Facial nerve preservation in patients with large acoustic neuromas treated by a combined middle fossa transtentorial translabyrinthine approach

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With large acoustic neuromas, the primary goal of surgery is safe total removal of the tumors, and the secondary goal is preservation of nearby neural structures, including the facial nerve. In a series of 15 consecutive patients with large cerebellopontine angle tumors, all of which were more than 2.5 cm in diameter, tumor excision was performed by a one-stage combined middle fossa-translabyrinthine approach. There were 13 acoustic neuromas, 10 of which were more than 4 cm in diameter, one petrous apex meningioma 4 cm in diameter, and one facial neuroma 3 cm in diameter. The tumors were totally removed in all 15 patients. The facial nerve was preserved in 12 of 13 evaluable patients. In the 14th patient the nerve had been transected in a previous suboccipital procedure with incomplete removal, and in the 15th patient the nerve was sutured following excision of a facial neuroma. Thus, the nerve was lost at surgery in only one patient.

This combined approach provided very clear visualization of the cerebellopontine angle, including the brain stem and the lower cranial nerves. It enabled identification of both the origin of the facial nerve at the brain stem and the lateral segment of the nerve in the internal auditory canal. Anterior extensions of tumor growing through the tentorial hiatus were easily removed. The results in these 15 patients show that this approach is excellent for total removal of large acoustic neuromas with preservation of the facial nerve. It is especially suitable for large tumors with anterior extensions.

KEY WORDS - acoustic neuroma • total removal • facial nerve preservation • translabyrinthine approach • transtentorial approach • cerebellopontine angle

The goals of acoustic neuroma surgery are, first, safe total removal of the tumor, and, second, sparing of all nearby neural structures including the facial and cochlear nerves. Preservation of facial nerve function and sparing of serviceable hearing are accomplished more frequently now, due to earlier diagnosis when the tumors are smaller, and improved microsurgical techniques. However, in spite of newer methods of investigation, such as evoked potential monitoring,3 and improved radiological assessment with newer generation computerized tomography (CT) scanners, large tumors are still encountered, due mainly to the capricious nature of this tumor with respect to production of symptoms.15 Indeed, it is likely that Dott's admonition that "the right time to remove an acoustic neuroma is when it is no larger than a grain of wheat,"19 will still frequently fall upon deaf ears, and that surgeons will continue to be confronted with acoustic neuromas that seem as large as a bushel of wheat.

During the past few years, several different surgical approaches have been developed for the removal of acoustic neuromas. An important factor in selection of approach is the size of the tumor. In our institution, until 1976, the standard approach for large tumors was the suboccipital approach, because its wide exposure enabled total removal in almost all instances. In 1978, we were confronted with a young woman with a very large acoustic neuroma which had a sizeable anterior extension growing forward through the tentorial hiatus. In our desire to achieve a complete tumor removal and to spare the facial nerve, we used a lateral approach similar to that described by King.14 Since then, we have preferred this approach for large
tumors, because it has proven satisfactory for achieving the goals of total tumor removal and facial nerve preservation. This paper describes the operative technique and results in a consecutive series of our first 15 patients with large cerebellopontine angle neoplasms treated by this approach.

Operative Technique

Fifteen patients with cerebellopontine angle tumors, 2.5 to 6 cm in diameter, were treated by a combined translabyrinthine-middle fossa transtentorial approach. Patients were placed in the supine position with the head turned 90°, and immobilized by a headholder with three-point fixation so that the squamous portion of the temporal bone lay horizontally. In seven patients, a ventricular catheter was inserted into the lateral ventricle on the side of surgery, through a coronal burr hole. The skin incision was made upward from the mastoid and encircled the external ear, with the anterior limb ending at a point overlying the zygomatic arch (Fig. 1).

