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Outcome of aggressive removal of cavernous sinus meningiomas

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Despite recent advances in surgery of the cavernous sinus, meningiomas in that area offer a formidable challenge. The rationale for aggressive surgical removal of cavernous sinus meningiomas is based on the presumption that the extent of removal is inversely related to the rate of recurrence. Over the past 10 years, 41 patients with histologically benign meningiomas involving the cavernous sinus underwent aggressive surgery. Total removal, as confirmed by intraoperative inspection and postoperative radiological studies, was achieved in 31 patients (76%). Twelve patients have been followed for more than 5 years; 10 underwent total tumor removal and only one of these experienced recurrence (5 years after surgery). The other two patients underwent subtotal removal and had symptomatic and radiological evidence of regrowth 3 and 4 years after surgery. Pre-existing cranial nerve deficits improved in only 14% of the patients, remained unchanged in 80%, and worsened permanently in 6%. Seven patients experienced a total of 10 new cranial nerve deficits, four of which involved the nerves subserving ocular motor function. Extraocular muscle function did not worsen in the 25 patients with a seeing eye ipsilateral to the tumor, and no instance of visual worsening occurred.

Two patients died 4 months after surgery, one from severe delayed vasospasm and hypothalamic infarction and the other because of a myocardial infarction. Another patient died from a pulmonary embolus on the 9th postoperative day. There were three instances of cerebral ischemia; one was transient, lasting less than 24 hours, while two were related to injury of the middle cerebral artery and resulted in residual hemiplegia. Other complications included three cases of nonfatal pulmonary emboli, two cerebrospinal fluid leaks, and one instance each of exposure keratitis, acute hypothyroidism, and cerebral edema.

Key Words • **meningioma** • **carotid artery** • **cavernous sinus** • **ophthalmoplegia**

Surgical therapy of vascular and neoplastic disease involving the cavernous sinus is being reported with greater frequency.[5,12,13,16,17,23,25] Surgical entry into the cavernous sinus has generally been considered associated with a high patient morbidity rate, especially relating to the ocular motor (third, fourth, and sixth cranial nerves) and trigeminal nerves;[10,27] however, this has been found not necessarily to be the case. Even extensive dissection of the cavernous sinus, which is required for the aggressive removal of cavernous sinus meningiomas, can be performed with acceptable levels of morbidity and mortality.[5,11,16,17,22,23,25] In this article, we report our experience over the past 10 years with 41 patients harboring basal meningiomas that involved the cavernous sinus. Our approach to these meningiomas has been aggressive because all evidence points to a lower risk of recurrence and increased patient longevity with complete removal of these lesions.[1,6,8,14,19–21,26]

Clinical Material and Methods

Patient Population

Over the past 10 years, 62 patients with benign tumors of the cavernous sinus were operated on by the senior author (O.A.M.). These patients were cared for at the King Faisal Specialist Hospital (1982 to 1985), the University of Mississippi Medical Center (1985 to 1990), and the Loyola University Medical Center (1990 to 1992). In this series, 41 patients (66%) had the histological diagnosis of a benign meningioma. These patients are the focus of this report.

Of the 41 patients, 27 were women and 14 men, with a mean age of 52 years (range 30 to 72 years). Most of the patients presented with progressive neuropathies; the optic and ocular motor nerves (third, fourth, and sixth cranial nerves) were most commonly affected (Table 1). The mean preoperative Karnofsky Performance Scale (KPS) score was 70 (range 50 to 90). Thirty-eight patients were available for follow-up study for

TABLE 1
Preoperative cranial nerve dysfunction in 41 patients

Dysfunctional Cranial Nerves	No. of Cases
II	33
III	14
IV	11
V	7
VI	18
VII	0
VIII	1
IX–XII	0

a mean duration of 45 months (range 2 months to 10 years). Twelve patients were followed for more than 5 years.

Patient Evaluation

A complete medical, neurological, and radiological evaluation was carried out for each patient. A neuro-ophthalmologist examined the patients before and after surgery. Computerized tomography (CT) and magnetic resonance (MR) imaging were used to define the extent of tumor involvement in each patient. Although MR imaging, both with and without gadolinium enhancement, was the modality of choice for evaluation of the tumor itself (Fig. 1), CT of the skull base with appropriate bone window settings gave indispensable information about tumor extension and degree of hyperostosis.

