Surgical Strategy for Meningioma Extension into the Optic Canal

Hiroshi SHIMANO, Shiro NAGASAWA*, Shinji KAWABATA, Ryusuke OGAWA, and Tomio OHTA

Department of Neurosurgery, Osaka Medical College, Takatsuki, Osaka; *Department of Neurosurgery, Soseikai General Hospital, Kyoto

Abstract

Neuroimaging of the extension of meningioma into the optic canal was evaluated for planning the surgical strategy. Intracanalicular extension and localization were retrospectively analyzed in 13 patients with frontal base meningioma near the optic canal, based on the findings of visual field defects, magnetic resonance (MR) imaging, and surgical observations. MR imaging confirmed intracanalicular localization in one of three patients with tumors extending into the optic canals, and indicated the tumor in the others. The visual field defect did not precisely correspond to the tumor localization. Unroofing of the optic canal was performed in four patients and no adverse effects were observed. The interhemispheric approach was employed for tumors localized medially in the canal, and the pterional approach for tumors localized laterally. MR imaging is useful to evaluate the intracanalicular extension, but aggressive confirmation during surgery is essential. Tailored unroofing of the optic canal and removal of the intracanalicular tumor can be performed with few adverse effects and results in good tumor control.

Key words: meningioma, optic canal, optic nerve, surgery

Introduction

Frontal base meningiomas develop from the olfactory groove, planum sphenoidale, tuberculum sellae, and sphenoid ridge.2,6,12,14 The enlarging tumors displace and envelop important structures such as the optic nerve, internal carotid artery, and anterior communicating artery, and subsequently extend into the optic canal and orbital cavity.10,12,14

Gamma-knife treatment is effective to control residual and recurrent intracranial meningiomas. Residual tumor which is difficult to resect from critical structures can be treated with the gamma-knife.31 Tumor nodules and neoplastic dural remnants around the optic pathway should be resected as completely as possible due to the high risk of radiation-related optic neuropathy.4,5,10 However, preoperative evaluation of the intracanalicular extension and localization is sometimes difficult.1,2,6,8

The present study reviewed a recent series of frontal base meningiomas. Tumor extension into the optic canal and localization relative to the optic nerve were retrospectively analyzed based on neuro-ophthalmological findings, preoperative magnetic resonance (MR) imaging, and surgical observations.

Materials and Methods

Thirteen patients, five males and eight females aged between 33 and 70 years, underwent surgery for frontal base meningiomas near the optic canal between 1996 and 1998. The tumor was attached to the sphenoid wing in seven patients (1 lateral type, 3 middle third type, and 3 medial type), the tuberculum sellae in four, and the planum sphenoidale in two. Following neuro-ophthalmological and MR imaging examinations, macroscopic total removal was performed in all patients. A microsurgical mirror or endoscope was used to identify any extension of the tumor into the optic canal. Tumor extension was removed by tailored unroofing of the canal and resection until normal dura. Opening of the air sinus in the anterior clinoid process was completely sealed using muscle pieces and fibrin glue.
Results

MR imaging showed that the maximal diameter of tumors ranged from 2.0 to 10.0 cm. Extension of meningoima into the optic canal appeared as a contrast-enhanced mass on T₁-weighted imaging (Fig. 1) and/or a defect of the cerebrospinal fluid space on T₂-weighted imaging (Fig. 2). Tumor was identified in three optic canals in three patients (Table 1). No extension into the canal was confirmed in six patients. However, MR imaging provided little information on tumor extension in four patients because of individual variation of skull base structures and the deformed surrounding tissues. The tumor was localized laterally within the canal in one patient (Case 11). MR imaging could not localize the tumor in the canal in the other two patients (Cases 10 and 12), but was suspected to be on the medial side because of the extracanalicular location of the optic nerve (Table 2).

Visual impairment varied among the patients, but a visual field defect was observed in four patients (Table 1). One of the three patients with a tumor in the canal (Case 10) had temporal hemianopia associated with tuberculum sellae meningoima extending on the medial side of the canal (Table 2). However, the intracanalicular localization of the tumor was not suggested by the visual field defect in the other two patients. Case 11 complained of periodic blurred vision, but no sign of visual impairment was detected.

