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Long-term Visual Outcome after Nonradical Microsurgery in Patients with Parasellar and Cavernous Sinus Meningiomas

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Abstract

To determine the long-term visual outcome in patients with parasellar and cavernous sinus meningiomas treated with nonradical surgery.

Retrospective clinical review of 29 patients with parasellar or cavernous sinus meningiomas and visual sensory or ocular motor dysfunction at presentation, all of whom had at least 10 years of follow-up after initial diagnosis and treatment with nonradical surgery.

Nineteen of 29 patients had a unilateral or bilateral optic neuropathy at presentation, and 7 patients developed a unilateral or bilateral optic neuropathy during a mean follow-up period of 13.6 years. However, 27 (93%) of 29 patients retained vision of 20/40 or better in at least one eye, and 14 patients (48%) retained vision of 20/40 or better in both eyes. New

ocular motility deficits developed in 3 (10%) of 29 patients during the follow-up period.

Radical surgery is not required to achieve long-term useful visual function for patients with parasellar or cavernous sinus meningiomas.

Advances in neuroimaging, microsurgery, postoperative care and follow-up, and alternative treatment options have shifted the focus of brain tumor management from prolongation of life to preservation of neural function. This trend is particularly evident in the treatment of meningiomas. Indeed, during the last decade, observation without intervention, radical tumor resection, partial resection followed by radiation therapy or stereotactic radiosurgery, and stereotactic radiosurgery alone have all been advocated as potential treatment options (1, 4, 5, 7, 8, 12, 31, 33). Because decisions regarding the therapy of meningiomas are frequently predicated on the development, existence, or progression of neurological deficits, the potential risks and benefits of various operative as well as nonoperative interventions must be clear.

In this article, we report the long-term visual outcome in patients with parasellar and cavernous sinus meningiomas who underwent nonradical, subtotal, microsurgical resection of their tumors, as advocated by Wilson (33). The majority of patients who have these tumors present with visual complaints, such as decreased visual acuity, visual field deficits, and double vision. Consequently, treatment is primarily aimed at preventing further visual deterioration on the ipsilateral as well as the contralateral side. Although several studies have reported the results of surgery on visual acuity or visual fields (3, 6, 16, 26, 30), little is known about the long-term visual prognosis in these patients; i.e., more than 10 years after surgery. Moreover, many of these studies have not investigated other visual parameters, such as color vision, pupillary reactivity, appearance of the disc, ocular motility and alignment, and proptosis. In this article, we report the visual findings in 29 patients, each of whom underwent nonradical, subtotal resection of a parasellar or cavernous sinus meningioma at least 10 years previously.

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PATIENTS AND METHODS

We retrospectively reviewed the charts of all patients treated in the Neuro-Ophthalmology Unit of the Wilmer Eye Institute, Johns Hopkins Hospital, with the diagnosis of parasellar, medial sphenoid wing, or cavernous sinus meningioma and examined by one of the senior authors (NRM). A total of 135 charts were identified; 52 of the patients had been diagnosed at least 10 years earlier. Ophthalmology records were available for 29 (56%) of these patients. All charts were reviewed for the following data: age at presentation, sex, years of follow-up, presenting symptom, location of tumor, time interval from symptoms to diagnosis, time interval from diagnosis to treatment, surgery performed, dates of surgery, total dosage and dates of any radiation therapy, progression of tumor, and years from therapy to progression. Ophthalmological indices were also recorded at presentation and at the most recent examination. They included visual acuity, color vision, presence of a relative afferent pupillary defect (RAPD), appearance of the optic discs, visual field, proptosis, and function of the oculomotor, trochlear, trigeminal, abducens, and facial nerves. All available surgical and neuroimaging reports were reviewed. Imaging studies were also reviewed when possible.

We defined a change in visual acuity as a worsening or improvement of two or more lines of Snellen acuity. Decreased acuity was defined as Snellen acuity of 20/40 or less in an eye that previously had vision of 20/20 or better and in which no other cause for decreased vision was found at examination.

Visual field data were derived from both kinetic perimetry and automated static perimetry at presentation and at follow-up. Actual fields were available in most charts, but it was necessary to rely on written descriptions in others. Therefore, only gross changes in the field of vision were considered significant. Subtle changes may have been missed in this analysis.