Injury or compromise of the carotid artery resulting in major hemispheric stroke was the main risk when performing surgery in and around the cavernous sinus. Careful preoperative assessment of the cerebral circulation was imperative, as was identifying the pathological vasculature. The anatomical features of the cerebral circulation, including the presence of patent anterior and posterior communicating arteries, were defined by standard angiographic techniques and cross-compression studies.

The anatomical presence of collateral circulation, however, did not necessarily indicate that the physiological collateral vessels were adequate to compensate for major arterial occlusion. For this reason, each patient's cerebrovascular physiology and reserve potential were also studied. Cerebral blood flow was studied using the ^{133}Xe inhalation technique with a CO_2 challenge before and during manual compression of the carotid artery ipsilateral to the tumor. Transcranial Doppler ultrasound studies of the velocity and direction of blood flow in the internal carotid, middle cerebral, anterior cerebral, and ophthalmic arteries were performed before and during compression. These studies helped to depict flow reversal in the anterior cerebral artery and the velocity of flow in the middle cerebral artery during carotid artery compression. Not all patients underwent each study; the preoperative assessments described evolved over the period of the study.

Immediately after standard angiography was performed, patients received heparin administration, and the internal carotid artery to be studied was temporarily occluded by an intravascular balloon. During the 20 minutes of occlusion, the patients were carefully monitored with repeated clinical evaluations. After the balloon was inflated, the patients were also given an intravenous injection of a gamma-emitting isotope that had a single-pass effect in the cerebral microcirculation, and a postocclusion single-photon emission CT (SPECT) scan was performed. Patients who did not pass the balloon occlusion test were believed to be at high risk for stroke after carotid occlusion. Those patients who tolerated the balloon occlusion test clinically but had evidence of poor physiological flow reserves on SPECT scans, cerebral blood flow studies, or transcranial Doppler ultrasound studies were thought to be at moderate risk of stroke. Those patients whose cerebral blood flow and transcranial Doppler ultrasound studies and SPECT scans were normal after a balloon occlusion test were believed to be at low risk for stroke after carotid artery occlusion.

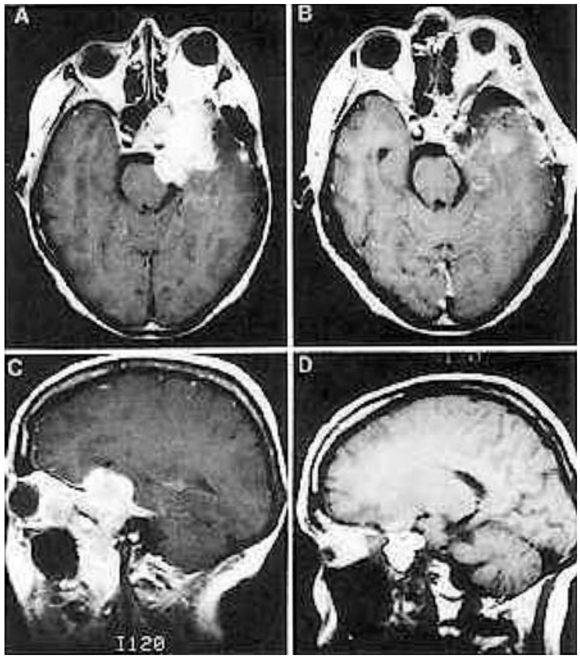

FIG. 1. Pre- and postoperative gadolinium-enhanced magnetic resonance images, axial (A and B) and sagittal (C and D) projections (TR 800 msec, TE 20 msec). The extension of this cavernous sinus meningioma into the orbit, the sphenoid and ethmoid sinuses, and the infratemporal fossa through an enlarged foramen ovale is clearly depicted on the preoperative studies (A and C). The postoperative studies (B and D) show complete tumor removal and the presence of autologous fat used to pack the sphenoid sinus.

Operative Technique

Although many approaches to the cavernous sinus have been described, we prefer the cranio-orbital zygomatic craniotomy. A modification of the supraorbital approach, described by Jane and colleagues,[15] is used.

