Despite recent technological advances in the neurosurgical field, direct surgical approaches to the anterosuperior portion of the cerebellum and avoidance of unexpected complications in the relatively small space of the posterior fossa remain challenges for neurosurgeons. Suboccipital approaches offer the advantage of wide exposure, but have the disadvantage of the risk of injury to the normal cerebellar tissue around the tumor bed, thus interfering with good recovery following surgery. Recently, the occipital transtentorial approach has become a standard choice in our department for the treatment of pineal region tumors. Over a 5-year period during which we used the same approach with a longer tentorial incision, we treated 14 patients with anterosuperior cerebellar tumors by direct surgery. The advantages of this surgical procedure, the accuracy of surgical-assisted systems, and the operative results in this group of patients are presented and discussed.

Abbreviations used in this paper: CPA = cerebellopontine angle; CT = computerized tomography; MR = magnetic resonance.

Clinical Material and Methods

Patient Population

Given the advancements in MR imaging, endoscopy (light malleable micro-endoscope; Clarus Medical, Minneapolis, MN), and navigation-assisted microsurgery (View Scope or Viewing Wand navigating system; Elekta Instruments, Atlanta, GA), since May 1995 we have treated 14 patients who presented with anterosuperior cerebellar tumors in the posterior fossa (Table 1). These patients ranged in age from 6 months to 71 years. Their lesions included four hemangioblastomas, three cerebellar astrocytomas, three medulloblastomas, two metastatic tumors, one recurrent astrocytoma, and one rhabdoid cell tumor. All patients underwent surgical treatment by the same surgical team and via the same surgical approach. Endoscopy combined with neuronavigation was used for large, deep-seated tumors extending to the fourth ventricle. Of the 14 patients, total or gross-total removal was achieved in 12 patients and subtotal removal in two patients. There was no incidence of mortality or morbidity in the 14 patients, and all functional outcomes were good to excellent postoperatively. Postoperative magnetic resonance imaging revealed that none of the patients had suffered brain damage or infarction around the cerebellum, brainstem, or occipital lobe.

Conclusions. Although this study was the first in which a specific examination of the efficacy of the occipital transtentorial approach in patients with anterosuperior cerebellar tumors was undertaken, our findings suggest that this surgical approach is very useful, safe, and accurate for removing the primary tumor and evaluating the surrounding anatomy, as well as for determining operative strategy.

Key Words • anterosuperior cerebellar tumor • medulloblastoma • hemangioblastoma • astrocytoma • occipital transtentorial approach
angle of the tentorium, which was determined on the basis of sagittal MR images (Fig. 1 left). In this position, the surgeon can move the microscope comfortably in all directions and the tumor bed is usually observed just beneath the microscope. We did not use the three-quarter prone approach to treat posterior fossa tumors, because the surgical approach to the anterosuperior portion of the cerebellum courses caudally and not mediodorsally as in the approach to pineal region tumors.

**Craniotomy and Dural Incision.** The choice of craniotomy was based on the side, location, and shape of the venous sinuses and feeding arteries of the tumor, and provided good orientation for the surgeon and sufficient space for placement of surgically assisted systems. A U-shaped skin incision (Fig. 1 right) was created over the confluence and the unilateral transverse sinus. The incision extended 5 cm from the confluence and its width extended 2 cm contralateral and 5 cm ipsilateral to the superior sagittal sinus. Generally, four burr holes were placed adjacent to the venous sinuses, and a relatively small osteoplastic bone flap was created to expose the edge of the confluence, the lower part of the superior sagittal sinus, and the upper half of the transverse sinus to the operative field. The medial and inferior boundaries of the operative field were located under the transverse and sagittal sinuses, respectively. A curved dural incision was made along the confluence and measured approximately 4 cm. Attention should be paid not to overextend the lateral boundary while creating the dural incision because the inferior cerebral veins are present beneath the lower portion of the lateral occipital lobe and drain into the tentorial sinus or transverse sinus.