The translabyrinthine dissection was then performed with a more extensive exposure than for purely intracanalicular tumors. The bone of the superior, inferior, and posterior walls of the internal auditory canal was removed. The petrous apex was removed superomedially, and the exposure was carried to the jugular bulb inferiorly. Superiorly the tegmen was thinned, while posteriorly the bone overlying the posterior cranial fossa dura was completely removed, exposing the sigmoid sinus.

A small temporal bone flap hinged on temporalis muscle was then turned down as shown in Fig. 1. The remaining bone of the floor of the middle fossa overlying the translabyrinthine exposure was removed completely, with the anteromedial limit being the superior petrosal sinus. The dura over the temporal lobe was opened vertically well forward to avoid the veins coming from the lateral and inferior aspects of the temporal lobe (Fig. 2). The dural opening was then carried inferiorly across the floor of the middle fossa as far as the superior petrosal sinus. In no case was it necessary to coagulate the draining veins. The posterior fossa dura was then divided vertically down to the jugular bulb, after which the superior petrosal sinus was divided between hemostatic clips. The tentorium was divided to the incisura, at which point the midbrain and fourth cranial nerve were visualized. In most patients, a copious amount of cerebrospinal fluid (CSF) could then be drained from the cisternaambiens. The final stage of the dural opening was then made at right angles to the previous incisions by dividing the posterior fossa dura from the sigmoid sinus posteriorly to the porus acusticus anteriorly. Temporal lobe retraction was minimized by using a self-retaining retractor. Indeed, the only retraction required was during incision of the medial edge of the tentorium. With the dura opened in this fashion, the lateral, anterior, and superior aspects of the cerebellopontine angle were exposed and the main body of the tumor uncovered, extending from the brain stem medially to the fundus of the internal canal laterally (Fig. 3). A second self-retaining retractor was used to retract the cerebellar hemisphere in a posteromedial direction.

Tumor excision was accomplished by gutting the central core with various-sized biopsy forceps and curved tumor dissectors, and removing the fragments by suction. After enucleation, the capsule was separated from the cerebellum, medulla, and pons. Frequently, this allowed visualization of the origins of
Transtentorial translabyrinthine approach to acoustic tumors

Fig. 3. The dura has been opened widely displaying the lateral and superior aspects of the tumor. The temporal lobe retractor can be removed after the tentorium is divided.

the seventh and eighth cranial nerves at the brain stem (Fig. 4). The eighth cranial nerve was then detached from the brain stem to aid in mobilization of the tumor. The seventh nerve was then identified at the lateral end of the internal auditory canal by mobilizing the overlying tumor. The remaining tumor at the porus acusticus and in the cerebellopontine angle was then removed, revealing the full intracranial course of the seventh nerve (Fig. 4).

Representative CT scans of the tumors in this series are shown in Fig. 5. Many of them had significant extensions anteriorly, and all caused medial displacement of the brain stem and fourth ventricle.

Fig. 4. The tumor bed is seen following total excision of a large tumor which has markedly stretched the facial nerve. The lateral approach allows visualization of both the medial and lateral segments of the nerve and thus facilitates its preservation.

Fig. 5. Preoperative computerized tomography scans showing the acoustic neuromas. Left: Case 1. This is the first patient in whom the combined approach was used. This approach is especially suited to tumors with significant anterior extension through the tentorial hiatus. Center: Case 12. A large anterior segment of this tumor was protruding through the tentorial hiatus. The tumor was completely removed with excellent recovery of facial function. Right: Case 8. This is the largest acoustic neuroma in the present series. The very large posterior component was removed initially by a suboccipital approach and then the combined approach was used to remove the remaining tumor, with preservation of the facial nerve. Facial nerve function was graded as good.
TABLE 1
Data for 15 patients operated on in this series

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<th>Case No.</th>
<th>Age (yrs)</th>
<th>Pathology</th>
<th>Tumor Size (cm)</th>
<th>Facial Nerve Intact Postop</th>
<th>Follow-Up (mos)</th>
<th>Facial Nerve Function</th>
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Operative Results

