Cranial Nerve Preservation in Surgery for Large Acoustic Neuromas

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ABSTRACT

Facial nerve outcomes and surgical complication rates for other cranial nerves were evaluated retrospectively after the resection of large acoustic neuromas. The charts of all patients who underwent surgical removal of an acoustic neuroma between 1992 and 2001 at New York University Medical Center were reviewed. Fifty-four patients with tumors measuring 3 cm or larger were included in the study. Four patients had neurofibromatosis type 2, two of whom underwent bilateral removal of acoustic neuromas. Translabyrinthine microsurgical removal of tumor was performed in 47 of 56 cases (84%). In all cases, EMG monitoring, improved sharp microdissection, and ultrasonic aspiration were employed. Facial nerve function was assessed using the House-Brackmann facial nerve grading system immediately after surgery and at follow-up visits. A House-Brackmann grade III or better was achieved in 90% of patients, and a grade II or better was achieved in 84% of patients. Ultimate facial nerve outcome was excellent after the surgical resection of large acoustic neuromas. Preoperative cranial nerve palsies also improved after surgery. The translabyrinthine approach for tumor removal is our treatment of choice for acoustic neuromas 3 cm or larger.

KEYWORDS: Acoustic neuroma, translabyrinthine approach, facial nerve

The therapeutic management of patients with a large acoustic neuroma involves several important issues. Management options include observation, stereotactic radiosurgery, and microsurgical removal. If left untreated, tumor growth would cause further neurological sequelae. Large tumors are particularly worrisome because if left untreated,

they often compromise the function of other cranial nerves, obstruct the flow of cerebrospinal fluid (CSF), and compress the brainstem. Patients with tumors larger than 3 cm are seldom candidates for Gamma knife therapy because of the need to program more than one isocenter for the radiation dose. Multiple isocenter dosing exposes

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normal neural tissue to excess amounts of radiation.^{1,2}

In most cases, surgical outcomes have been favorable, with mortality rates approaching zero.^{3,4} Significant postoperative morbidity, however, can result from surgical treatment, especially with large tumors.^{5,6} Hearing preservation is rarely a factor considered in the management of very large tumors. Facial nerve preservation and reducing other neurologic complications therefore become the primary concerns. Changes in surgical approach, improvements in microsurgical dissection techniques, and advances in instrument and monitoring technology have greatly improved the morbidity rates associated with acoustic neuroma surgery.

In an attempt to assess facial nerve outcomes and complication rates of patients treated surgically for large acoustic neuromas, we retrospectively reviewed our recent series. Patients with tumors 3 cm or larger were chosen as the study population because these tumors are associated with some degree of brainstem compression, always cause significant stretching or thinning of the facial nerve, and usually contact the upper or lower cranial nerves or both. This information is important for obtaining informed consent from patients and establishing expectations about outcome. It represents our current abilities and the use of approach and technology in the management of large acoustic tumors.

CLINICAL MATERIALS AND METHODS

The records of all patients who underwent surgical removal of an acoustic neuroma between January 1992 and October 2000 at New York University (NYU) Medical Center were analyzed retrospectively. Data were derived from the NYU Department of Otolaryngology Acoustic Neuroma Database, and the two senior authors (NLC, JTR Jr.) performed all surgeries. The study was terminated October 2000 to allow a minimum of 1 year of follow-up time. Neurofibromatosis type 2 (NF2)

patients were included in the analysis. Outcomes of microsurgical removal for large acoustic neuromas were analyzed for postoperative facial nerve function. The variables evaluated included totality of tumor removal, sporadic versus NF2 pathology, preoperative facial nerve function, additional complications, and other cranial nerve deficits. Facial nerve function was reported using the House-Brackmann grading scale. Follow-up ranged from 17 months to 10 years. The House-Brackmann grade at most recent follow-up was recorded. All facial nerve results were recorded before facial reanimation procedures, if they were required.