**Occipital Retraction and Tentorial Incision**

Retraction of the occipital pole rostrally was the most important step in preventing further complications during the approach to the tentorial edge. If the retraction force tends to extend from the lateral to medial direction, there may be a high risk of injury to the bridging veins in some cases. Using a relatively small craniotomy, we usually observed no bridging veins around the occipital pole, but in some patients the internal occipital vein was present near the deep-medial portion of the occipital pole. Therefore, care must be taken not to injure these bridging veins. After the occipital pole was retracted further, the boundary of the tentorial notch was visualized. Tearing the arachnoid membrane to drain residual cerebrospinal fluid resulted in a wide surgical space. If the microoperative field was still insufficient to allow a tentorial incision, a ventricular catheter was placed into the occipital horn of the lateral ventricle, allowing the occipital pole to be retracted superiorly by a single brain retractor. Following careful observation of the edge of the tentorium, an incision parallel to, and 1 cm from, the straight sinus was made. This tentorial incision was made by creating a small hole apart from the border of the transverse sinus by using a linear incision parallel to the straight sinus was made using a microscrew (Fig. 2 upper left). The incised tentorium was then tented separately to allow the surface of the anterosuperior

## Table 1

**Characteristics of 14 patients with anterosuperior cerebellar tumors who underwent surgery via the occipital transtentorial approach**

<table>
<thead>
<tr>
<th>Case No</th>
<th>Age (yrs)</th>
<th>Sex</th>
<th>Diagnosis</th>
<th>Tumor Location</th>
<th>Tumor Removal</th>
<th>Postop Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.5</td>
<td>F</td>
<td>medulloblastoma</td>
<td>vermis</td>
<td>gross total</td>
<td>excellent</td>
</tr>
<tr>
<td>2</td>
<td>0.5</td>
<td>F</td>
<td>rhabdoid cell tumor</td>
<td>vermis, pineal, midbrain</td>
<td>gross total</td>
<td>died 5 mos postop</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>F</td>
<td>astrocytoma</td>
<td>anterosuperior cerebellum</td>
<td>subtotal</td>
<td>excellent</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>M</td>
<td>medulloblastoma</td>
<td>vermis</td>
<td>gross total</td>
<td>minimal truncal ataxia</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>M</td>
<td>medulloblastoma</td>
<td>vermis</td>
<td>vermis</td>
<td>excellent</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>F</td>
<td>astrocytoma</td>
<td>vermis-hemisphere</td>
<td>gross total</td>
<td>excellent</td>
</tr>
<tr>
<td>7</td>
<td>10</td>
<td>M</td>
<td>astrocytoma recurrence</td>
<td>anterosuperior cerebellum</td>
<td>subtotal</td>
<td>excellent</td>
</tr>
<tr>
<td>8</td>
<td>14</td>
<td>M</td>
<td>astrocytoma</td>
<td>anterosuperior cerebellum</td>
<td>gross total</td>
<td>excellent</td>
</tr>
<tr>
<td>9</td>
<td>19</td>
<td>M</td>
<td>hemangioblastoma</td>
<td>superior cerebellum</td>
<td>subtotal</td>
<td>exceptional</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
<td>M</td>
<td>hemangioblastoma</td>
<td>anterosuperior cerebellum</td>
<td>subtotal</td>
<td>excellent</td>
</tr>
<tr>
<td>11</td>
<td>60</td>
<td>M</td>
<td>metastatic tumor</td>
<td>anterosuperior cerebellum</td>
<td>subtotal</td>
<td>excellent</td>
</tr>
<tr>
<td>12</td>
<td>68</td>
<td>M</td>
<td>hemangioblastoma</td>
<td>anterosuperior cerebellum</td>
<td>total</td>
<td>excellent</td>
</tr>
<tr>
<td>13</td>
<td>70</td>
<td>F</td>
<td>metastatic tumor</td>
<td>anterosuperior cerebellum</td>
<td>total</td>
<td>excellent</td>
</tr>
<tr>
<td>14</td>
<td>71</td>
<td>M</td>
<td>hemangioblastoma</td>
<td>anterosuperior cerebellum</td>
<td>total</td>
<td>excellent</td>
</tr>
</tbody>
</table>
cerebellum to come into microsurgical view (Fig. 2 lower left).

Tumor Removal. When the aforementioned portion of the examination had been concluded, tumor removal was then performed (Fig. 2 upper right). If the tumor was located in the distant anterior cerebellum, sharp incision of the quadrigeminal arachnoid membrane was essential. This procedure improved our field of vision for observation of the basal vein, the vein of Galen, and the pre-central cerebellar vein. Histological samples were readily obtained directly from the superficial portion of the tumor. After verifying the pathological characteristics of the tumor, inner decompression was performed using both bipolar coagulation and suction to achieve accurate assessment of ranges of resectability. The ultrasonic aspirator was not always used, because it may interfere with surgical procedures within a relatively narrow operative field, resulting in overretraction of the occipital lobe. For large and deep-seated tumors, avoidance of injury to the superior medullary velum, tectum, and posterior medial choroidal artery was necessary. In addition, an endoscope was used to access the remnant of the tumor, its relatively microanatomical structures, and the fourth ventricle (Fig. 2 lower right). Postoperatively, ventricular drainage was continued during the first 48 hours regardless of whether a shunting operation was performed afterward.