The frontal interhemispheric approach was performed in seven patients and the pterional approach in six. Unroofing of the optic canal was carried out in four patients (Table 2). Intracanalicular tumors were identified before surgery in three patients and tumor extension was suspected during surgery in one patient (Case 5). The interhemispheric approach was employed in two patients with tumors localized medially in the canal (Cases 10 and 12). The tumor nodule was dissected from the laterally shift-

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**Table 1 Summary of patients**

<table>
<thead>
<tr>
<th>MR imaging of tumor extension in the optic canal</th>
<th>No. of patients</th>
<th>Tumor in optic canal at surgery</th>
<th>Visual field defect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tumor in optic canal</td>
<td>3 (Cases 10–12)</td>
<td>3</td>
<td>2 (Cases 10, 12)</td>
</tr>
<tr>
<td>No tumor in optic canal</td>
<td>6</td>
<td>1 * (Case 5)</td>
<td>1 (Case 10)</td>
</tr>
<tr>
<td>Not determined</td>
<td>4</td>
<td>0</td>
<td>1 (Case 10)</td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

*Histological examination disclosed no tumor component. MR: magnetic resonance.

**Fig. 1** Case 10. T₁-weighted magnetic resonance images with contrast medium of the tuberculum sellae meningoima showing extension into the right optic canal (arrow) in the axial (upper) or sagittal (middle) slices, and marked lateral shift of the extracanalicular optic nerve on the right side (arrowhead) on the coronal slice (lower), suggesting the tumor was localized medial to the nerve in the canal.
ed optic nerve and then removed under direct vision (Fig. 3). The pterional approach followed by removal of the anterior clinoid process and unroofing of the optic canal was used in the other two patients. MR imaging visualized the tumor extension on the lateral side of the canal in Case 11 of the tuberculum sellae meningioma, and the tumor was successfully removed between the internal carotid artery and the optic nerve (Fig. 4). Intraoperative observation of Case 5 with medial sphenoid ridge meningioma showed the dura at the falciform fold was thickened, suggesting en plaque spread of the tumor into the canal. Partial unroofing and resection were carried out, but histological examination disclosed no tumor components.

The visual field defect disappeared in three patients but was unchanged in one after surgery. No recurrence was observed during the follow-up period of 12–40 months.

### Table 2 Patients undergoing optic canal unroofing

<table>
<thead>
<tr>
<th>Case No.</th>
<th>MR imaging findings</th>
<th>Mode of visual field defect</th>
<th>Surgery</th>
<th>Histological diagnosis of tumor in optic canal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Attachment; Diameter (cm)</td>
<td>Extension into optic canal</td>
<td>Location in optic canal</td>
<td>Tumor location in optic canal</td>
</tr>
<tr>
<td>10</td>
<td>tuberculum sellae; 3.0</td>
<td>+</td>
<td>medial*</td>
<td>temporal hemianopia</td>
</tr>
<tr>
<td>11</td>
<td>tuberculum sellae; 2.0</td>
<td>+</td>
<td>lateral</td>
<td>none</td>
</tr>
<tr>
<td>12</td>
<td>planum sphenoidale; 5.0</td>
<td>+</td>
<td>medial*</td>
<td>central scotoma</td>
</tr>
<tr>
<td>5</td>
<td>sphenoidal ridge; 2.0</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
</tbody>
</table>

*Tumor extension in the optic canal was suspected from the extracanalicular location of the optic nerve. MR: magnetic resonance.

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Discussion

Meningiomas of the frontal base compress the optic nerve to varying degrees depending on the size and attachment location. In general, planum sphenoidale meningiomas displace the optic nerve inferiorly and sphenoid ridge meningiomas medially. Tuberculum sellae meningiomas arise from the regions of the tuberculum sellae, chiasmatic sulcus, limbus sphenoidal, and diaphragma sellae, and are usually 2–4 cm in diameter at clinical presentation.\textsuperscript{1,2,5,9–12,13} Most tumors displace the optic nerve superolaterally with potential extension on the medial side of the optic canal, but some tumors with extremely lateral attachments displace the nerve superomedially.

