Improvements in central nervous system imaging have resulted in detection of greater numbers of small acoustic neuromas. Small tumors have comprised a progressively larger proportion of our series in recent years, but patients presenting with intracanalicular acoustic neuromas are still rare. Early detection of intracanalicular acoustic neuromas raises the issue of whether or not treatment is required and, if so, whether surgical removal is the most appropriate treatment. If it is, the surgeon must then decide which approach should be used.

Available evidence indicates that a majority of acoustic neuromas are observed to grow, and most will be associated with progressive hearing loss, or, less frequently, sudden persistent hearing loss. If the objective of treatment is to preserve serviceable binaural hearing, early treatment may be advisable. Surgical approaches that permit hearing conservation include the suboccipital or retrosigmoid and the middle fossa approaches, and radiosurgery offers an alternative to surgical removal.

Early treatment is advantageous only if serviceable hearing can be maintained in an acceptable percentage of patients along with low perioperative morbidity levels regarding such considerations as facial nerve function. We report our experience with excision of intracanalicular acoustic neuromas via the retrosigmoid approach, review the experience of others using the retrosigmoid–suboccipital and the middle fossa approaches, and consider radiosurgery as an alternative method of treatment in the light of reported experience.

Clinical Material and Methods

The consecutive series of operations for intracanalicular acoustic neuromas discussed in the present report forms part of a larger series of 514 consecutive acoustic neuroma excisions. Three hundred ninety-nine of these operations (78%) were performed via a translabyrinthine approach, which we prefer for medium and large tumors (extracanalicular diameter exceeding 1.5 cm) and/or for patients with nonserviceable hearing (Fig. 1).

The remaining 115 patients (22%) underwent operation via a retrosigmoid approach. Ninety-four of these patients (18% of the series) were selected for attempted hearing preservation on the basis of the following findings: maximum extracanalicular tumor diameter of 1.5 cm and/or for patients with nonserviceable hearing (Fig. 1).
Hearing preservation in removal of intracanalicular acoustic neuromas

Operative Approaches
514 Acoustic Neuromas

![Pie chart showing numbers and percentages of surgical approaches in 514 cases of acoustic neuroma. EC = extracanalicular (tumors extending medial to porus acusticus); IC = intracanalicular; RLHC = retrosigmoid hearing conservation; SO = suboccipital; TL = translabyrinthine.]

Fig. 1. Pie graph showing numbers and percentages of surgical approaches in 514 cases of acoustic neuroma. EC = extracanalicular (tumors extending medial to porus acusticus); IC = intracanalicular; RLHC = retrosigmoid hearing conservation; SO = suboccipital; TL = translabyrinthine.

mors as defined by a projection of 4 mm or less medial to the porus acusticus (Fig. 1). The operations for intracanalicular tumors were performed between April 1985 and April 1996.

Intraoperative monitoring of ipsilateral cochlear and cochlear nerve function was performed by means of the cochlear nerve action potential (CNAP) recorded either transtympanically from the middle ear promontory or intracranially directly from the eighth cranial nerve. In some instances brainstem auditory evoked potential monitoring was also performed. Click stimuli were delivered to the external auditory canal by means of an earphone and tube. Monitoring methods have been detailed in a previous report.

Operations were performed with the patient prone and the head and neck slightly flexed and rotated 15 to 20° to the ipsilateral side. A retroauricularly based scalp flap was made with a 3-cm craniotomy extending to the posterior margin of the sigmoid sinus and exposing the inferior margin of the transverse sinus. A lumbar subarachnoid drain was introduced after induction of anesthesia, allowing for withdrawal of a small amount of cerebrospinal fluid immediately prior to dural opening.

Postoperative audiological follow-up review was maintained for a minimum of 1 year. Follow-up imaging was performed postoperatively at 1, 3, and 5 years. This consisted of computerized tomography scanning in the early part of the series and magnetic resonance (MR) imaging in the later part.

Results

Hearing was preserved postoperatively at near or better than preoperative levels in 13 (50%) of 26 patients with intracanalicular tumors (Tables 1 and 2, Fig. 2). Three of 26 patients with intracanalicular tumors actually had SRTs of 55 dB preoperatively and therefore did not meet our rigorous standard for serviceable hearing, despite an SDS of 60% or greater. Of these three patients, two retained postoperative SDSs and an SRT/pure tone average (PTA) similar to their preoperative levels. Inclusion of the three patients with preoperative SRTs of 55 dB did not, therefore, influence outcome. Of the remaining 23 patients with intracanalicular tumors, 11 (48%) retained serviceable hearing postoperatively (Table 1).

In patients with an extracanalicular tumor diameter exceeding 4 mm, serviceable hearing was preserved in 20 (29%) of 68 (Fig. 2). Six additional patients in this group (9%) retained nonserviceable hearing and the remaining 42 (62%) were anacoustic (Fig. 2). Postoperative audiological follow-up review has not documented a significant decline in hearing in any patient who had an intracanalicular tumor.

At follow-up evaluation 25 (96%) of 26 patients demonstrated normal or near-normal facial function, Grade I or II according to the House and Brackmann classification (Table 3). One patient had Grade III facial nerve function.