Illustrative Cases

Case 2
This 6-month-old girl was admitted to another hospital because she exhibited a disturbance of consciousness preceded by 2 weeks of decreased activity and vomiting. She was referred to our hospital after ventricular drainage had been instituted for hydrocephalus and a tumor had been observed in the pineal region. She was noted to have conjugate upward gaze palsy and papilledema. Magnetic resonance images revealed a large tumor in the posterior fossa and pineal region, which displayed homogeneous enhancement (Fig. 3 upper). At surgery, the tumor was gross-totally removed (Fig. 3 lower) and diagnosed as a rhabdoid cell tumor. Following surgery, the patient received chemotherapy, consisting of intravenous administration of cisplatin and etoposide. One month after chemotherapy was concluded, results of follow-up radiological examination showed that the tumor had grown rapidly, and the patient died 5 months after her first hospitalization. Although the prognosis in this case was poor due to...
the malignant character of the rhabdoid cell tumor, using the occipital transtentorial approach allowed us to remove the tumor totally.

Case 3

This 1-year-old girl exhibited a shuffling gait and loss of appetite for 2 months. On MR images obtained in July 1998, we observed a large ring-enhancing anterosuperior cerebellar cystic mass that lay beneath the tentorium and extended to the midbrain (Fig. 4 left), which was diagnosed as a pilocytic astrocytoma after being partially resected via a left occipital transtentorial approach (Fig. 4 center). The bottom of the tumor bed remained and 2 weeks later total resection of the residual tumor was performed (Fig. 4 right) via a medial suboccipital approach. After the second operation, the patient’s general condition and vital signs normalized and her growth and development were assessed to be within normal limits. Follow-up review was carefully performed at our hospital.

Case 4

This 1-year-old boy experienced intermittent nausea with vomiting for 3 months. Magnetic resonance images obtained in March 1997 revealed one large enhancing mass that involved the entire superior portion of the posterior fossa beneath the tentorium (Fig. 5 upper). A diagnosis of medulloblastoma was based on an examination of surgical frozen-section samples, and gross-total tumor removal was performed via the left occipital transtentorial approach (Fig. 5 lower). Postoperatively, the patient was treated with cisplatin and etoposide chemotherapy (six cy-
cles). Regularly scheduled chemotherapy was continued until the child reached 3 years of age, at which time radiotherapy was performed. He is still in good health with minimal truncal ataxia and his case is regularly followed in our outpatient department.

Case 6

This 7-year-old girl exhibited progressive truncal ataxia with difficulty walking in May 1995. Magnetic resonance images obtained in July of that year revealed a 4-cm-wide enhancing mass in the superior portion of the cerebellum beneath the tentorium (Fig. 6 upper), which was diagnosed as a pilocytic astrocytoma after the tumor was totally removed via an occipital transtentorial approach (Fig. 6 lower). No residual enhancing tumor was observed on postoperative MR images. Currently, this patient is free from clinical symptoms and signs without tumor recurrence.

Case 9

This 19-year-old man presented with intermittent severe global headaches and difficulty walking in April 1990. Magnetic resonance studies performed 2 months later revealed communicating hydrocephalus with a 6-cm-wide diffuse, enhancing mass involving the right antero-superior cerebellum. A right ventriculoperitoneal shunt was placed; no malignant cells were seen in the ventricular fluid and all cultures were negative for pathogens. In July 1990, at one of our principal related hospitals, subtotal removal of the tumor in the left CPA and dorsal medulla was performed via a left suboccipital approach. The histological diagnosis was hemangioblastoma. Four years later, a solid mass was newly observed in the right CPA. Although gamma knife surgery was performed, the mass gradually enlarged. In October 1996, subtotal removal of...
the newly developed tumor was undertaken through a right suboccipital approach after embolization of the tumor’s main feeding arteries. The patient’s daily activity level decreased to that of one confined to a wheelchair. In May 1998, he was transferred to our department for further treatment for a tumor recurrence. Magnetic resonance images revealed a 6-cm-wide diffuse, enhancing mass involving the right CPA and the right anterosuperior cerebellum (Fig. 7 upper and center). On angiograms we observed that the vessels feeding the tumor were the right superior cerebellar, right anterior inferior cerebellar, and right marginal tentorial arteries (Fig. 7 upper right). We planned to treat the recurrent tumor by performing embolization first, but the patient unfortunately became coma-

