Stage II vestibular schwannoma: Predictive factors for postoperative hearing loss and facial palsy

S. Milhe de Saint Victor, D. Bonnard, V. Darrouzet, O. Bellec, V. Franco-Vidal

Service d’otorhinolaryngologie et de chirurgie de la base du crâne, CHU Pellegrin, université Victor-Segalen Bordeaux-2, place Amélie-Raba-Léon, 33076 Bordeaux cedex, France

KEYWORDS
Stage II vestibular schwannoma; Hearing conservation; Facial function conservation; Translabyrinthine approach; Retrolabyrinthine approach

Summary
Objectives: To assess predictive factors for deafness and facial palsy after vestibular schwannoma surgery on a translabyrinthine or retrolabyrinthine approach, and to compare sequelae results to those for gamma knife radiosurgery.

Patients and methods: A retrospective study included 70 patients operated on for stage II vestibular schwannoma (Koos classification). Postoperative hearing was assessed on pure-tone average and speech discrimination score, and facial palsy on the House and Brackmann classification, preoperatively and at 1 year postoperatively. Various predictive factors were assessed for both. Statistical analysis used the Fischer exact test, with a significance threshold of \( P < 0.05 \).

Results: Hearing was conserved in 18.9% of patients operated on with a retrolabyrinthine approach, with 8.1% conserving useful hearing. Facial function was conserved in 91.4%. Predictive factors for hearing conservation did not achieve statistical significance, but showed trends for: preoperative pure-tone average threshold \( \leq 30 \) dB and speech discrimination score \( \geq 70 \% \), age less than 55 years, tinnitus, nearly normal auditory brainstem response (ABR) latency, and homogeneous tumor on MRI. Predictive factors for conserved facial function likewise did not achieve statistical significance, but showed trends for: age less than 55 years, deafness of progressive onset, absence of cardiovascular risk factors, nearly normal ABR latency and tumor size \( < 13.5 \) mm on MRI.

Conclusion: Facial nerve risk is largely the same with surgery or gamma knife radiosurgery. Concerning hearing, gamma knife radiosurgery seems to provide better hearing conservation, but only over the short term.

© 2012 Published by Elsevier Masson SAS.

Introduction

Vestibular schwannoma (or acoustic neurinoma) is increasingly diagnosed. This can be explained by more widespread MRI access and increasingly precise imagery. The question
arising is that of management. Options are many, from simple surveillance to a variety of surgical techniques, via gamma knife radiosurgery and fractionated radiation therapy. In France, small (stage I) tumors are generally managed by surveillance if symptomatology is mild, as their evolution is usually very slow. Large (stage III or IV) tumors more often lead to surgery, given the acute complications related to early edema associated with radiation therapy.

There remains the question of stage II tumors, for which there is no consensus as to indications for surgery versus gamma knife radiosurgery. They are increasingly encountered, whether diagnosed at that stage and continuing to progress or as stage I tumors increasing in volume under surveillance. Moreover, hearing and facial function conservation has become a critical issue now that surgical mortality has greatly diminished.

First described by Darrouzet et al. [1], the retrolabyrinthine approach is the most recent otoneurosurgical approach, performed in very few centers. It has all the advantages of transpetrosal approaches, but with the additional possibility of conserving auditory function. Gamma knife radiosurgery, developed relatively recently, has the specificity of elevated topographic selectivity, enabling 1-step treatment with a low marginal dose that spares adjacent healthy tissue.

The present study therefore sought predictive factors for hearing loss and facial, palsy secondary to translabyrinthine or retrolabyrinthine surgery in our department. Results in terms of these sequelae were also compared to those for gamma knife radiosurgery found in the literature.

Patients and methods

A retrospective study was made of the files of 70 patients operated on for stage II vestibular schwannoma (Koos classification) between March 2000 and June 2008: 36 male, 34 female; aged 33 to 73 years (mean, 55.6 yrs). In 34 cases the tumor was on the right side and in 36 on the left. Surgical approaches were translabyrinthine (n = 33) or retrolabyrinthine (n = 37). A translabyrinthine approach was used when hearing function was deemed non-useful and a retrolabyrinthine approach in patients with useful preoperative hearing, and usually when the tumor did not extend to the fundus of the internal auditory canal (IAC), which is difficult to control on a retrolabyrinthine approach. Peroperative facial nerve monitoring (NIM nerve monitoring system) was systematic. Tumor resection was total in all cases. One case of cochlear nerve neurinoma and all patients with type-2 neurofibromatosis were excluded from the study; 70 patients were included.