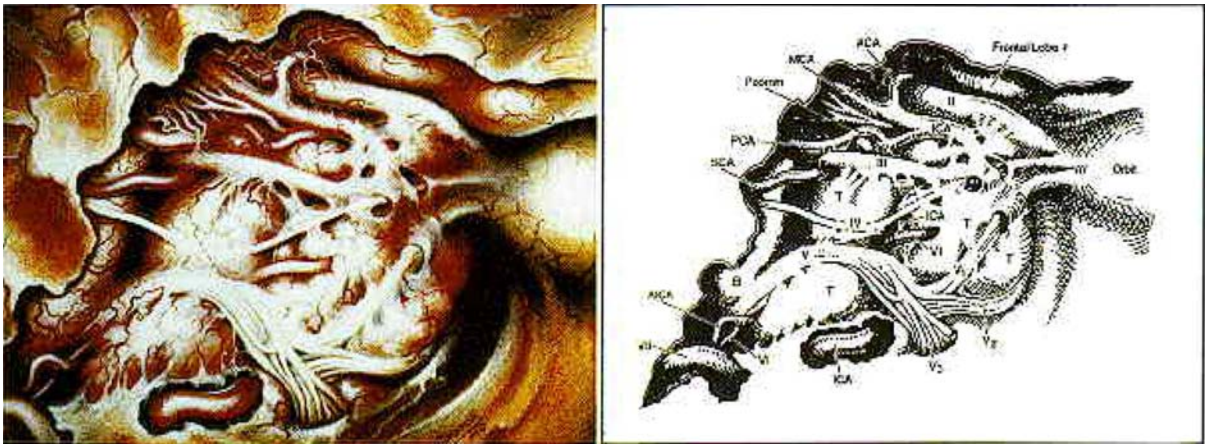

FIG. 2. Illustration *(left)* and diagram *(right)* of the fully dissected cavernous sinus meningioma. II = optic nerve; III = oculomotor nerve; IV = trochlear nerve; V = trigeminal nerve; V_1 = ophthalmic nerve; V_2 = maxillary nerve; V_3 = mandibular nerve; VI = abducens nerve; VII = facial nerve; B = brain stem; ACA = anterior cerebral artery; MCA = middle cerebral artery; ICA = internal carotid artery; Pcomm = posterior communicating artery; PCA = posterior cerebral artery; SCA = superior cerebellar artery; AICA = anterior inferior cerebellar artery; T = tumor.

For the cranio-orbital zygomatic approach, an incision is made at the zygomatic arch on the involved side and is carried across to the contralateral superior temporal line. Care is taken to preserve the superficial temporal artery in the event that an external carotid-to-internal carotid artery (intracranial-extracranial, EC-IC) bypass procedure is necessary. The scalp posterior to the incision is undermined, and a large pericranial flap is elevated. The superior and deep temporal fasciae are incised 1 to 2 cm superior and parallel to the zygomatic arch; the arch itself is subperiosteally dissected free and sectioned. The superior and lateral orbital margins are exposed, and the periorbita is dissected free. The supraorbital nerve and vessels are carefully preserved. A burr hole is placed just posterior to the frontozygomatic suture, allowing entry into the orbit and the anterior cranial fossa which are separated by the orbital roof. An osteotomy of the roof is begun at this point and carried medially. An entry hole is placed above and lateral to the nasion and usually transgresses the frontal sinus. An osteotomy is then made from this entry site to the superior medial orbital rim and into the roof of the orbit. A third entry hole is made posteriorly and inferiorly just above the root of the zygoma. The lateral orbital wall is sectioned and the burr holes are connected with the footed attachment of the drill.* An osteotomy of the orbital roof is created with an osteotome, drill, or Gigli saw, and the flap is elevated in one piece. A second, separate orbital osteotomy is performed by placing osteotomies medially, posteriorly, and laterally in the orbital walls. The superior orbital fissure is then opened.

The anterior clinoid process is removed extradurally, exposing the subclinoid carotid artery. The temporal dura is elevated, and the middle meningeal artery, greater superficial petrosal nerve, arcuate eminence, and foramen ovale are identified. The middle meningeal artery and greater superficial petrosal nerve are sectioned and the bone posterior to the foramen ovale and medial to the foramen spinosum is removed to expose the intrapetrous internal carotid artery. Both proximal and distal control of the carotid artery is secured in this way.