There was one case with a small amount of enhancing tissue visualized in the lateral end of the internal auditory canal on follow-up MR imaging. The appearance of this enhancing tissue has remained unchanged on three consecutive annual MR studies.

Discussion

There appears to be a trend toward greater success in hearing preservation in the treatment of intracanalicular tumors. The difference in the rate of serviceable hearing conservation between the 26 intracanalicular tumors and the 68 tumors with extracanalicular diameter of up to 1.5 mm.
cm in the present series was not statistically significant ($p = 0.09$).

Three patients with intracanalicular tumors (Cases 11, 12, and 14) demonstrated SRTs of 55 dB. This reflects a slight change in hearing during our relatively long preoperative waiting periods. Two of these three patients retained postoperative hearing levels that did not differ significantly from those seen preoperatively (Cases 11 and 12). Despite satisfactory outcomes in these two cases we would not recommend any change in criteria for patient selection.

The quality of successfully preserved hearing was close to or better than that seen on the preoperative level (Table 1). Because the continuity of the cochlear nerve was preserved in all instances, hearing loss probably occurred as a result of ischemia affecting the cochlea or cochlear nerve. Continuous intraoperative monitoring of the CNAP, with or without brainstem auditory evoked potentials, did not prevent loss of serviceable hearing in half of the patients with intracanalicular tumors.

It is probable that most acoustic neuromas show growth during long-term follow-up review. Norén and Greitz,22 for example, found that 70% of all acoustic neuromas followed using computerized tomography or MR imaging showed detectable growth and that 100% of those followed for more than 4 years demonstrated detectable growth. Other reports of clinical experience have suggested that some acoustic neuromas may not show detectable growth over time.30,33,36 Variable growth rates have been reported, usually with a mean of 0.1 to 0.2 cm per year,19,21,33,34,38 but in exceptional cases demonstrating growth rates of up to 1 cm per year.23

Autopsy data indicate that the incidence of asymptomatic acoustic neuroma may be higher than is generally believed.10,16,33 Leonard and Talbot,16 for example, found four asymptomatic intracanalicular acoustic neuromas in 490 cadavers (0.8%). Stewart, et al.,32 also found occult intracanalicular vestibular schwannomas in five (0.97%) of 517 patients. Both of these studies were hospital based and did not involve consecutive cases; therefore the results may not be representative of the general population, in whom acoustic neuromas are diagnosed at a rate of approximately nine per million per year.35 Tos, et al.,35 found only two intracanalicular tumors (0.32%) in a total of 615 consecutively diagnosed acoustic neuromas. Although a relatively small portion of diagnosed acoustic neuromas may not show detectable growth on follow-up examination,21,38 the preceding figures would suggest a much higher proportion of stable intracanalicular tumors. Despite a high awareness of clinical presentation and improvement in neuroimaging in recent years, intracanalicular acoustic neuromas are not being diagnosed in numbers that would suggest that the findings published by Leonard and Talbot16 and Stewart, et al.,32 are representative of tumor incidence in the general population.

Attempts to predict the tumor growth rate on the basis of patient age and sex and the histological or immunohistochemical characteristics of the tumor have thus far yielded disappointing results.24,34

Progressive hearing loss probably occurs in most acoustic neuromas. Sterkers, et al.,31 reported progressive hearing loss in 77% of patients with small tumors, with sudden deafness developing in 13%. Haines and Levine9 reviewed experience reported with intracanalicular acoustic neuromas and found that four (57%) of seven evaluable patients had experienced progressive hearing loss on follow-up review. In three of these four patients hearing loss had progressed to nonserviceable hearing. It therefore appears that if preservation of serviceable binaural hearing is an objective in the management of intracanalicular acoustic neuromas, early surgery should be considered to prevent progressive or sudden hearing loss and tumor progression to a size that would increase risks related to surgical removal, particularly with respect to facial nerve function.

Surgical removal of intracanalicular acoustic neuromas is performed by the retrosigmoid–suboccipital or the middle fossa approach. The advantages for the surgeon of
Hearing preservation in removal of intracanalicular acoustic neuromas

![Hearing Preservation](image)

Fig. 2. Pie graphs showing hearing preservation results in 94 patients comparing intracanalicular tumors (left) and tumors extending medial to the porus acusticus (right). N = number of patients.

using the retrosigmoid approach are its familiarity and easily identified anatomical landmarks, and avoidance of excessive manipulation of the facial nerve and temporal lobe retraction. Apparent disadvantages are the incomplete exposure of the lateral end of the internal auditory canal, which could potentially pose a greater risk of injury to the cochlear nerve and of incomplete tumor removal, cerebellar retraction, possible injury to the endolymphatic duct or sac, and a higher incidence of postoperative pain.

The middle fossa approach is preferred by some surgeons because it affords easy access to the lateral end of the internal auditory canal and avoidance of cerebellar retraction. This approach is less familiar to the surgeon, with fewer reliable anatomical landmarks. It entails retraction of the temporal lobe with the attendant risk of neurological deficit or convulsive seizures and makes more manipulation of the facial nerve probable because of its position between the surgeon and the cochlear nerve.