Study variables were: postoperative hearing at 1 year, and presence and severity of postoperative facial palsy at 1 year. Possible preoperative predictive factors for postoperative hearing loss or facial palsy that were studied were: age, preoperative hearing parameters (hearing thresholds, type of deafness (progressive, fluctuating or sudden), and tinnitus), and history (diabetes, cardiac factors (angina or acute coronary syndrome, and minor cardiovascular risk factors: smoking, high blood pressure, hypercholesterolemia)). Auditory brainstem response (ABR) (wave V latency and interaural wave V latency difference) and schwanna parameters on MRI (size (maximal diameter), homogeneous aspect versus heterogeneity with islands of necrosis not enhanced by contrast medium) were also studied. IAC penetration grade on MRI was assessed on the Darrouzet classification [1]: grade 1, tumor occupying less than half the length of the IAC; grade 2, tumor occupying more than half the length of the IAC, but sparing the fundus; grade 3, tumor occupying the entire cochlear recess including the fundus.

Statistical analysis used the Fisher test, with the significance threshold set at P < 0.05. Hearing was assessed by mean pure-tone audiometry (PTA) loss at 500, 1000, 2000 and 4000 Hz and speech discrimination score (percentage understood words at 35 dB above the intelligibility threshold) for 2-syllable word-lists. Useful hearing was defined by a mean PTA threshold ≤ 50 dB and a discrimination score ≥ 50%, and correctable hearing as a mean PTA threshold of 51–90 dB with discrimination score 5–49%. Hearing was considered conserved if useful or correctable. Facial function was assessed on the House and Brackmann classification.

Results

Hearing was conserved in 18.9% of cases (7/37) after a retrolabyrinthine approach. Three of the 37 patients (8.1%) conserved “useful” hearing.

Facial function I was conserved in 91.4% of cases (64/70); five patients had grade III and one grade IV facial palsy at 1 year.

Hearing conservation

There were no significantly predictive factors for hearing conservation. There were, however, some trends (Table 1).

23.5% of conserved hearing, versus 15% of over-55 year-olds. Progressive hearing loss showed slightly better prognosis than sudden or fluctuating hearing loss. Hearing was conserved in 26% of patients with tinnitus. Absence of minor cardiovascular risk factors showed a trend toward slightly better prognosis. None of the patients in this series were diabetic or with history of heart pathology.

Nearly normal ABR wave V latency and interaural wave V latency difference tended to be favorable: 31% of patients with wave V latency < 6.60 ms and 30.8% of those with interaural wave V latency difference < 0.9 did not show total deafness. Tumor size did not show the kind of impact that might be expected: hearing was conserved in half of those with grade 3 IAC penetration. On the other hand, no patients with heterogeneous tumor on MRI were able to conserve hearing.

The better the preoperative hearing, the better the chances of conservation. 75% of patients with preoperative PTA threshold ≤ 30 dB and discrimination score ≥ 70% showed useful postoperative hearing, whereas none of those with poorer preoperative hearing did so.
Table 1  Probability of conserving useful or correctable hearing according to various factors.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Hearing conservation (%)</th>
<th>Factor</th>
<th>Hearing conservation (%)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTA threshold ≤ 30 dB and</td>
<td>26.7</td>
<td>PTA threshold &gt; 30 dB and</td>
<td>13.6</td>
<td>0.4</td>
</tr>
<tr>
<td>discrimination score ≥ 70%</td>
<td></td>
<td>discrimination score &lt; 70%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age &lt; 55 yrs</td>
<td>23.5</td>
<td>Age &gt; 55 yrs</td>
<td>15</td>
<td>0.67</td>
</tr>
<tr>
<td>Progressive hearing loss</td>
<td>20</td>
<td>Non-progressive hearing loss</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>Absence of tinnitus</td>
<td>0</td>
<td>Tinnitus</td>
<td>26</td>
<td>0.15</td>
</tr>
<tr>
<td>CVRF-free</td>
<td>17.6</td>
<td>CVRF</td>
<td>11.5</td>
<td>1</td>
</tr>
<tr>
<td>Wave V &lt; 6.6 ms</td>
<td>31</td>
<td>Wave V &gt; 6.6 ms or ABR non-</td>
<td>8.3</td>
<td>0.21</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interpretable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ILD V &lt; 0.9 ms</td>
<td>30.8</td>
<td>ILD V &gt; 0.9 ms</td>
<td>15.4</td>
<td>0.64</td>
</tr>
<tr>
<td>Tumor size &lt; 13.5 mm</td>
<td>18.8</td>
<td>Tumor size &gt; 13.5 mm</td>
<td>36.3</td>
<td>0.39</td>
</tr>
<tr>
<td>Grade 1 or 2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>14.8</td>
<td>Grade 3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>50</td>
<td>0.09</td>
</tr>
<tr>
<td>Homogeneous</td>
<td>35.3</td>
<td>Heterogeneous</td>
<td>0</td>
<td>0.14</td>
</tr>
</tbody>
</table>

