The rate of vestibular schwannoma (VS) recurrence after total tumor removal is low and ranges from 0.5% to 9.2%. The source of recurrences could be microscopic tumor deposits left on the facial nerve, in the fundus of the internal auditory canal, or on the preserved cochlear or vestibular nerves. Partial resection of VS is associated with regrowth in up to 44% of cases after a mean follow-up of 6.2 years.

The management of recurrent VS is challenging and controversial. Repeated radiosurgery is associated with more side effects than the primary procedure. Resection of such VS can also be very difficult due to adhesions and scarring, and can be associated with worse facial nerve outcome. Hence, the recommended goals of surgery vary from merely tumor debulking to total resection. Furthermore, the reported outcome is not consistent in the published reports due to differences in the surgical technique, heterogeneity of the patient groups, and the different perspectives regarding the radicalness of tumor resection.

According to the concept put forward by the senior author (M.S.), primary microsurgical tumor resection is the first line of treatment of VS. Similarly, in case of recurrences or regrowth of known tumor remnants, the goal of surgery should be to remove the tumor completely and thus cure the patient. This concept was initially published in 1997 by Samii and Matthies, reporting on 56 cases of recurrent VA. In the present study, we systematically evaluated the outcome after complete microsurgical re-

**Microsurgical management of vestibular schwannoma after failed previous surgery**

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**OBJECTIVE** Microsurgical treatment of recurrent vestibular schwannoma (VS) is difficult and poses specific challenges. The authors report their experience with 53 cases of surgically treated recurrent VS. Outcome of these tumors was compared to that of primarily operated on VS. Special attention was given to the facial nerve functional outcome.

**METHODS** A retrospective analysis was performed of the patients who underwent surgery for recurrent VS at one institution from 2000 to 2013. The preoperative data, intraoperative findings, and outcome in terms of facial nerve function and improvement of the preoperative symptoms were analyzed and compared with those in a control group of 30 randomly selected patients with primarily operated on VS. A multivariate regression analysis was performed to test the factors that could affect the facial nerve outcome in each group.

**RESULTS** Fifty-three consecutive patients underwent surgery for recurrent VS. Seventeen patients were previously operated on and received postoperative radiosurgery (Group A). Thirty-six patients were previously operated on but did not receive postoperative radiosurgery (Group B). The overall postoperative facial nerve function was significantly worse in Groups A and B in comparison with the control group (Group C). Interestingly, there was no significant difference in the facial nerve outcome among the 3 groups in patients who had good preoperative facial nerve function. The tumor size and the preoperative facial nerve function are variables that significantly affect the facial nerve outcome. Most of the patients showed improvement of the preoperative symptoms, such as trigeminal hypesthesia, gait disturbance, and headache.

**CONCLUSIONS** Complete microsurgical tumor removal is the optimal management for patients with recurrent or regrowing VS. The procedure is safe, associated with favorable facial nerve outcome, and may also improve existing neurological symptoms.

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**KEY WORDS** vestibular schwannoma; facial nerve preservation; outcome; recurrent; skull base

**ABBREVIATIONS** CPA = cerebellopontine angle; HB = House-Brackmann; VS = vestibular schwannoma.


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section of growing VS after previous microsurgical treatment in 53 patients operated on between 2000 and 2013. In particular, we examined the functional results and the surgery-related morbidity. The results were compared with those of a randomly selected group of patients whose tumors were primarily surgically treated. The factors that could influence the surgical outcome were analyzed and are discussed in this article.

Methods

This study included all patients with VS recurrence or regrowth after previous microsurgical resection who have been sequentially operated on at our center from 2000 to 2013. Patients with neurofibromatosis Type 2 were excluded. The preoperative clinical and radiological findings, operative findings, and postoperative data were analyzed retrospectively. Special attention was given to the preoperative facial nerve function, the possibilities of intraoperative facial nerve identification and preservation, and the postoperative facial nerve function, and the surgical outcome. Data from all patients operated on primarily for VS during the same period were plotted in a Microsoft Excel file, and the control group was randomly selected using the Excel random selection tool. Patient inclusion for all 3 groups was not influenced by the investigators to avoid any possible selection bias. All patients were operated on via the retrosigmoid approach, using similar operative technique. The long-term outcome was assessed in all cases at 1 year after surgery.

