Evidence of meningioma infiltration into cranial nerves: clinical implications for cavernous sinus meningiomas

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Anatomical and biological studies of cavernous sinus meningiomas help us understand the biological heterogeneity of these tumors. The question of whether cavernous sinus meningiomas infiltrate cranial nerves is clinically important because of the effect on treatment planning. In the authors’ experience of treating 36 patients with cavernous sinus meningiomas, tumor invasion into a cranial nerve was documented in two patients in whom a cranial nerve was resected during the cavernous sinus dissection. In both patients, histological examination using hematoxylin and eosin and bodian stains showed infiltration of the cranial nerves by a benign meningioma which, to the best of the authors’ knowledge, is a condition previously unreported. This histological finding of meningioma invasion into a cranial nerve demonstrates the biological heterogeneity of cavernous sinus meningiomas and raises concern about the invasive character of meningioma. Because not all tumor cells can be identified radiologically or by direct visualization at surgery, occult tumor infiltration predisposes a patient to recurrence despite the best neurosurgical efforts. Evidence of cranial nerve infiltration by meningioma suggests that, in some circumstances, cavernous sinus dissection in the hope of total removal of a meningioma may be futile and, in the long term, may provide no advantage over treatment options with lower morbidity.

KEY WORDS • meningioma • tumor recurrence • tumor invasion • cavernous sinus • skull base

Clinical Material and Methods

Patient Population

Between 1989 and 1993, 36 patients at the University of Cincinnati hospitals underwent skull base surgery for resection of holocavernous meningiomas. Patients (25 women and 11 men) ranged in age from 24 to 75 years (mean 52 years). Twenty-eight patients had their initial evaluation and surgery at our institution. Eight were referred from other institutions to undergo a second operation when recurrent tumor developed after the initial surgery. No patient with recurrent tumor underwent radiation treatment prior to the second operation.

Surgical Findings

Indications for an intracavernous operation included at least one of the following: progressive cranial neuropathy, documented tumor growth, or the prospect of achieving total tumor resection by excising the intracavernous component of the tumor. Early postoperative gadolinium-
enhanced magnetic resonance (MR) images showed that eight patients had no evidence of residual tumor and 28 patients had residual tumor. In two patients, a cranial nerve was resected during the cavernous sinus dissection. In Case 1, the patient’s holocavernous meningioma involved Meckel’s cave as well as the cavernous sinus and it completely encased the third division of the trigeminal nerve; this nerve was resected with the tumor in attempting complete resection. In Case 2, the trochlear nerve could not be identified during the dissection of the lateral wall of the cavernous sinus. Histological examination of the patient’s partially resected tumor specimen showed meningioma invasion into the trochlear nerve.

Histological Grading of Tumors

For both patients in whom a cranial nerve was resected during cavernous sinus surgery, the neuropathological records were reviewed and the meningioma classified as benign, atypical, or malignant. The criteria used for histological grading were described and recently revised by the World Health Organization (WHO). These criteria include hypercellularity, loss of cellular architecture, nuclear pleomorphism, mitotic index, tumor necrosis, and brain invasion.

Cranial Nerve Histology

Cranial nerves resected during surgery were further examined for evidence of tumor encasement or infiltration. Cranial nerves were placed in paraffin blocks, which were cut into 10-μm thick sections. Specimens were examined histologically using hematoxylin and eosin as well as bodian staining to identify the cranial nerve and tumor.

Results

Of the 36 patients with cavernous sinus meningiomas treated by surgical resection, two also had resection of a cranial nerve in which histological evidence of tumor infiltration into the nerve was confirmed. Tumor infiltration was shown by staining the paraffin sections with hematoxylin and eosin and bodian stains.

Illustrative Cases

Case 1. This 62-year-old woman who had complete left-eye blindness initially underwent resection of a benign meningioma of the left sphenoid wing. Two years later, MR imaging revealed a 2-cm meningioma of the right cavernous sinus abutting the ICA and filling Meckel’s cave; this distant lesion recurred contralateral to the initial surgical site in a previously inviolate region of the brain. Because growth of this tumor would threaten motility in her only functioning eye, surgery was performed for tumor resection. At surgery, the meningioma was found to extend along the third division of the trigeminal nerve and into the anterior temporal fossa. The tumor appeared to infiltrate the third division of the trigeminal nerve, which was resected along with the tumor. Postoperatively, the patient had anesthesia in the right dermatome of the third division of the trigeminal nerve.

