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699 Stereotactic Radiosurgery of Cavernous Sinus Meningiomas as an Addition or Alternative to Microsurgery
Clinical Study

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ABSTRACT: TO EVALUATE THE response of cavernous sinus meningiomas to stereotactic radiosurgery, we reviewed our 54-month experience with 34 patients. All patients underwent radiosurgery with a 201-source cobalt-60 gamma unit. Twenty-eight patients (82%) had previous histological confirmation of a meningioma (1 to 5 cranial base craniotomies per patient); 6 (18%) were treated on the basis of neuroimaging criteria alone. The single-fraction radiation tumor margin dose (10 to 20 Gy) was designed to conform to the irregular tumor volumes in all patients. The maximum radiation dose to the optic nerve or tract was reduced to 9 Gy in 31 patients. No patient had tumor growth (100% tumor control) during the follow-up interval (median, 26 mo). Tumor regression was observed in 56% of patients imaged at an average of 18 months. Eight patients (24%) improved clinically at follow-up examinations. Four patients developed new or worsened cranial nerve deficits during the follow-up interval; two had subsequent full improvement. No patient developed an endocrinopathy or new extraocular muscle paresis. Stereotactic radiosurgery, using multiple isocenter dosimetry facilitated by the gamma unit, is an accurate, safe, and effective technique to prevent the growth of tumors involving the cavernous sinus. Despite the proximity of such tumors to adjacent cranial nerves, complications were rare. The maximum length of hospital stay was 36 hours, and all patients returned to their preoperative employment status within 3 to 5 days. Although even longer follow-up is required, stereotactic radiosurgery using the gamma knife technique was found to be a low-morbidity alternative to aggressive microsurgical removal of small to moderate-sized tumors of the cavernous sinus.

KEY WORDS: Cavernous sinus; Meningioma; Stereotactic radiosurgery

Despite recent advances in microsurgical skill, anesthetic management, and postoperative neurointensive care, the morbidity after aggressive microsurgical removal of cavernous sinus meningiomas remains high [29]. These tumors may envelop or displace critical cranial nerves, and, depending on their size, surround and even occlude the carotid artery. Both extradural and intradural microsurgical approaches to tumors of the cavernous sinus have been described recently and include transzygomatic, pterional, infratemporal, and transpetrosal routes [9,15,32,33]. In recent reports from major centers, mortality rates after microsurgical resection were as high as 6% [9]. The incidence of new postoperative cranial neuropathies varied from 19 to 86%, and the combined cerebrospinal fluid leakage, infection, and other surgical morbidity rates approached 31% of patients [9,15,32]. Total tumor excision was obtained in 60 to 70% of patients [9,15,32].

Stereotactic radiosurgery is a potentially effective alternative to the microsurgical removal of cavernous sinus meningiomas. The goal of radiosurgery is the preservation of neurological function and the prevention of further tumor growth. Kond-ziolka and colleagues [19] previously reported a 3-year actuarial tumor control rate of 96% in 50 meningioma patients undergoing gamma knife radiosurgery. Steiner [34], reporting the results from several institutions, noted a 90 to 100% tumor control rate after meningioma radiosurgery, many of those tumors were in the cavernous sinus.

This report evaluates the current efficacy and safety of stereotactic radiosurgery in a series of 34 patients with growing or recurrent cavernous sinus meningiomas. We conclude that these results warrant the consideration of stereotactic radiosurgery as a primary management modality for appropriately selected meningiomas in this region.