Fig. 7. Case 9. Gadolinium-enhanced T1-weighted MR images (upper left and center) and right vertebral artery angiogram (upper right) obtained in a 19-year-old man, revealing a hemangioblastoma located in the CPA and the vessels feeding it. Postoperative MR images (lower) demonstrate no sign of tumor.

Fig. 8. Case 13. Upper: Gadolinium-enhanced MR images obtained in a 70-year-old woman, revealing a metastatic tumor. Lower: Contrast-enhanced CT scan obtained postoperatively, demonstrating no sign of tumor.
tose prior to embolization. Total tumor removal was performed in June 1998 by using an occipital transtentorial approach (Fig. 7 lower). Although a transient diplopia related to surgical intervention near the tectum was observed, recovery was obtained within 2 weeks.

No tumor recurrence was observed on the most recent MR image obtained in July 2000. The patient’s daily activity level has increased to that of one confined to a wheelchair and he displays left-hand tremor and truncal ataxia.

Case 13

This 70-year-old woman presented with difficulty walking and headaches 3 years after she had undergone surgery for lung cancer. On MR images, a large, enhancing, left-sided posterior fossa mass was demonstrated in March 1999 (Fig. 8 upper). The tumor was completely resected via a left occipital transtentorial approach (Fig. 8 lower) and a diagnosis of metastatic brain tumor was made. The patient responded to surgical treatment and irradiation, and is presently in good health without neurological deficits.

Case 14

This 71-year-old man had undergone gross-total removal of an anterosuperior cerebellar hemangioblastoma in one of our affiliated hospitals when he was 65 years of age. When he presented at our service, he exhibited lethargy, scanning speech, and ataxia, which had lasted longer than 2 months. Computerized tomography scans, digital subtraction angiograms, and MR images obtained in January 2000 revealed a large, enhancing, centrally seated anterosuperior cerebellar mass indicative of recurrence of the posterior fossa tumor (Fig. 9 upper row and lower left). A hemangioblastoma with the same histological characteristics as the one previously diagnosed was completely removed via the occipital transtentorial approach (Fig. 9 lower center and right). No evidence of recurrence was found 6 months following the operation, with no detection of new neurological deficits or abnormal CT or MR imaging findings.

Results

Patient Population

Since April 1995, we have used endoscopy combined with a neuronavigation system in 14 patients with anterosuperior cerebellar tumors. Using the occipital transtentorial approach and assisted by supplemental systems, microsurgeries were performed through relatively small bone windows. Twelve patients underwent total or gross-total removal of tumors, including four hemangioblastomas, two cerebellar astrocytomas, three medulloblastomas, two metastatic tumors, and one rhabdoid cell tumor. Partial removal was performed for one astrocytoma and a recurrent astrocytoma, due to deep tumor extension throughout the entire vermis and midbrain.

Clinical Course

There was no incidence of mortality or morbidity in this
group of patients. No sacrifice of bridging veins occurred during any operation. Postoperative MR images revealed that none of the patients had suffered brain damage or infarction around the fourth ventricle, cerebellum, brainstem, or occipital lobe. None of the patients experienced episodic seizures or hemianopsia postoperatively. Although transient diplopia related to surgical intervention near the tectum was observed in Case 9, recovery was obtained within 2 weeks. During the follow-up period, no patients exhibited aggravation of their cerebellar symptoms and signs.

Discussion
Cerebellar tumors extending into the anterosuperior portion of the posterior fossa are uncommon, and the role of surgery in their treatment of such tumors remains controversial. Even in those reports that focus on larger series of patients, evaluation of surgical procedures, and operative results have been limited. In the treatment of these tumors thorough resection is strongly correlated with a decrease in the rate of morbidity. Therefore, determination of a safe surgical approach is necessary for adequate planning for surgery and identification of those anatomical structures at risk during complete tumor removal. To date, however, evaluations of the effectiveness of the occipital transtentorial approach in the treatment of anterosuperior cerebellar tumors have been absent from the literature, most likely as a consequence of the relatively low frequency of these lesions. In the present study, 14 patients with this type of disease underwent surgery performed via the occipital transtentorial approach with the aid of assisted systems. In these 14 patients, total or gross-total removal was achieved in 12, with excellent postoperative results. Although this study is the first in which the efficacy of the occipital transtentorial approach and its results in patients with anterosuperior cerebellar tumors have been specifically examined, our findings indicate that the occipital transtentorial approach can provide a sufficient operative field with minimal retraction of the occipital lobes and the peritumoral venous system in the treatment of anterosuperior cerebellar tumors.

