Objective: To investigate the postoperative auditory and facial nerve function results after cerebellopontine angle meningioma removal.

Design: Retrospective chart review.

Setting: Tertiary care referral center.

Patients: Twenty-one patients undergoing surgical removal of cerebellopontine angle meningiomas by the senior author (R.J.W.).

Interventions: Translabyrinthine or retrosigmoid approach for tumor extirpation.

Main Outcome Measures: Postoperative auditory (pure-tone average and speech discrimination score) and facial (House-Brackmann scale) function within 1 year of follow-up.

Results: Twenty-three operations were performed on 21 patients. Hearing preservation through the retrosigmoid approach was attempted in 11 patients (48%). Normal hearing (class A) was preserved in 9 of 10 patients. Normal postoperative facial nerve function (House-Brackmann grade I) was conserved in 11 (65%) of 17 patients.

Conclusions: This review demonstrates that successful hearing preservation is possible with meningiomas. Therefore, the retrosigmoid approach should be used whenever serviceable hearing is present preoperatively. Normal facial nerve function can also be preserved in the majority of patients.


Approximately 10% of all intracranial tumors originate in the cerebellopontine angle (CPA), with vestibular schwannomas comprising the majority of tumors in this location. Meningiomas are the second most common neoplasm in the CPA, representing 10% to 15% of tumors. They are histologically considered to be benign tumors arising from the arachnoid villi of the venous sinuses. The usual sites of attachment of the posterior fossa meningiomas are the posterior surface of the petrous bone, tentorium, clivus, cerebellar convexity, and foramen magnum, in decreasing order of frequency. According to Nager and Masica, meningiomas originate in 4 specific locations in the posterior petrous pyramid: the internal auditory meatus, jugular foramen, region of the geniculate ganglion, and sulcus of the greater and lesser superficial petrosal nerves. This may account for the variability of location of meningiomas and for their relationship to critical structures.

Clinical manifestations of meningiomas are usually otologic or neurologic, secondary to involvement of contiguous structures of the posterior fossa. Presenting symptoms commonly include hearing loss, imbalance, tinnitus, facial numbness, and headaches. Less frequently, patients may complain of trigeminal neuralgia, diplopia, nausea, facial paresis, otalgia, or loss of taste. Indeed, the clinical symptoms of meningiomas can be very similar to those of vestibular schwannomas, thus making the preoperative differentiation between the 2 neoplasms difficult.

Surgical removal is the accepted treatment for CPA meningiomas. Hearing conservative and ablative approaches have been effectively used for tumor extirpation. Hearing ablative surgery is performed in patients without serviceable hearing, usually through the translabyrinthine approach. The retrosigmoid and middle fossa techniques allow for hearing preservation whenever serviceable hearing is present. Meningiomas of the CPA present a challenge to the neurotologist for several reasons: (1) they are uncommon CPA tumors; (2) they are difficult to distinguish from vestibular schwannomas, clinically; (3) the morbidi-
**PATIENTS AND METHODS**

Twenty-one patients underwent surgical removal of histologically confirmed CPA meningiomas by the neurotologic and neurosurgical teams at Hinsdale and Evanston Hospitals (Illinois) between October 1982 and October 1998. A retrospective analysis was performed on these patient records. The presenting clinical symptoms were determined for all of these patients. Tumor size and site of origin were determined from the preoperative magnetic resonance (MR) or computed tomography scans and operative reports. Tumors were classified as premeatal (arising anterior to the internal auditory canal) or retromeatal (arising from the temporal bone posterior to the internal auditory canal). The surgical approach used for removal of these tumors depended on preoperative hearing level, age, and the general health of the patient. The translabyrinthine approach was used in patients with poor preoperative hearing, regardless of tumor size. This generally translated into pure-tone average (PTA) greater than 50 dB and speech discrimination score (SDS) less than 50%. The retrosigmoid or suboccipital approach was used in patients with class A or B hearing, even in patients with large tumors (≥3.5 cm).

Preoperative and postoperative auditory and facial nerve function was assessed within 1 year of follow-up. For patients undergoing hearing preservation surgery, the mean PTA and SDS were calculated. Based on the PTA and SDS, preoperative and postoperative hearing was classified based on the system used by the Committee on Hearing and Equilibrium guidelines. The preoperative and postoperative facial nerve function was graded based on the House-Brackmann scale.