The presence of optic neuropathy was determined by evaluation of several measures of optic nerve function, including visual acuity, color vision, pupillary responses to light stimulation, visual field, and appearance of the

optic disc. An optic neuropathy was considered present if more than one abnormal parameter was consistently present and could not be explained by other ocular conditions (e.g., cataract, congenital color blindness, retinal disease). A patient was considered to have proptosis if a difference between the eyes of more than 2 mm, as measured with a Hertel exophthalmometer, was present.

We defined nonradical surgery as removal of all intracranial, intradural tumor; removal of the tumor-bearing dura; exploration of the optic canal when indicated; removal of the accessible intracavernous tumor; orbital exploration with resection of intraorbital tumor when indicated; and removal of hyperostotic or infiltrated bone. Our definition excluded radical cavernous sinus extirpation, carotid artery bypass, and the extended, combined extradural-intradural approaches used for very large tumors.

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RESULTS

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Patient population

Table 1 depicts the demographic characteristics of the patients in the study. There were 23 female patients (79%) and six male patients (21%). The mean age at presentation of the 29 patients was 51.7 years (range, 16–72 yr); the mean age at presentation was 59.3 years for male patients (range, 38–72 yr) and 49.7 years for female patients (range, 16–69 yr). The length of ophthalmological follow-up ranged from 10 to 22 years (mean, 13.6 yr; median, 12 yr).

TABLE 1. Demographic Characteristics of the Patients

Patient No.	Sex	Age (yr) at Diagnosis	Follow-up (yr)
1	F	58	21
2	F	49	14
3	F	50	10
4	F	47	20
5	F	64	17
6	F	48	10
7	M	64	16
8	M	72	15
9	F	57	18
10	F	33	10
11	M	61	13
12	F	43	10
13	M	65	12
14	F	42	13
15	F	44	12
16	F	45	10
17	F	69	10
18	F	16	18
19	F	56	12
20	F	53	11
21	F	55	22
22	F	52	11
23	F	65	11
24	F	57	17
25	F	39	11
26	F	46	12
27	M	56	14
28	M	38	11
29	F	55	13

Demographic Characteristics of the Patients

The interval from onset of symptoms to diagnosis was determined in 23 patients. The mean time to diagnosis was 26.7 months (range, 1 mo to 14 yr). Five patients were diagnosed within 1 month of the onset of symptoms. In 10 patients, the diagnosis was made 2 or more years after the onset of symptoms.

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Presenting symptom

Decreased vision was the most common presenting symptom and was present in 14 patients (48%). This was followed in frequency by proptosis in 7 patients (24%) and double vision in 2 patients (7%). One patient each (3.4%) presented with isolated ptosis, transient visual obscurations, headache, seizure, episodic difficulties with speech, and blackouts.

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Surgery

The tumor location, as well as could be determined, is summarized in Table 2. Twenty-eight (97%) of 29 patients underwent a total of 37 operations (Table 2). Of these, 27 underwent nonradical surgery on their tumors, whereas 1 patient had radical surgery in the cavernous sinus, performed as a second procedure in a patient with a blind, ophthalmoplegic eye. The time from diagnosis to treatment was determined in 25 patients; the mean time was 8.5 months (range, 1 mo to 8 yr). Seventeen patients underwent surgery within 1 month of diagnosis, and an additional 5 patients had surgery within 1 year.

TABLE 2. Tumor Location, Treatment, and Progression[a]

