Current Results of the Surgical Management of Acoustic Neuroma

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ABSTRACT

A retrospective analysis of 162 consecutive cases in 160 patients who underwent microsurgical resection of vestibular schwannomas between October 1995 and June 2001 was undertaken to compare the results with those of other treatment modalities. Patient hospital records, operative video pictures, neuroimaging studies, audiograms, and follow-up data were reviewed. The mean follow-up period was 24 months.

There were 34 small (<1.5 cm), 92 medium (1.5–3 cm), and 36 (>3 cm) large tumors. Six were recurrent tumors. Gross total resection was accomplished in all 34 small tumors and 92 medium tumors but only in 50% of the large tumors. Among the 126 small and medium tumors, the facial nerve was saved anatomically in 124 patients. On long-term follow up, facial function was preserved in 94.4% of all patients. Anatomically, the cochlear nerve was preserved in 55.9% of the small and 20.7% of the medium tumors. Function was preserved (Gardner-Robertson class 1 and 2) in 25% of the small and in 19.4% of the medium tumors. Cerebrospinal leakage was present in 10.5%, meningitis in 9.9%, wound infection in 3.7%, and hematoma or contusion in 2.5%. Only one patient died (mortality rate 0.6%). Our data reflect that surgical removal should be the standard management for acoustic tumors, particularly for large and medium tumors, and can be accomplished with acceptable complication rates.

KEYWORDS: Acoustic neuroma, complications, surgical outcome

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Refined microsurgical techniques, advanced intraoperative monitoring of cranial nerve function, and improved neuroanesthesia have improved the surgical outcomes associated with acoustic neuromas. Mortality rates have dropped below 1%, facial nerve preservation rates have improved above 90%,^{1,2} and hearing preservation has become a realistic goal for small tumors. Despite these advances, microsurgical treatment is still associated with some risks, and the potential exists for serious complications.

As radiosurgery becomes more popular and is accepted as an alternative to microsurgery for the treatment of selected patients, surgical outcomes associated with the resection of acoustic neuromas will need to be compared with the outcomes of other treatment modalities. We analyzed our current results to compare them with other surgical series and with radiosurgical outcomes, and discuss the management strategy of acoustic tumors.

METHODS AND MATERIALS

Clinical Material

Between October 1995 and June 2001, 160 patients with 162 vestibular schwannomas underwent microsurgical resection.

Ages ranged from 15 to 75 years (mean age, 47.3 years). The most prevalent age was in the 5th

decade (Table 1). There were 74 right-sided tumors and 86 left-sided tumors in 76 males and 84 females.

The size of the tumors was classified as small (less than 1.5 cm maximum diameter), medium (1.5–3 cm), and large (larger than 3 cm). There were 34 (21%) small tumors, 92 (56.8%) medium tumors, and 36 (22.2%) large tumors. There were 7 recurrent tumors. Among the 34 small tumors, 17 patients had intracanalicular tumors (10.5%). Five patients had their first operations at other hospitals, and two patients underwent two operations at our hospital because of recurrences.

The common presenting symptoms were hearing loss in 156 (96.5%), dysequilibrium in 58 (35.9%), tinnitus in 49 (30.3%), facial weakness in 17 (10.6%), trigeminal symptoms in 14 (8.5%), headache in 16 (9.9%), and swallowing difficulty in 3 (1.4%). The duration of symptoms ranged from 1 month to 10 years.

Two underwent a reoperation for a recurrence. One patient had a recurrence 6 months after partial removal of a large acoustic neuroma (maximum diameter, 5.5 cm). The second patient also had a large tumor (maximum diameter, 5 cm) that recurred 2 years after the patient's initial subtotal resection. One patient had neurofibromatosis type II. The follow-up period ranged from 3 months to 4.8 years (mean follow up, 24 months). Hospital stays ranged from 3 days to 30 days (median 5 days; mean, 6.4 days).

Surgical Technique

All patients underwent microsurgical resection of their acoustic neuroma via a suboccipital approach in the lateral position. A lumbar drain, prophylactic antibiotics, and short-term steroids were used in every case.

In all patients, brainstem evoked responses (BSER) and electromyographic responses from the facial muscles were monitored. Trigeminal nerve function and extraocular muscle function were also

Table 1 Patients' Age by Decade and Gender

Age	Male (n=76)	Female (n=84)	Total (n=160)
<20	1	1	2
20–29	3	5	8
30–39	15	22	37
40–49	24	23	47
50–59	22	25	47
60–69	7	7	14
70<	4	1	5

monitored. An experienced neuro-otological surgeon assisted with drilling the internal auditory canal.

RESULTS

Tumor Control

The extent of tumor removal was classified as total, near total, and subtotal. Even if there was no evidence of tumor mass on postoperative MRI, it was regarded as a near total removal if the surgeon thought that a tiny fragment of tumor was firmly attached to the cranial nerves or brain stem. Gross total removal was defined as tumors that were removed totally or near totally. Gross total removal was achieved in all 34 small tumors and 92 medium tumors (Table 2). However, gross total removal was achieved in only 50 % of the large tumors. Three patients developed a recurrence within 6 months, 2 years, and 9 months respectively. These three patients had very large tumors, and subtotal removals were performed during the initial operations to decompress the brain stem. Two patients underwent a reoperation, and one patient underwent Gamma knife radiosurgery for their recurrence.