Recurrence of meningioma at this location is fairly high\textsuperscript{6} and gamma-knife irradiation must be limited to residual meningioma that is close to the optic nerve or chiasm.\textsuperscript{9} Accordingly, microsurgical procedures are required to thoroughly resect the residual tumor from the optic pathway and from the canal for optimum tumor control if the patient’s age and medical condition permit.\textsuperscript{1,5,13} Two surgical routes have been proposed for meningiomas of the frontal base near the optic nerves, the lateral route through the pterional\textsuperscript{2,14} or subfrontal approach,\textsuperscript{6} and the medial route through the interhemispheric approach.\textsuperscript{1,6} The optic nerve and the carotid artery may hinder the access to an intracanalicular tumor nodule depending on the location relative to the approach route. Accordingly, we recommend the frontal interhemispheric approach for medially located tumors likely to extend into the canal on the medial side and the pterional approach for laterally located tumors likely to extend on the lateral side.

The visual field defect did not necessarily correspond to the optic nerve compression by the intracanalicular tumor. The discrepancy may result from compression in the extracanalicular region, the tumor being too small to develop signs, or causes other than mechanical compression. MR imaging is useful to establish the surgical strategy for meningiomas,\textsuperscript{11} but could not always visualize intracanalicular extension or location of the tumor. Accordingly, the presence or absence of tumor nodules or neoplastic dural remnants must be confirmed during surgery using a microsurgical mirror or endoscope. Tumor nodule is characterized by a round mass of more than a few millimeters, whereas neoplastic remnant appears as apparent dural thickening near the entrance to the canal. Exploratory and tailored unroofing of the optic canal is required if tumor extension cannot be excluded.

Surgical management of the tumor within the

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canal will contribute to optimum control of frontal base meningioma in combination with gamma-knife treatment for possible residual tumor in other regions.

References


Address reprint requests to: S. Nagasawa, M.D., Department of Neurosurgery, Osaka Medical College, 2–7 Daigaku-cho, Takatsuki, Osaka 569–8686, Japan.

Commentary

The authors should be commended for dealing in very close detail with the treatment of frontobasal meningiomas. To remove 99% of a meningioma of the region and leave 1% of the tumor in the optic canal (OC), represents only a temporary relief for the surgeon and the patient (for one to three years), but under no condition can it be a permanent solution to the patient’s problem. The rest of the tumor in the OC does continue growing, and hence does exert pressure against the optic nerve (ON) in the OC, and subsequently causes further loss of function of the compressed ON. The problem is even worse since the circumferentially (completely or partially) incased ON may not tolerate radiosurgery, and this is why gamma knifeing of the rest of the tumor in the OC is at least questionable, if not contraindicated when the ON is already damaged by the tumor. Complete surgical removal of the tumor in the OC is the best solution, providing that the invaded dura is also resected, and that the vascularization of the ON is preserved. The authors attempt, with good arguments, to convince the reader of the importance of the removal of the tumor from the OC. However, they do not mention that the compression of the ON by the tumor, located at the entrance of the OC, — as well as in the OC, and of course, outside the OC, — does displace the ON from the inferomedial (tuberculum sellae and diaphragma sellae meningioma) and from the lateral or inferolateral (ACP meningioma) against the sharp and ridged falciiform ligament, which represents the most serious conflict of the normal anatomical structure against the ON. The size of the meningioma itself is important; however, the meningioma on plaque, which might be still small, may also cause serious compression of the ON in the OC.