Patient No.	Tumor Location	Surgery	Radiation Therapy (cGy)	Progression/ Years to Progression
1	R SW	R Cran	N	N
2	R SW	R Cran ×2	N	Y/7, 2[b]
3	R SW	R Cran	5000	Y/5
4	R SW	R Cran	N	Y/13
5	R SW	R Cran, R Orb	N	Y/10
6	R SW	R Cran	N	N
7	L SW, L ORB	L Cran	N	Y/7
8	R SW, R ORB	R Cran, R Orb	N	Y/<1
9	R CS	R Cran ×2	5040	Y/6, 2[b]
10	R SW, R OC, R ORB, Bilat CS	R Cran, R OC decompression	N	N
11	R SW, R CS	R Cran	N	Y/4
12	L SW	L Cran	N	N
13	L SW	L Cran	N	N
14	R SW	R Cran	N	N
15	R SW, R ON	R Cran ×2, R OC decompression	N	Y/3
16	L SW	L Cran	N	Y/7
17	R SW	N	N	N
18	PS, Bilat CS, Bilat OC	Bilat OC decompression	5400	Y/10
19	L SW	R Cran	N	N
20	R CS	R Cran ×2	5580	Y/1, 10[b]
21	R SW, R ON	R Cran	N	Y/21
22	L SW, L CS, L ORB	L Cran ×2, CS radical decompression	5040	Y/3
23	R SW, R OG	R Cran	N	N
24	L SW	L Cran ×2	5200	Y/14, 2[b]
25	R SW	L Cran ×2, L Orb	N	Y/8
26	L SW	L Cran	N	N
27	L CS, L ORB	L Cran ×2	5040	Y/13, 1[b]
28	L SW, L OC	L Cran ×2	N	Y/12
29	R SW	R Cran	N	Y/9

[a] R, right; SW, sphenoid wing; Cran, craniotomy; N, no; Y, yes; Orb, orbitotomy; L, left; ORB, orbit; CS, cavernous sinus; OC, optic canal; Bilat, bilateral; ON, optic nerve; OG, olfactory groove.
[b] Second number is time to progression after initial surgery.

Tumor Location, Treatment, and Progressiona

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Radiation

Seven patients received radiation therapy (mean dose, 5186 cGy; range, 5000–5580 cGy). No patient received radiation as sole treatment or at the time of primary surgery.

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Tumor progression and recurrence

Tumor progression, as determined by neuroimaging, occurred in 18 patients (62%) during a mean follow-up period of 13.6 years. Of the 9 patients who were followed for 15 or more years, 8 (89%) had tumor progression. The mean time from primary treatment to identification of progression was 8.2 years (range, 1 mo to 21 yr).

Two of the seven patients who received secondary radiation progressed at 1 and 10 years after radiation. The mean postradiation follow-up in these patients was 8.2 years (range, 1 mo to 11 yr).

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Visual acuity

Table 3 indicates the visual function at presentation and at final examination for the 29 patients in this study. Among 58 eyes in the 29 patients, 26 eyes (46%) in 23 patients remained normal throughout the follow-up period, whereas 32 eyes (55%) had an optic neuropathy at presentation (22 eyes of 19 patients) or developed an optic neuropathy during the period of follow-up (10 eyes of 7 patients) (Table 4). Of the 22 eyes in 19 patients with an optic neuropathy at presentation, 14 eyes (62%) had stable or improved vision at final examination. Thus, 40 (69%) of 58 eyes remained normal or had no worsening of vision during the follow-up period, despite a preexisting optic neuropathy, whereas 18 eyes experienced worsening of vision during the follow-up period, either from worsening of a preexisting optic neuropathy (8 eyes) or from the development of a new optic neuropathy (10 eyes). Overall, 27 (93%) of 29 patients retained visual acuity of 20/40 or better in at least one eye, and 14 (48%) of 29 patients retained visual acuity of 20/40 or better in both eyes (Table 3).

TABLE 3. Visual Function on Initial and Final Examinations (Visual Acuity, Color Vision, and Visual Field)[a]