Hematoxylin and eosin–stained sections of the tumor showed characteristics of a syncytial meningioma: low cellularity, normal cytoarchitecture, normal appearing nuclei, lack of mitosis, and no evidence of brain invasion. By criteria of the WHO classification system, this tumor was graded a benign meningioma. Tissue sections of the third division of the trigeminal nerve showed that the tumor had invaded the nerve (Fig. 1).

Case 2. This 32-year-old man suffered a grand mal seizure and subsequently developed complete ophthalmoplegia and total blindness in his right eye. When MR imaging showed a large, right holocavernous meningioma, surgical resection of this tumor was planned. The patient tolerated preoperative balloon test occlusion of the right ICA. At surgery, the tumor appeared to encase the trochlear nerve, which could not be clearly identified. This nerve was resected with the tumor during dissection of the lateral wall of the cavernous sinus. After partial removal, some tumor still adhered to the right cavernous sinus.

Fig. 1. Case 1. Photomicrographs showing tissue sections cut through the meningioma containing the third division of the trigeminal nerve. Left: Section showing that the meningioma (arrowheads) has invaded into and disrupted the nerve axons (arrow). H & E, original magnification × 500. Right: Section clearly showing the meningioma within the axons of the nerve (arrows). Bodian, original magnification × 500.
ICA. Postoperatively, the patient had no new neurological deficit.

Hematoxylin and eosin–stained paraffin sections of the tumor showed characteristics of a benign syncytial meningioma. The lack of mitotic figures in normal appearing nuclei, the presence of normal cytarchitecture, and lack of brain invasion are characteristic of a benign meningioma. Tissue sections containing the trochlear nerve showed tumor infiltration (Fig. 2).

Discussion

In this study, we report two cases of meningioma infiltration into the cranial nerves. This condition raises concern about the resectability of cavernous sinus meningiomas.

Histological Grading of Meningiomas

Several histological varieties are included in the WHO classification of meningioma that divide most into the benign variants: meningothelial, fibroblastic, and transitional meningioma. Histologically atypical and malignant meningiomas are relatively rare. Meningioma infiltration into cranial nerves is not included in the WHO grading system for meningioma, perhaps only because this finding had never been demonstrated previously.

Treatment Controversy

Controversy continues about whether cavernous sinus meningiomas should be removed surgically, treated by radiation therapy, or treated by a combination of surgery and radiation therapy. The recent finding of infiltration of the ICA by cavernous sinus meningioma heightens this controversy. Continued refinements in skull base microsurgical techniques have enabled some neurosurgeons to achieve a surgically and radiologically complete resection for meningiomas of the cavernous sinus. Early results indicate that cavernous sinus meningiomas can be removed by skull base surgical techniques safely and with low morbidity. However, it is too soon to comment on the incidence of recurrence in these cases. Recurrence of cavernous sinus meningiomas is due, generally, to inadequate surgical resection.

Clinical Implications

In this study, we have documented meningioma infiltration into the cranial nerves in and around the cavernous sinus, fueling the controversy regarding treatment of these lesions. In both of our illustrative cases, microscopic examination confirmed that the cranial nerve had been infiltrated by the tumor. Similar cranial nerve infiltration probably occurs in cases of cavernous sinus meningioma in which infiltration is suspected but the cranial nerve specimen is not obtained for histological examination.

Is total resection ever feasible for cavernous sinus meningiomas? Tremendous surgical advances have been made in the area of skull base surgery, especially around the cavernous sinus. It is interesting to note that both of the present cases involved large holocavernous meningiomas. One might postulate that aggressive, early surgical resection of small cavernous sinus meningiomas could prevent such infiltration by preventing them from becoming holocavernous. However, we share Ojemann’s recent concern to cause no harm in skull base surgery. Therefore, this evidence of meningioma infiltration into cranial nerves should be considered when planning treatment for skull base meningiomas.

Conclusions

Treatment of cavernous sinus meningiomas has been a subject of controversy. Our previously unreported finding of meningioma infiltration into cranial nerves adds to this controversy because it suggests that complete resection may be impossible without resecting the involved cranial nerves. In these circumstances, cavernous sinus dissection in an attempt at complete resection of the tumor, in the long term, may provide no advantage over treatment options with lower morbidity.
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