Surgery for acoustic neurinoma

An analysis of 100 translabyrinthine operations


Departments of Neurosurgery and Otology, Addenbrooke’s Hospital, Cambridge, England

A consecutive series of 100 translabyrinthine operations for removal of acoustic neurinoma is reported. Complete tumor removal was achieved in 97% of cases. There were three perioperative deaths, and the postoperative morbidity rate was low. The facial nerve was preserved anatomically in 82% of patients. Preoperative facial weakness and tumor size larger than 2.5 cm were predictive of poor facial recovery. In patients with an intact nerve but complete facial palsy 1 week after surgery, electroneuronography was a good predictor of the final facial outcome and may influence the timing of rehabilitative procedures. With the exception of patients who have small tumors and good speech discrimination (where a suboccipital approach may preserve hearing acuity), the translabyrinthine operation is the procedure of choice for removal of acoustic neurinomas in patients who have normal hearing in the contralateral ear.

KEY WORDS □9 brain neoplasm □9 acoustic neurinoma □9 translabyrinthine approach □9 suboccipital approach □9 outcome

Controversy about the most appropriate route for excision of acoustic neurinomas continues. The first successful operation is attributed to Sir Charles Ballance in 1894.1 The retrosigmoid suboccipital approach was described by Krause in 1903,23 but the mortality rate at that time was appalling, ranging from 67% to 84%.6 This prompted Cushing to undertake subtotal removal, which reduced the mortality rate to around 25%3 by 1917, and to 4% by 1931.4 Dandy5 attempted total tumor removal with preservation of the facial nerve, which he achieved with a mortality rate of approximately 40%.

The translabyrinthine approach was proposed by Panse in 1904,27 and developed by Quix29 and Schmiegelow.31 Both Dandy and Cushing were scathing in their criticism of this operation, which they considered futile, dangerous, and necessarily resulting in facial nerve destruction and incomplete tumor removal.6 Despite the discouraging comment, William House19 reintroduced this exposure in 1964, employing modern microsurgical techniques. In his report of 41 operations there were no deaths, and all patients experienced some return of facial function.19 Excision was incomplete in 10% of his patients.

Attempts have been made recently to compare these “neurosurgical” and “otological” approaches.7 Several large series have been reported with excellent results; most advocate the suboccipital route;2,7,30,32,33 the translabyrinthine route is equally impressive.11,12,22,37 The division between the two approaches has hitherto been based largely upon tumor size. The consensus has often been that, while small tumors may be removed through the labyrinth, larger lesions are best approached suboccipitally. In this report, we present the results of our first 100 translabyrinthine operations, the majority of which were for large tumors.

Clinical Material and Methods

The case records of consecutive patients with acoustic neurinoma operated on by the senior authors (D.G.H. and D.A.M.) between 1981 and 1987 were reviewed retrospectively. One hundred operations were performed through the labyrinth. During the same period a further 14 acoustic neurinomas were removed suboccipitally with good results and without mortality. These 14 cases have not been included in the following analysis.

Ninety-seven tumors were primary, and three were recurrences following a previous suboccipital operation.
performed elsewhere. Two patients with von Recklinghausen's disease had large bilateral tumors, and in each case one lesion was excised suboccipitally in an attempt to preserve hearing. There were 44 males and 56 females, with a mean age of 53 years (range 19 to 76 years). The tumor size was classified according to Pulec, et al.28 Of the 100 tumors, 4 were small (intracanalicular), 30 were medium-sized (extending beyond the internal meatus but < 2.5 cm in diameter), and 66 were large (> 2.5 cm). Of the patients with large lesions, 21 had tumors between 2.5 and 3.4 cm, 26 had tumors of 3.5 to 4.4 cm, and 19 had tumors larger than 4.5 cm. The tumors were left-sided in 47 patients and right-sided in 53.

The most common symptom was partial or complete hearing loss, which occurred in 96 cases. Deafness was sudden in eight patients. Tinnitus affected 71 patients, and was usually at a high frequency. Unsteadiness was present in 77 cases; mastoid pain or otalgia was experienced by 28, and headaches by 29. Facial numbness affected seven patients, and seven complained of diplopia. There was one case of dysphagia.