Electromyographic electrodes are placed directly into the lateral and superior rectus and the superior oblique muscles. A curvilinear durotomy is performed, and the sylvian fissure is split. The actual route of entry into the cavernous sinus is dictated by the extent of tumor involvement. The superior and lateral walls are the usual portals of tumor entry.

In our series, dissection of the meningioma from the cavernous sinus was performed in a standard fashion. Entry into the cavernous sinus was usually through the superior and lateral walls, and the dura propria of the optic nerve was opened longitudinally along the length of the optic canal. The distal dural ring was opened; this opening was extended posteriorly to the oculomotor trigone, thus also opening the proximal dural ring and allowing wide entry into the anterior and superior cavernous sinus space. The carotid artery was released from its proximal and distal dural rings and mobilized laterally, allowing dissection in the medial cavernous sinus space. Lateral entry to the cavernous sinus was gained through any of the various surgical triangles defined by the cranial nerves of the lateral walls of the cavernous sinus. An incision was made beneath the projected course of the third cranial nerve, allowing elevation of the outer layer of the lateral wall of the cavernous sinus, which was peeled away. The natural space between the third and fourth cranial nerves and the first division of the trigeminal nerve was used to expose the

* Drill manufactured by Midas Rex, Fort Worth, Texas.

TABLE 2

*Cranial nerve function at last follow-up examination of 38 patients**

Cranial Nerves	Preoperative Deficits	Postoperative Function: Improved	Unchanged	Worse	New Neuropathies
II	33	5	28	0	0
III	14	1	11	2	3
IV	11	0	10	1	1
V	7	0	7	0	6
VI	18	6	10	2	0
VII	0	0	0	0	0
VIII	1	0	1	0	0
IX–XII	0	0	0	0	0
totals	84 (100%)	12 (14%)	67 (80%)	5 (6%)	10

* Mean follow-up period 45 months (range 2 months to 10 years).

intracavernous carotid artery and the sixth cranial nerve coursing just lateral to it (Fig. 2). Within the cavernous space, the tumor was removed using suction, bipolar coagulation, and microdissection. In most patients, it was possible to develop a plane of cleavage along the carotid artery.

Results

Tumor Removal and Nerve Function

Complete tumor removal, as judged by the surgeon and confirmed by postoperative and follow-up images, was achieved in 31 (76%) of the 41 patients, including 10 of the 12 patients with follow-up periods longer than 5 years. Aggressive but only subtotal removal was possible in the other 10 patients. In five of these patients, subtotal removal was carried out in order to preserve or to avoid any risk to the carotid artery. In two patients with anterior clinoidal meningioma type I, no adequate plane of dissection existed between the tumor and the supraclinoid carotid artery.[2] Preoperative evaluation placed the other three patients in a high-risk group for stroke with carotid artery occlusion; thus, some tumor was left along the artery to avoid any risk of arterial injury. Extension of the tumor into both cavernous sinuses precluded complete removal in two patients. In another two, surgical removal was technically inadequate because of incomplete removal of the petrous apex and posterior clinoid process, which obscured a significant tumor extension into the posterior fossa. The final subtotal removal was in a patient who had a blind eye contralateral to a recurrent tumor in the cavernous sinus. Reconstruction or replacement of the carotid artery was not necessary in any patient, although the middle cerebral artery was lacerated and required repair in one patient. A prophylactic EC-IC bypass was performed in one patient before definitive tumor removal was undertaken. Cranial nerve repair was necessary in one patient after transection of the oculomotor nerve; the patient did not recover the function of that nerve.