Patient No.	Visual Acuity (R, L)		Color Vision (R, L)[b]		Visual Field Defects	
	Initial	Final	Initial	Final	Initial	Final
1	NLP, 20/20	NLP, 20/20	10/10 OS	10/10 OS	No field OD	No field OD
2	20/25, 20/20	20/20, 20/20	0/10, 4/10	3.5/10, 9/10	Inferior arcuate OD	Bilat inferior defects
3	20/50, 20/20	20/40, 20/20	10/10, 10/10	8/10, 9/10	None	Inferior arcuate OD
4	20/30, 20/20	LP, 20/20	0/10, 10/10	0/10, 10/10	Constricted OD	Residual temporal island OD
5	NLP, 20/25	20/400, 20/20	10/10 OS	1/10, 10/10	No field OD	Constricted OD
6	20/15, 20/15	20/20, 20/20	10/10, 10/10		None	None
7	20/20, 20/20	20/30, HM	10/10, 9.5/10		None	Severe constriction OS
8	20/25, 20/25	20/40, 20/25	"Normal"	0/10, 8/10	None	Constricted OD
9	20/20, 20/20	LP, 20/30	9.5/10, 9.5/10		None	Temporal defect OS
10	20/40, 20/20	20/40, 20/15	0/10, 10/10	1.5/10, 10/10	Constricted OD	Constricted OD
11	20/15, 20/15	20/15, 20/20	10/10, 9.5/10	7/10, 8.5/10	None	Superonasal defect OD
12	20/20, 20/20	20/15, 20/15	"Normal"	10/10, 10/10	None	None
13	20/20, 20/25	20/20, 20/20	9.5/10, 5/10	10/10, 10/10	Superior arcuate defect OS	None
14	NLP, 20/20	NLP, 20/20	9.5/10 OS	10/10 OS	None	None
15	20/80, NLP	20/50, NLP	0/10 OD		Temporal defect OD	Constricted OD
16	20/25, LP	20/20, NLP	10/10 OD		No field OS	No field OS
17	HM, 20/20	NLP, 20/30	9/10 OS	0/10 OS	No field OD	No field OD, constricted OS
18	20/20, HM	20/300, HM	6.5/10 OD	2.5/10 OD	No field OS, superior defect OD	No field OS, superior defect OD
19	20/25, CF	20/20, 20/25	"Desaturation OS"			
20	20/50, 20/25	20/40, 20/25	5/10, 10/10	10/10, 10/10	Global depression OD	None
21	20/50, 20/30	HM, 20/20		7.5/10 OS	Constricted OD	No field OD, constricted OS
22	20/20, 20/20	20/15, 20/25	10/10, 9/10	10/10, 10/10	None	Inferior defect OS
23	20/20, 20/20	20/30, 20/30	8.5/10, 9.5/10	9.5/10, 10/10	None	None
24	20/20, 20/20	20/15, 20/60		10/10, 1/10	Inferior defect OS	Constricted OS
25	20/20, 20/20	20/20, 20/15	10/10, 10/10	9.5/10, 10/10	None	None
26	20/20, 20/70	20/20, 20/20	10/10, 1/10	10/10, 10/10	Inferior defect OS	Inferior defect OS
27	20/15, 20/20	20/20, NLP	10/10, 10/10	10/10 OD	None	No field OS
28	20/15, 20/20	20/15, 20/80	10/10, 10/10	10/10, 0/10	Inferior defect OS	Inferior defect OS
29	20/25, NLP (OS blind from birth)	20/15, NLP	0/10 OD	9/10 OD	Temporal defect OD, no field OS	Temporal defect OD, no field OS

[a] R, right; L, left; NLP, no light perception vision; OS, left eye; OD, right eye; Bilat, bilateral; LP, light perception vision; HM, hand motion vision; CF, counting fingers vision.

[b] Color vision recorded as number of plates correctly identified out of 10 plates tested using Hardy-Rand-Rittler Pseudoisochromatic Plates.

Visual Function on Initial and Final Examinations (Visual Acuity, Color Vision, and Visual Field)a

TABLE 4. Presence and Development of Cranial Neuropathies, Including Optic Neuropathy[a]

Patient No.	Optic Neuropathy		Cranial Neuropathies 3–7	
	Initial	Final	Initial	Final
1	OD	OD	None	None
2	OU	OU	None	None
3	OD	OD	None	R 3, 4, 6
4	OD	OD	None	None
5	OD	OD	R 3, 5	R 3, 5
6	None	None	None	None
7	None	OS	None	None
8	OD	OD	R 3, 4, 6	R 3, 4, 6
9	None	OU	R 6	R 3, 6, 7; L 3
10	OD	OD	None	None
11	None	OD	None	None
12	None	None	None	None
13	OS	OS	None	None
14	OD	OD	None	None
15	OU	OU	None	None
16	OS	OS	L 3, 4, 6	L 3, 4, 6, 7
17	OD	OU	None	None
18	OU	OU	None	None
19	OS	OS	L 3	None
20	OD	OD	R 3	R 3, 4, 5, 6
21	OD	OU	None	None
22	None	OS	None	L 3, 4
23	None	None	None	None
24	None	OS	None	None
25	None	OD	R 5	R 5
26	OS	OS	L 3, 6	L 3, 6
27	None	OS	L 3	L 3, 4, 5, 6, 7
28	OS	OS	None	None
29	OD	OD	None	None

