Removal of large acoustic neurinomas (vestibular schwannomas) by the retrosigmoid approach with no mortality and minimal morbidity

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METHODS

Patient population
The subjects consisted of 89 consecutive patients with unilateral acoustic neurinomas in the period from 1992 to 2001. The extrameatal diameter of the tumours was ≥3 cm in 50 of the 89 tumours (large; 56%), and <3 cm in 39 (small to medium; 44%). In this study we analysed the 50 patients with large tumours. Patients with neurofibromatosis type 2 or with a recurrent tumour were excluded from the study.

Surgical procedure
All operations were done by single neurosurgeon (IY), using the retrosigmoid suboccipital transmeatal approach in the lateral position. A curvilinear skin incision of 12 cm length was placed 3–4 cm posterior to the mastoid. A longer incision placed more medially was used in patients with short thick necks, while a shorter skin incision placed more laterally was used in those with long thin necks. Irrespective of the tumour size, a retrosigmoid suboccipital craniotomy of 5 cm length and 4 cm width was made to expose the posterior part of the sigmoid sinus and the inferior part of the transverse sinus. The foramen magnum was not usually opened.

Surgical removal is the sole treatment for large acoustic neurinomas because stereotactic radiosurgery is not applicable.1,2 The translabyrinthine,3,4 retrosigmoid suboccipital,5,6 and middle fossa approaches8,9 are the three basic approaches for the removal of these tumours. Recent papers have recommended the translabyrinthine approach for the removal of large tumours and have reported good results with this technique.4,5,6,8,9 However, we have used the retrosigmoid suboccipital approach for over 20 years for the removal of acoustic neurinomas of all sizes. In this study, we reviewed 50 consecutive patients with large tumours that were removed by the retrosigmoid approach over the past 10 years.

Objective: To evaluate the safety and efficacy of removing large acoustic neurinomas (≥3 cm) by the retrosigmoid approach.

Methods: Large acoustic neurinomas (mean (SD), 4.1 (0.6) cm) were removed from 50 consecutive patients by the retrosigmoid suboccipital approach while monitoring the facial nerve using a facial stimulator-monitor. Excision began with the large extrameatal portion of the tumour, followed by removal of the intrameatal tumour, and then removal of the residual tumour in the extrameatal region just outside the porus acusticus. The last pieces of tumour were removed by sharp dissection from the facial nerve bidirectionally, and resected cautiously in a piecemeal fashion.

Results: There were no postoperative deaths. The tumour was removed completely in 43 of 50 patients (86%). The facial nerve was anatomically preserved in 92% of the patients and 84% had excellent facial nerve function (House-Brackmann grade 1/2). One patient recovered useful hearing after tumour removal. Cerebrospinal fluid leak occurred in 4%, but there were no cases of meningitis. All but two patients (96%) had a good functional outcome.

Conclusions: The method resulted in a high rate of functional facial nerve preservation, a low incidence of complications, and good functional outcomes, with no mortality and minimal morbidity. Very favourable results can be obtained using the retrosigmoid approach for the removal of large acoustic neurinomas.
was considered significant. Data were analysed using the Karnofsky scale. The completeness of tumour removal was judged by surgical records and postoperative MRI. Tumour removal was complete in 43 patients (86%) and subtotal in seven. All seven subtotal removals were done in the early study period (1992 to 1996). The proportions of cases with subtotal/total removal were 7/27 (26%) and 0/23 (0%) in the periods from 1992 to 1996 and from 1997 to 2001, respectively. The difference between the two periods was significant (p = 0.01, Fisher’s probability test). Removal was subtotal in the following: in three patients who requested subtotal removal rather than risk facial palsy, so a small part of the tumour adhering to the facial nerve was intentionally left; in two patients in whom a small part of the tumour adhering to the brain stem was left because hypertension and tachycardia occurred when we attempted to dissect the tumour; and in one patient in whom intraoperative cerebellar swelling resulted in subtotal removal.

Completeness of tumour removal

Functional outcome

The facial nerve was anatomically preserved during the tumour removal in 46 patients (92%). Of four patients in whom the facial nerve was divided, three underwent primary nerve anastomosis using a nerve graft and one underwent hypoglossal–facial nerve anastomosis. These facial nerve reconstructions resulted in intermediate facial nerve function. Of 46 patients with anatomically preserved facial nerves, 42 (84%) showed excellent facial nerve function, three (6%) showed intermediate function, and one showed poor function (fig 2).

Postoperative complications and functional outcome

There were no postoperative deaths. Cerebellar haemorrhage resulted in persistent ataxia in two patients. A supratentorial epidural haematoma occurred in one patient who underwent ventricular drainage for hydrocephalus. Two patients developed CSF leaks, which were treated by lumbar drainage only, and no surgical repair was necessary. There were no postoperative cases of meningitis. Preoperative trigeminal neuropathy improved or resolved completely in most patients after tumour removal. Hypaesthesia of the face was exacerbated in three patients. Useful hearing was not preserved in 49 patients; however, in one patient tumour removal improved the hearing from class C to class B, and useful hearing was restored (fig 3). Endotracheal intubation during surgery caused bilateral recurrent nerve palsy in two patients, resulting in transient hoarseness and swallowing disturbance.18,19 One patient developed dyspnoea from neck swelling and needed a temporary tracheostomy.