PATIENTS AND METHODS

Between May 1988 and January 1992, 34 patients (27 women and 7 men) with cavernous sinus meningiomas underwent stereotactic radiosurgery with the 201-source cobalt-60 gamma knife at the University of Pittsburgh. Twenty-nine patients (85%) had meningiomas that primarily involved the cavernous sinus. Six patients had tumors that invaded the cavernous sinus secondarily (Fig. 1). Three patients (9%) had received between 50 and 60 Gy of fractionated external beam radiotherapy previously (2, 6, and 11 yr, respectively, before radiosurgery). Twenty-eight patients (82%) had undergone between one and five previous operations (average, 1.8 operations per patient) and tumor removal attempts. The interval between initial tumor recognition to radiosurgery varied from 3 months to 13 years (median, 2 yr). The interval between last craniotomy to radiosurgery varied from 1 month to 11 years (median, 1 yr). One patient underwent a craniotomy and nondiagnostic tumor biopsy. Six patients (18%) had characteristic neurodiagnostic imaging changes considered pathognomonic of a meningioma; before radiosurgery, all six were evaluated for 6 months to 4 years (median, 2.5 yr) after the discovery of tumor, and all had documented tumor growth.

Patients were accepted for radiosurgery if the average tumor dimension was less than 35 mm in diameter, if the tumor was sufficiently far from the optic nerves or tracts (usually greater than 4 mm), and if primary or additional microsurgery was rejected (by either physician, patient, or both) for fear of an unacceptable risk.

The presenting neurological deficits of the patients are listed in Table 1. Their median age was 55 (range, 22 to 78). Sixteen patients (47%) had an oculomotor neuropathy, 8 (24%) had a trochlear neuropathy, and 11 (32%) had an abducens neuropathy. Twenty-one patients (62%) had neurological deficits that developed as a complication of a previous surgical procedure. The median Karnofsky performance score was 90 (range, 60 to 100).

The Leksell Model "G" stereotactic coordinate frame (Elekta Instruments, Atlanta, GA) was applied to the patient under local anesthesia before high-resolution contrast-enhanced computed tomography (CT) or magnetic resonance imaging (MRI) tumor localization. The median tumor diameter in this series was 21.5 mm. The median tumor volume was 5170 mm^3 (range, 520 to 20,400 mm^3). Multiple isocenter computer dose planning was performed on a Microvax computer system (Digital Equipment Corp., Westminster, MA). The treatment isodose, central tumor dose, and tumor margin dose were determined jointly by the attending neurosurgeon, radiation oncologist, and medical physicist. The dose was selected after evaluations of the size, location, and the projected radiobiological risk to adjacent critical cranial nerves. The selection of the dose was guided by a dose-volume analysis of our previous experience with gamma knife radiosurgery for meningiomas [17,18,24]. The dose was calculated by determining tumor volume and its relationship to the integrated logistic equation for a 3% risk of permanent symptomatic brain injury [10]. The minimal tumor radiation dose (dose at tumor margin) ranged from 10 to 20 Gy (median, 16 Gy). Thirty-three tumors (97%) were able to be covered completely by the 50% or greater isodose line. The 4-, 8-, 14-, and 18-mm collimators were used either separately or in combination. Multiple irradiation isocenters were required to treat 91% of the cavernous sinus tumors because of their irregular and complex shapes [11]. In selected cases, one or more of the 201 collimator sources were blocked to reduce exposure to the lens. Collimator "plugging" patterns (Fig. 2) often were used to "shift" the radiation dose away from critical areas, such as the brain stem, optic nerves, chiasm, and tract [12]. For 31 patients, we were able to restrict the single fraction dose to the optic tract to less than 9 Gy.

Immediately after radiosurgery, all patients were given a single intravenous dose of methylprednisolone. All patients were discharged within 36 hours. Follow-up imaging was requested at 6-month intervals for the first 2 years, and then yearly.

RESULTS

Immediate perioperative results

The early adverse effects of radiosurgery, which resolved within 24 hours, included transient nausea or vomiting in 15% and headache in 12% of the patients. During the fixation of the stereotactic frame, one patient sustained an asymptomatic dural laceration from a skull pin inadvertently inserted into a craniotomy defect. All patients were discharged the day after radiosurgery and were able to resume their preradiosurgical functional level and employment within 3 to 5 days.