[a] OD, right eye; OU, both eyes; R, right; OS, left eye; L, left; 3, oculomotor nerve; 4, trochlear nerve; 5, trigeminal nerve; 6, abducens nerve; 7, facial nerve.

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Color vision

Four patients had improvement in color vision in one eye (Table 3), and one had improvement in color vision in both eyes. Four patients experienced worsening in one eye, and one in both eyes.

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RAPD

Nineteen patients (66%) had a RAPD initially, compared with 22 patients (76%) at the most recent examination. Overall, four patients developed a new RAPD during the course of follow-up, whereas one patient's RAPD resolved. The patient whose RAPD resolved after surgery also experienced postoperative improvement in color vision and visual field in the affected eye.

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Visual field

During the period of follow-up (Table 3), 10 patients (34%) had worsening of the visual field in one eye, 3 (10%) had worsening in both eyes, 4 (14%) had improvement in one eye, and 2 (7%) had worsening in one eye and improvement in the other.

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Optic atrophy

During the course of follow-up, 11 patients (38%) exhibited worsening of pallor of the ipsilateral optic disc, and 4 (14%) had worsening of pallor of

the contralateral disc. In 14 patients (52%), the appearance of the optic discs remained unchanged.

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Cranial nerve function

Nine patients (31%) had cranial neuropathies other than an optic neuropathy at presentation (Table 4). Five of these patients had isolated cranial neuropathies, whereas four had multiple cranial neuropathies. The ocular motor nerves were most often affected, with single or multiple ocular motor nerve pareses being present in eight (89%) of the nine patients, one of whom also had a trigeminal sensory neuropathy. The ninth patient had an isolated trigeminal neuropathy.

During the follow-up period, six (67%) of the nine patients with preexisting cranial neuropathies experienced worsening of one or more of their neuropathies, development of one or more new cranial neuropathies, or both, whereas one of the nine patients experienced complete resolution of an oculomotor nerve palsy. In addition, two patients who had no cranial neuropathy at presentation developed one or more cranial neuropathies during the follow-up period.

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Proptosis

Proptosis worsened in five patients during the study. Permanent improvement was seen in only one patient postoperatively. One patient initially improved after surgery but subsequently worsened as the tumor progressed.

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DISCUSSION

In this article, we describe the long-term visual outcomes in patients with parasellar and cavernous sinus meningiomas after nonradical surgery, eventually followed in some cases by conventional radiation therapy. Decisions regarding therapeutic intervention in these histologically benign, slow-growing tumors are frequently predicated on the existence, development, or progression of visual deficits in the ipsilateral eye or are based on attempts to preserve visual function in the contralateral eye. Our findings indicate a favorable long-term prognosis for vision in patients with parasellar and cavernous sinus meningiomas treated by conventional therapy rather than radical surgery. Indeed, long-term visual deficits appear no more likely to occur than deficits resulting from radical surgery, which has greater operative mortality and morbidity.

In general, postoperative, nonophthalmic neurological morbidity is uncommon in patients with parasellar and cavernous sinus meningiomas; however, hemiparesis, ataxia, deafness, vocal cord paralysis, epilepsy, diabetes insipidus, anosmia, hypopituitarism, and permanent confusional states have all been reported after surgery (2, 9, 30, 32). Among our 29 patients, one developed panhypopituitarism, and three required long-term anticonvulsive therapy. Currently, all of the patients receiving anticonvulsive drugs have been seizure-free for at least 2 years. Of course, it is impossible to draw conclusions about the neurological outcome of the 23 patients (44%) on whom we were unable to obtain follow-up. Perhaps they had a worse neurological outcome, thus explaining why we were unable to contact them for follow-up assessment. We can say, however, that at least half the patients with parasellar or cavernous sinus meningiomas initially evaluated at our institution at least 10 years ago have done well neurologically. In addition, because we practice in a tertiary referral center, it is possible that both our patients and our results are different from those of other surgeons who practice community-based neurosurgery.