As shown in Table 1, 15 patients with large cerebellopontine angle tumors were operated on with this combined approach using the operating microscope. All tumors were 2.5 cm or greater in diameter. This is essentially the same criterion for large tumors as defined by others.9,10 There were 13 acoustic neuromas, 10 of which were more than 4.0 cm in diameter, one petrous apex meningioma of 4.0 cm, and one facial neuroma of 3.0 cm in a patient with von Recklinghausen's disease. The tumors were totally removed in all 15 patients. The facial nerve was preserved in 12 of 13 evaluable patients. In the 14th patient the nerve had been transected in a previous suboccipital procedure with incomplete removal, and in the 15th patient the nerve was sutured following excision of a facial neuroma. Thus, the nerve was preserved at surgery in 13 of 14 patients (93%).

The one patient who died (Case 13) had had three prior suboccipital attempts at removal in other institutions. His surgery and immediate postoperative course were uneventful. In fact, he was making plans for his return home when, on the 8th postoperative day, he suddenly fell to the floor at his bedside, struck his head hard, and became obtunded. A CT scan revealed some air in the ventricles. The operative site was explored but there was no evidence of a clot. His coma (likely the result of brain-stem infarction due to his fall) persisted, and he died approximately 3 months later. There were four cases of postoperative CSF leakage presenting as rhinorrhea. In two, middle ear attic leaks were found, and closed with a temporalis muscle graft via a tympanotomy under local anesthesia. In the other two, the leak was closed under general anesthesia, in one by a tympanotomy and packing of the hypotympanum with bone wax, and in the other by occlusion of the eustachian tube with muscle.

We now routinely occlude the eustachian tube orifice with periosteum, muscle, and a bone plug at the time of closure of the craniotomy, and this has reduced markedly the incidence of postoperative rhinorrhea. Two patients had one seizure each in the early postoperative period. One of them has been seizure-free since then (36 months), and the other had one further seizure during the next 21 months of follow-up review.

In the 14 survivors, facial nerve function returned in 10 patients (71%), and was assessed as excellent in five and good in five (Table 2). Excluding the patient whose nerve was transected at a previous operation, six of the eight patients with acoustic neuromas of 4.0 cm or greater showed excellent or good facial nerve function (75%). The three patients with nerves judged to be intact at surgery in whom there was no recovery were all older patients (Cases 2, 3, and 4). At 13, 15, and 17 months after surgery, respectively, in the absence of spontaneous recovery of facial nerve function, these three patients underwent facial-hypoglossal

TABLE 2
Summary of results in 14 surviving patients with large cerebellopontine angle tumors

<table>
<thead>
<tr>
<th>Tumor Type</th>
<th>No. of Cases</th>
<th>Average Tumor Size (cm)</th>
<th>Facial Nerve Intact Postop</th>
<th>Mean Follow-Up (mos)</th>
<th>Facial Nerve Function</th>
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anastomosis. The patient whose facial nerve was lost at surgery (Case 10) had a facial-hypoglossal anastomosis 6 months postoperatively.

Discussion

The method described above for large tumors should be considered in the context of the overall management in our institution of patients with acoustic neuromas and other cerebellopontine angle tumors, as outlined previously.21 The combined middle fossa-translabyrinthine approach is also used for moderate-sized tumors (less than 2.5 cm in diameter) in patients with "non-serviceable hearing," defined as a speech reception threshold of greater than 50 dB and a discrimination score of less than 50%. In patients with tumors less than 2.5 cm and serviceable hearing, the suboccipital approach is used, in an attempt to preserve the cochlear nerve. Very small tumors confined to the internal auditory canal or those with a small protrusion into the cerebellopontine angle (less than 5 mm) in patients in whom hearing is non-serviceable are treated through a translabyrinthine approach. Acoustic neuromas in elderly patients over 70 years old without hydrocephalus are usually not treated surgically unless 6-monthly serial CT scans show progressive enlargement of the tumor. Patients with symptomatic hydrocephalus are treated by CSF shunting only, unless the tumor enlarges.