Papilledema was present in 15 patients. Spontaneous nystagmus was found in 43 patients; in half of these cases, the deficit was a Brun's type of bidirectional nystagmus with a coarse nystagmus to the ipsilateral side, and a first-degree vestibular nystagmus to the contralateral side.3 The corneal reflex was depressed in 64 patients, and diminished sensation in the face was found in 34. Romberg's test was positive in 39 patients and Unterberger's test was positive in 28; a further 38 were too unsteady to be assessed.

Preoperative facial nerve function was graded by the House and Brackmann classification system17 (Table 1). In two of the three recurrent tumors the facial nerve had been sacrificed at the previous operation, but rehabilitative procedures had been undertaken. One additional patient experienced hemifacial spasm.

All patients underwent a complete audiological and vestibular assessment. Abnormal caloric responses were obtained in 97 patients, and auditory evoked brainstem responses were abnormal or absent in 98. Details of the shape of the pure tone audiogram are given in Fig. 1. Plain radiographs of the internal auditory meatus were taken in 96 patients, and were abnormal in 77 (80%) of them. Computerized tomography (CT) with intravenous contrast material was undertaken in 99 patients, and was abnormal in all but one case; in addition, CT air metathography was used in 18 patients and all results were abnormal. The fourth ventricle was displaced in 55 patients, and hydrocephalus was present in 23 (Fig. 2). Fifteen patients required shunting prior to tumor excision, and two others required shunting postoperatively.

The translabyrinthine operation was performed as described by House.19 It was selected for all patients except those who had small tumors and socially useful hearing with good speech discrimination. Hearing preservation was also attempted on one side in the two patients with bilateral tumors; the hearing in the other ear was so poor and the tumor so large that hearing...
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FIG. 3. Relationship between a patient's position in the series and loss of facial nerve (left) and mean tumor size in patients with facial nerves lost at operation (right).

preservation was not attempted. All operations, both translabyrinthine and suboccipital, were performed with the patient supine. Neither ventricular nor lumbar drainage procedures were undertaken perioperatively, nor were steroids administered routinely. Lumbar punctures were performed daily for the first 5 days.

Postoperative electroneuronography was undertaken around the 8th day in 12 patients with intact nerves who preoperatively had House Grade I facial nerve function. A percentage degeneration was calculated by comparing the ipsilateral amplitude of the compound action potential with that of the contralateral (normal) side. Patients were reassessed at intervals for 6 months, at which time their facial function was regraded.

Results

Complete tumor excision was achieved in 97 patients. There has been no case of tumor recurrence during a follow-up period of 1 to 7 years. Incomplete excision was considered appropriate in two frail elderly patients, and in a third patient whose tumor capsule was densely adherent to the brain stem. The facial nerve was preserved in 82% of the 98 patients with an intact nerve preoperatively. The success of preservation of the facial nerve improved consistently during the early part of the series (Fig. 3), indicating the "learning curve" for the technique. Currently, approximately 90% of facial nerves are preserved.

There were three perioperative deaths early in the series. All of these patients had tumors larger than 3.5 cm in diameter. One death followed brain-stem infarction, and one patient succumbed from a postoperative cerebellopontine angle hematoma. The third death resulted from a pulmonary embolus. Thirteen patients had leakage of cerebrospinal fluid (CSF), three of whom developed meningitis. Three of the leaks responded to lumbar drainage alone; the remainder required reexploration. All of the CSF leaks occurred among the first 42 cases in the series, and as a result the technique of wound closure was modified. In the present method, a posterior tympanotomy slot is cut in order to facilitate packing of the eustachian tube with fat. The middle ear cavity and aditus are filled with bone pâté (a mixture of bone dust and blood). A patch of fascia lata is then applied to the posterior canal wall and aditus, and sealed with fibrin glue (Tisseele).* Finally, the remaining cavity in the temporal bone is filled with long strips of fat placed through the dural defect just into the cerebellopontine angle. These too are sealed with fibrin glue. With this method there has been no further case of CSF leak.

A transient postoperative bulbar palsy developed in five patients with large tumors, but full recovery occurred in every case. A temporary lateral tarsorrhaphy was required in 58 patients. Ninety-four patients (excluding the three who died and the three with recurrent tumors) were regraded according to the House classification 1 year after surgery. Fourteen were in Grade I, 15 in Grade II, 24 in Grade III, 14 in Grade IV, 12 in Grade V, and 15 in Grade VI. Of the 41 patients with a poor result (House Grades IV to VI), 34 (83%) had large tumors.