Tumor size was classified according to the Hannover classification of tumor extension: T1, tumors limited to the internal auditory canal; T2, intracanalicular tumors with bulging into the cerebellopontine angle (CPA); T3a, tumors filling the CPA but not reaching the brainstem; T3b, tumors filling the CPA and reaching the brainstem; T4a, tumors compressing the brainstem; and T4b, tumors compressing the brainstem and displacing the fourth ventricle.

Preoperative and postoperative facial nerve functions were reported according to the House-Brackmann grading system.8 The facial nerve function was classified as good (HB Grade I–II), fair (HB Grade III–IV), or poor (HB Grade V–VI).

Patient Population

We identified 53 patients who fulfilled the inclusion criteria of the study. Seventeen patients had been operated on and then received radiosurgery (Group A). The mean age in this group was 45 years (range 20–75 years), and the male:female ratio was 7:10. In Group A, 11 patients had undergone 1 operation, 5 patients had undergone 2 operations, and 1 patient had undergone 4 operations. Following partial tumor removal, these patients had been treated with radiotherapy: 15 with the Gamma Knife, 1 with the CyberKnife, and 1 with fractionated radiation. The time interval between the radiosurgery and our surgery ranged from 12 to 51 months (mean 25 months).

Thirty-six patients were previously operated on for VS and did not receive postoperative radiotherapy (Group B). The mean age for Group B was 45 years (range 16–72 years), and the male:female ratio was 5:7. In Group B, 32 patients had undergone 1 operation, 3 patients had undergone 2 operations, and 1 patient had undergone 7 operations. The mean period between the previous surgery and the current surgery was 55 months (range 4–228 months). Only 3 patients had been operated on previously by the senior author (M.S.) and had recurrent tumors. The tumors had been removed completely in 2 patients, but 1 patient experienced a recurrence 11 years later and the other 19 years later. In the third case, a thin layer of the tumor was left on the facial nerve at primary surgery and was regularly followed up with MRI. After 3 years, the residual tumor showed a tendency to grow and to compress the brainstem.

The mean age of patients in Group C was 50 years (range 35–66 years), and the male:female ratio was 17:13. The patient and tumor characteristics are summarized in Table 1.

Statistical Analysis

Univariate analysis was performed. The chi-square test was used to verify the significance of difference in outcome between the 3 groups. The deviation was considered significant if the p value was < 0.05. The multivariate regression analysis was performed to test the significance of the variables in the 3 groups. We tested the significance of the variation in age, tumor size, and the preoperative facial nerve function and their influence on the postoperative facial nerve function.