Inclusion Criteria for Large Acoustic Neuroma

Tumor measurements were derived from preoperative gadolinium-enhanced magnetic resonance images (MRI). A size of 3 cm or greater was chosen as the inclusion criterion and determined by the greater value of two measurement methods. In the first, intracanalicular length was added to the extracanalicular diameter parallel to the long axis of the internal auditory canal (total internal auditory canal involvement = 10 mm maximum value). The second value was the largest extracanalicular diameter.

Study Group

The records of 437 patients operated on for lesions of the cerebellopontine angle between 1992 and 2000 were reviewed retrospectively. Fifty-four patients (26 males, 28 females) had acoustic neuromas greater or equal to 3 cm. Four of these patients had NF2, two of whom underwent bilateral operations for large tumors. Therefore, the total number of surgeries was 56. Six patients had recurrent tumors. The age of the patients ranged from 18 to 85 years (mean age, 53 years). Twenty-nine acoustic neuromas were on the left and 27 were on the right side. The average size of tumor was 37 mm (range, 30 to 60 mm).

Surgical Techniques and Perioperative Care

All tumors were removed through a translabyrinthine (82%) or retrosigmoid/transmeatal (18%) approach. In 1992, the translabyrinthine approach became the procedure of choice because it allows direct exposure of the tumor with minimal brain retraction and identification of the facial nerve in the lateral aspect of the internal auditory canal. Details of the surgical technique have been described previously.⁷⁻⁹ Continuous electromyographic monitoring of the facial nerve and the monopolar facial nerve stimulating probe were used in all cases. All patients underwent continuous hemodynamic monitoring. Foley catheters were used to monitor urinary output. Lower cranial nerve potentials, corticobulbar evoked potentials, and somatosensory and motor-evoked potentials were monitored in patients with the largest tumors when deemed appropriate by the operating surgeons. Ultrasonic aspiration was used to aid in tumor debulking.

Intravenous steroids were administered intraoperatively and postoperatively in any case where facial nerve stimulation was lost during surgery or when the operating surgeon thought that the facial nerve had been sufficiently traumatized to warrant the treatment. When facial nerve weakness was detected postoperatively in any patient, steroids were also administered. All patients treated surgically for acoustic neuroma undergo MRI 3 months after surgery and then annually for 5 years.

RESULTS

Totality of Tumor Removal and Intraoperative Preservation of Cranial Nerve VII

Total tumor removal was achieved in 41 patients (73%). In five patients (9%), an intraoperative decision was made to perform a near-total removal

to minimize the risk of injury to the brainstem or facial nerve. Residual tumor volume was considered to be minimal or unmeasurable. To date, none of these patients has had discernible tumor on follow-up MRI examination. A planned subtotal was performed on 10 patients (18%), 9 of whom were elderly or had significant medical problems. Subtotal removal was performed to relieve preoperative symptoms caused by mass effect on vital structures of the central nervous system. Intraoperatively, the facial nerve was reported intact in 52 cases (93%). The facial nerve was cut in three cases, and in one case the facial nerve was not identified.

Facial Nerve Outcome

Facial nerve outcome was evaluated according to the House-Brackmann grading scale.¹⁰ The entire series was first analyzed without regard to totality of tumor removal. For the entire series excluding patients with a preoperative facial palsy ($n = 50$), grade I was achieved in 36 cases (72%), grade II in 6 cases (12%), grade III in 3 cases (6%), grade IV in 2 cases (4%), and grade VI in 3 cases (6%). For the 46 cases with a sporadic pathology, grade I was achieved in 34 cases (74%), grade II in 6 cases (13%), grade III in 3 cases (7%), grade IV in 2 cases (4%), and grade VI in 1 case (2%). In patients with NF2 and normal preoperative facial nerve function, a final facial nerve outcome was grade I in two cases (50%) and grade IV in two cases (50%) (Table 1).

