Acoustic neuroma surgery
in Northern Ireland 1976–1986

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SUMMARY
Forty acoustic neuromas have been removed surgically between 1976 and 1986. The condition was unilateral in 32 and bilateral in four. There were 31 large, four medium and five small tumours. Excision was complete in 16 and incomplete in 24. Of the incomplete removals 14 were subtotal leaving microscopic remnants, eight were partial capsular and two were intracapsular. Follow-up ranged from two months to ten years (median 3·5 years).

There was one early death in an 83-year-old. The overall incidence of post-operative complete facial paralysis was 20% but reached 55% for large tumours when excision was complete. Twenty-eight patients had hearing before operation and in eleven patients some preservation of hearing was possible (39%). In these, the excision was complete in three, subtotal in four, partial capsular in three and intracapsular in one.

Of the unilateral tumours, there have been three recurrences requiring repeat surgery. All were initially incompletely excised. Two were of an invasive nature causing considerable erosion of the petrous temporal bone making complete excision impossible. For the bilateral tumours a deliberate incomplete excision was first performed on one side to ensure preservation of hearing. Further excision on this side was then left until such time as hearing was lost. Complications included CSF otorhinorrhoea (5%), persistent but temporary numbness and vomiting (10%), meningitis (5%), facial numbness (5%) and hoarseness and dysphagia (3%).

INTRODUCTION
The most common tumour arising in the eighth cranial nerve is usually termed an acoustic neuroma. Because of tradition we shall continue to use this term but it is important to state at the outset that it is doubly inaccurate — the tumour most commonly arises from the vestibular nerve, and is a schwannoma.

The first successful operation on an acoustic neuroma was performed in 1894 by Sir Charles Ballance.1 In those days the mortality rate for total tumour removal was very high. At the 1913 International Congress of Medicine, the mortality rates of three eminent European surgeons — Horsley of London, Eiselsberg of Vienna and Krause of Berlin — ranged from 67%—84%. These results prompted
Cushing\textsuperscript{2} to perform partial removal, with a reduction in operative mortality to 20\%. However, although the mortality was reduced, one fourth of the surviving patients died within five years as a result of recurrence or revision surgery. In 1925 Dandy\textsuperscript{3} using the suboccipital approach reported an operative mortality rate of 40\% for total tumour resection. The survivors invariably had permanent complete postoperative facial paralysis.

In 1964, House\textsuperscript{4} introduced a microsurgical translabyrinthine technique for the removal of acoustic neuromas with a considerable reduction in both mortality and morbidity. He reported an operative mortality of 5.4\% and in the survivors a 94\% preservation of facial function. He also suggested the development of a team approach to the removal of acoustic tumours, with co-operation between otologists and neurosurgeons. Rand and Kurze\textsuperscript{5} in 1965 were the first to treat acoustic tumours by microsurgery using the suboccipital route.

Until the last two decades most patients had little or no residual auditory function by the time of diagnosis. Because of improved methods of investigation and diagnosis this now is frequently not the case and a further challenge is to preserve residual cochlear function while accomplishing the main goals of surgical excision and preservation of facial function.

PATIENTS AND METHODS

Between 1976 and 1986, 48 acoustic neuromas were treated surgically in the Royal Victoria Hospital, Belfast. This report analyses the results obtained in 40 of these tumours under the care of an individual neurosurgeon and two otologists. All of the procedures were carried out through a suboccipital craniectomy as described by Smyth et al.\textsuperscript{6}

There were 32 patients with unilateral and 4 with bilateral tumours. Two of the patients with bilateral tumours were brothers; their mother had a unilateral tumour, and a sister had bilateral tumours but these latter two do not form part of this report. All four of this family had von Recklinghausen’s neurofibromatosis. The tumour was on the right side in 19, and the left side in 21 cases. There were 22 males and 14 females. Age ranged from 11–83 years (median 44 years).