Rehabilitative procedures were offered to all patients with a poor result. In one, a primary nerve anastomosis at the time of tumor resection produced Grade III facial nerve function. Facial-hypoglossal nerve anastomosis was performed in six cases; a Grade III result was achieved in four, a Grade IV result in one, and a Grade V result in one. Twenty-six patients underwent a total of 72 dynamic or static rehabilitative measures, such as an upper-lid gold weight, a face lift, temporalis nerve transfer, or cross-facial anastomosis.

Of the 12 patients studied by electroneuronography, one had House Grade II function at the end of the 1st week, one had Grade IV, and 10 had Grade VI. Four patients showed incomplete nerve degeneration, and all rapidly attained House Grade I or II. In contrast, all of the eight patients who exhibited complete degeneration had a protracted and incomplete recovery. After 6 months, one had achieved House Grade III, three were in House Grade IV, and three remained in House Grade VI.

The quality of life, excluding facial function, was

* This blood-based product has recently been withdrawn pending further tests to exclude possible transmission of an infective agent.
assessed in the 97 survivors. An excellent outcome was achieved in 77, who made a complete recovery and were able to resume their previous employment. A fair result was obtained in 20% of patients, who were independent but unable to work, often as a result of failure of vestibular compensation. A poor result was obtained in 3% of patients, who were rendered severely disabled and were no longer independent. All patients with results classified as “fair” or “poor” had had large tumors (Table 2).

Of the 14 suboccipital operations, the cochlear nerve was preserved in 13, and the facial nerve remained intact in every case. Only three patients (23%) retained any hearing postoperatively, and this was considered socially useful in only two. All of these patients had small tumors, and the outcome was excellent in every case.

Discussion

The present goals of acoustic neurinoma surgery have altered considerably in the last 75 years. The mortality rate has fallen steadily from 80% to less than 5% with the introduction of microsurgical techniques and modern anesthesia. Reduction in morbidity is now the focal point of discussion, principally related to the preservation of facial function and the salvage of useful hearing. The success of each is undoubtedly related to tumor size. Early detection is therefore of considerable importance.

Sensorineural deafness is the most common presentation, and audiological tests often suggest a retrocochlear hearing loss. High-frequency hearing loss is the most common abnormality seen on pure-tone audiometry, while brain-stem auditory evoked potentials are the most sensitive indicator of a retrocochlear lesion. Of patients with acoustic neurinomas, 98.5% will show an abnormality in at least two of the following investigations, namely: caloric testing, auditory evoked brain-stem responses, and plain radiology of the internal auditory canal. These investigations provide a good screening test for the condition, and would prove cost-efficient if adopted to find tumors at an early stage.

There has been much discussion in the literature concerning the merits of the translabyrinthine, suboccipital, middle fossa, and combined approaches to the cerebellopontine angle. Good results have been achieved with each technique, suggesting that an experienced surgical team and the use of microsurgical techniques are of greater importance than the surgical approach per se. We prefer the translabyrinthine operation for medium- and large-sized tumors. It provides a more direct route to the cerebellopontine angle, and exposure is at the expense of bone rather than cerebellar retraction (Fig. 4). The facial nerve can be exposed on either side of the tumor, and in our hands this increases the chance of its preservation. Although a number of series employing the suboccipital route show high anatomical preservation rates for the facial nerve, most are in patients selected for hearing preservation procedures. These groups inevitably have a high proportion of smaller tumors, and therefore a better prognosis. In unslected series, anatomical preservation rates are generally around 71% to 90% for the suboccipital route and 82% to 96% for the translabyrinthine group. Despite the comments of some, this difference cannot be accounted for by a disparity in the number of total excisions achieved. In our series, 97 patients had complete removal of their tumor. Of the remaining three, either the patients were elderly or the tumor capsule was densely adherent to the brain stem. Tumor involving the only hearing ear may also require incomplete excision if the cochlear nerve and inner ear vasculature are to be preserved.