Results

Preoperative Patient Condition

In Group A, 14 patients presented with gait distur-

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in yrs, mean (range)</td>
<td>45 (20–75)</td>
<td>45 (16–72)</td>
<td>50 (35–66)</td>
</tr>
<tr>
<td>M:F</td>
<td>7:10</td>
<td>5:7</td>
<td>17:13</td>
</tr>
<tr>
<td>Interval in mos, mean (range)</td>
<td>25 (12–51)†</td>
<td>55 (4–228)‡</td>
<td></td>
</tr>
<tr>
<td>Tumor extension HC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>0</td>
<td>1 (5.8)</td>
<td>0</td>
</tr>
<tr>
<td>T2</td>
<td>0</td>
<td>0</td>
<td>4 (13.3)</td>
</tr>
<tr>
<td>T3a</td>
<td>2 (11.7)</td>
<td>11 (30.5)</td>
<td>5 (16.6)</td>
</tr>
<tr>
<td>T3b</td>
<td>0</td>
<td>6 (16.6)</td>
<td>7 (23.3)</td>
</tr>
<tr>
<td>T4a</td>
<td>8 (47)</td>
<td>7 (41.1)</td>
<td>8 (26.5)</td>
</tr>
<tr>
<td>T4b</td>
<td>7 (41)</td>
<td>11 (64.7)</td>
<td>6 (20)</td>
</tr>
<tr>
<td>CN VII HB grade</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>3 (17.6)</td>
<td>14 (38.8)</td>
<td>30 (100)</td>
</tr>
<tr>
<td>II</td>
<td>6 (35.2)</td>
<td>11 (64.7)</td>
<td>0</td>
</tr>
<tr>
<td>III</td>
<td>2 (11.7)</td>
<td>4 (11.1)</td>
<td>0</td>
</tr>
<tr>
<td>IV</td>
<td>2 (11.7)</td>
<td>4 (11.4)</td>
<td>0</td>
</tr>
<tr>
<td>V</td>
<td>1 (5.8)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>VI</td>
<td>3 (17.6)</td>
<td>3 (8.3)</td>
<td>0</td>
</tr>
<tr>
<td>Total no. of pts</td>
<td>17</td>
<td>36</td>
<td>30</td>
</tr>
</tbody>
</table>

CN = cranial nerve; HC = Hannover classification; pts = patients.
* Values are number (%) of patients unless otherwise indicated.
† Time between radiosurgery and current surgery.
‡ Time between previous surgery and current surgery.
bance, 10 with dizziness, 10 with headache, 7 with swallowing difficulties, 5 with trigeminal hypesthesia, and 3 with double vision. In Group B, 33 patients presented with gait disturbance, 30 presented with headache, 20 with dizziness, 12 with lower cranial nerve dysfunction, 10 with trigeminal nerve hypesthesia, and 3 with double vision. All patients were deaf on the side of the VS. In Group C, 16 patients presented with dizziness, 15 with progressive hearing loss, 10 with tinnitus, and 4 with gait disturbance.

**Indication for Surgery and Surgical Technique**

The indication for surgery in Groups A and B was sustained tumor growth on serial MRI examination with or without the appearance of new symptoms or worsening of the preexisting symptoms. The surgery in all patients was performed using a technique that was similar to one previously described.24–28

**Operative Findings/Facial Nerve Preservation**

The surgery for tumors in patients from Group A and B was generally more challenging. The reason was the frequent absence of a dissection plane between the tumor and normal tissue, the disruption of the arachnoid layers, the weak or absent tumor capsule, and the presence of severe adhesions. Four patients in Group A had preoperative facial palsy of Grade V–VI; the facial nerve could not be identified intraoperatively. In 2 patients, who had facial nerve palsy of Grade III–IV preoperatively, facial nerve preservation was not possible. One of these patients had healthy facial nerve stumps, and a sural nerve cable graft was performed, while in the second patient, a facial hypoglossal nerve anastomosis was performed in a second setting. In 3 patients from Group B who presented with Grade V–VI facial palsy, the facial nerve could not be identified intraoperatively. Facial nerve preservation was not possible in 3 patients with good and fair preoperative facial nerve function. In 2 patients for whom healthy facial nerve ends could be identified intraoperatively, sural nerve interpositional grafting was performed. In the third patient, a facial hypoglossal anastomosis was performed in a second setting. In the control group, anatomical facial nerve preservation was achieved in all patients. Gross-total resection of the tumor was achieved in all patients from the 3 groups.

**Early Postoperative Facial Nerve Function**

Five patients from Group A had good facial nerve outcome (HB Grade I–II), 6 patients had fair outcome (HB Grade III–IV), and 6 had poor facial nerve outcome (HB Grade V–VI). The early facial nerve outcome was related to the preoperative facial nerve condition. Of the 9 patients with good preoperative facial nerve function, 5 had good function after surgery and 4 had good facial function. For those patients who had fair function before surgery, 2 had fair function postoperatively and 2 experienced deterioration. Facial nerve outcome in relation to preoperative facial nerve function is summarized in Table 2.

