosum (the frontotemporal and orbitozygomatic approach). Two osseous flaps were obtained from the frontotemporal and superolateral orbital bones. The frontotemporal portion was completely separated and set aside while the superior and lateral orbital walls could be left attached to the zygomatic arch. The craniotomy could be extended to include the superior orbital rim to resect the tumor in its entirety. Careful attention was paid to avoid disrupting the deep portion of the levator
muscle. Once the craniotomy was carried out, zygoma osteotomy was performed to the malar eminence, the frontozygomatic suture, and the zygomatic arch (away from the temporomandibular joint). The body of the zygoma was then cut through its midportion and directed toward the anterolateral end of the inferior orbital fissure, preventing entrance to the maxillary sinus. Infraorbital cuts were made along the sphenopalatine fossae.

Diamond burrs could be needed when drilling around the orbital apex to gain control of the meningioma, as they provide access to the orbital contents and apex and to the pterygopalatine and infratemporal fossae.

The lateral orbital rim was then taken away to be drilled down to remove all aspect of the tumor. Templates were drawn on the parietal scalp. Two split calvarial bone grafts were taken from these templates and were rigidly fixed with X plates and 1.2-mm screws to recreate the superior and lateral orbital walls (Figure 1A). This complex was then plated to the remaining superior orbital rim and zygoma. Abdominal fat was harvested and placed in the temporal space and around the superior and lateral bony grafts when needed (Figure 1B). The pericranial flap was used as a watertight seal to protect the bony reconstruction. The cranial flap was then placed back in the normal anatomic position (Figure 1C), the cranial bone defect was filled with hydroxyapatite cement to prevent topographic concavity, and the temporalis muscle was resuspended and the skin closed in a 2-layer fashion. The maxillary sinus was not entered; dural grafts were sometimes necessary; and if the frontal sinus was entered, cranialization could be necessary.

PATIENT EVALUATION

From December 1995 to March 2004 we performed a retrospective analysis of 22 patients who underwent resection of sphenoid wing meningiomas with reconstruction at the University of Michigan Multidisciplinary Skull Base Center. A complete medical history was taken and a physical examination performed by our cranial skull base and neurosurgical team for all patients. Patient assessment included visual acuity, visual fields, subjective degree of proptosis, extraocular motion, lid position, status of optic nerve, and temporal fullness. All patients underwent CT scans and magnetic resonance imaging preoperatively and postoperatively. Radiation was used for selected patients who had subtotal excision. Total excision was confirmed by postoperative imaging. Follow-up ranged from 4 months to 9 years.

RESULTS

The patients, 5 men and 17 women, ranged in age from 31 to 73 years (mean age, 53 years). They were analyzed according to age, presenting symptoms, functional and aesthetic satisfaction, history of radiation, tumor volume, tumor recurrence, and complications. Most patients presented with incidental proptosis (n=8) or proptosis associated with diplopia or visual loss (n=7). Other presenting signs and symptoms included visual field or acuity loss (n=5), swelling/dysthesias of cranial nerve V (n=2), or seizure and dysphagia (n=1). Eighteen patients had involvement of the sphenoid wing only. The tumor extended to the cavernous sinus, middle fossa, and infratemporal fossa in 2 patients and in another patient it had further extension, causing encasement of the tumor around the carotid artery. One patient had meningioma involving the clinoid. One patient required frontal cranialization because of tumor extension. Two patients required orbital decompression because of tumor involvement of the apex.

Reconstruction consisted of calvarial bone and abdominal fat grafts in 11 patients. Ten patients underwent reconstruction with bone only and 1 patient with titanium mesh and abdominal fat. Blood loss ranged from
minimal to 1200 mL. Most patients had a 3-day hospital stay, of which 1 day was spent in the intensive care unit. The exception was 1 patient who had a 20-day hospital stay, with 12 of those days in the intensive care unit because of pneumocephalus.