TABLE 3

*Grading of extraocular muscle function**

Grade	Definition
excellent	no diplopia, minimal or no ptosis
good	no diplopia in the primary position, diplopia in any direction of gaze, mild ptosis
fair	diplopia in the primary position, which can be corrected with a change in head position or with optical prisms, moderate ptosis
poor	uncorrectable diplopia, complete ptosis

* Modified from Linskey and Sekhar.[18]

TABLE 4

*Extraocular muscle function at last follow-up examination of 38 patients**

Preoperative Function	No. of Cases	Postoperative Function: Excellent	Good	Fair	Poor
excellent	16 (6)	16 (6)	0	0	0
good	6	0	5	1	0
fair	8 (2)	0	5 (1)	2	1 (1)
poor	8 (5)	0	0	0	8 (5)

* Mean follow-up period 45 months (range 2 months to 10 years). Numbers in parentheses represent "nonseeing" eyes.

Function was improved in only 14% of the affected cranial nerves (Table 2). Most preoperative cranial nerve deficits remained static (80%); however, function worsened in 6%, and 10 new cranial neuropathies were produced in seven patients (18%). The third and fifth cranial nerves were most significantly at risk during cavernous sinus surgery. Extraocular muscle function was graded using a modification of the system proposed by Linskey and Sekhar[18] (Table 3). Pre- and postoperative extraocular muscle function is compared in Table 4. Those patients with good or excellent function usually remained in that group; patients with poor function rarely improved.

Mortality

Three patients died. One died in the early postoperative period because of a large pulmonary embolus; the other two died 4 months after surgery. The first of the latter two died from a myocardial infarction after total removal of a large tumor involving the sphenoid sinus, orbit, cavernous sinus, anterior and middle cranial fossae, and the infratemporal fossa. This patient was blind and completely ophthalmoplegic before and after the operation. The second patient died due to cerebral arterial vasospasm that resulted in a hypothalamic infarction. A considerable amount of blood was seen in the subarachnoid cisterns on the postoperative CT scan, and the patient became obtunded on the 5th postoperative day. Cerebral angiography confirmed the presence of arterial narrowing. Despite aggressive hypervolemic hypertension hemodilutional therapy, the

TABLE 5
Modified tumor removal grading system of Kobayashi, et al.*

Grade	Definition
I	complete microscopic removal of tumor and dural attachment with any abnormal bone
II	complete microscopic removal of tumor with diathermy coagulation of its dural attachment
III_A	complete microscopic removal of intra- and extradural tumor without resection or coagulation of its dural attachment
III_B	complete microscopic removal of intradural tumor without resection or coagulation of its dural attachment or of any extradural extensions
IV_A	intentional subtotal removal to preserve cranial nerves or blood vessels with complete microscopic removal of attachment
IV_B	partial removal leaving tumor <10% in volume
V	partial removal leaving tumor >10% in volume, or decompression with or without biopsy

* Adapted from Kobayashi, *et al.* (unpublished data).

patient developed an area of cerebral infarction involving the hypothalamus.

Each of these deaths, although related to the patient's pathology and surgery, was not directly attributable to cavernous sinus surgery *per se*. All three patients had had a complete tumor removal.

Morbidity

Cerebral ischemia occurred in three instances. Injury to a small perforating vessel in one patient resulted in a transient (24-hour) hemiparesis. The other two patients suffered a permanent deficit of the dominant hemisphere, caused by injury not to the cavernous carotid artery but to the ipsilateral middle cerebral artery. In the first patient, coaptation of the middle cerebral artery occurred during use of an yttrium-aluminum-garnet laser. The second patient had undergone two previous surgical procedures and had received proton-beam irradiation before surgery. The preoperative angiogram suggested radiation-induced vascular disease. Intraoperatively, the middle cerebral artery fragmented while being dissected from the tumor. Despite immediate reanastomosis under barbiturate-induced coma, the patient was left with a permanent deficit in the dominant hemisphere.

Other instances of morbidity included three patients who suffered from transient diabetes insipidus or nonfatal pulmonary emboli. A cerebrospinal fluid leak occurred in two patients, one of whom required reoperation. There was one instance each of exposure keratitis, acute hypothyroidism, and cerebral edema. All patients recovered completely except for the three who died, the two patients with stroke, and the patient with exposure keratitis, who developed corneal ulceration and blindness because of noncompliance.

The mean postoperative KPS score was 70 (range 50 to 90). Of the 38 patients for whom follow-up data were available, 23 had KPS scores greater than 70. Of the remaining 15 patients with KPS scores less than 70, six experienced improvement after surgery but did not gain independence and three were worsened by the surgery. In two of these three patients, function dropped from an independent level to dependency. The KPS score in six patients did not change.