Clinical response

Clinical evaluations after radiosurgery were performed by the treating or referring physician for all the patients. The median clinical follow-up was 26 months (range, 6-49 mo) (Table 2). Twenty-three patients (67%) were unchanged. Eight patients (24%) gradually improved after radiosurgery: three had improved oculomotor nerve function; three had improvement of facial sensation; and two patients had both. Six months after radiosurgery, one 71-year-old patient died from lung carcinoma and glomerulonephritis.

Imaging response

The median imaging follow-up interval for all 34 patients was 24 months (range, 6-54 mo). Table 3 details the changes in tumor volume and imaging characteristics. No patient had evidence of tumor growth after radiosurgery (tumor control rate of 100%). Nineteen tumors (56%) regressed (Fig. 3). Tumor regression became evident an average of 1.2 years after radiosurgery. The loss of central tumor contrast enhancement (presumed tumor necrosis) occurred in eight patients (24%); the development of high T2 signal in the surrounding brain was observed in three patients. Higher radiation doses (within the range used) did not correlate with later tumor regression or loss of contrast enhancement.

Complications of radiosurgery

Suspected delayed transient radiation injury occurred in two patients (6%). One patient had 20/30 vision in her left eye before radiosurgery. At 6 months, her visual acuity decreased to 20/70, and by 12 months, it had returned to 20/30 after a 6-week course of oral methylprednisolone (Fig. 4). A second patient developed ophthalmic division hypesthesia and decreased corneal sensation 3 months after radiosurgery; all trigeminal sensation returned to normal by 12 months.

Two patients who received doses of 12 and 10.5 Gy to the optic chiasm, respectively, developed delayed optic neuropathies. Thirty-one months after radiosurgery, one patient developed a progressive unilateral hemianopsia that has persisted during 11 subsequent months of observation. A third patient developed a permanent worsening of a preexisting ptosis 24 months after radiosurgery. Two patients developed partial/complex seizures at an average of 16 months after radiosurgery; both responded to appropriate anticonvulsant therapy. A third patient received 11.2 Gy to the optic chiasm during radiosurgery of an intrasellar and cavernous sinus meningioma without any adverse sequelae at 26 months follow-up.

DISCUSSION

Current strategies for managing cavernous sinus meningiomas

Clinical decisions regarding therapeutic alternatives for newly diagnosed cavernous sinus meningiomas are difficult, in part because of the variable growth rates reported for these tumors. Most information regarding the natural history of cavernous sinus meningiomas is based on tumor growth after incomplete surgical resection [1,4,7,25-27,31,36]. Miraminoff et al. [27] reported a total excision rate of 57% and a 5-year probability of recurrence of 19% in a subset of patients with parasellar meningiomas. Twenty-four patients with basal meningiomas were evaluated 2 to 18 years after the onset of symptoms by Goodman and associates [13]. "Unequivocal tumor growth" occurred in only 3 of the 24 patients, and no patient required tumor debulking. A period of clinical and radiological observation appears to be a reasonable option for some newly diagnosed cavernous sinus meningiomas. All patients in the present series exhibited growth of their tumors that was confirmed by clinical and/or radiological progression.

The clinical condition of the patient also must be considered when different surgical options are entertained. In a patient with progressive visual loss caused by optic nerve or chiasm compression, microsurgery offers the most immediate chance for a return of visual function. In elderly patients with meningiomas, the potential morbidity of surgery may be unacceptably high [2,6,8]. Radiosurgery under local anesthesia may decrease these risks. Finally, patients for whom balloon occlusion testing or other tests of carotid artery dependency fail may not be appropriate candidates for radical intracavernous surgery; radiosurgery can offer primary or adjuvant treatment to such patients.

The role of fractionated radiation therapy for the treatment of residual meningiomas remains controversial, in part because some series reported the use of low radiation doses [14]. Other reports indicated that fractionated radiation therapy reduced by half the rate of recurrence of incompletely removed tumors [3,5,35]. Conventional fractionated radiation therapy should be considered for those patients with tumors too large for radiosurgery and for those patients who are not suited for treatment consisting of microsurgical removal.