CVRF: minor cardiovascular risk factors (smoking, high blood pressure, hypercholesterolemia); ILD V: interaural wave V latency difference; ABR: auditory brainstem response; PTA: pure-tone audiometry.

<sup>a</sup> Grade: internal auditory canal (IAC) penetration grade.

Facial function conservation

There were no significantly predictive factors for facial function conservation. There were, however, some trends (Table 2).

Young age showed a trend to favor facial function conservation, as did progressive hearing loss onset and absence of minor cardiovascular risk factors. On ABR, increased wave V latency and interaural differential showed trends to predict postoperative palsy. Facial function was conserved in all patients with maximal tumor diameter < 13.5 mm. Tumor grade and homogeneity/heterogeneity seemed to be without impact.

Only two patients with facial palsy were free of minor cardiovascular risk factors, which were present in all the others, and notably in four patients with grade 2 palsy at 1 year.

Discussion

Study aims

We focused on stage II vestibular schwannoma, as the choice between surgery and gamma knife radiosurgery is especially delicate here; we also wanted to determine potential conservation of hearing and facial function on the two surgical techniques employed in our department. We further sought predictive factors among the preoperative data available for optimal conservation of these two functions which are so important for quality of life. We therefore analyzed the files of the 70 patients operated on for stage II vestibular schwannoma between 2000 and 2008.

The following discussion will examine published results for hearing and facial function conservation with gamma knife radiosurgery and try to determine predictive factors so as better to differentiate indications between our surgical approaches versus gamma knife radiosurgery.

Hearing conservation

Retrolabyrinthine surgery provided 18.9% hearing conservation and 8.1% useful hearing. We retrieved a large number of studies of conservation rates with gamma knife radiosurgery, mainly for small series, and therefore focused rather on the meta-analyses and recent literature reviews presented in Table 3, so as to get a general picture of gamma knife radiosurgery’s potential.

It emerged that results were highly variable, ranging from 11 to 89% conservation. This was all the more disturbing as the procedure is very much automated, in contrast to surgery. The more recent results are the best, thanks to the reduction in radiation dose over recent years. The variability, however, is probably related to pretreatment auditory system status, which influences radiation resistance independently of the procedural technique. Results at first glance appear better than with surgery (18.9% conservation in the present series), but there is a question as to the long-term evolution of hearing following gamma knife radiosurgery, given the sometimes late negative effect of radiation. Thus Chopra et al. [2], in a series of 216 patients treated by gamma knife radiosurgery with marginal doses of 12-13 Gy, reported 71% hearing conservation at 3 years but only 44% at 10 years, and stressed long-term impairment of hearing following gamma knife radiosurgery. The hypotheses to account for this are: direct radiation effects on the
auditory system, and on the cochlea in particular; reduced auditory system blood flow due to vessel hyalination; and increased IAC tumor volume.

On the relatively small present series, no significant predictive factors for hearing conservation emerged, but certain interesting trends were found. Favorable factors for hearing conservation on a retrolabyrinthine approach were: preoperative PTA threshold ≤ 30 dB and discrimination score > 70%, age < 55 years, tinnitus, nearly normal ABR latency, and homogeneous tumor on MRI. Patients with tinnitus had probably been identified earlier, introducing a bias. MRI is of interest in case of unilateral tinnitus. Hearing was conserved in half of grade 3 tumor patients: the retrolabyrinthine approach was tried in such cases where pre-operative hearing was very good despite tumor penetration involving the IAC fundus.