Thus, in our institution, patients with tumors larger than 2.5 cm, regardless of their hearing preservation, are treated by the combined lateral approach using the combined middle fossa-translabyrinthine exposure described above. The results have been satisfactory, with total excision of the 15 consecutive large neoplasms in the cerebellopontine angle, including 13 acoustic neuromas of 2.5 cm or greater (Tables 1 and 2).

Large acoustic neuromas have traditionally been removed through the suboccipital approach pioneered by Cushing and skilfully employed by McKenzie and Alexander. Unfortunately, in these early series very large tumors could not always be totally removed because of adherence to the brain stem, raised intracranial pressure, and bleeding. However, with the operating microscope and microsurgical instruments, current practitioners such as Drake, DiTullio, et al., and Yaşargil and Fox have been able to totally remove most large acoustic neuromas, with a low mortality rate and with preservation of the facial nerve in the majority of cases operated on from the suboccipital approach. For example, Drake achieved total removal of 25 of 28 large tumors, with preservation of facial function in 60% of the survivors (four deaths). DiTullio, et al., achieved total removal in 40 out of 45 patients (89%) with large tumors of 4 cm or greater; they reported only three operative deaths. Postoperatively, facial nerve function was judged "intact" in 19 patients (42%), "partial" in 19 patients (42%), and absent in seven patients (16%), although each of the former two categories included "three individuals who had undergone facial reanastomosis or delayed facial-hypoglossal anastomosis.26 Thus, with large tumors, the standard, traditional suboccipital operation utilizing modern microsurgical techniques has given very satisfactory results. These results should be used as a benchmark against which alternative approaches can be judged.

Several alternative approaches have been reported for the removal of large tumors. House has used mainly the translabyrinthine approach for removal of both large and small tumors, and, according to the calculations of DiTullio, et al., only 23 (36%) of the 64 large tumors in House's series could be completely removed. There were 10 deaths, and facial nerve function was absent in 29% of patients with tumors up to 4 cm. Clemis achieved total removal in only 27 of 37 patients treated by the translabyrinthine approach, and used a second-stage suboccipital approach to remove the remaining tumor. However, Glasscock and Hay had 21 patients with acoustic neuromas 2.5 cm or larger in their series of 36 patients operated on by the translabyrinthine approach, and achieved total tumor removal in all 21 with no deaths and preservation of partial or complete facial nerve function in all but two patients. It is of interest that the same group later advocated a combination of the translabyrinthine and suboccipital approaches for dealing with large tumors, and reported 24 large tumors of 4 cm or greater. Although the results in those operated on with the combined translabyrinthine suboccipital approach were not separated from those of other approaches, no deaths resulted, and the authors concluded that they preferred this type of combined procedure for large tumors. In comparison with the earlier combined translabyrinthine suboccipital approach developed by Hitselberger and House, Glasscock, et al., did not divide the sigmoid sinus and the operations were completed in one stage. Clemis also used this combined translabyrinthine suboccipital approach, but death occurred in both patients in whom the sigmoid sinus was divided.

Sheptak and Jannetta have advocated a two-stage suboccipital approach for large acoustic neuromas. In 23 patients with tumors of 4 cm or greater, complete tumor excision was achieved in all with no mortality, and with postoperative preservation of facial nerve function in at least 15 patients; two patients were treated too recently for assessment. They concluded that the two-stage procedure was better tolerated in some cases by both patients and surgeons.

The middle fossa transtentorial approach to the cerebellopontine angle was initially used by Stieglitz, et al., in 1896 and was subsequently refined by Naffziger and Fay. These early approaches were considerably farther posterior than our approach. In most instances they involved elevation of the occipital lobe with division of the draining veins. They were conceived not only as an access route to tumors of the
cerebellopontine angle, but also to relieve pressure in the posterior fossa and to allow a larger channel for infratentorial CSF to reach the supratentorial subarachnoid space. Rosomoff shifted the dissection farther forward and approached the cerebellopontine angle from underneath the temporal lobe. Through a temporal craniotomy with intradural elevation of the temporal lobe, the tentorium was divided. This was essentially an intradural approach and usually necessitated the division of the vein of Labbé and other draining veins. These middle fossa approaches all involved division of the tentorium; the middle fossa subtemporal approaches described by House and Kurze and Doyle were essentially extradural approaches to the superior aspect of the internal auditory canal and did not include division of the tentorium to reach the cerebellopontine angle.