Twenty-nine patients presented with unilateral deafness (Table 1). The first symptom was tinnitus in three, vertigo in two and progressive bilateral deafness in

| Symptoms                        | No  | Signs                   | No |
|---------------------------------|-----|-------------------------|----|
| Deafness                        | 39  | Ataxia — Gait           | 17 |
| Tinnitus                        | 26  | Arm                     | 6  |
| Unsteadiness of gait            | 16  | Reduced corneal reflex  | 14 |
| Facial numbness/paraesthesia    | 8   | Nystagmus                | 7  |
| Headache                        | 5   | Facial weakness         | 5  |
| Vertigo                         | 4   | Papilloedema            | 3  |
| Facial pain                     | 3   | Vocal cord paresis      | 1  |
| Hemifacial spasm                | 1   |                         |    |
| Vomiting                        | 1   |                         |    |
| Hoarseness                      | 1   |                         |    |
| Dysphagia                       | 1   |                         |    |

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two. Where vertigo was the first symptom, one patient had had a totally deaf ear on the side of the tumour following mastoid surgery 20 years previously and the other had a tumour which arose medial to the internal auditory meatus and reached but did not enter the meatus.

There are three stages of clinical progression. In Stage I only the eighth nerve is involved, with deafness and tinnitus being the only symptoms. In Stage II other neurological manifestations are present, usually cerebellar ataxia and trigeminal nerve involvement. Patients in Stage III have raised intracranial pressure and papilloedema. There were 31 large (>2.5 cm diameter), four medium (1.0–2.5 cm) and five small (<1.0 cm) tumours. Small and medium tumours all presented in Stage I, apart from one patient with bilateral tumours, as did 40% of the large tumours (Table II). The duration of symptoms ranged from a few months to 25 years but there was no correlation between size of tumour and duration of symptoms.

### Table II

Tumour size and clinical stage at presentation, and completeness of surgical excision

| Tumour size | Tumour Stage | Excision |
|-------------|--------------|----------|
|             | I     | II   | III    | Total | Complete | Incomplete |
| Small       | 4     | 1    | —     | 5     | 4        | 1          |
| Medium      | 3     | 1    | —     | 4     | 3        | 1          |
| Large       | 12    | 16   | 3     | 31    | 9        | 22         |

Tumour excision was complete in 16 and incomplete in 24 cases. Of the incomplete removals 14 were subtotal, eight were partial capsular and two were intracapsular. Subtotal removal ranged from a microscopic plaque of tumour capsule left attached to the facial nerve or brainstem to a cuff of tumour remaining extending from the porous acousticus to the brainstem surrounding the facial and vestibulocochlear nerves. The reasons for incomplete excision included the patient's age or debility, fluctuating vital signs during surgery, attempts to preserve facial or cochlear function, or adherence of the tumour to the brainstem. In the four patients with bilateral tumours, a deliberate decision was taken before operation to perform an incomplete excision in all the operations on the first side and in two of the four second side operations, thereby attempting to ensure some preservation of hearing for as long as possible. Varying degrees of cerebellar hemisphere excision were required in 13 tumours, 12 large and one medium sized, to improve exposure and reduce retraction. The duration of follow-up ranged from two months to ten years (median 3.5 years).

**RESULTS**

**Morbidity**

There was one death during hospitalization, on the 12th postoperative day. This occurred in an 83-year-old woman who had a large tumour which necessitated surgery and was incompletely removed. Her initial postoperative course was satisfactory but she later developed a basal pneumonia and died.
Facial nerve function one year postoperatively

In the nine small and medium sized tumours facial nerve function was preserved fully in eight (89%) and partially in one (11%). In the 31 large tumours facial function was preserved fully in 19 (61%), partially in four (13%) and there was a permanent and complete facial paralysis in eight (26%). (Table III).