Tumor progression is a potential cause of long-term morbidity of patients with meningiomas. For example, Couldwell et al. (9) cited a 13% recurrence rate with a mean follow-up of 6.1 years in 109 cases of petroclival meningiomas, and Chan and Thompson (8) reported a 15% recurrence rate over 9 years in convexity meningiomas thought to be completely excised. Jääskeläinen (15) reported a 19% overall recurrence

rate over a 20-year period in “completely removed” intracranial meningiomas, and Mirimanoff et al. (24) reported an increased risk of recurrence over time, with 3% of “completely excised” meningiomas recurring at 5 years and 25% recurring at 10 years. In our series of conservatively treated parasellar or cavernous sinus meningiomas, 18 (62%) of 29 patients showed evidence of tumor growth or recurrence during a mean follow-up of 13.6 years, and 26 (89%) of 29 patients followed for 15 or more years showed evidence of tumor progression or recurrence. These findings are in agreement with those of other authors who have reported that the risk of tumor progression or recurrence increases the longer the patient is followed and is substantial after 15 years in patients with incompletely excised tumors.

There is increasing evidence that radiation therapy after surgery reduces the risk of recurrence or progression of meningiomas (22, 23, 25). For example, Goldsmith et al. (14) reported a 5-year progression-free survival rate of 89% and a 10-year progression-free survival rate of 77% for patients who were treated with conventional radiation therapy after subtotal resection of their intracranial meningiomas. In this study, patients treated with radiation therapy after 1980 had a progression-free survival rate of 98%. Nevertheless, radiation therapy is not without risk; Goldsmith et al. (14) reported a 3.6% morbidity rate in their series. Radiation-induced complications include complete blindness in one or both eyes, hypopituitarism, dementia, and secondary tumors (1, 10, 14). Our study does not address the issue of whether or not radiation therapy is beneficial in preventing tumor progression, because none of our patients received conventional radiation therapy after initial surgery, and only 7 (24%) of the 29 patients received conventional radiation therapy because of subsequent tumor progression (Table 3). None of these patients experienced any radiation-induced complications, but two of the patients had further tumor progression despite radiotherapy.

Stereotactic radiosurgery (high-dose, single-fraction, focal radiation therapy) has gained increasing acceptance as an alternative to microsurgery for benign tumors of the anterior cranial base. This treatment appears to control tumor growth with acceptable side effects (17, 20, 22). Duma et al. (13) reported no growth in 34 patients followed for a mean of 26 months

after stereotactic radiosurgery in addition or as an alternative to surgery for cavernous sinus meningiomas, and Liscak et al. (21) reported no change in tumor volume in 48% of 67 cases and decreased tumor volume in the remaining 52% of cases of cavernous sinus meningioma over a follow-up period that ranged from 2 to 60 months (median, 19 mo). Clinical manifestations, including ocular motor nerve palsies and optic neuropathy, improved in 19 (36%) of 53 patients for whom data were available. Kondziolka et al. (17) evaluated 99 consecutive patients who underwent radiosurgery for meningioma between 1987 and 1992. Fifty-seven (57%) of these patients had undergone a subtotal (45 patients) or gross total (12 patients) resection of their tumor. Over a follow-up period that ranged from 53 to 120 months, clinical tumor control rate was 97%. Sixty-one (63%) of the tumors became smaller, 31 (32%) remained unchanged in size, and five (5%) became larger. Despite these findings, the lack of true, long-term follow-up and the disparate treatment protocols make the role of stereotactic radiosurgery for parasellar meningiomas difficult to define. Furthermore, the structures of the anterior visual system appear to exhibit a higher sensitivity to single-fraction radiation than other cranial nerves (20), which may affect long-term visual outcomes for patients treated in this manner. One of the patients in this study was treated with radiosurgery after progression following primary surgery, but we have no long-term data on the results of this treatment. The role of radiosurgery, either used as monotherapy or in combination with other treatment modalities, remains to be determined.