In Group B, 12 of 25 patients with good preoperative function remained unchanged after surgery, 11 of 25 patients experienced deterioration of preoperative function.

**Facial Nerve Function After 1 Year**

In Group A, 11 (64.7%), 2 (11.7%), and 4 (23.5%) patients had good, fair, and poor facial nerve function, respectively. The patients who underwent facial nerve reconstructive procedures improved to HB Grade IV facial nerve function after 1 year. They showed further improvement after 2 years and reached HB Grade III. In Group B, 23 (63%), 9 (25%), and 4 (11%) patients had good, fair, and poor facial nerve function outcome, respectively. Two patients in whom facial nerve reconstructive procedures were performed improved slightly—to Grade IV for one patient and V for the other patient. After 2 years, these patients showed further improvement to Grade III and VI, respectively. The facial nerve outcomes for patients after 1 year are summarized in Table 3. One year after surgery, 29 patients (96%) in Group C had good facial nerve function, and 1 patient had Grade III facial nerve palsy.

**Outcome of Hearing**

All patients in Groups A and B were deaf on the side of the VS before surgery. Nine patients in Group C had useful hearing before surgery. Useful hearing was preserved after surgery in 5 (55.5%) of the 9 patients.

**TABLE 2. Preoperative and postoperative facial nerve function in Group A (after previous microsurgical resection and previous radiosurgery)**

<table>
<thead>
<tr>
<th>Preop Facial Nerve Function</th>
<th>No. (%)</th>
<th>Postop Facial Nerve Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>9 (62.9)</td>
<td>5 (29) 4 (23.5) 0</td>
</tr>
<tr>
<td>Fair</td>
<td>4 (23.5)</td>
<td>0 2 (11.7) 2 (11.7)</td>
</tr>
<tr>
<td>Bad</td>
<td>4 (23.5)</td>
<td>0 0 4 (23.5)</td>
</tr>
<tr>
<td>Total</td>
<td>17 (100)</td>
<td>5 (29) 6 (35.2) 6 (35.2)</td>
</tr>
</tbody>
</table>

**TABLE 3. Preoperative and postoperative facial nerve function in Group B**

<table>
<thead>
<tr>
<th>Preop Facial Nerve Function</th>
<th>No. (%)</th>
<th>Postop Facial Nerve Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>25 (69)</td>
<td>12 (33) 11 (30.5) 2 (5.5)</td>
</tr>
<tr>
<td>Fair</td>
<td>8 (22.3)</td>
<td>0 7 (19.4) 1 (2.7)</td>
</tr>
<tr>
<td>Bad</td>
<td>3 (8.3)</td>
<td>0 0 3 (8.3)</td>
</tr>
<tr>
<td>Total</td>
<td>36 (100)</td>
<td>12 (33) 18 (47.2) 6 (19.4)</td>
</tr>
</tbody>
</table>

* Values are number (%) of patients.
Postoperative Outcome

In Group A, gait disturbance improved in 12 of 14 patients, dizziness improved in 7 of 10, swallowing difficulties improved in 4 of 7, and the trigeminal hypesthesia improved in 3 of 5 patients.

One patient experienced new temporary abducens nerve palsy; 1 patient had postoperative CSF rhinorrhea, which was managed with CSF lumbar drainage for 10 days; and 1 patient had a postoperative hematoma that required surgical evacuation.

In Group B, gait disturbance improved in 30 of 33 patients, headache improved in 25 of 30, dizziness improved in 16 of 20, lower cranial nerve dysfunction improved in 7 of 12, and trigeminal nerve hypesthesia improved in 8 of 10 patients.