**Table III**

The influence of tumour size and completeness of surgical excision on facial nerve function postoperatively. The result was considered good when function was normal or near normal, and fair when weakness and asymmetry were marked.

| Size   | Surgical excision | Good | Fair | None | Total |
|--------|-------------------|------|------|------|-------|
| Large  | Complete          | 2    | 2    | 5    | 9     |
|        | Incomplete        | 17   | 2    | 3    | 22    |
| Medium | Complete          | 2    | 1    | 0    | 3     |
|        | Incomplete        | 1    | 0    | 0    | 1     |
| Small  | Complete          | 4    | 0    | 0    | 4     |
|        | Incomplete        | 1    | 0    | 0    | 1     |
| Total  |                   | 27   | 5    | 8    | 40    |

Large tumours were completely excised in nine patients, of whom five (56%) had a complete facial paralysis; in three of these the nerve was known to have been divided or damaged during the operation. Excision was incomplete in large tumours in 22 patients of whom only three (14%) had a complete facial paralysis. Of these 22 patients there were 13 in whom excision was subtotal and of these only one (8%) had a complete facial paralysis. The overall incidence of complete facial paralysis was 20%.

Cochlear nerve function following surgery

Twenty-eight patients had varying degrees of hearing before operation. Of these, 17 (61%) had no recordable hearing postoperatively; the cochlear nerve was seen to be divided in seven. Some hearing conservation was therefore achieved in 11 patients (39%). (Table IV). Of these, excision was complete in three, subtotal in four, partial capsular in three and intracapsular in one. Of the completely excised tumours two were large and one was medium sized. In two of these three the hearing preservation has been maintained at two and five years. However, the remaining patient developed meningitis three weeks postoperatively and there was a gradual decline in his hearing threshold so that at seven years there was no recordable hearing. Of the 13 large tumours that have been subtotal excised, prolonged preservation of cochlear function has been possible in three.

If a speech discrimination of 50% is considered to be essential for useful hearing only three out of the 40 ears still have useful hearing and of these only one had a complete excision.

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Table IV

Cochlear nerve function following surgery: average pure tone hearing is recorded in decibels at 500–4000 Hz and speech discrimination is recorded as a percentage of normal

| Size       | Surgical excision | Preoperative | Early Postoperative | Follow-up                                      |
|------------|-------------------|--------------|---------------------|------------------------------------------------|
| Small      | Subtotal          | 65           | 76%                 | 50 | 88% | Gradual decline (repeat surgery at 3 years) |
| Medium     | Complete          | 30           | 84%                 | 65 | 72% | Meningitis (gradual decline to nil)         |
| Medium     | Partial capsule   | 50           | 80%                 | 45 | 80% | Gradual decline to nil (repeat surgery at 3 years) |
| Large      | Complete          | 20           | 52%                 | 45 | 84% | 2 years                                    |
| Large      | Complete          | 30           | 92%                 | 60 | 24% | 5 years                                    |
| Large      | Subtotal          | 55           | 92%                 | 70 | 24% | 4 years                                    |
| Large      | Subtotal          | 65           | 72%                 | 60 | no record | 1 year                                   |
| Large      | Subtotal          | 85           | nil                 | 95 | nil | 4 years                                    |
| Large      | Partial capsule   | 30           | 96%                 | 35 | 96% | 1 year                                    |
| Large      | Partial capsule   | 45           | 80%                 | 60 | 88% | 4 years                                    |
| Large      | Intracapsular     | 65           | 72%                 | 65 | 76% | Gradual decline to nil                     |
Other complications

Balance was impaired in 16 patients before operation. Only two remained significantly handicapped by balance problems beyond one year postoperatively. Cerebrospinal fluid otorhinorrhoea occurred in two patients both of whom required a second operation. Persistent nausea and vomiting occurred postoperatively in two patients lasting from several days to four weeks; all eventually settled. Other complications consisted of two cases of meningitis, two of facial pain, two of facial numbness and one of hoarseness and dysphagia.

To date there have been six recurrences requiring repeat surgery. Three were patients with bilateral tumours where the initial surgery was deliberate incomplete excision to preserve hearing, in the knowledge that further surgery would be required; repeat surgery was performed three to nine years later. The other three cases were patients with large tumours. One was initially incompletely excised and required repeat surgery after three years. The other two were unusually invasive with extensive erosion of the petrous bone, making complete excision impossible even at repeat surgery.

DISCUSSION

The risk of death following excision of an acoustic neuroma remains low. The incidence for this series was 2.5%. The size of the tumour tends to determine the difficulty of the operation and the postoperative morbidity and mortality. One of the four patients with bilateral tumours subsequently developed neurofibromata elsewhere in the central nervous system and died from that cause.