The weakest points of this report are the description of the approaches to the region, as well as the excision of the meningioma from the OC. It is very difficult to agree with the interhemispheric approach to the OC of either side. Among the most important factors for disagreement are: venous drainage from the frontal lobe, preservation of the olfactory nerve and, in particular, the bulb of the olfactory nerve and the olfactory fila; retraction of the already tumor-damaged frontal lobe and bleeding from the tumor during debulking, since the feeders to the tumor lie at the skull base. In contrast to the fronto-temporal (pterional) approach, the venous drainage from the...
Frontal lobe can be preserved intact, the olfactory nerve is not additionally stretched, the frontal lobe is not retracted, the tumor can be devascularized before it is debulked, and hence very little or no bleeding occurs during resection of the tumor. The most important, and surely the best way, is to remove the ACP and to open the OC from the extradural side. However, to perform this, one should be aware of the possible pneumatization of the walls of the OC, as well as the pneumatization of the ACP. If this is the case, then the opening of the optic canal and the resection of the ACP should really be appropriately tailored in order not to enter the bony sinuses. Preoperative visualization of the extension of the meningioma of the region into the OC by MRI is vitally important, so too is the visualization of extension of the air cells into the aforesaid bony structures of the walls of the OC and the ACP. One should be aware that a CSF leak, following the opening of the air cells, can be a difficult problem to solve. The authors should be commended for their fine presentation of extending the meningioma into the OC by MRI (Figs. 1 and 2); however, Figs. 3 and 4 are closer to imaginary drawings than realistic intraoperative photographs. And last but not at least, it should also be mentioned, that in the available literature the opening of the OC, as well as the resection of the ACP, has been dealt with in close detail and that the information from that literature would also be very welcome in this report.

Vinko V. Dolenc, M.D.
Department of Neurosurgery
University Hospital Center
Ljubljana, Slovenia

This review by Shimano et al. of 13 patients with meningiomas in the region of the sphenoid wing and tuberculum sella highlights an important problem. These tumors in the vicinity of the optic nerve have a propensity to enter and travel along the optic canal. This feature may not be recognizable in the preoperative imaging and may be clinically silent at the visual examination. For reasons that they have pointed out, namely the fact that radiosurgery cannot be safely given to this area, it is imperative for the surgeon to recognize the possibility of tumor extension and remove tumor from the canal by unroofing from medially or laterally as needed. Unroofing the optic canal is also an important technique when the tumor is distorting the nerve and angulating it sharply at the dural edge of the optic canal. In these instances, unroofing the nerve and opening the dural canal allows safer manipulation of the nerve which is no longer tethered at the falcialform ligament in order to achieve a good tumor resection. During manipulation of the optic nerve in the canal, the surgeon should be aware of the tenuous blood supply of the nerve that can produce an ischemic injury. Entry into the ethmoid or sphenoid sinuses must be recognized and effectively obliterated to prevent a cerebrospinal fluid leak.

Chandranath Sen, M.D.
Department of Neurosurgery
The Mount Sinai Medical Center
New York, N.Y., U.S.A.

This paper presents MRI findings and surgical strategy for frontal base meningioma extending into the optic canal. Although meningioma extension into the optic canal may, not infrequently, affect the prognosis, either total resection or postoperative γ knife irradiation can be unfavorable, if considering the possible injury to the optic nerve proper or small vessels. I myself make it a rule to leave adhered portion of tumors around the optic nerve without unroofing of the optic canal. The recurrence from the peripheral residual tumor is far less frequent than expected. Furthermore, inappropriate drilling and/or separating the pseudocapsule from the optic nerve rather provokes unfavorable postoperative complication. However, in case “tailored unroofing” of the optic canal is indispensable, surgeons should be reminded of the following 4 points as Prof. Fukushima recommends.

1) It is often helpful to retract the dura along the anterior rim of the tuberculum sellae at the diaphragmatic groove, and to precisely locate the medial edge of the optic canal and the falcialform ligma-ment (porus opticus).

2) Drilling of the medial portion of the optic canal should be minimum to avoid exposure of the sphenoid sinus, because the bone overlying the sinus is extremely thin.

3) Diamond burr (preferably 3–4 mm size, coarse type) drilling of the optic canal should be done with vigorous irrigation to cool down the burr and the bone.

4) The bony wall should not be completely drilled out, instead the thin shell cortex at the last drilling phase may be elevated using an appropriate microsurgical dissector. Complete drilling throughout the bone sometimes injures the optic nerve or sheath by direct compression or thermal effect.

Tetsunori Yamashima, M.D.
Department of Neurosurgery
Kanazawa University School of Medicine
Kanazawa, Japan

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