Therefore, for the entire series, grade III or better was achieved in 90% of the cases, grade II or better in 84% of the cases, and grade I in 72% of the cases. Excluding patients with either diminished preoperative facial nerve function or NF2 ($n = 46$),

Table 1 Facial Nerve Outcomes by House-Brackmann Grade

	I	II	III	IV	V	VI
Entire series ($n = 50$)	36	6	3	3		3
Sporadic ($n = 46$)	34	6	3	2		1
NF2 only ($n = 4$)	2			2		

NF2, neurofibromatosis type 2.

Table 2 Facial Nerve Outcomes

	I	≤II	≤III	>III
Entire series	72% (36/50)*	84% (42/50)	90% (45/50)	10% (5/50)
Sporadic	74% (34/46)	87% (40/46)	93% (43/46)	7% (3/46)
NF2 only	50% (2/4)	50% (2/4)	50% (2/4)	50% (2/4)

*() = number of patients in each group.
 NF2, neurofibromatosis type 2.

the final facial nerve outcome was grade III or better in 93% of the cases, grade II or better in 87% of the cases, and grade I in 74% of the cases. Among the four patients with NF2, grade I was achieved in 50% of the cases and grade VI in 50% of the cases (Table 2).

In the 38 cases in which total tumor removal was achieved regardless of tumor pathology, grade III or better was achieved in 97% of the cases, grade II or better in 91% of the cases, and grade I in 74% of the cases. Of the seven patients who underwent a planned subtotal removal, all had a postoperative grade of I. For unplanned near-total removal, grade I was achieved in 40% of the cases. The remaining 60% of cases had a facial nerve outcome worse than grade III (Table 3).

In cases with total tumor removal excluding patients with NF2 ($n = 35$), grade I was achieved in 74% of the cases, grade II or better in 91% of the cases, and grade III or better in 97% of the cases. Of the six patients who underwent a planned subtotal resection, all had a grade I outcome. Of the five patients who underwent an unplanned near-total resection, 40% were grade I, 20% were grade IV, and 20% were grade VI after surgery (Table 4).

Six patients (11%) presented with grade VI facial nerve paralysis. Two patients presented with a grade II. One maintained a facial nerve function of grade II and the other had a final outcome of grade IV. One patient who was grade III at presentation had complete paralysis as a final outcome.

Cranial Nerve Complications

Preoperative hyperesthesia of cranial nerve V manifested as tongue pain and numbness persisted in one patient. Four patients (7%) had ipsilateral sixth cranial nerve palsies; one resolved and three persisted. In one of these patients, cranial nerve VI was transected intraoperatively. Two patients developed a cranial nerve VI palsy after a postoperative intracranial hemorrhage. One patient had ipsilateral vocal cord paralysis. One patient had a temporary contralateral vocal cord paralysis, which was attributed to brainstem shifting after a large tumor was removed. This patient also had temporary dysarthria and ataxia. One patient had temporary contralateral cranial nerve IX, X, XI, XII palsy, brachial plexus palsy, and a persistent Horner's syndrome due to a contralateral severe sialadenitis with a large

Table 3 Facial Nerve Outcomes by Totality of Tumor Removal: Sporadic and NF2

	I	≤II	≤III
Total removal	74% (28/38)*	91% (34/38)	97% (36/38)
Planned subtotal	86% (6/7)	86% (6/7)	86% (6/7)
Unplanned near total	40% (2/5)	40% (2/5)	40% (2/5)

*() = number of patients in each group.
 NF2, neurofibromatosis type 2.

Table 4 Facial Nerve Outcomes by Totality of Tumor Removal: Sporadic Only

	I	≤II	≤III
Total Removal	74% (26/35)	91% (32/35)	97% (34/35)
Planned subtotal	100% (6/6)	100% (6/6)	100% (6/6)
Unplanned near total	40% (2/5)	40% (2/5)	40% (2/5)

() = number of patients in each group.

neck phlegmon. All temporary palsies resolved within 6 months.