Facial Nerve Preservation

Among the 126 small and medium-size tumors, the facial nerve was preserved anatomically in 124 patients (98.4%, Table 3). On long-term follow up,

94.4% of all patients showed preserved facial function. Functional recovery was achieved in 96.8% for small and medium tumors. Facial dysfunction was aggravated more than 2 House-Brackmann (H-B) grades in 9 (5.6%) patients. Of the patients in whom anatomic preservation was achieved, 19.7% showed transient postoperative worsening of facial function.

Hearing Preservation

Anatomically, the cochlear nerve was preserved in 55.9% of small tumors and 20.7% of medium tumors, but function (Gardner-Robertson class 1 and 2) was preserved in only 25% of small tumors and 19.4% of medium tumors (Table 4). Among the 17 intracanalicular tumors, 10 patients had serviceable hearing preoperatively and 5 patients maintained serviceable hearing postoperatively.

Complications

Postoperatively, one patient died (0.6%) of massive gastrointestinal bleeding and severe brain swelling due to a cerebral infarction involving the middle cerebral artery territory. Other complications included 17 (10.5%) cerebrospinal fluid (CSF) leaks and meningitis in 16 (9.9 %) patients. There were 10 (6.2%) cases of bacterial meningitis and 6 (3%) cases of aseptic meningitis. Wound infection occurred in 6 patients (3.7%), cerebellar contusion in 4 (2.5%), hydrocephalus in 4, pneumonia in 3, exposure keratitis in 3, and lateral gaze limitation in 3.

Among the 17 patients with CSF leaks, lumbar drains were placed in 4 and a mastoidectomy with revision was done in 13. One patient developed a delayed leak 9 months after surgery, and one patient showed a recurrent leak after treatment with lumbar drainage. If postoperative meningitis was confirmed by staining and culture for lumbar CSF, long-term intravenous antibiotics were administered. If the patient showed signs of aseptic meningitis, slow tapering steroid therapy was used.

Table 2 Extent of Removal of 162 Acoustic Neuromas

Extent of Removal	Small (<1.5cm)	Medium (1.5–3.0cm)	Large (>3cm)	Total (%)
Total	32	76	11	119 (73.4)
Near total	2	16	7	23 (14.2)
Subtotal			18	18 (11.1)

Gross total: total + near total.

Table 3 Facial Nerve Preservation After Resection of 162 Acoustic Neuromas

Tumor Size	Extent of Removal			No. Anatomic Preservation	No. H-B Grade at Last Follow-Up		
	T	N	S		1-2	3-4	5-6
Small	32	2	0	34	34		
Medium	76	16	0	90	83	5	4
Large	11	7	18	30	24	11	1

T, total; N, near total; S, subtotal; H-B, House-Brackmann.

Four patients had hydrocephalus, two of whom needed ventriculoperitoneal shunts. Ventriculoperitoneal shunts were preoperatively placed in two patients. Eight patients with facial weakness received gold weight lid implants, and one patient underwent facial-hypoglossal nerve anastomosis.

DISCUSSION

An estimated 2000 to 3000 new cases of unilateral acoustic neuromas are diagnosed in the United States each year (incidence of 1 per 100,000 per year).³ With the use of MRI, small tumors are increasingly being detected. However, the actual incidence of both symptomatic and asymptomatic

tumors is unclear. Autopsy studies suggest that acoustic neuromas may be present in 2.4% of individuals dying from unrelated causes. Furthermore, the natural history of small acoustic neuromas is still uncertain in terms of their growth rate and the development of hearing dysfunction.⁴ Three treatment options are considered for patients with an acoustic neuroma: surgical removal, radiation therapies such as gamma knife radiosurgery or LINAC radiosurgery, and observation with periodic audiography and MRI. Recent studies that evaluated the growth rates of untreated tumors suggest that most acoustic neuromas enlarge within 1 or 2 years.⁵⁻⁷

Most patients sought treatment for hearing loss, which was found in 94.6%⁸ of the patients at the initial examination. A gradual loss of high frequencies is most common, but some patients showed

Table 4 Hearing Preservation After Surgical Resection of 162 Acoustic Neuromas

	Anatomic Preservation	Preop Hearing	Postop Hearing	Functional Preservation
Small (34)	19 (55.9%)			
GR class 1		13	5	
2		7		
1+2		20	5	5/20 (25%)
Medium (92)	19 (20.7%)			
GR class 1		20		
2		11	6	
1+2		31	6	6/31 (19.4%)
Large (36)	0			
GR class 1		2		
2		5		
1+2		7	0	0

GR, Gardner-Robertson.

sudden hearing loss of about 10%.^{9,10} Tinnitus is also common, and about half of patients have tinnitus preoperatively. Dizziness, unsteadiness, vertigo, and a sensation of fullness in the ear can also follow the onset of hearing loss. As the tumor enlarges, numbness or altered sensation on the face or tongue, headache, diplopia, unsteady gait, difficulty with coordination, hoarseness, and difficulty swallowing may occur.