Oncological Results

Of the 28 patients who had their cavernous sinus meningiomas totally removed and who are available for follow-up review, three suffered recurrence. Ten of these patients were followed for longer than 5 years, only one of whom had a recurrence in the retroclival area; there was no evidence of intracavernous recurrence in this patient. Of the remaining patients, all with less than a 3-year follow-up period, two had early recurrence (one after 6 months and one after 12 months). The extensive nature of the earliest recurrence in this series suggested a change in tumor biology to a more aggressive form, although confirmatory reoperation has not yet been carried out. The recurrence in the patient 1 year after surgery was local within the cavernous sinus. Among the 10 patients whose tumors were subtotally removed, regrowth occurred in two. These regrowths became radiologically and symptomatically evident at 3 and 4 years after surgery. The mean follow-up period in the remaining eight patients was less than 1 year, which is an inadequate length of time to determine the incidence of regrowth.

Discussion

Tumor Classification

Meningiomas are classified as either primary tumors of the sinus or extensions of a tumor from an extracavernous origin[23] (MD Cusimano, *et al.*, unpublished data). Primary meningiomas of the cavernous sinus are rare.[9,27] A more frequent occurrence is that of a secondary ingrowth of a meningioma arising from the inner sphenoid wing (clinoidal meningioma) or the petroclival area. Meningiomas that secondarily involve the cavernous sinus are more easily removed because the tumor may be compressive rather than invasive in nature.[25]

No generally accepted preoperative classification of cavernous sinus meningiomas exists. A classification scheme proposed by Sekhar and Altschuler[23] uses as parameters the extent of cavernous sinus involvement by tumor and the disposition of the intracavernous internal carotid artery. This classification correlated well with the extent of resection accomplished and the operative difficulties in the authors' series (MD Cusimano, *et al.*, unpublished data).

To a much larger degree, the difficulty of classifying cavernous sinus meningiomas involves defining the extent of tumor removal. In the microsurgical era, Simpson's classification,[26] proposed in 1957, is clearly inadequate. We have just begun to apply a new classification system based on that proposed by Kobayashi, *et al.* (unpublished data) (Table 5). We have added a Grade III_A to address the removal of extradural tumor. With this system, most of the cavernous sinus meningiomas with total removal described in this series were Grade II or III_A. Kobayashi and colleagues reported a 0% recurrence rate in 63 patients who had Grade I to III removal of skull-based meningiomas in various locations with a mean follow-up period of 5 years. This finding agrees with the 10% recurrence rate in our patients and the 6% recurrence rate reported by Cusimano, *et al.* (unpublished data). Both groups of patients underwent total removal of their cavernous sinus meningiomas.

Morbidity

A major factor preventing many surgeons from removing meningiomas of the cavernous sinus has been the concern about injuring the ocular motor and trigeminal nerves. Lesoin and Jomin[17] believed that complete ophthalmoplegia was to be expected after removal of a meningioma from the cavernous sinus. Reporting on 91 cases of patients with cavernous sinus tumors, however, Sekhar and associates[24] found that, of their 57 patients with good or excellent preoperative extraocular muscle function, 49 (86%) retained this level of function. At the last follow-up review, 21 of our 22 patients with good or excellent preoperative extraocular muscle function had returned to that level of function. Those patients with fair or good extraocular muscle function tended to remain in those groups (69% in this study, 74% in that of Sekhar and colleagues).

Instances of improved extraocular muscle function did occur in our series, which was restricted to cavernous sinus meningiomas, but they were rare (five (13%) of 38 cases, Table 4). When individual cranial nerve function was analyzed, improvement was found to be rare (14%) (Table 2); the function of most cranial nerves remained unchanged after surgery (80%). This included cranial nerves with any level of dysfunction, from minimal to complete. Permanent impairment of the cranial nerve function occurred in 6% of the cranial nerves. This degradation of function occurred in cranial nerves that were already dysfunctional. Ten new permanent cranial nerve palsies occurred in seven patients (Table 2). In only one instance did these new cranial nerve palsies change the functional grade of the patient's extraocular movement. These rates contrast sharply with rates in a study involving tumors of the cavernous sinus of nonmeningeal origin;[11] in that study, 50% of cranial nerves improved in function, 38% were unaltered, and 12% worsened. Removal of cavernous sinus meningiomas requires much more extensive dissection of the dural sheaths covering the cranial nerves, which increases the likelihood of vascular compromise and decreases the chance of functional improvement.