In Group C, gait disturbance improved in all 4 patients, dizziness improved in 14 of 16 patients, and tinnitus improved in 7 of 10 patients.

The improvement of preoperative symptoms is presented in Table 5.

**Table 5. Improvement of the preoperative symptoms in all groups**

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preop</td>
<td>Postop</td>
<td>Preop</td>
</tr>
<tr>
<td>Gait disturbance</td>
<td>14</td>
<td>12 (86)</td>
<td>33</td>
</tr>
<tr>
<td>Headache</td>
<td>10</td>
<td>10 (100)</td>
<td>30</td>
</tr>
<tr>
<td>Dizziness</td>
<td>10</td>
<td>7 (70)</td>
<td>20</td>
</tr>
<tr>
<td>Swallowing difficulties</td>
<td>7</td>
<td>4 (57)</td>
<td>12</td>
</tr>
<tr>
<td>Trigeminal hypesthesia</td>
<td>5</td>
<td>3 (60)</td>
<td>10</td>
</tr>
<tr>
<td>Double vision</td>
<td>3</td>
<td>0 (0)</td>
<td>3</td>
</tr>
</tbody>
</table>

* Postoperative values represent the number (%) of patients who improved after surgery.

Discussion

Vestibular schwannomas are benign, slowly growing tumors, with an average growth rate of 1–2 mm/year. They typically present with progressive sensory neural hearing loss, tinnitus, and gait disturbance. Current surgical techniques for these tumors are related to favorable facial nerve function and hearing outcome. After incomplete removal, the remnants tend to grow further in up to 44% of cases after a mean follow-up of 6.2 years. Some authors believe that the growth rate may be even higher than in cases that are not operated on. On the other hand, VSs may recur even after total removal, and the recurrence rate ranges from 0.5% to 9.2%.

The therapeutic options for recurrent or continuously growing residual VS include either microsurgical resection or radiosurgery. Microsurgical resection of VS that has been previously operated on or irradiated is demanding because of scar formation and adhesions. The published data indicate less favorable functional and general outcome than in cases primarily operated on. The task is even more difficult in patients with recurrence after combined microsurgery and radiosurgery. Opinions on the therapeutic strategy vary from decompression or partial removal to complete removal.

Radiosurgery is also an option for the management of recurrent VS after failed radiosurgery or microsurgery.
Tumor shrinkage is observed in 21% to up to 75% of the cases. Delayed facial nerve palsy occurs, however, in 5%—21% after a median follow-up time of 43–47 months.11,17,18 Interestingly, such delayed facial nerve palsy is more evident in patients who underwent radiosurgery after previous microsurgery than in patients who underwent radiosurgery only.11

In this article, we report on a series of 53 consecutive patients operated on for a growing VS after previous microsurgery with or without postoperative radiosurgery. Special focus was put on the functional results and surgery-related morbidity. Furthermore, we analyzed the factors that could influence the surgical outcome. The management concept was that in cases of recurrence or regrowth of known tumor remnants, surgery is the optimal treatment mode and should aim at complete tumor removal. The indication for surgery in all cases was progressive tumor enlargement on serial MRI with or without the appearance or progression of already existing symptoms, mainly gait disturbance, headache, new appearance of swallowing difficulties, and trigeminal pain.

**Surgical Considerations and Intraoperative Finding**

Some authors recommended using a different surgical approach from that which was used in the previous failed resection to avoid the scar tissue and the disturbed anatomy.1,3,14 Other authors, however, used a standard approach, even if it was used in the previous surgery. Roche et al. recommended the enlarged translabyrinthine approach for microsurgical resection of recurrent VS.22 Roberson et al. had also recommended translabyrinthine resection in cases of recurrence after previous surgery with the suboccipital approach.21 Hong et al. used the retrosigmoid approach for resection of recurrent VS.7 We favor the retrosigmoid approach, both in primary surgeries and in recurrences, because it provides an optimal overview of the CPA and the internal auditory canal, including the brainstem area, and allows greater flexibility.