Although improvements in cranial base microsurgical techniques have facilitated the surgical excision of cavernous sinus tumors, the overall complication rates have remained high [29]. In a series of patients with 63 intracavernous tumors, Dolenc and colleagues [9] reported 4 deaths (6%). Transient new postoperative deficits of oculomotor, abducens, trochlear, or trigeminal nerves occurred in 37 patients (58%); 12 patients (19%) had permanent deficits [9]. Four patients required more than one operation. Five patients developed cerebrospinal fluid fistulae, and four developed meningitis. After cavernous sinus microsurgery, 22% of the patients were unable to return to their previous occupation. The tumor recurrence rate was not reported.

In a series of 42 patients with cavernous sinus tumors, Sekhar and associates [32] reported "total excision" in 29 (69%). Although no patient in this review was reported to have a permanent postoperative oculomotor nerve deficit, 33% had persistent trigeminal nerve deficits. Extraocular muscle function was impaired permanently in 12% of patients; 31% suffered other surgical complications, including wound infection and cerebrospinal fluid leakage. In a series of seven patients with cavernous sinus meningiomas resected via the transzygomatic approach, Kawase et al. reported permanent extraocular movement disorders in two and trigeminal neuropathies in six patients [15]. Total excision was achieved in five of seven patients.

Current technique of radiosurgery

Because their margins are well delineated by contrast-enhanced MRI, cavernous sinus meningiomas often prove to be suitable targets for radiosurgery [17]. We continue to evaluate dose-volume relationships in cranial base tumors in order to assess those patients suitable for radiosurgery [17-19,21]. Currently, we believe that tumors measuring less than 35 mm in average diameter and maintaining a distance of 4 mm from the optic nerves or chiasm will permit single fraction dose selection that will be associated with long-term tumor control. We use multiple isocenter dosimetry with varying collimator sizes (often requiring 4- and 8-mm beam diameter collimators) to conform the radiation dose to the tumor margins. This technique has decreased the rate of facial and trigeminal neuropathies after radiosurgery of acoustic neuromas [21].

Dose selection and tolerance for cranial nerves or major vessels

Despite the intimate relationships of vital cranial nerve structures to cavernous sinus tumors, only 3 of 34 patients developed new cranial nerve deficits. In contrast to our experience with acoustic tumors [21], trigeminal nerve deficits after cavernous sinus radiosurgery were rare. The purely motor cranial nerves supplying the extraocular muscles appear to be relatively resistant to the radiation doses given in this experience [18].

The optic nerves, chiasm, and tract seem less tolerant than motor nerves near the cavernous sinus. We endeavored to keep the maximum radiation dose to these structures to less than 9 Gy. This was achieved in 31 patients. Three early patients received doses in excess of 9 Gy (12, 10.5, and 11.2 Gy, respectively) to the optic nerves or chiasm, and two developed visual worsening. Predictions from the integrated logistic formula seem inadequate for dose selection when the optic nerves or chiasm are close to the tumor margin. An estimate of the length of the cranial nerve irradiated may be one predictor for the subsequent development of radiation injury [22]. We are currently studying the dose-response relationships of optic chiasm radiosurgery in a rat model [20].

The advantages of dose planning with MRI compared with CT were highlighted by our review of patients who developed optic neuropathies. Both patients who had optic nerve radiation injuries had stereotactic dose-planning based on CT scan images. The inferiority of coronal reformatted CT images compared with high-resolution nonreformatted coronal MR images most likely led to suboptimal identification of the normal structures surrounding the tumor and subsequent suboptimal isodose shaping. This led to the delivery of doses to the chiasm (10-12 Gy), which we now believe to be excessive, of some patients with larger volume tumors. We now use high-resolution sagittal, axial, and coronal MR images exclusively for dose planning. This, combined with the ability to shape isodose curves, using multiple isocenters and complex blocking patterns of the 201-cobalt sources of the gamma unit, would likely further reduce the risk of cranial nerve injuries.