Facial nerve preservation is excellent after removal of small and medium sized tumours. In an attempt to reduce the morbidity associated with removal of large tumours, subtotal excision was performed in 42%. Where the tumour was large, the incidence of complete facial paralysis was 56% with complete excision and 8% with subtotal excision.

Although the cochlear nerve can be isolated and spared during tumour removal, the blood supply of the tumour and the cochlear nerve is intertwined making preservation of hearing more difficult than preservation of facial function. Of those patients in whom there was residual hearing before operation, some hearing conservation has been possible in 39%. Paradoxically, for the five small tumours hearing preservation has been possible in only one (20%), whereas of the 19 large tumours with preoperative recordable hearing, preservation of hearing was possible in eight (42%). Although Sterkers noted that postoperative facial function was always normal when hearing was preserved, we did not find this to be the case. Of the three cases where excision was complete and cochlear function was preserved, two had a permanent and complete facial paralysis.

One of the advantages of the translabyrinthine technique claimed by King and Morrison is that it avoids damage to the cerebellum which they believe is responsible for ataxia after the posterior fossa approach. However, in this series only two patients who did not have preoperative ataxia were unsteady after the operation and both recovered within a few months. Thirteen patients had excision of the lateral third of the cerebellar hemisphere; this did not appear to cause postoperative ataxia.

Cerebrospinal fluid otorhinorrhoea appears to be a relatively common postoperative complication in other series. King and Morrison experienced a 14% incidence following translabyrinthine removal and Harner and Ebersold a 12%
following the suboccipital approach; we noted an incidence of only 5%. One case occurred as a result of incomplete waxing of exposed mastoid air cells and the other because of the presence of a posteromedial air cell tract in the posterior wall of the internal auditory meatus.¹⁰

To date the incidence of clinical recurrence requiring repeat surgery is 15%. These are largely limited to the deliberately incomplete operations on bilateral tumours and the invasive tumours where there is considerable erosion of the petrous temporal bone. Cross¹¹ has suggested that subtotal removal might cause regression of the tumour, perhaps from interruption of its blood supply. Silverstein et al.¹² have advocated subtotal excision chiefly for elderly patients with large tumours thereby enabling them to live the remainder of their lives without distressing neurological symptoms. In this series, of the 14 patients who had an initial subtotal excision, two (14%) have required a further operation because of clinical recurrence, the duration of follow-up being from 1.2 – 8 years.

The management of patients with bilateral tumours presents formidable difficulties because of the risk of total deafness, loss of labyrinthine function and bilateral facial paralysis. Of the four patients in this series with bilateral tumours, three were diagnosed as being bilateral at first presentation. In these patients, all of whom had residual bilateral hearing, our approach was to perform a deliberate incomplete excision on one side, concentrating on decompression of the internal auditory meatus, where compression ischaemia of the cochlear nerve probably takes place. Most of the tumour was removed leaving a bridge of tumour covering the seventh and eighth cranial nerves between the internal auditory meatus and brainstem. Any further excision was then left until such time as hearing was lost. With successful preservation of hearing on the first side, a complete excision was then performed on the opposite side in one patient and an incomplete excision in two. Following the initial incomplete operation on the first ear with preservation of the hearing, all experienced a gradual and progressive decline in the hearing over a period of three to five years, reaching a stage where there was no residual hearing on that side. Repeat surgery has since been performed in two. So far we have managed to preserve some hearing in one ear in two out of the four patients with bilateral tumours. Facial function was preserved fully following the initial operation on both sides in all patients, but repeat surgery in one has resulted in a complete unilateral facial paralysis.

The mortality rate for acoustic neuroma removal using the suboccipital approach remains low. For small and medium sized tumours preservation of facial function is excellent; for large tumours when completely excised there is still a high incidence of complete facial paralysis. The likelihood of hearing preservation remains low when excision is complete. Subtotal excision has reduced the morbidity associated with surgery and the incidence of clinical recurrence has been low.

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