**RESULTS**

**PATIENT CHARACTERISTICS**

Twenty-one patients underwent 23 procedures for surgical removal of CPA meningiomas; 11 patients (52%) were female and 10 (48%) were male. The age range of the patient population was 37 to 74 years with an average age of 55.7 years. The clinical symptoms most commonly consisted of hearing loss, imbalance, tinnitus, facial numbness, and headaches. Less frequently, patients presented with vertigo, aural fullness, facial paresis, diplopia, or otalgia (Table 1). The mean symptom duration at presentation was 24.8 months with a range of 1 month to 10 years.

**TUMOR CHARACTERISTICS**

Fourteen (67%) of the 21 tumors were located on the right side and 7 (33%) tumors on the left side. The meningioma size was determined as the largest tumor dimension in centimeters on MR or computed tomographic scan. The average size of the tumors was 2.4 cm with the range from 0.8 to 5 cm. Figure 1 demonstrates the typical MR appearance of CPA meningioma. The tumor location was purely extracanalicular in 10 (48%), purely intracanalicular in 2 (9%), and both extracanalicular and intracanalicular in 9 (43%) of the patients (Table 2).

The tumor location was classified as premeatal in 11 (52%) and retromeatal in 10 (48%) patients. The site of origin was as follows: petrous ridge in 13 (62%), petroclival region in 4 (20%), tentorium in 2 (9%), and internal auditory canal in 2 (9%) patients.

Twenty patients with meningiomas were newly diagnosed patients. The last patient had recurrent meningioma previously resected at another institution 22 years ago. Hearing conservation was attempted in 11 patients by the retrosigmoid approach in patients with class A or B hearing preoperatively. Nine of the meningiomas were removed by the translabyrinthine approach and 1 by the retrosigmoid approach in patients with nonserviceable hearing. Residual disease was treated by surgery in 2 patients with nonserviceable hearing; thus, 23 total procedures were performed on 21 patients.

Patients were monitored for residual and recurrent disease by interval MR imaging with gadolinium enhancement. Imaging was performed at 1, 2, and 5 years postoperatively. The patients were considered free of disease when no tumor was identified at the 5-year follow-up MR study. Any evidence of new disease 5 years after surgery was classified as recurrent disease and any evidence of disease within 5 years postoperatively, especially in patients of subtotal resection, was classified as residual disease. Based on these criteria, 1 case of recurrence occurred 10 years after hearing preservation surgery by the retrosigmoid approach. The patient was subsequently treated with stereotactic radiosurgery with stabilization of tumor growth.

Nineteen of the 21 patients underwent complete resection of the meningioma at the first procedure. Two patients underwent subtotal resection of the meningioma and were classified as having residual disease. In the first patient, subtotal resection was performed secondary to intraoperative hemorrhage. Residual disease was evident 2 years postoperatively; this was successfully removed by the translabyrinthine approach. The second patient underwent subtotal resection of a 2.2-cm meningioma; the tumor was noted to be aggressive histologically with cytologic atypia and mitotic figures. This patient subsequently underwent retrosigmoid removal of a residual tumor 2 years later. Residual disease was documented 2 years later that required radiation therapy associated with unchecked tumor growth; and (4) the formidable task of complete tumor resection with minimal functional impairment.

There is relative paucity in the literature of reports critically assessing the postoperative auditory and facial nerve function after CPA meningioma surgery. Recent studies have suggested that hearing levels can be successfully preserved with CPA meningiomas, even in the presence of large tumors. Facial nerve function can also be conserved in a significant number of patients. In this study, we review the auditory and facial nerve function of 21 patients undergoing CPA meningioma surgery.
therapy; this disease has been stable for 3 years after radiation treatment.

AUDITORY RESULTS

Clinically, 10 of the 11 patients retained good or serviceable hearing after surgery; 10 patients had class A hearing preoperatively. Postoperatively, 9 of the 10 patients had preservation of class A hearing. One patient retained class B hearing after the surgery. One patient with class C hearing preoperatively was noted to have class D hearing postoperatively (Figure 2). The average preoperative PTA for these 11 patients was 16 dB with a SDS of 86%. Subsequent to surgery, the average PTA was 20 dB and the SDS was 87%.

The tumor size ranged from 1.8 cm to 3.5 cm in the 9 patients who retained class A hearing after surgery. Another patient with a 2.5-cm tumor, initially with class A hearing, developed class B hearing after the surgery. The last patient in the hearing preservation group had class C hearing with a 0.8-cm petrous ridge meningioma, preoperatively. This patient had class D hearing after the surgery. Tumor size did not affect the ability to successfully preserve hearing in this group of patients.

Eight of the meningiomas in the hearing preservation group were classified as purely extracanalicular; class A hearing was present in 6 (75%) of these patients postoperatively. Three were identified as being extracanalicular; extension into the internal auditory meatus did not affect hearing outcomes as all 3 patients retained class A hearing postoperatively.