The success rates for serviceable hearing preservation by the retrosigmoid and middle fossa approaches are shown in Table 2. Reported serviceable hearing preservation rates do not differ statistically from those found in the present series. This is true also of success rates reported for the middle fossa approach. The small series reported by Haines and Levine approaches statistical significance compared to the present series or any of the other series shown in Table 2 because of Haines and Levine’s 100% success rate for serviceable hearing preservation in six patients via the middle fossa approach.

It appears that outcome with respect to preservation of serviceable hearing does not differ as a result of using either the posterior or middle fossa surgical approaches. In fact, metaanalysis of the results from middle fossa compared with posterior fossa approaches, as set forth in Table 2, does not show a statistically significant difference in favor of either approach.

It is probable, therefore, that factors other than surgical approach have a more important effect on hearing conservation success. Cohen, et al., have shown that a maximum intracanalicular tumor diameter of 7 mm was associated with a significantly greater likelihood of serviceable postoperative hearing preservation. Other parameters assessed (for example, a preoperative SRT of less than or equal to 30 dB, SDS greater than or equal to 70%, and origin from the superior vestibular nerve) did not have a significant influence on hearing outcome.

The impact of CNAP monitoring on hearing preservation remains uncertain. We have found CNAP monitoring to be of great value in cranial nerve ablation and decompression procedures but of less certain value in acoustic neuroma removal. We have previously documented a significant difference in hearing preservation rates between monitored and unmonitored patients but the two groups differed chronologically. We have also previously demonstrated that a CNAP threshold shift of 20 dB or less is highly predictive of serviceable postoperative hearing. Nevertheless, in acoustic neuroma surgery, intraoperative changes in CNAP often correlate poorly with events in the operative field; therefore, the influence of monitoring on the performance of surgery is dubious despite its high predictive value.

Facial nerve function at follow-up review was normal or almost normal (House and Brackmann Grades I and II) in all but one of our patients. Comparison with other studies shows a similar outcome in series in which the retrosigmoid–suboccipital over the middle fossa approach was used. Reported results for the middle fossa approach are slightly less favorable overall. Metaanalysis of the series summarized in Table 3 suggests an advantage for the retrosigmoid–suboccipital over the middle fossa approach in regard to facial nerve outcomes.

The retrosigmoid approach tends to be associated with more postoperative pain, which may be relatively severe and of long duration. Our earlier experience confirmed the frequency of this problem. We found that 67% of our patients who underwent a conventional retrosigmoid approach experienced significant postoperative pain. We have been able to reduce rather dramatically the incidence of postoperative pain to 5% by modifications to the surgical approach. The mechanism of postoperative pain in this context is uncertain, but muscle attachment to the reconstituted dura may be important. Replacement and stabilization of the bone flap appears to have been a significant factor in reducing postoperative pain.

Radiosurgery may be considered as an alternative method of management for intracanalicular acoustic neuromas. There is little available information on preservation of useful hearing after radiosurgical treatment of small tumors. Ogunrinde, et al., report good results with preservation of serviceable hearing (SDS ≥ 50% and SRT/PTA ≤ 50 dB) at 12 months posttreatment in five (50%) of 10 patients with acoustic neuromas having intracanalicular diameters of 1 cm or less. In contrast, the overall experience of Hirsch and Norén with radiosurgery of acoustic neuromas having extracanalicular diameters of 3 cm or less was less satisfactory. In patients with unilateral tumors, four (21%) of 19 retained serviceable hearing (PTA < 50 dB and SDS > 80%) at 1 year posttreatment. Moreover, Hirsch and Norén found that hearing continued to deteriorate in many of their patients, so that only half as many patients exhibited hearing preservation at 4 years as at 1 year.

Delayed hearing deterioration after microsurgical removal of acoustic neuromas is known to occur, although
from reported experience this would appear to be a relatively rare occurrence. As discussed, we did not document significant delayed hearing deterioration in any of the patients with intracanalicular tumors for up to 1 year of postoperative follow-up review. Our previously reported experience, with a mean follow-up duration of 4 years in patients with postoperative hearing preservation, identified one patient in whom hearing declined to a nonserviceable level over time.

The experience of Goel, et al., is interesting. They reported delayed hearing deterioration in three (20%) of 15 patients in whom hearing preservation had been successful. These three patients showed fluctuation of hearing levels and eventual stabilization. Because all three of these patients retained serviceable hearing on final follow-up examination, the significance of delayed deterioration is questionable, as is the benefit of corticosteroid and diuretic agents, which two-thirds of the patients in that series received.

Pending a means of reliably predicting growth of intracanalicular acoustic neuromas, it appears that preservation of serviceable binaural hearing and normal facial nerve function is best served by early operation. The retrosigmoid approach is familiar to neurosurgeons and yields results comparable to those of the middle fossa approach for hearing preservation and, possibly, superior results for facial nerve function.

References

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460
Hearing preservation in removal of intracanalicular acoustic neuromas


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