King has cited Henderson (unpublished data) as the first to combine the middle fossa translabyrinthine approach with the translabyrinthine approach. Morrison and King in 1973 detailed their modification of this approach in the management of acoustic neuromas, and in 1980 they reported their experience with 57 tumors, 44 of which were over 2.5 cm in diameter. In the latter paper, a further modification of the technique was described in which they exposed less of the cortex of the temporal lobe. The dura on the inferior surface of the temporal lobe was incised near the superior petrosal sinus; the sinus was then divided and the tentorial incision carried a variable distance medially depending on the size of the tumor. An additional 17 patients with large tumors were operated on through this modified approach. The modification was developed because of the high incidence of epilepsy (22%) after the initial combined approach; the epilepsy was attributed to temporal lobe changes due to the increased retraction of the temporal lobe afforded by division of the tentorium. They thought that limiting the dural opening to the area around the superior petrosal sinus exposed a smaller area of the temporal cortex to possible trauma and yet afforded adequate access to the cerebellopontine angle. In all, King and Morrison used these two combined approaches in 61 patients with large tumors and were able to completely remove all the tumors except three; in these three patients, a subsequent suboccipital approach was necessary for complete removal. There were only two deaths in the series, but only 20% of the patients with large tumors had preservation of facial nerve function.

Our operative approach is similar to that outlined in the 1973 report by Morrison and King and our overall results are similar to theirs, except that we have been able to preserve facial function in a higher percentage of patients with large tumors. We believe that this combined approach has numerous advantages over other approaches for large tumors. The upper pole of the tumor at the brain stem can be identified very early, and consequently the fifth nerve, which is frequently stretched forward by a large tumor, is directly visualized and at less risk during removal of the lesion. The superior petrosal vein is usually clearly seen and can be coagulated and divided without difficulty. Even in very large tumors, the facial nerve can always be identified in the lateral end of the internal canal, and after the tumor is enucleated, the capsule can be carefully dissected from the brain stem to allow identification of the root entry zone of the facial nerve. Thus, the nerve can be identified at both its medial and lateral ends and the adherent tumor can be separated from the nerve, especially at the porus where the nerve is invariably most attenuated and at greatest risk. The divided tentorium cerebelli serves to decompress the posterior cranial fossa as well. None of the 15 patients treated in this manner has required a permanent CSF shunt, which supports one of the original hypotheses of those who pioneered the middle fossa transtentorial approach to the cerebellopontine angle. Removal of the lower pole of the tumor is accomplished subsequent to gutting the main bulk of the tumor, which facilitates its dissection from the lower cranial nerves. If necessary, the combined approach can be performed after a suboccipital approach if there is a major posterior extension of the tumor, as in one case in this series (Case 8, Fig. 5 right).

The combined translabyrinthine middle fossa approach allowed us to completely remove large cerebellopontine angle tumors with minimum trauma to surrounding structures. In our institution, it is at present the approach of choice for tumors over 2.5 cm in diameter. Recently, we have used the modifications for opening the temporal lobe dura and tentorium suggested by King and Morrison and have found them satisfactory for moderate-sized tumors. In these instances, the dura under the temporal lobe is opened 0.5 cm lateral and parallel to the superior petrosal sinus (eliminating opening No. 1 in Fig. 2). The midpoint of this incision is opposite to the intended site of division of the superior petrosal sinus (No. 3 in Fig. 2). For large tumors, we still prefer to divide the tentorium completely, from the superior petrosal sinus to the tentorial hiatus.

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References


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