Of the 22 patients, 3 had had prior resection of their meningiomas at another institution and complete resection was achieved at our institution for 1 of these 3; including this patient, 11 had complete tumor resection but 1 of them was lost to follow-up. There was residual disease in a total of 10 patients owing to tumor involvement of the carotid artery or cavernous sinus; among these 10 patients, 3 requested that complete resection not be attempted because they did not want to risk any loss of vision. Of the patients who had incomplete resections, 1 was lost to follow-up, 3 remained stable during a minimum follow-up of 6 years, 1 had marginal growth without any further treatment per patient desire, 3 had postoperative radiation therapy, 1 had reresection, and 1 had reresection with postoperative radiation. Use of the center's neuronavigation system (Stealth; Medtronic Inc, Minneapolis, Minn) was required for 1 reoperation. All patients received external beam radiation except 1, who decided to receive proton beam radiation at another institution.

Complications were evaluated at the 1-year postoperative visit. Fourteen patients experienced no long-term complications, 2 patients had postoperative trismus that is resolving with therapy; 2 patients had transient diplopia, which resolved within 1 year; 2 other patients underwent surgery less than 1 year ago but have experienced mild ptosis and/or mild diplopia; 1 patient has permanent diplopia requiring prism glasses for correction; 3 patients have third cranial nerve palsy; and 1 patient has permanent frontal branch paralysis, which required a direct brow-lift for symmetry. There were no leaks of cerebrospinal fluid and no tracheotomies were necessary. The patient with a prolonged hospital stay had pneumocephalus with midline shift requiring ventriculostomy and, later, another craniotomy to evacuate epidural fluid. This patient also had presumed pulmonary embolus and underwent placement of a Greenfield filter.

Cosmetic results were judged satisfactory in 20 of the 22 patients by the involved physicians. Satisfactory meant symmetry, no proptosis, no contour deformity, and no pulsating exophthalmos. All patients but 3 were pleased with their cosmetic result. One of 2 patients who experienced temporal wasting also had left brow ptosis; the patient later had a brow-lift because of frontal branch weakness and received a temporal implant (Medpor; Porex Surgical Inc, Newnan, Ga) to correct contour deformity. The other patient’s temporal wasting was deemed mild by the physician. Proptosis was still present in 1 patient but it was markedly decreased and this patient was very satisfied with the cosmetic results. On postoperative magnetic resonance imaging and CT scans, all patients had good orbital volume with the exception of the patient who had mild persistent proptosis. There were no cases of pulsating exophthalmos or enophthalmos.

Three patients are complaining of postoperative pain—long-term atypical facial pain and headaches for 2 of these 3 patients, and, for the third, pain in the area of a screw, but this patient is only 6 months postoperative.

**REPORT OF A CASE**

A 59-year-old woman who presented with incidental proptosis but no diplopia or impairment of extraocular motion (Figure 2A and B) was diagnosed as having extensive sphenoid wing meningioma involving the entire lateral orbital wall and most of the superior orbital wall (Figure 3A and B). She underwent excision of tumor.
and reconstruction with split calvarial bone, hydroxyapatite cement, and abdominal fat grafts. Her tumor was completely resected, as evidenced by a postoperative CT scan. Preoperative, intraoperative, and postoperative CT scan images are shown in Figure 3. Four months after surgery she has good reduction of her proptosis (Figure 2B and C) and her mild ptosis should resolve within 6 months. Her reconstruction noted on the postoperative CT scan showed re-creation of superior and lateral orbital wall. She is also afforded good temple volume and no orbital displacement.

**COMMENT**

Most of our patients were diagnosed as having sphenoid wing meningioma after presenting for incidental proptosis and, as often observed with patient having sphenoid wing meningiomas, most were women. None had previous radiation therapy or was diagnosed as having neurofibromatosis type 2. Some of our patients had the tearing, chemosis, periorbital edema, asymmetric intraocular pressure, or disc edema that can be initial signs of sphenoid wing meningioma. Visual and oculomotor dysfunction is the next sign of tumor progression. Other presenting signs and symptoms include afferent dysfunction, lateral or superior rectus muscle restriction, ptosis, and neuropathy of cranial nerves II, III, and IV. Growth of these tumors can lead to blindness and neurological sequelae of cavernous sinus or orbital apex involvement. Resection alone would leave these patients with significant deformity and a pulsating exophthalmos.