Stereotactic radiosurgery of the ventrolateral pons in the normal primate model [19] and radiosurgery of the basilar and middle cerebral arteries in rabbits [16] have demonstrated the tolerance of normal large vessels to both low- and high-radiation doses (20-150 Gy). Despite the presence of well-circumscribed necrosis at the target site within brain parenchyma, no effects within any component of the vessel wall were identified (studied from 2-24 mo in the rabbit and 2-12 mo in the baboon). Patients in this series tolerated doses of up to 40 Gy to their intracavernous carotid artery without clinical sequelae or change in the flow-void signal from that artery on follow-up imaging.

Rationale for radiosurgery as an alternative or adjunct to microsurgery

Recently, 15-year follow-up data from the Swedish experience with gamma knife radiosurgery for acoustic neuromas have been reported [28]. More recent follow-up data are available for their experience with meningiomas [34]. Our 100% tumor control rate for cavernous sinus meningiomas now extends to 54 months (median, 26 mo) but still requires further long-term analysis. Many of the tumors in this series decreased in size within 18 months of radiosurgery. Improvement in their clinical condition was observed in eight patients (24%) and occurred even in the absence of tumor regression.

To assess the complication rate from previous microsurgery in our series of 28 patients undergoing postresection radiosurgery, we retrospectively reviewed their pre- and postmicrosurgery neurological status. Twenty-one patients (63%) had new permanent neurological deficits after microsurgery. The relative radiation tolerance of motor cranial nerves and the carotid artery further substantiates the role of gamma knife radiosurgery as a safe and effective option for tumors in the cavernous sinus region. Our 6% incidence of delayed cranial nerve complications and the absence of surgical morbidity and mortality rates after gamma knife radiosurgery compare favorably to those results reported from microsurgical centers of excellence; an argument can be made for gamma knife radiosurgery as a primary management modality for tumors in elderly patients and for those patients with minimal cranial nerve deficits. Radiosurgery was associated with three additional short- and long-term benefits: 1) reduced length of hospital stay (< 36 h); 2) reduced patient costs [23]; and 3) the patients returned to their preradiosurgery functional status within 5 days. These factors warrant additional analysis of the long-term value of radiosurgery as an alternative to microsurgery.

Stereotactic radiosurgery may prove especially valuable as an adjunct to microsurgical subtotal removal. Morbidity from intracavernous surgery may be markedly decreased by planning in advance for a less aggressive intracavernous surgical resection, followed by delayed radiosurgery to the intracavernous tumor residua.

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COMMENTS

It is generally accepted that total resection of meningiomas is highly curative, with long-term disease-free survival rates exceeding 90%. The article by Duma et al. provides early data applicable to patients who require alternative treatments, such as patients in whom total resection without unacceptable morbidity is impossible, those in whom only a subtotal resection or biopsy is achieved, and those who refuse surgery. The authors have demonstrated favorable results after radiosurgery in 34 patients with histological or radiological evidence of meningioma. With a median follow-up slightly greater than 2 years in their study, the authors observed rates of 100% progression-free survival, 56% tumor regression, 24% presumed tumor necrosis, 24% clinical improvement, and 12% clinical complications (6% temporary).

Given what is currently known regarding radiation effects on meningiomas and normal glial cells (the main dose-limiting normal tissue cells surrounding most intracranial tumors), these results are hardly surprising. Both meningiomas and normal human glial cells are late-responding tissues, and irradiation of small volumes containing only late-responding tissues is expected to be relatively insensitive to the number of fractions delivered. In fact, at our institution, where magnetic resonance imaging or computed tomography have been used in the radiotherapy treatment planning process since 1981, the actuarial rate of progression-free survival after fractionated external beam radiotherapy for unselected patients with meningioma is 98% at 5 years (compared with 77% at 5 years if the patients were treated before the advent of magnetic resonance imaging or computed tomography for planning) [1,2]. For small meningiomas, such as optic nerve sheath meningiomas, complete resolution of cranial nerve deficits after external beam therapy is not unusual and often occurs before tumor size reduction is appreciated on magnetic resonance imaging. Thus, radiotherapy and radiosurgery for small meningiomas are similar in several respects: both can be expected to provide excellent progression-free survival; both can provide excellent clinical responses; and both incorporate modern imaging-based planning and patient immobilization to accurately deposit the dose at the target. They differ mainly in procedural details.