Surgical resection of acoustic neuromas has been continuously refined and operative mortality rates have decreased to less than 1% with good facial nerve preservation.^{11,12} Intraoperative neurophysiological monitoring of the facial and cochlear nerves facilitates preservation of these cranial nerves.¹³

Microsurgical resection of acoustic neuromas can be accomplished via three operative approaches: the translabyrinthine approach, middle fossa approach, and retrosigmoid suboccipital approach.¹⁴⁻¹⁶ The choice of surgical approach is influenced by the size and position of the tumor, the surgeon's preference and experience, and the likelihood of preserving hearing on the affected side.¹⁷ We used the retrosigmoid suboccipital approach for all of our cases. In the literature on microsurgical experience, complete resection of tumors has been achieved in almost all patients and facial nerve function has been preserved in 65% to 100% of the patients.^{1,2,18-20} The rate of hearing preservation ranges from 13 to 82%,^{1,2,18,19,21-23} but there is some disagreement over what constitutes "serviceable" hearing.²¹ The incidence of tumor regrowth after complete resection of acoustic neuromas through the suboccipital approach has been reported to be between 0 and 9%.^{1,24}

CSF leakage remains the most common complication of acoustic neuroma surgery. An early series of operations for acoustic neuromas reported CSF leak rates as high as to 35% with large tumors. In contrast, in a recent series the rate of CSF leaks was less than 10%.²⁵ Fishman and co-workers²⁶ reported a 17% incidence of CSF leaks, and continuous lumbar drainage stopped the leak

in 87%. We have performed early operations for CSF leaks rather than placing lumbar drains. The incidence of postoperative bacterial meningitis ranges from 2% to 10% in current published series and is usually associated with a CSF leak.²⁵ Aseptic meningitis may occur in as many as 10% of acoustic neuroma patients. Some patients prefer radiosurgery to surgical resection because the potential to preserve hearing and facial nerve function is greater and the interventional risks are less.^{19,27-29} The long-term tumor control rates are reported to be 86 to 95%.¹⁹ The most frequent complications following acoustic neuroma radiosurgery are delayed and often transient cranial neuropathies that develop 1 to 21 months after radiosurgery in 5 to 36% of patients. Facial nerve weakness has been reported in 17% after radiosurgery and hearing preservation in 75% after radiosurgery.¹⁹ Overall, our surgical outcomes are comparable to reported surgical data and to radiosurgical data (Table 5). The rate of tumor control with resection was superior to that of radiosurgery for large tumors and the complication rate was acceptable. The facial nerve was preserved in more than 95%, which is comparable to radiosurgery in the long-term follow up. However, the rate of hearing preservation was unsatisfactory.

CONCLUSION

Most acoustic neuromas grow within several years of diagnosis.^{5,7} The early detection of acoustic neuromas with MRI and treatment with either microsurgery or radiosurgery is warranted. Small and medium-sized tumors should be removed totally with preservation of facial function. Hearing preservation is considered only for patients with small tumors, with Class 1 and 2 hearing, and good brain stem waves III and V. For large tumors subtotal resection with preservation of facial nerve is warranted.

Table 5 Comparison of Authors' Series with Published Series

Author/Year	No. Patients	Mortality Rate (%)	CSF Leak (%)	Gross Total Resection	CNVII Preservation (%)	Patients Available for Follow-Up (%)	Mean Follow-Up (Mo)	Recurrences (%)
<i>Current study</i> (Lee, 2001)	162	1 (0.6)	10.5	100%, S&M 50% L	100% S 92.7% M	100%	24	4 (2.5)
Jannetta, 1996	691	7 (1)	17% total, 15% retrosig., 21% translab.	83 (94% S 85% M 70% L)	94% S 88% M 75% L	379 (55%)	29	13 (3.4)
Ojemann, 1992	410	2 (0.5)	8	80	95–100% S 75% M 56% L	N/A	≤12	12 (3)
Ebersold, 1992	255	2 (0.8)	11	97	92.6	160 (63%)	12	N/A
Hardy, 1989	100	3 (3)	31	97	82	97 (100%)	N/A	N/A
Shiobara, 1988	125	2 (1.6)	8.8	87	80	N/A	N/A	N/A
Glasscock, 1986	568	4 (0.7)	14	99	94% S 92% M 55% L	N/A	N/A	2 (0.4)
Welch, 1985	77	4 (5)	3 (3.9)	84	100% S 78% M 34% L	N/A	N/A	N/A

Tumor size: S, small; M, medium; L, large; CN, cranial nerve.

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Commentary

Dr. Buchheit was well known for his expertise in dealing with acoustic tumors during his active career. This review thoroughly defines the outcomes expected of surgery for acoustic neuromas by the best surgeons currently involved. Cure of the tumor is the rule. The mortality rate is extremely low, but not zero. Cranial nerves are usually preserved, and satisfactory facial function can be obtained in almost all patients with smaller tumors.