Treatment

The indications for surgical treatment of cavernous sinus meningiomas are presently twofold. Surgery is offered to those patients with a deteriorating neurological function and to those whose tumors are seen to be enlarging on serial MR imaging.[4,23] Based on the outcomes of cranial nerve and extraocular muscle function in this series of patients, it is reasonable to assume that patients with good or excellent nerve function before surgery will fare better after surgery than those with poor nerve function. Unfortunately, many patients have a complete cavernous sinus syndrome; clinical improvement is unlikely in these patients.

A prerequisite to effective cavernous sinus surgery is adequate exposure and complete control of the proximal and distal carotid artery, which are best achieved by approaches that allow wide basal access.[5,12,13,17,23–25] The path of entry into the cavernous sinus is generally dictated by the areas of tumor involvement. Knowledge of the anatomical triangles of the cavernous sinus facilitates safe entry into the cavernous space. Injury of cranial nerves should be primarily repaired if possible, or a cable graft should be used. Repair of the sixth cranial nerve has been the most successful clinically.[3]

If injury to the intracavernous carotid artery occurs, direct repair by suture or clip graft or both should be attempted under temporary arterial occlusion. If this is not possible, an immediate bypass (either EC-IC or saphenous vein-carotid artery anastomosis) should be carried out. Use of a barbiturate or etomidate and hypothermia may lessen ischemic injury.

We do not recommend or perform carotid artery excision for meningiomas affecting the cavernous sinus. Carotid artery resection does not improve oncological removal because microscopic tumor deposits nearly always remain on the cranial nerves related to the cavernous sinus. Evidence supporting this idea has been presented by Sen and associates (unpublished data), who showed extensive interdigitation of meningioma cells with fascicles of the branches of the trigeminal nerve in the lateral walls of the cavernous sinus. Only with *en bloc* resection of the cavernous sinus is a true oncological cure likely.[17] This procedure, however, would produce unacceptable morbidity in patients with less than a complete cavernous sinus syndrome or in patients dependent upon carotid artery circulation.

For patients with benign meningiomas, the extent of surgical removal correlates most highly with decreased risk of recurrence and increased longevity.[1,6,8,14,19,21,26] The literature supports our goal of aggressive tumor resection. This goal should obviously be tempered if experience revealed an unacceptable morbidity rate or an insignificant incidence of oncological control. We have found, however, that extensive surgery within the cavernous sinus is not associated with excessive morbidity. Most patients do not have a permanent increase in neurological deficits related to surgery. Furthermore, recurrence rates of 6% and 10% in two large surgical series of cavernous sinus meningiomas (this series and that of Cusimano, *et al.* (unpublished data)) are significant improvements over recurrence rates of 20% to 50% for medial sphenoid wing meningiomas reported in the literature.[7,8,10,20,21,26]

It has been common practice to perform subtotal removal of cavernous sinus meningiomas and to follow this by radiotherapy, either with conventional external beam therapy or with stereotactically focused radiotherapy. Also a current experimental trial is testing the efficacy of RU-486, an antiprogesterone agent, in the treatment of "unresectable" benign meningiomas. The aim of both of these treatment plans is to reduce the morbidity associated with entry into the cavernous sinus. In this series of patients, however, the only morbidity directly related to cavernous sinus dissection was the worsening of function in 6% of the already dysfunctional cranial nerves and the production of 10 new cranial neuropathies in seven patients (18%). These new neuropathies were mostly confined to the production of hypesthesia in the trigeminal nerve distribution, although two patients (one with a nonseeing eye) dropped a grade in extraocular muscle function.

Complete resection of cavernous sinus meningiomas is possible in most cases. This can be done with acceptable levels of morbidity and mortality. Although the follow-up period in these patients has been short, increasing evidence shows that the recurrence rate is lessened.

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