Other studies investigated predictive factors for hearing conservation following surgery on a middle fossa or retrosigmoid but never a retrolabyrinthine approach. Tumor size was often reported as a predictive factor [3–7], but these studies concerned schwannomas of all stages, whereas we focused on stage II. Preoperative hearing quality seemed to be a predictive factor for conservation [3–6,8]. The impact of age and ABR latency varied from study to study [3,4,8,9].

Turning to predictive factors for hearing conservation after gamma knife radiosurgery, Yang et al. [10] found no significant impact of age or tumor size in 5825 patients from 74 reports. In recent studies, favorable factors were: Gardner and Robertson class I preoperative hearing [11–13], young age [12–14], presenting symptoms (notably tinnitus) over and above hearing impairment [12–14], normal ABR [11], and low-grade IAC penetration.

Common factors are thus primarily preoperative hearing quality as indicating optimal chances of conserving hearing after gamma-knife radiosurgery or classical surgery; age and nearly normal ABR also appear to be significant, although not confirmed in all studies. There is no evidence in the literature regarding cardiovascular risk factors as predictive, whether following classical surgery or gamma knife radiosurgery, and tumor size in stage II schwannoma does not seem to be influential.

### Table 2 Probability of conserving facial function according to various factors.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Facial function conservation (%)</th>
<th>Factor</th>
<th>Facial function conservation (%)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age ≥ 55 yrs</td>
<td>96.6</td>
<td>Age ≥ 55 yrs</td>
<td>85.7</td>
<td>0.38</td>
</tr>
<tr>
<td>Progressive hearing loss</td>
<td>92.9</td>
<td>Non-progressive hearing loss</td>
<td>85.7</td>
<td>0.59</td>
</tr>
<tr>
<td>CVRF-free</td>
<td>93.8</td>
<td>CVRF</td>
<td>88.2</td>
<td>0.67</td>
</tr>
<tr>
<td>Wave V &lt; 6.6 ms</td>
<td>95.5</td>
<td>Wave V &gt; 6.6 ms or ABR</td>
<td>90.5</td>
<td>0.65</td>
</tr>
<tr>
<td>ILD V &lt; 0.9</td>
<td>100</td>
<td>ILD V &gt; 0.9</td>
<td>85</td>
<td>0.23</td>
</tr>
<tr>
<td>Tumor size &lt; 13.5 mm</td>
<td>100</td>
<td>Tumor size &gt; 13.5 mm</td>
<td>85</td>
<td>0.11</td>
</tr>
<tr>
<td>Grade 1 or 2a</td>
<td>91.9</td>
<td>Grade 3a</td>
<td>92.3</td>
<td>1</td>
</tr>
<tr>
<td>Homogeneous</td>
<td>89</td>
<td>Heterogeneous</td>
<td>87.5</td>
<td>1</td>
</tr>
</tbody>
</table>

CVRF: minor cardiovascular risk factors (smoking, high blood pressure, hypercholesterolemia); ILD V: interaural wave V latency difference.

* Grade: internal auditory canal (IAC) penetration grade.

### Table 3 Hearing and facial function conservation following gamma knife radiosurgery in the literature.

<table>
<thead>
<tr>
<th>Meta-analysis/literature review</th>
<th>Hearing conservation</th>
<th>Facial function conservation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rutherford and King (2005) [23]</td>
<td>33 to 79%&lt;sup&gt;a&lt;/sup&gt;</td>
<td>95 to 99%</td>
</tr>
<tr>
<td>≈ 75% in most recent series</td>
<td>96 to 99%</td>
<td></td>
</tr>
<tr>
<td>Myrseth et al. (2007) [24]</td>
<td>50 to 89%&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Yang et al. (2009) [10,18]</td>
<td>11 to 77%&lt;sup&gt;c&lt;/sup&gt;</td>
<td>55 to 100%</td>
</tr>
<tr>
<td>Mean 57%</td>
<td>Mean 96.2%</td>
<td></td>
</tr>
<tr>
<td>50 to 70% in most recent series</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22 to 74%&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bhandare et al. (2010) [25]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Variation in definition of hearing conservation between studies.
<sup>b</sup> Gardner and Robertson class I, II or III.
<sup>c</sup> Gardner and Robertson class I or II.
<sup>d</sup> Gardner and Robertson class I, II, III or IV.
<sup>e</sup> House and Brackmann grade I or II.
Facial function conservation