We agree with the authors that additional long-term analysis is required to further define the role of radiosurgery. Because modern imaging studies used for targeting may underestimate the true volume requiring treatment, and because radiosurgery treatment margins are typically tighter than radiotherapy margins, it is theoretically possible that several more years of follow-up will reveal occasional late recurrences at the periphery of radiosurgery volumes. Aside from this, perhaps the outstanding issue to be resolved has to do with establishing the lowest radiosurgery dose necessary to prevent progression to further reduce the risks of complications. If regression of the tumor is considered desirable, then the dose levels chosen seem appropriate, at least for the 56% of patients in whom tumor regression was observed. For most patients with intracranial tumors, however, freedom from progression is a sufficient goal and might allow selection of a lower radiosurgery dose. Necrosis, possibly seen within 24% of meningiomas treated with radiosurgery, may not be necessary to prevent progression and is not typically observed after external beam radiotherapy.

We currently use beam radiotherapy for patients with meningiomas that are not totally resected, whether large or small, and for all sites, including the cavernous sinus. The data of Duma et al. show that radiosurgery may be a good alternative for carefully selected patients, reinforcing our belief that few patients with meningiomas should fail to be cured.

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Duma and colleagues have studied 34 patients with cavernous sinus meningiomas who were treated with radiosurgery. With a median follow-up of 26 months, no patient had tumor growth and tumor regression was observed in 56%. Two patients developed delayed optic neuropathies, but no other serious complications were observed.

As the authors discuss, computerized dose planning with isodose shaping to fit the tumor margin as well as clear visualization of the surrounding vital structures (i.e., optic chiasm) are vital to the success of this treatment method. With the gamma knife, the most frequently employed dose shaping strategies are multiple isocenter planning and beam plugging. A possible drawback to the multiple isocenter approach is dose inhomogeneity--multiple "hot spots" within the target. Beam plugging reduces the dose rate and, consequently, increases the treatment time.

With linear accelerator radiosurgery systems, the most commonly employed dose-shaping strategy is arc weighting; that is, by dropping certain arcs, the shape of the isodose curves can be substantially altered. An alternative strategy, currently in development, is conformal radiosurgery, which involves dynamically changing the shape of the beam collimator to match the beam's eye view of the lesion. These strategies do not result in dose homogeneity and do not significantly reduce dose rate.

Both gamma knife and linear accelerator systems are increasingly using magnetic resonance imaging for dose planning, even though various magnetic resonance imaging artifacts may result in spatial inaccuracies. The authors have made yet another excellent presentation of a possible application of radiosurgery. As they discuss, much longer follow-up in many more patients will be needed to firmly establish the role of radiosurgery in the treatment of meningiomas.

