Meningiomas that involve large segments of the superior sagittal sinus (SSS) remain a technical management challenge due to their intimate relationship with surrounding brain and blood vessels. While resection can be curative, it may not be feasible with acceptable risk. Left untreated, tumor progression can lead to debilitating headaches, neurological deficits, and even stupor, coma, and death due to venous congestion and increased intracranial pressure.

Over the past 2 decades, meningioma radiosurgery has proven to be safe and effective for selected tumors in critical locations. The use of radiosurgery is typically limited by tumor volume. We report the use of stereotactic radiosurgery to manage a long-segment recurrent SSS meningioma far larger than often considered for this approach.

Case Report

History and Examination. This 49-year-old right-handed woman came to neurosurgical attention in 2003 when she developed mild aphasia and progressive headaches. She was found to have a 6-cm-diameter left frontal dural-based mass. Subsequent resection showed a WHO Grade I meningioma without atypical features. Her immediate postoperative course was uncomplicated, and her symptoms gradually resolved.

Two years later she developed a recurrence along the lateral aspect of the anterior SSS that was managed using Gamma Knife surgery (GKS) (Elekta AB). Three years afterward she had a second focus of recurrence along the falx, which was treated with radiosurgery. Eighteen months later she had further progression into the anterior third of the SSS (posterior to the first target volume) accompanied by mild morning headaches. Due to this larger volume extension, the patient was referred for intensity modulated radiation therapy (IMRT), and she received 54 Gy in 30 fractions over 42 days.

The patient returned to the clinic 6 months after IMRT with continued mild morning headaches. She denied any nausea, vomiting, sensory disturbances, or change in her vision or strength. Findings from her neurological examination were unremarkable.

Abbreviations used in this paper: GKS = Gamma Knife surgery; IMRT = intensity modulated radiation therapy; SSS = superior sagittal sinus.
Contrast-enhanced brain MRI (Fig. 1 upper) showed a mass within the SSS originating from the site of IMRT and extending posteriorly all the way into the confluence of sinuses. The length of this tumor extension beyond the IMRT volume was 16 cm. The T2-/FLAIR-weighted images showed no signs of cerebral edema attributable to venous congestion.

Radiosurgery. Stereotactic radiosurgery was performed using a Leksell stereotactic frame (Elekta AB), MRI-guided dose planning, and the Perfexion model Gamma Knife unit. The long-segment radiosurgical planning was facilitated by placing the tumor into 3 separate adjacent dose matrices that allowed accurate dose planning over the entire length of the tumor. A tumor margin dose of 12 Gy and a maximum dose of 24 Gy was delivered to the posterior two-thirds of the SSS including the extent just inferior to the confluence of sinuses (Fig. 2).

Postoperative Course. The patient’s immediate postoperative course was uncomplicated, and her headaches gradually improved over the course of the next 6 months. Magnetic resonance imaging showed tumor volume regression beginning at 6 months. Magnetic resonance venography at 3 years showed that the SSS was patent. Five years after radiosurgery the patient is symptom free and has not had any further progression of her disease within the SSS (Fig. 1 lower).

Discussion

Meningiomas of the SSS constitute 21%–31% of meningiomas. These tumors pose a significant technical challenge because of their intimate relationship with critical vascular structures. In cases in which resection is possible, the surgery can be curative but morbidity and mortality are significant. Left untreated, meningiomas invasive of the SSS can lead to sinus occlusion followed by venous outflow obstruction and increased intracranial pressure presenting with vision loss, debilitating headaches, and, in extreme cases, lethargy, coma, and death.

The anterior one-third of the SSS, particularly anterior to the vein of Trolard, can usually be sacrificed without significant morbidity or mortality. A multitude of surgical techniques have evolved to approach tumors of the posterior two-thirds of the sinus. In a series advocating aggressive resection and reconstruction of the SSS, high rates of morbidity and mortality have been reported. In a series of 108 surgically managed intrinsic meningiomas of the SSS, 28.7% overall morbidity was observed, including 9 patients with significant cerebral edema. Two
deaths were noted to be attributable to a postoperative hematoma formation and a pulmonary embolism, and 15 patients experienced a recurrence. Other authors have noted a morbidity of 10.6% and mortality 6.4% in smaller series of aggressive resection.

In a large multicenter trial we previously demonstrated that resection followed by stereotactic radiosurgery for parasagittal meningiomas was an effective treatment for tumors larger than 3 cm³ while radiosurgery alone could be effective for smaller masses. Recently other authors have reported a complication rate of 7% and a recurrence rate of 19.6% in a series of patients in which subtotal resection was followed by stereotactic radiosurgery for meningiomas invasive to the SSS. One limitation of stereotactic radiosurgery for meningiomas is the risk of developing cerebral edema for tumors in parasagittal meningiomas.

The excision and radiosurgical treatment of the dural tail has been a significant point of controversy. In 2004 DiBiase et al. reported that patients whose dural tail was included in the treatment had a 96% 5-year disease-free survival in contrast to 77.9% in patients who did not. While this has been the point of some criticism, it has been our practice to tailor the radiosurgery volume only to imaging-defined tumor that can be clearly documented. Thin, regional enhancement that may be part of a “dural tail” is typically observed. Some of the recurrences after radiosurgery can occur from this tissue, as can be seen after resection.

To date, parasagittal meningioma radiosurgery has focused on focal tumors along short SSS segments. The role for radiosurgery along long SSS segments is not known. Indeed, for the patient in this case who had undergone resection, anterior SSS and falx radiosurgery, and anterior-middle third SSS radiotherapy, no known solution was available to manage tumor that had progressed for the entire SSS length. While we considered further IMRT, this would have exposed the patient’s brain to larger volumes of radiation, and the first course of IMRT had proved ineffective in stopping tumor progression. Despite the fact that the longest linear tumor extent was 16 cm, the axial dimensions were less than 15 mm. In addition, the superficial location meant that much of the radiation falloff would be located in the adjacent skull. Thus, we believed that the concept of long-segment SSS radiosurgery would be safe. This case demonstrates the unique technical role of radiosurgery in managing a difficult neurosurgical challenge with long-term efficacy and safety. We believe that radiosurgery will have an increasing role to play in unique clinical scenarios caused by meningiomas.