Mortality rates for the two approaches are similar, but postoperative morbidity and hospital stay are generally shorter when the translabyrinthine route is used. A series of 116 geriatric patients treated for acoustic neurinomas, principally via the labyrinth, was recently managed with a mortality rate of less than 1% and with little morbidity.

**TABLE 2**

<table>
<thead>
<tr>
<th>Tumor Size</th>
<th>No. of Survivors</th>
<th>Final Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>intracanalicular</td>
<td>4</td>
<td>100%</td>
</tr>
<tr>
<td>2.5 cm</td>
<td>30</td>
<td>83%</td>
</tr>
<tr>
<td>2.6-3.4 cm</td>
<td>21</td>
<td>85%</td>
</tr>
<tr>
<td>3.5-4.4 cm</td>
<td>24</td>
<td>71%</td>
</tr>
<tr>
<td>&gt; 4.5 cm</td>
<td>18</td>
<td>61%</td>
</tr>
</tbody>
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* Follow-up period: 1 to 7 years.

![Fig. 4. Postoperative computerized tomography scan following translabyrinthine removal of an acoustic neurinoma.](image) Exposure of the cerebellopontine angle and internal auditory meatus is more direct than with a suboccipital approach. An island of bone can be seen covering the sigmoid sinus, thereby allowing it to be depressed without risk of injury.
Anatomical preservation of the facial nerve does not necessarily result in a good functional outcome. The timing of reassessment is also important, as facial function may fade several days after surgery. Subsequent recovery is not assured, and is rarely complete.\(^{10,22}\)

Primary nerve grafting is the procedure of choice for nerves divided at operation. For postoperative rehabilitation, facial-hypoglossal nerve anastomosis provides better results than dynamic and static rehabilitative procedures. However, the timing of surgery is important. Facial function may return after a year of paralysis but, if this does not occur, facial-hypoglossal nerve anastomosis at this stage is usually either impossible or unsatisfactory because of degeneration in the distal facial nerve. Electroneuronography performed at 1 week appears to be a good predictor of a poor outcome, and may permit early rehabilitation for patients with little prospect of a good spontaneous recovery.

Complete hearing loss is a disadvantage of the translabyrinthine operation. Yet in only 1% of affected ears will hearing be normal following acoustic neurinoma removal via the suboccipital approach,\(^{16}\) and it is extremely rare for hearing to be better than the preoperative level.\(^{25}\) Anatomical preservation of the cochlear nerve correlates poorly with function, and any remaining hearing is present in only about one-third of those undergoing hearing preservation operations.\(^{11}\) In only a small percentage of this group is the hearing “useful.” Success falls off rapidly with tumors larger than 2 cm, and there are very few cases of hearing preservation with tumors larger than 3 cm.\(^{11,13}\) The success of hearing preservation cannot be predicted from preoperative audiological investigations.\(^{25}\) Intraoperative monitoring of cochlear function has been attempted, but its value is uncertain.\(^{26}\) Despite sparing 13 cochlear nerves in the 14 of our patients who underwent a suboccipital operation, hearing was preserved in only three (23%), and was useful in only two.

Although there is no doubt that efforts must be made to save hearing in a solitary hearing ear or, when the tumor is bilateral, hearing loss need not be profound before it becomes socially useless if the other ear is normal. In such cases, preservation of hearing threshold alone is insufficient. For hearing to be useful socially there must be both good speech discrimination and a pure-tone audiogram within 20 dB of the normal ear. In one series, only 16% of patients with an intact cochlear nerve were able to use the telephone with the affected ear; 4.4% of the entire group had undergone suboccipital removal of their tumor.\(^{2}^{\text{3}}\) For this reason we agree with others\(^{8,20}\) that, for patients with unilateral lesions, facial nerve preservation takes priority over hearing. With smaller tumors, anatomical preservation of the facial nerve approaches 100% with either route, and the degree of hearing loss should then determine the surgical approach. Contrary to the generally held view, for larger tumors the increased chance of preserving the facial nerve and the generally lower morbidity rate in our hands makes the translabyrinthine operation the procedure of choice.

Acknowledgments

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References

20. House WF, Luetje CM: Acoustic Tumours, Vol II. Man-

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Address reprint requests to: David G. Hardy, F.R.C.S., Department of Neurological Surgery, Addenbrooke’s Hospital, Hill’s Road, Cambridge CB2 2QQ, England.