Tumor location affected the possibility of successful hearing preservation (premeatal vs retromeatal). Hearing conservation using the retrosigmoid approach was attempted in all 10 retromeatal patients, regardless of tumor size. Postoperatively, class A hearing was preserved in 8 of 9 patients. One patient retained class B hearing after the surgery. Another patient with class B hearing preoperatively developed class C hearing postoperatively. Ten of 11 premeatal patients did not have serviceable hearing preoperatively. These patients underwent tumor resection by the translabyrinthine approach. One premeatal patient with class A hearing successfully retained the same level of hearing postoperatively.

FACIAL NERVE FUNCTION RESULTS

Facial nerve function results were available on 19 patients. The postoperative facial nerve function on 2 patients could not be determined from clinical records and were excluded from the analysis. Seventeen patients had a grade I House-Brackmann score preoperatively. Eleven (65%) of 17 patients maintained a grade I score after the surgery. In the remaining patients with grade I preoperative facial nerve function, 2 (11.5%) retained grade II, 2 (11.5%) maintained grade III, 1 (6%) retained grade IV, and 1 (6%) developed grade VI function after surgery (Figure 3). In the patient with postoperative grade VI facial function, the facial nerve had to be divided secondary to intimate involvement with the tumor. One patient had grade VI function preoperatively; his facial function improved to a grade IV score subsequent to tumor removal. Another patient with grade III function before surgery developed grade VI function postoperatively.

The 17 patients with normal preoperative facial nerve function were divided into groups based on tumor size (<2.0 cm, 2.0-4.0 cm, and >4.0 cm) to determine the effect of tumor size on postoperative facial function. In the smaller than 2.0-cm group, 2 of 5 of the patients had normal postoperative function. Seven of 10 patients in the 2.0- to 4.0-cm group had normal function after the surgery. Only 1 in 2 patients had normal facial nerve function when the preoperative tumor size was larger than 4.0 cm. Tumor size did not statistically affect postoperative facial function using the Fisher exact test (P=.52).

The tumor location affected the postoperative facial nerve function. All 10 patients with retromeatal tumors had grade I facial nerve function preoperatively. All of these patients retained grade I function after surgery. Seven patients with premeatal tumors had grade I function preoperatively. Only 1 patient maintained grade I function after surgery. Facial function in the remainder

Table 1. Symptoms in 21 Patients With Cerebellopontine Angle Meningiomas*

<table>
<thead>
<tr>
<th>Symptom</th>
<th>HPS (n = 11)</th>
<th>HAS (n = 10)</th>
<th>Total (N = 21)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hearing loss</td>
<td>8 (72)</td>
<td>9 (90)</td>
<td>17 (80)</td>
</tr>
<tr>
<td>Tinnitus</td>
<td>5 (45)</td>
<td>4 (40)</td>
<td>9 (42)</td>
</tr>
<tr>
<td>Dysequilibrium</td>
<td>4 (36)</td>
<td>5 (50)</td>
<td>9 (42)</td>
</tr>
<tr>
<td>Facial numbness</td>
<td>1 (10)</td>
<td>3 (30)</td>
<td>4 (19)</td>
</tr>
<tr>
<td>Vertigo</td>
<td>2 (18)</td>
<td>2 (20)</td>
<td>4 (19)</td>
</tr>
<tr>
<td>Headache</td>
<td>2 (18)</td>
<td>0</td>
<td>2 (10)</td>
</tr>
<tr>
<td>Facial weakness</td>
<td>1 (9)</td>
<td>0</td>
<td>1 (5)</td>
</tr>
</tbody>
</table>

*Values are number (percentage) of patients. HPS indicates hearing preservation surgery; HAS, hearing ablative surgery.
of the patients was as follows: grade II (2), grade III (2), grade IV (1), and grade VI (1). Another premeatal patient with grade VI preoperative function developed grade IV function postoperatively. The last patient with grade III function preoperatively developed grade VI function after surgery. The Fisher exact test was used to determine the statistical difference between facial nerve outcomes. The Fisher exact test was used to determine the statistical difference between facial nerve outcomes. The Fisher exact test was used to determine the statistical difference between facial nerve outcomes.

Complications occurred in 6 patients postoperatively in this series; auditory impairment and facial nerve deficits were considered separately. A total of 15 complications occurred during the 23 procedures. Cerebrospinal fluid leak, the most common complication, was seen in 4 patients. Postoperative pneumonia and lower cranial nerve deficits occurred in 3 patients. Tracheostomy secondary to respiratory failure was required in 2 patients. In these 2 patients, the tumor size was 4.0 cm and 5.0 cm, respectively. Subdural hygroma, cerebellar hematoma, and meningitis were seen in 1 patient each (Table 3).