Functional outcome was good in 48 patients (Karnofsky score, 90). Two patients had Karnofsky scores of 80 and 70 because of persistent ataxia. In five patients tumour removal caused resolution of severe preoperative ataxia as well as of the peritumoral oedema (fig 4). Of 15 patients with preoperative hydrocephalus, five (33%) required CSF diversion.
Long term follow up and tumour recurrence
The follow up period after the tumour removal was 12 to 115 months (mean 58 (33) months). There were no deaths relating to the acoustic neurinoma during the follow up period. Three patients died from cancer (two of the stomach and one of the pancreas), one from myocardial infarction, and one from an intracerebral haemorrhage. Four patients (8%) had tumour recurrence and underwent a second tumour removal. The interval between the first and second operations was between 27 and 54 months (mean 41 (11) months). The initial tumour removal in these four patients with tumour recurrence was subtotal, and none of 45 patients with total removal had recurrences (p<0.0001, $\chi^2$ test with Yates correction) (fig 5).

DISCUSSION
Preoperative characteristics of large acoustic neurinomas
In our series, 22% of patients with large tumours had useful hearing preoperatively, higher than previously reported.20 Trigeminal neuropathy, the second most common cranial nerve sign, occurs in of 45%20 to 70% of patients.20 In our series, the preoperative trigeminal neuropathy usually resolved after tumour removal. Patients with large tumours commonly present with cerebellar ataxia.20

Hydrocephalus caused by acoustic neurinoma results not only in symptoms of increased intracranial pressure (headache and papilloedema), but also in symptoms of normal pressure hydrocephalus (gait disturbance, dementia, incontinence) in elderly patients.20 22 Pirouzmand et al reported that 36 of 39 patients (92%) with cerebellopontine angle tumour associated with hydrocephalus showed symptoms of normal pressure hydrocephalus.22 Although tumour removal often causes resolution of hydrocephalus,21 24 one third of patients required CSF diversion.

Table 1 Clinical characteristics of 89 unilateral acoustic neurinomas

<table>
<thead>
<tr>
<th></th>
<th>Large tumour (&gt;3 cm)</th>
<th>Small-medium tumour (&lt;3 cm)</th>
<th>p Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of patients</td>
<td>50</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>Age (years) (mean, SD, range)</td>
<td>52 (15), 8 to 73</td>
<td>51 (11), 24 to 69</td>
<td>NS</td>
</tr>
<tr>
<td>Sex (male:female)</td>
<td>21:29</td>
<td>21:18</td>
<td>NS</td>
</tr>
<tr>
<td>Side of tumour (right:left)</td>
<td>22:28</td>
<td>19:20</td>
<td>NS</td>
</tr>
</tbody>
</table>

Clinical signs and symptoms

| Hydrocephalus       | 15 (30%)             | 1 (3%)                      | $p<0.01$ |
| Papilloedema        | 5 (10%)              | 1 (3%)                      | NS       |
| Trigeminal neuropathy | 39 (78%)             | 15 (38%)                    | $p<0.01$ |
| Facial palsy        | 0 (0%)               | 0 (0%)                      | NS       |
| Hearing loss        | 48 (96%)             | 36 (92%)                    | NS       |
| IX and X cranial nerve signs | 7 (14%)          | 0 (0%)                      | $p=0.02$ |
| Cerebellar ataxia   | 32 (64%)             | 0 (0%)                      | $p<0.01$ |

*The proportional difference between the large and small to medium tumours was analysed using the $\chi^2$ test with Yates correction.

Table 2 Preoperative hearing of 50 patients with large acoustic neurinomas

<table>
<thead>
<tr>
<th>PTA (dB)</th>
<th>No of patients</th>
<th>Hearing level*</th>
<th>No of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;30</td>
<td>4</td>
<td>Class A</td>
<td>4</td>
</tr>
<tr>
<td>30–50</td>
<td>8</td>
<td>Class B</td>
<td>7</td>
</tr>
<tr>
<td>50–70</td>
<td>11</td>
<td>Class C</td>
<td>12</td>
</tr>
<tr>
<td>&gt;70</td>
<td>27</td>
<td>Class D</td>
<td>27</td>
</tr>
</tbody>
</table>

*Hearing level classification according to the guidelines of the Committee on Hearing and Equilibrium of the American Academy of Otolaryngology, Head and Neck Surgery Foundation. PTA, pure tone average.