Although 26 (89%) of our 29 patients had evidence of a unilateral or bilateral optic neuropathy at follow-up, 27 (93%) of the 29 patients had visual acuity at follow-up of 20/40 or better in at least one eye, and 14 patients (48%) had visual acuity of 20/40 or better in both eyes. This level of vision allows most persons to perform all activities of daily living, including driving, watching television, and reading newspaper-size print.

Ocular motor nerve palsies can effectively eliminate useful vision from an otherwise normal-seeing eye because of double vision. Because the trochlear and abducens nerves each supply only one extraocular muscle, pareses of these nerves can often be treated successfully with surgery, prism therapy, injections of botulinum toxin, or a combination of these modalities.

However, because the oculomotor nerve supplies four extraocular muscles, paresis of this nerve frequently precludes restoration of single binocular vision. Although 5 (17%) of the 29 patients in this study developed new ocular motor nerve pareses during the follow-up period, only 3 (10%) of these patients developed a new oculomotor nerve paresis. These results compare favorably with those of DeMonte et al. (11), who performed radical cavernous sinus surgery on 41 patients over a 10-year period. In their study, 3 (11%) of 27 patients without an oculomotor nerve deficit developed one during a mean follow-up period of 45 months.

We are aware that the patients in our study may not reflect the typical patients seen by neurosurgeons across the country; however, we believe that our patients are similar to those who would be considered for radical surgery at other institutions. We thus believe that it is appropriate to generalize the findings of this study.

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CONCLUSION

Our findings suggest that radical surgery in the cavernous sinus region for meningiomas, as advocated by some authors (1, 3, 11, 12, 27–29), may not provide any advantage in improving preexisting cranial nerve palsies, in delaying or preventing the progression of preexisting cranial neuropathies, or in preventing the development of new cranial neuropathies. In addition, our data indicate a favorable long-term prognosis for useful vision for patients with parasellar and cavernous sinus meningiomas treated without radical tumor removal, carotid bypass, or both. In view of these findings, as well as recent reports indicating that cavernous sinus meningiomas can invade both the cavernous portion of the internal carotid artery (18) and the cranial nerves (19), thus precluding complete removal even with radical surgery, we agree with Wilson (33) that without compelling evidence that radical surgery can preserve or improve visual sensory function and maintain ocular motility for a long period, nonradical surgical debulking of extracavernous tumor followed by radiation therapy (or perhaps stereotactic radiosurgery) may be the best option for most patients harboring parasellar or cavernous sinus meningiomas.

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COMMENTS

This is an excellent long-term follow-up study. Publication of such studies is sorely needed, especially at a time when there is so much controversy about the indications for aggressive resections of benign tumors, now that we have the techniques to perform them. The real issue is delineation of the indications and advantages of these approaches. We can arrive at such a definition only by understanding the natural history of these tumors and their history with other surgical approaches. This study offers that understanding in regard to the visual outcome with parasellar meningiomas. The authors have considered only gross field changes as significant. As clinical patient function and long-term survival should be our baseline, I

find this appropriate. There could be a question of bias, as only 56% of the 52 patients treated could be followed, but I suspect that if the other patients had been more symptomatic, they would have returned. This is somewhat conjectural.

The authors call their surgery nonradical. However, it is defined as removal of all intracranial intradural tumor; removal of the tumor-bearing dura; exploration of the optic canal when indicated; removal of the accessible intracavernous tumor; orbital exploration with resection of intraorbital tumor when indicated; and removal of hyperostotic or infiltrated bone. This is not a simple biopsy or decompression of "peak and shriek" surgery. This is an aggressive surgical removal. Yet the authors note a 62% 13.6-year progression and an 89% 15-year progression rate. The average time to progression was 8.2 years. With radiation, two of seven patients progressed at 1 and 10 years. The authors point out that most studies have reported the results of progression-free intervals after stereotactic radiation treatment or stereotactic radiosurgery and not anywhere near this length of time, and these results may not accurately reflect the adequate control that has been touted. This point is very well taken.