### COMPLICATIONS

Review of the literature shows few reports on sound audiometric data for CPA meningiomas. This is compounded by the significant variability in the data that are available on the postoperative auditory results.2.0-13 With this in mind, the goal of this retrospective analysis was to closely examine preoperative and postoperative audiometric results for patients undergoing hearing conservation surgery through the retrosigmoid approach. Hearing preservation was attempted in 11 patients who underwent CPA meningioma resection in this series. Class A hearing was preserved in 9 of 10 patients. The last patient with class A hearing prior to surgery retained class B hearing postoperatively.

These data compare favorably to the auditory results available from the other series. Grey et al.5 attempted hearing preservation in 11 patients and were able to achieve serviceable or better hearing in 8 (73%) patients. Nassif and associates6 attempted hearing preservation in 16 of 56 patients with meningiomas presenting to the House Ear Clinic, Los Angeles, Calif. Hearing levels were “preserved near the preoperative level in 75% of patients postoperatively.”6 Similarly, Schaller et al.7 reviewed postoperative auditory function after CPA meningioma removal in 13 patients with successful hearing preservation being achieved in 69% of the patients. These studies have shown that preoperative tumor size does not influence hearing results as noted in this study.

Preoperative tumor location affected the ability to preserve hearing with surgery. Ten of 11 patients with premeatal tumors had nonserviceable hearing (class C or D) preoperatively. All 10 patients underwent successful tumor removal by the translabyrinthine approach. In contrast, 9 patients with retromeatal tumors had class A hearing preoperatively. Eight of 9 patients maintained hearing at this level after retrosigmoid tumor removal. Similarly, Schaller et al.7 noted that hearing preservation was generally only possible for retromeatal tumors. All premeatal patients in their study had nonserviceable hearing preoperatively.2 The observed differences are likely secondary to the relationship of the tumor to the cochlear-facial nervovascular bundle. Premeatal meningiomas are located on the inner side of the arachnoid; thus, the relationship between the tumor and the internal auditory canal is more intimate. The difficulty in achieving a clean plane of separation between the nerves and the tumor results in lower likelihood of preservation of auditory and facial function. Retromeatal tumors are generally separated from the nerves by an arachnoid layer; they are less likely to invade the nervovascular structures of the internal auditory canal and allow for conservation of auditory and facial function.

Hearing preservation was not attempted in patients with class C or D hearing preoperatively in this study. Case reports by Vellutini et al.8 and Maurer and Okawara9 have demonstrated that hearing restoration can occur with meningiomas, even in the face of profound preoperative deficit. More data are clearly required before one can recommend hearing conservation for all patients, regardless of

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>14 (67)</td>
</tr>
<tr>
<td>Left</td>
<td>7 (33)</td>
</tr>
<tr>
<td>Size, cm†</td>
<td>2.4 (0.8-5.0)</td>
</tr>
<tr>
<td>HPS</td>
<td>2.1 (0.8-3.5)</td>
</tr>
<tr>
<td>HAS</td>
<td>2.3 (1.0-5.0)</td>
</tr>
<tr>
<td>Location</td>
<td></td>
</tr>
<tr>
<td>Premeatal</td>
<td>11 (52)</td>
</tr>
<tr>
<td>Retromeatal</td>
<td>10 (48)</td>
</tr>
<tr>
<td>Extracanalicular</td>
<td>10 (48)</td>
</tr>
<tr>
<td>Intracanalicular</td>
<td>2 (9)</td>
</tr>
<tr>
<td>Extracanalicular/intracanalicular</td>
<td>9 (43)</td>
</tr>
</tbody>
</table>

*Values are number (percentage) unless otherwise indicated. HPS indicates hearing preservation surgery; HAS, hearing ablative surgery.
†Size data are average (range).
preoperative hearing status, with presumptive diagnosis of CPA meningioma.

The success rate of hearing conservation achieved in CPA meningioma surgery is significantly different than vestibular schwannoma surgery. In a review of 10 large series, Gardner and Robertson\textsuperscript{15} found the hearing preservation rate to be 33% for these tumors. Similarly, Cohen et al\textsuperscript{13} demonstrated successful hearing conservation in 32% of the patients with anatomic preservation of the cochlear nerve. The chance of hearing preservation was poor for vestibular schwannomas larger than 1.5 cm; thus, the translabyrinthine approach was recommended for patients in this category. Although no definitive explanation exists, the observed difference in results may be related to the more intimate involvement of the acoustic tumors with the cochlear nerve or its blood supply. Thus, direct trauma to the nerve or disruption of the blood supply during tumor extirpation may result in lower success rate in hearing preservation with vestibular schwannomas.