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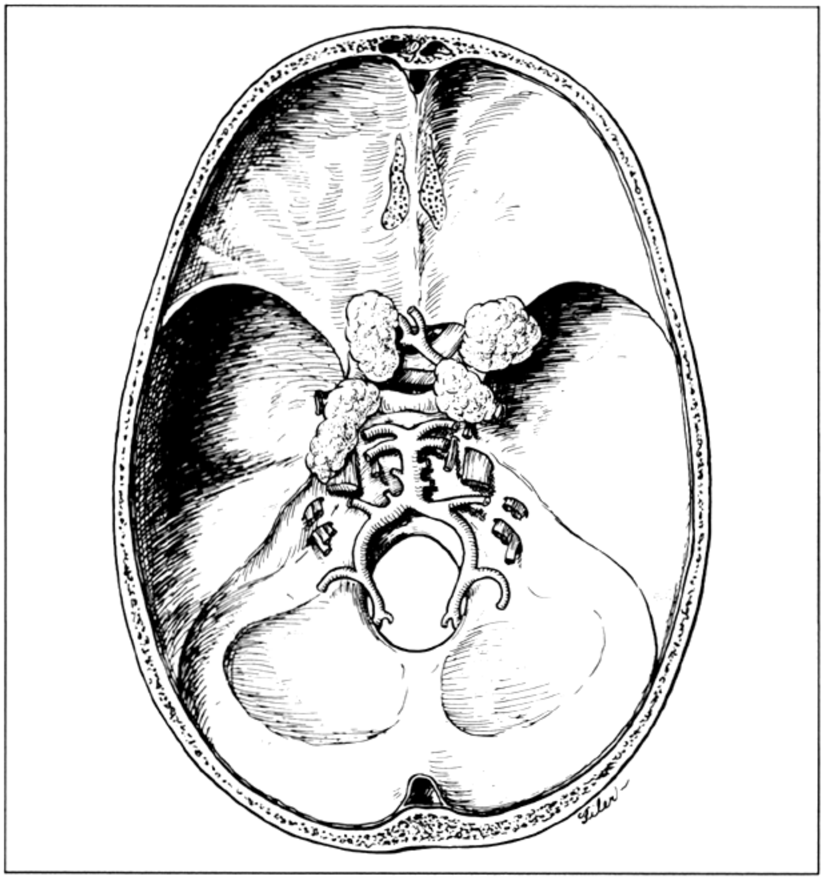

Figure 1. Drawing of the locations of meningiomas that encompassed or invaded the cavernous sinus.

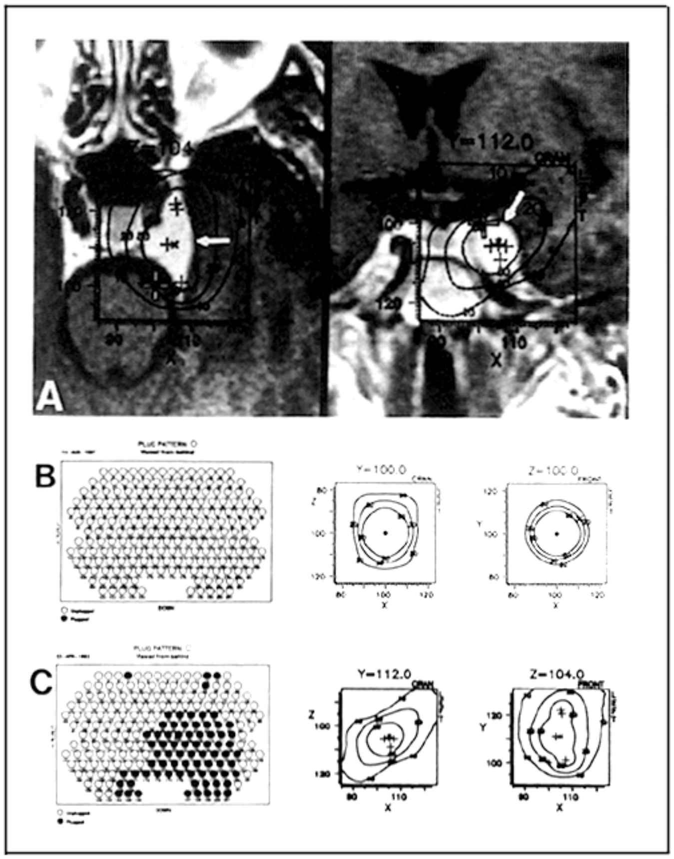

Figure 2. *A*, complex isodose planning using the 4-, 8-, and 14-mm collimators with the 50% isodose line (*arrow*) to conform precisely to the margins of a left intracavernous meningioma. *B*, appearance of coronal and axial isodose plots with no plugging of the 201 cobalt sources. *C*, effect of the complex source plugging pattern for the patient in *A*. Note how the plug pattern compresses the lower isodoses on the medial side of the tumor, thus reducing the radiation dose delivered to the optic chiasm.