Table 3 Tumour consistency and size of 89 acoustic neurinomas

<table>
<thead>
<tr>
<th>Tumour consistency</th>
<th>Large tumour (&gt;3 cm)</th>
<th>Small-medium tumour (&lt;3 cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid</td>
<td>18</td>
<td>34</td>
</tr>
<tr>
<td>Partly cystic</td>
<td>18</td>
<td>4</td>
</tr>
<tr>
<td>Mostly cystic</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>39</td>
</tr>
</tbody>
</table>

Tumour consistency was significantly different between the large and small to medium tumours ($p<0.0001$). $\chi^2$ test.
Facial nerve preservation

The facial nerve was anatomically preserved in 92% of the patients in our series. The anatomical facial nerve preservation rate is 80–90% with the removal of large tumours either by the translabyrinthine approach or by the retrosigmoid approach. Preservation of facial nerve function has been reported to be 70–80% after the removal of large tumours either by the translabyrinthine approach or by the retrosigmoid approach. The definition of a functional facial nerve includes both excellent (H-B grade 1/2) and intermediate (H-B grade 3/4) function. The reported preservation rate of excellent function after the removal of large tumours is 42–52.6%. The high rate of preserved facial nerve function in our series (84%) can be attributed to our use of intraoperative monitoring with the facial nerve stimulator-monitor. This monitoring apparatus uses bipolar electrical stimulation in which low amplitude stimulus allows the accurate localisation of the unrecognisably distorted facial nerve. Surgical techniques for preserving facial nerve function include the early identification of the root entry/exit zone and maximum caution in resecting the last lump of tumour in the extrameatal region just outside the porus acusticus.

Hearing preservation and the surgical approach

The chance of preserving useful hearing is small with the removal of large tumours, and thus many surgeons have recommended the translabyrinthine approach. However, retrosigmoid tumour removal improved the hearing of one patient in our series to a useful level. Using the retrosigmoid approach, Samii et al. preserved useful hearing in 8% of patients with large tumours who had good hearing preoperatively, and Fahlbusch et al. retained the hearing of 27.5% of their patients with large tumours who had preserved preoperative auditory brain stem responses (ABR). We routinely monitor the ABR and the cochlear nerve compound action potentials (CNAP) intraoperatively when removing small acoustic neurinomas with the intention of preserving hearing. With most large acoustic neurinomas, ABR potentials are not preserved preoperatively and intraoperative CNAP recording is technically impossible.

Postoperative complications

Cerebellar and brain stem injuries are the major complications of the retrosigmoid approach, with an incidence of 1.0–2.2%. A cerebellar haematoma developed in one patient of our series owing to perforation of the tumour capsule and rupture of the draining vein on the capsule during internal tumour decompression with the ultrasonic surgical aspirator. Ataxia occurs after the translabyrinthine removal of large tumours with an incidence of 12.6%, although the mechanism has not been reported. We observed that preoperative ataxia resolved rapidly after retrosigmoid tumour removal. CSF leaks and meningitis are the most common complications after the removal of acoustic neurinomas. The translabyrinthine removal of large tumours is associated with a high incidence (14–18%) of CSF leaks. However, the incidence of CSF leaks was 4% in our series. To prevent
CSF leaks, we have routinely evaluated the pneumatisation of the temporal bone using preoperative bone window computed tomography (Yamakami I, unpublished data), and have reconstructed the internal auditory meatus. Reconstruction of the meatus prevents CSF leakage through the surrounding air cells. Watertight dural closure and the absence of an epidural or subcutaneous drain prevent CSF leaks. The incidence of meningitis after the translabyrinthine removal of large tumours is 3.7–9.2%;10–12 there was no case of meningitis in our series.

Sluyter et al reported that aphasia, attributed to left temporal lobe dysfunction, occurred in 12 of 58 patients (21%) after the translabyrinthine removal of large left sided acoustic neurinomas, and that 3.3% of 120 patients had persistent epileptic seizures requiring drug treatment.11 The venous drainage of the temporal lobe depends on the vein of Labbé and the sigmoid sinus. By compromising these veins,38–40 translabyrinthine surgery can cause temporal lobe injury. The retrosigmoid approach does not affect the venous drainage from the temporal lobe, and there was no temporal lobe dysfunction in our series.

Postoperative chronic headache has been reported to be a troublesome complication after the retrosigmoid approach.41 Bone dust generated by the intradural drilling can cause chronic postoperative headaches,42 so when we drill the posterior wall of the internal auditory meatus, we protect the cerebellopontine angle with pieces of rubber dam and clean out the bone dust by continuous irrigation and suction. We routinely do a cranioplasty to prevent the posterior fossa dura from scarring the suboccipital muscle.43 No patients in our series complained of chronic headache postoperatively.

Long term follow up and tumour recurrence

The tumour recurrence rate after the removal of acoustic neurinomas is 0.4–2%;44 however, the rate after the removal of large tumours has not yet been reported. All patients in our series underwent regular long term follow up with MRI, which showed that the recurrence rate after the removal of these large tumours was 8%. However, all these cases occurred after subtotal removal (four of seven patients), and no recurrence was seen after total tumour removal. The completeness of tumour removal definitely determines tumour recurrence.
References