Based on these data, the possibility of hearing conservation is clearly superior for CPA meningiomas, even for large-sized tumors. Hearing preservation should be attempted in retromeatal meningiomas of all sizes, if feasible, with good or serviceable hearing (class A or B) preoperatively. Thus, it is crucial to differentiate between meningiomas and vestibular schwannomas preoperatively, as hearing preservation is rare with large acoustic tumors. Gadolinium-enhanced MR imaging has been reliably used to differentiate between these 2 tumors. Meningiomas generally possess a broad dural base on the posterior petrous face with an enhancing tail. They are usually not centered around the internal auditory meatus and rarely cause erosion or penetration of the internal auditory canal. In addition, they may present with signs of calcification and local hyperostosis. In contrast, vestibular schwannomas tend to be round, often cystic masses that are centered around the internal auditory meatus causing erosion or extension into the internal auditory canal.\textsuperscript{5}

Facial nerve function was satisfactorily preserved in majority of the patients in this series. Seventy-six percent of the patients with normal preoperative facial function retained grade I or II function postoperatively. Two patients developed grade VI function postoperatively, including 1 patient in whom the facial nerve was divided secondary to involvement with the tumor. This compares favorably with the findings by Schaller et al.\textsuperscript{2} Six of 10 patients with normal preoperative facial function retained grade I or II function, while another 30% of patients maintained grade III or IV function postoperatively.

Preoperative facial nerve paresis has been found to be a risk factor for postoperative facial dysfunction. Schaller et al\textsuperscript{2} noted that all 3 patients with preoperative facial paresis developed grade VI paralysis in their series. Similarly, 1 patient with grade III paralysis in our series worsened to grade VI subsequent to the surgery. Interestingly, another patient with grade VI dysfunction preoperatively gradually improved to grade IV function after surgery.

Tumor size has also been noted to be a risk factor for facial paresis after meningioma removal. All patients in the Schaller et al series with grade III or worse facial function after surgery had preoperative tumor size larger than 3.0 cm. Our series did not show statistical correlation with regard to tumor size and postoperative facial function. The general trend demonstrated that 66% (4 of 6) and 73% (8 of 11) of patients retained grade I or II facial function for tumor sizes smaller than 2.0 cm and 2.0 to 4.0 cm, respectively. One in 2 patients maintained normal postoperative facial function when tumor size was larger than 4.0 cm.

Tumor location affected the postoperative facial nerve function. All 10 retromeatal patients with preoperative grade I function retained function at this level postoperatively when undergoing retrosigmoid tumor removal. Only 1 of 7 premeatal patients retained grade I facial function. The more intimate involvement of the premeatal tumors with the facial and cochlear nerves may account for the lower likelihood of preservation of facial function. Nevertheless, given the success rate in maintaining good facial function postoperatively, facial nerve preservation should always be attempted, when possible, with CPA meningiomas.

This retrospective study demonstrates that CPA meningioma removal can be successfully achieved by both translabyrinthine and retrosigmoid approaches. The retrosigmoid approach was effectively used for preservation of auditory and facial function for retromeatal meningiomas in this series. The translabyrinthine approach was efficacious for removal of premeatal meningiomas with nonserviceable hearing. Thus, hearing preservation should

### Table 3. Complications of Cerebellopontine Angle Meningioma Surgery

<table>
<thead>
<tr>
<th>Complication</th>
<th>No. (%) of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cerebrospinal fluid leak</td>
<td>4 (26)</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>3 (20)</td>
</tr>
<tr>
<td>Lower cranial nerve deficit</td>
<td>3 (20)</td>
</tr>
<tr>
<td>Tracheostomy</td>
<td>2 (13)</td>
</tr>
<tr>
<td>Subdural hygroma</td>
<td>1 (6)</td>
</tr>
<tr>
<td>Cerebellar hematoma</td>
<td>1 (6)</td>
</tr>
<tr>
<td>Meningitis</td>
<td>1 (6)</td>
</tr>
</tbody>
</table>

### Figure 3. Postoperative facial nerve function results in patients with grade I function preoperatively.

### CONCLUSIONS
be attempted for retromeatal meningiomas whenever feasible, even in the face of large tumors. Facial nerve function can also be preserved following meningioma removal, and the success rate for facial nerve preservation is greater with retromeatal compared with premeatal tumors.

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REFERENCES