In the past, the various surgical approaches to the anterosuperior cerebellum in the posterior fossa, the suboccipital approach was the method of choice. The suboccipital approach may offer the advantage of wide exposure, but it has the disadvantage of encountering the tumor beneath the deep venous system, which interferes with additional surgical removal or injures the deep feeding arteries of the tumor. Destruction of the vermis or compression of the cerebral peduncle and dentate nucleus during surgical procedures may cause postoperative cerebellar mutism. Splitting of the vermis itself may cause postoperative cerebellar ataxia. Moreover, strong flexion of the head and neck is required during surgery in which the suboccipital approach is used and may increase jugular venous pressure, resulting in unpredictable brain edema or hydrocephalus, particularly in pediatric patients. For pediatric patients whose conditions are complicated by hydrocephalus, penetration of the fixation pin into brain tissue during operative three-pin head fixation may occur when the suboccipital approach is used. Another now popular approach is the three-quarter prone approach with the operative side down, which allows one to take advantage of gravity and avoid the use of a retractor on the medial side of the occipital lobe. This position features minimal retraction of the parietal and occipital lobes and allows easy assessment of the third ventricle, pineal region, and midbrain. Nonetheless, we did not use the three-quarter prone approach to treat posterior fossa tumors, because, unlike that used for pineal region tumors, the surgical approach to the anterosuperior portion of the cerebellum was through the caudal route and not from the mediodorsal direction. This is also the reason we used the occipital transtentorial approach with retraction of the occipital pole rostral to the anterosuperior portion of the cerebellum.

On the other hand, the occipital transtentorial approach provides a good view of the floor of the quadrigeminal region without strong flexion of the patient’s neck and head. In this position, the surgeon can move the microscope comfortably in all directions and the tumor bed is usually observed just beneath the microscope. The lateral semiprone position also was not used in the present study, even for large deep-seated tumors. As for treatment of pineal region tumors, which has been described in recent reports, the occipital transtentorial approach can extend the wide operative view to the thalamus and to the anterosuperior portion of the cerebellum. This is the reason we selected the occipital transtentorial approach instead of using the suboccipital approach for treating the patients in Cases 3, 6, and 14 (Figs. 4, 6, and 9). Note that one should avoid overextending the lateral boundary during craniotomy because of the presence of the inferior cerebellar veins. It has been reported that inferior cerebral veins are present beneath the lower portion of the lateral occipital lobe and drain into the tentorial sinus or transverse sinus. Preservation of these inferior cerebral veins is necessary to avoid postoperative brain swelling, particularly in pediatric patients in whom a higher blood flow is present than that found in healthy adults.

It is occasionally difficult to resect large anterosuperior cerebellar tumors that extend into the fourth ventricle completely by using the occipital transtentorial approach. For this reason, we used endoscopy combined with neuronavigation in patients who harbored tumors extending into the fourth ventricle. We found that endoscopy combined with neuronavigation permitted identification of the primary tumor and provided images whose resolution was sufficiently high to afford a more accurate assessment of surrounding tissue and vascular anatomy around the upper half of the fourth ventricle. Endoscopy can also be used to improve intraoperative observation of a tumor beneath the ipsilateral straight sinus, which may interfere with the surgical field when complete removal is performed.

Conclusions
We use our best surgical judgment to treat anterosuperior cerebellar tumors through an occipital transtentorial approach with preservation of the superficial bridging veins and the deep veins around the pineal–tentorial region. No sacrifice of bridging veins or injury to the deep veins occurred in any operation performed, and the procedures implemented in this study did not lead to any case
Occipital transtentorial approach for posterior fossa tumors

of morbidity or mortality. Total or gross-total removal of tumor was achieved in 12 of the 14 patients and functional outcomes were good. In summary, the results of this study demonstrate that the occipital transtentorial approach is an accurate, safe, and minimally invasive means of treating anterosuperior cerebellar tumors.

References


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