We reviewed the University of Michigan’s 9-year experience with tumor excision and reconstruction in 22 patients. Lateral and superior orbital walls were reconstructed with split calvarial bone and abdominal free fat grafts to prevent pulsating exophthalmos; however, 10 patients required bone only for reconstruction as their volume loss did not require an abdominal fat graft. None of these 10 patients complained of pain or were unhappy with their cosmetic results, but 7 had progression of residual tumor, which was left owing to its proximity to vital structures. Titanium mesh combined with abdominal fat was used in 1 patient whose hyperostosis in the sagittal sinus prevented harvesting of calvarial bone graft. This patient was satisfied with the aesthetic result and had no residual disease. Most patients, 20 (90.1%) of 22, were satisfied with function and appearance; the 2 patients who were not had temporal wasting, although their abdominal fat grafts appeared to be of sufficient volume intraoperatively. One of these patients had postoperative radiation therapy after complete resection, which made her temporal wasting more profound. The temporal wasting was corrected with an implant and the asymmetry secondary to her frontal nerve weakness.

**Figure 3.** Preoperative and postoperative computed tomographic (CT) scan images of the same patient as in Figure 2. A, Preoperative axial scan. B, Preoperative coronal scan. C, Postoperative axial scan. D, Postoperative coronal scan.
was corrected with a brow-lift. The major limitation of this study is the subjective measurement of proptosis. This study would have more validity if an exophthalmometer had been used to measure preoperative and postoperative proptosis.

None of the patients who had complete resection of tumor experienced recurrence and 3 patients opted for incomplete resection to prevent loss of vision or loss of extraocular muscle function. Tumor tissue medial to the orbital apex or abutting the cavernous sinus was usually left in place. Leaving microscopic parts of tumor tissue around vital structures may be necessary, and they can be destroyed by radiation. Peele et al studied a large series of patients who had subtotal excision and postoperative radiation and found no recurrences during a mean 4 years of follow-up. Adverse effects were skin erythema and lateral brow alopecia. The patient who experienced excessive temporal wasting also experienced postoperative pain, and 2 patients who had complete tumor resection are being seen at the chronic pain clinic for long-term facial pain. Of the 2 patients who are experiencing chronic postoperative pain, 1 had cranial nerve V dysthesia preoperatively and 1 was pain-free preoperatively. The other 4 patients who underwent radiation therapy did not have chronic pain postoperatively.

The 2 patients who had diplopia postoperatively did not have it at presentation but they had decreasing visual acuity. Diplopia was considered to be caused by a minor imbalance of the extraocular muscles rather than by paralysis of the muscles, which is thought to be caused by tumor displacement, surgical retraction, or displacement of the nerves. The extraocular muscles in patients with diplopia were intact postoperatively except in 3, who developed extraocular movement abnormalities from cranial nerve III palsy. None of the patients had this at presentation, but the patient who had postoperative palsy of cranial nerve III had initial visual loss. Those who had visual field or visual acuity deficits at presentation were unable to regain function but did not experience progression of their loss. Mild ptosis is expected initially secondary to dissection around the levator, but it usually resolves within 6 to 12 months, as occurred in the patient in our case example. We had no cases of long-term paralysis.

None of the patients required tracheotomies. All had a hospital stay of less than 8 days, except for the patient who developed pneumocephalus. Tension pneumocephalus in this patient was thought to be due to inadequate seal of the frontal sinus, which was entered. This patient subsequently received abdominal fat grafts and bone grafts and underwent plugging of her frontal sinus with temporalis muscle and pericranial flap. Excessive blood loss did not correlate with complications or hospital stay. If the frontal bone was entered, the lateral aspect was drilled down and separated from intracranial contents by means of a pericranial flap. However, 1 patient required cranialization of the frontal sinus because of extensive tumor involvement.

Three-dimensional reconstruction with split calvarial bone and free abdominal fat grafts allowed for normal function and position of the globe and prevented significant frontozygomatic defects and pulsating exophthalmos, as seen in our series. This was demonstrated by postoperative visits and postoperative CT scans. Because of the indolent nature of this tumor, lifelong follow-up is recommended.

Accepted for Publication: November 16, 2004.

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Additional Information: An appendix indicating sex, abnormality at presentation, surgical procedure, nature of resection (complete/incomplete), incurred complications and/or recurrence, degree of satisfaction, and other relevant information is available for all patients from Dr Leake upon request.

REFERENCES