Translabyrinthine and retrolabyrinthine surgery provided 91.4% facial function conservation. Facial palsy was defined as House and Brackmann grade III or more, with grade II counted alongside grade I as in the literature. Comparison with gamma knife radiosurgery was based on the recent meta-analyses and reviews (Table 3). Results were fairly variable, but with more than 95% conservation overall. This was slightly better than with our surgical techniques, although it could also be said that facial function is conserved in more than 90% of cases whatever the technique—a much more satisfactory figure than for hearing conservation.

There were no significant predictive factors for facial function conservation, but there were certain interesting trends. Favorable factors for facial function conservation on a trans- or retrolabyrinthine approach were: age < 55 years, progressive hearing loss, absence of cardiovascular risk factors, nearly normal ABR latency, and tumor size < 13.5 mm. Tumor grade did not seem to influence facial palsy, probably because grade 3 tumors were usually managed by a translabyrinthine approach, facilitating facial nerve dissection within the IAC. Only two patients free of cardiovascular risk factors showed facial palsy at 1 year, versus eight with risk factors, including four with grade 2 tumor; this suggests that patients with cardiovascular risk factors take longer to recover from facial palsy.

Other studies investigated predictive factors for hearing conservation following surgery on a translabyrinthine, retrosigmoid or middle fossa approach. Tumor size systematically emerged in studies of vestibular schwannoma of all grades taken together [4,5,15,16]: it is now consensual that facial nerve risk increases with tumor stage. A study of stage II tumors managed with a retrosigmoid approach, however, found no significant impact of tumor size [17]. The role of age varied according to the study [16,17]. Certain studies reported other predictive factors: preoperative hearing quality [16], short clinical symptom duration [16,17], nearly normal ABR latency [16,17], homogeneous tumor [15,16], and wide angle between tumor and IAC [15,16].

Turning to predictive factors for facial function conservation after gamma knife radiosurgery, Yang et al. [18], in a series of 2204 patients from 23 reports, found a significant impact of age and tumor size. We were not able to retrieve any other studies of predictive factors for facial function conservation after gamma knife radiosurgery. Thus, young age and small tumor size seem to favor facial function conservation, whether following surgery or gamma knife radiosurgery. We were not able to retrieve any data on the impact of cardiovascular risk factors on facial function following surgery or gamma knife radiosurgery.

Other drawbacks of the various treatment attitudes

The issue of vertigo secondary to gamma knife radiosurgery is significant for patients’ quality of life, and is currently a matter of debate. Two studies [19,20] reported 13% [19] and 27% [20] vertigo onset rates secondary to gamma knife radiosurgery and a 6% rate of disappearance of vertigo, with the remaining patients showing persistent vertigo. Gamma knife radiosurgery fails to allow central vestibular compensation. The evolution of vestibular disorder was not analyzed in the present series, as we do not routinely perform postoperative videonystagmography; a further study will be needed, and is currently underway in our department.

Finally, follow-up duration is a key element, whichever the treatment option. For gamma knife radiosurgery, results appear only at 3 years and intermediate reports are of little value. The risk of malignant evolution, while low (at < 1/1000) is real [21]. Surgery involves a risk of recurrence as high as 10% [22], seen on regular MRI surveillance over several years. Recurrence develops from small fragments unintentionally left after surgery; patients will not necessarily experience heavy symptoms, however, and may not always need treatment.

Conclusion

Gamma knife radiosurgery shows better conservation of hearing, but over the short term. Facial nerve risk is much the same between surgery and gamma knife radiosurgery. The main predictive factors for hearing conservation are good preoperative hearing, young age, and short ABR latency. For facial function conservation, they are young age and small tumor size. The present study did not find one technique to be preferable to the other; nevertheless, the risk of malignant transformation following gamma knife radiosurgery in young patients is to be borne in mind. Clear and objective information should be given to the patient, who has the final choice.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References