Additional Postoperative Complications

Two patients developed intracranial hemorrhages that required surgical evacuation. One of these patients had temporary hemiparesis. Both patients required CSF shunting for hydrocephalus. Their tumors were 30 mm and 35 mm, respectively. Neither had hydrocephalus preoperatively. One patient developed an ipsilateral corneal abrasion that required canthoplasty but subsequently recovered complete facial nerve function. There were three CSF leaks (5%), two of which did not respond to conservative management and required surgery. One of these patients presented with meningitis (2%) and a new onset grade IV facial palsy, which eventually recovered to grade II. Three patients developed pseudomenigeoceles (5%); all resolved with conservative treatment. One patient with multiple medical problems developed temporary renal failure. One patient developed deep venous thrombosis, which was treated with anticoagulation therapy without sequelae.

DISCUSSION

The facial nerve outcomes in this series compare favorably with those of previous reports. Normal facial nerve outcomes have been reported at rates from 45 to 93% for tumors of all sizes.^{11–16} For our entire series of patients who presented with normal

facial nerve function, minimal decrease in facial nerve function was achieved in 84% (grade II or better).

Patients with NF2 tended to have poorer outcomes, although the number of patients with this pathology was too low for a meaningful statistical analysis. Tumors in NF2 patients typically are considered to be more difficult to remove with nerve preservation because neurofibromas contain an increased collagenous fibrous component that intertwines with adjacent nerves. The tumor-nerve interface also tends to be devoid of a clear histologic cleavage plane.¹⁷ Patients who presented with facial nerve palsy were found to have a higher risk of poor postoperative facial nerve functioning.

Planned subtotal resection appears to be a sound treatment modality for elderly and infirm patients with large symptom-producing tumors. Although one patient developed renal failure postoperatively, it was thought to be due to a pre-existing myeloproliferative disorder.

Postoperative intracranial hemorrhage was the major cause of significant morbidity in this series. Both patients with postoperative hemorrhages sustained abducens palsies and hydrocephalus requiring diversion of CSF. Overall our rate of major complications was acceptable and permanent morbidity was rare.

The translabyrinthine approach was favored because it affords good exposure of the tumor with minimal retraction of the cerebellum, and the facial nerve can be identified at a consistent anatomical location. Also, the translabyrinthine approach eases the repair of the facial nerve if it is transected. Additional enhancements in operative technique include the routine use of facial nerve monitoring,

ultrasonic aspiration, and sharp dissection. Bipolar electrocauterization is no longer used for tumor dissection.

CONCLUSION

Microsurgery is the uncontested treatment of choice for large acoustic neuromas. The translabyrinthine approach is the treatment of choice for acoustic neuromas 3 cm or larger. The ultimate facial nerve outcome of patients with large tumors in this series was excellent. Patients with NF2 or preoperative facial nerve palsy had poorer facial nerve outcomes and should be counseled appropriately. The overall complication rate associated with the microsurgical removal of large tumors is low.

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Commentary

The authors review their experience with surgical resection of acoustic neuromas over a 9-year period at the New York University Medical Center. All tumors were larger than 3 cm. Their results are consistent with what would be expected from a contemporary neurosurgical series at most experienced centers. Total tumor resection was achieved in 73%, and best subtotal removal was achieved in 18%. In 9% an intraoperative decision was made to perform a near-total tumor resection to minimize risk to the cranial nerves, especially the facial nerve. The facial nerve was cut in three cases.

Final facial nerve outcome of grade III or better was achieved in 90% of the patients and grade II or better was achieved in 84%. It appears that patients who underwent unplanned near-total

removal had the worst facial nerve outcomes, most likely because control of the facial nerve was lost intraoperatively. Clearly, patients who underwent planned subtotal resection had better facial nerve outcomes. Therein lies the thrill of this study. Surgeons should consider more frequent planned subtotal removal with adjunct postoperative radio-

therapy, especially in patients over the age of 65 years. As a result, facial and other cranial nerve outcomes would likely be much improved and major complications (e.g., intracranial or hemorrhage) would occur less frequently.

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