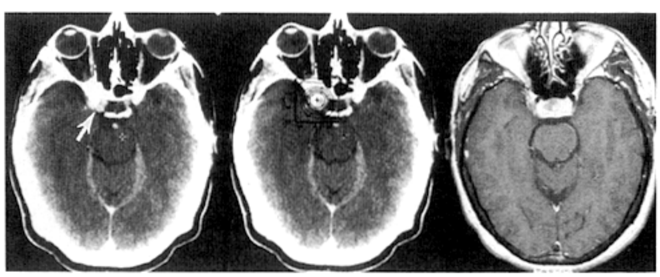

Figure 3. *Left*, contrast-enhanced CT scan before radiosurgery shows a right anterior cavernous sinus meningioma (*arrow*) in a 42-year-old woman. The patient had a craniotomy and resection 4 years previously. *Middle*, the single isocenter radiosurgical dose plan (15 Gy to the 70% isodose tumor margin). *Right*, reduction in tumor size is maintained 54 months after radiosurgery. Note the preservation of flow-void signal within the adjacent internal carotid artery

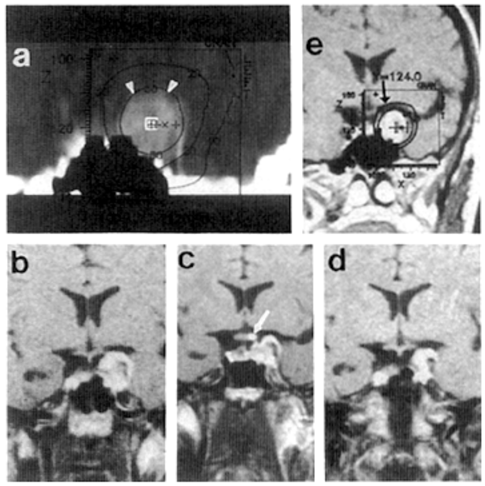

Figure 4. *a,* Reformatted coronal CT images and superimposed isodose plots for a recurrent left parasellar meningioma (50% isodose line, *arrowheads*). *b-d*, 3-, 6-, and 12-month follow-up MRI scans. At 6 months, the patient's visual acuity deteriorated from 20/30 to 20/70, and contrast enhancement was identified in the left side of the optic chiasm (*c*, *arrow*). Within 5 months, her acuity returned to 20/30 and subsequent MRI failed to detect contrast enhancement. Recalculation of the dose plan using MRI instead of CT revealed that the 30% isodose line (12 Gy) (*arrow*) intersected the optic chiasm (*e*)

Cranial Neuropathy	Number (%)
Reduced visual acuity	6 (18)
Oculomotor palsy	16 (47)
Trochlear palsy	8 (24)
Trigeminal sensory loss	15 (44)
Abducens weakness	11 (32)
Facial weakness	6 (18)
Deafness	4 (12)
Hemiparesis	3 (9)
Aphasia	2 (6)

[a] 62% of detected deficits were reported as a consequence of open surgical exploration of the tumor; 82% of patients had undergone previous surgery.

Table 1. Neurological Deficits before Radiosurgery for Cavernous Sinus Meningiomas (n = 34)[a]

	Total Follow-up in Months[a]				
	1–11	12–23	24–35	36–54	Total (%)
Unchanged	3	5	12	3	23 (67%)
Improved	1	3	2	2	8 (24%)
New deficit	0	1	1	0	2 (6%)
Died[b]	1	0	0	0	1 (3%)
Total	5	9	15	5	34 (100%)

[a] **Median, 26 mo, range, 4–54 mo.**
[b] **Unrelated causes.**

Table 2. Clinical Status after Cavernous Sinus Meningioma Radiosurgery

Tumor Volume	No.	%
Increased	0	0
Unchanged	15	44
Decreased	19	56
Reduced contrast enhancement	8	24
Peritumoral edema	3	9

[a] **Median follow-up, 24 mo (range 6–54 mo).**

Table 3. Tumor Imaging Changes after Radiosurgery for Cavernous Sinus Meningiomas[a]