In this group, 38% had a decline in vision in one eye, 10% had a loss in two eyes, whereas 14% improved. Overall, 93% retained functional vision in one eye, and 48% retained functional vision in two eyes. These are excellent results with a minimum of morbidity from surgery. Those who espouse more aggressive procedures must at least equal these results of long-term visual function without additional morbidity.

Kalmon D. Post

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Klink et al. present to us a very large series of 29 patients who had parasellar meningiomas and in whom the surgical approach was nonradical. With a fairly long follow-up period (≥10 yr), these authors can reasonably assess long-term mortality and morbidity issues. Importantly, they are able to make this assessment with particular attention to numerous ophthalmological outcome measures and find that this conservative approach is associated with a favorable long-term prognosis.

The patients in this study compare favorably with historical controls in whom radical resection was performed on parasellar meningiomas. As the authors recognize and address in their Discussion, this patient population may not be a fair sampling of all patients who present with parasellar meningiomas. There may have been some self-selection for a variety of reasons, including the reputation of their institution, the techniques available at this institution, and the philosophy of the neurosurgeons involved. Furthermore, although only one patient (about 2%) in their series developed a nonophthalmological problem (panhypopituitarism), a much larger percentage of the 52 patients originally diagnosed and treated (44%; 23 patients) were not available for follow-up. Yet, these patients might not have been available because of issues of mortality or significant neurological morbidity.

Fortunately, the authors discuss possible bias of the selected sample. Moreover, the patents in the present study did so very well, from an ophthalmological point of view, that it is unlikely that the unrepresented follow-up group did very poorly, in neurological terms. That they did so well ophthalmologically is especially interesting in that radiation to the parasellar area might be expected to induce visual loss from postradiation injury to the optic nerves or chiasm or ophthalmoplegia resulting from injury to the cranial nerves in the adjacent cavernous sinus.

Hence, weight must be accorded the authors' conclusion that, for parasellar meningiomas, radical resection may not be the optimal treatment, especially in patients in whom vascular bypass is being considered, as this is quite likely to impair ocular motility and render the patient functionally monocular.

Alfredo A. Sadun Neuro-ophthalmologist

Los Angeles, California

The authors have reviewed the records of a series of patients with incompletely removed parasellar meningiomas. The point of their report is contained in the last paragraph. In brief, radical surgery for parasellar meningiomas is neither curative nor free of major morbidity. Certainly, operations in the cavernous sinus are possible, including maneuvers such as

carotid grafting. Nonetheless, only irradiation has the potential to eliminate inevitable regrowth. The authors make this point clearly and forcefully. Cranial base surgery has a role, but when the cavernous sinus is involved, I fail to find justification for its use in the treatment of meningiomas.

Charles B. Wilson

San Francisco, California

The authors have conducted a thorough study of an important subject. It emphasizes the importance of a meticulous neuro-ophthalmological pre- and postoperative ("follow-up") evaluation in patients with cavernous sinus meningiomas. It is unfortunate, however, that almost one-half of the patients harboring meningiomas at this location in their institution were lost to follow-up and not included in this study. We wonder how large is the bias thus created.

Two important features pertaining to this study need to be emphasized. First, the authors' description of achieved surgical removal is actually very radical in areas outside the cavernous sinus and corresponds to Simpson Grade I of meningioma resection (2). They radically removed the involved dura and bone and even entered the optic canal when necessary. Although they considered the tumor inside the cavernous sinus not amenable to radical removal, they pursued radical removal in equally challenging areas. Consequently, tumor progression was experienced in two-thirds of patients during an average follow-up period of 13.6 years, and in 89% of patients with an average follow-up of 15 years. This tumor progression rate corresponds with those reported in the literature for partially resected cavernous sinus meningiomas. It strongly supports the need for radical tumor removal, contrary to the authors' conclusion.

Secondly, as their statistics reveal, a significant number of patients had progressive visual findings. More than one-third of the patients had worsening of visual acuity, almost one-half had worsening of the visual fields, and almost one-third had worsening function of the cranial nerves (Cranial Nerves III, IV, V, and VI). These results also strongly support the need for radical tumor resection, as emphasized in previous studies (1).

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Keywords:

Cavernous sinus; Cranial neuropathies; Double vision; Meningioma; Optic neuropathy; Parasellar; Visual outcome