The challenges of removing such VSs are related to the presence of fibroarachnoid scarring and the absence of a dissection plain between the tumor, facial nerve, and brainstem. Moreover, the facial nerve may be damaged during the previous surgery. All these considerations render surgical preservation of the neurovascular structures in the case of recurrence more difficult than in patients in the control group.3 Surgeries in the case of recurrence after microsurgery and followed by radiosurgery is even more difficult. The tumor may have a different consistency and the cranial nerves are more friable.4,6,15,20

It is helpful to use the facial nerve stimulation probe more frequently to detect and verify the nerve. Excessive use of the bipolar electrocautery should be avoided, especially before full identification of the facial nerve and its course. Another principle is to start the dissection from the “healthy” side, which is less affected by the previous surgery.

**Radicalness of Resection**

Some authors recommend partial resection or tumor debulking to avoid facial nerve damage in recurrent surgeries.9,23,29 Kemink et al., stressing the priority of preservation of the neurological function, favored partial tumor resection.10 We believe, however, that partial tumor removal provides a partial or temporary solution. The recurrence rate in incompletely resected tumors may be very high,2 especially if they already showed a growth tendency despite previous treatment.

Gross-total resection of the tumor was possible in all cases in the present series, providing the patient the potential to be cured. For a follow-up period extending to 11 years (the mean follow-up period was 5 years), there were no recurrent cases after secondary microsurgical resection of the tumor in the 3 groups.

**Neurological and Surgical Outcome**

Facial nerve outcome is a main determinant for assessing the success of microsurgery. Successful total tumor resection with preservation of facial nerve function has been demonstrated by other groups.2–6,11,20,22 The important finding of our study is that the main predictor of facial nerve outcome is the facial function prior to the reoperation. The outcome in patients with good or fair facial nerve function preoperatively was not significantly different in the 3 groups. The factors with the strongest predictive value in regard to the facial nerve function outcome are preoperative facial nerve condition and tumor size.

Therefore, if the surgeon finds it difficult to remove the tumor completely and to preserve the facial nerve at the initial surgery, it might be advisable to leave the most adherent portion of the tumor. Such remnants should be followed with regular MRI. In cases where the tumor shows a progressive growth tendency, especially if accompanied by neurological deterioration, a decision for new surgery should be made. Importantly, this surgery should be performed before the tumor has reached a large size. Only minor surgery-related complications or new deficits occurred in the present series.

Patients presenting with growing recurrent lesions frequently have multiple neurological deficits and complaints. The complete removal of tumor leads to improvement in a majority of patients, provided the deficits are caused by compression, not by destruction, of neural structures. In our series, gait difficulty improved in 86%—94% of patients, trigeminal hypesthesia in 86%—94%, and swallowing difficulty in 83%—87%. Double vision following the initial surgery, however, did not show any improvement. No patients experienced lasting new neurological disturbances in this series, which firmly indicates that redo surgeries may be as safe as the primary ones.

**Conclusions**

Complete microsurgical tumor removal is the optimal management form for patients with recurrent or regrowing VS. The procedure is safe, associated with favorable facial nerve outcome, and may also improve existing neurological symptoms.

The facial nerve outcome after surgeries for recurrent VS depends mostly on the preoperative facial nerve condition and tumor size. If gross-total resection cannot be achieved during the initial surgery without endangering
the facial nerve, we recommend regular MRI follow up of the residual tumor to detect early regrowth. A decision to reoperate in such cases should be made before the tumor reaches a large size.

References


Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: all authors. Acquisition of data: Metwali. Analysis and interpretation of data: Metwali, Gerganov. Drafting the article: Metwali. Critically revising the article: all authors. Approved the final version of the manuscript on behalf of all authors: Metwali. Statistical analysis: Metwali. Study supervision: Samii, Gerganov. Operating surgeon: Samii.

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