Hearing Preservation after Middle Fossa Vestibular Schwannoma Removal: Are the Results Durable?

Tyler S. Quist¹, Daniel J. Givens, MD¹, Richard K. Gurgel, MD¹, Roukoz Chamoun, MD², and Clough Shelton, MD¹

Abstract

Objective. To describe 5-year hearing preservation rates following microsurgical excision of vestibular schwannoma (VS) via the middle cranial fossa (MCF) approach.

Study Design. Case series with chart review.

Setting. This study was performed at a tertiary care academic medical center.

Subjects and Methods. Fifty-seven subjects with VS underwent resection via an MCF approach between February 1998 and January 2009. Pure-tone average (PTA) and word recognition score (WRS) were obtained preoperatively, immediately postoperatively, and at 5-year follow-up.

Results. Preoperative serviceable hearing (American Academy of Otolaryngology—Head and Neck Surgery class A/B) was present in 49 (86%) of the 57 patients, with an average PTA of 23 dB (range, 1-50 dB) and an average WRS of 97% (range, 76%-100%). Immediate postoperative serviceable hearing was maintained in 27 (55%) patients, with an average PTA and WRS of 31 dB (5-50 dB) and 96% (70%-100%), respectively. Five-year follow-up was available for 16 of the 27 patients. Twelve (75%) of the 16 patients maintained serviceable hearing with an average PTA and WRS of 35 dB (4-49 dB) and 95% (84%-100%), respectively. Of the 16 subjects who did maintain class A or B hearing, the mean change in PTA and WRS was 5 dB and 0.4%, respectively. Of the 4 patients who did not maintain class A/B hearing, average change in PTA and WRS was 16 dB (4.5-23 dB) and 16% (0%-40%), respectively.

Conclusions. For patients with VS in whom serviceable hearing is preserved following the MCF approach, the long-term hearing outcome remains durable in most patients.

Keywords
vestibular schwannoma, middle cranial fossa, hearing preservation

Vestibular schwannomas (VS) are typically benign, slow-growing tumors that arise from the vestibular division of the eighth cranial nerve.¹⁻⁵ Symptoms at presentation may include hearing loss, tinnitus, and dizziness/loss of balance.⁶ Physicians continue to debate the optimum treatment for patients with small intracanalicular VS and functional hearing. Treatment options include observation, stereotactic radiation therapy, and microsurgical resection. Hearing status and the possibility of hearing preservation with surgery constitute important elements in the overall decision-making process for patients.

In the past decade, there has been increased interest in nonsurgical treatment for VS.⁷ With the relative lack of short-term side effects, stereotactic radiosurgery is sometimes considered an uncomplicated outpatient procedure with minimal side effects and high chances of hearing preservation. Nevertheless, with adequate long-term follow-up, multiple studies have reported progressive hearing loss associated with both radiosurgery and observation of VS.⁸⁻¹¹

The middle cranial fossa approach (MCF) is commonly selected for patients with serviceable hearing and intracanalicular tumors, because it provides exposure of the entire internal auditory canal, including the fundus, and offers the possibility of hearing preservation. Published rates of immediate postoperative hearing preservation vary between 50% and 70%.¹²⁻¹⁵ Following tumor resection with hearing preservation, there has been a reported rate of delayed loss of serviceable hearing ranging between 11% and 30%, but few studies have evaluated the long-term hearing outcomes of the MCF approach.¹⁶⁻¹⁹

¹Division of Otolaryngology, University of Utah, Salt Lake City, Utah, USA
²Department of Neurosurgery, Kansas University Medical Center, Kansas City, Kansas, USA

This article was presented at the 2014 AAO-HNSF Annual Meeting & OTO EXPO; September 21-24, 2014; Orlando, Florida.

Corresponding Author:
Richard K. Gurgel, MD, Division of Otolaryngology—Head and Neck Surgery, University of Utah Hospitals, 50 N. Medical Dr, Salt Lake City, UT 84132, USA.
Email: richard.gurgel@hsc.utah.edu
The purpose of this article is to report our experience with the long-term hearing outcomes for patients treated with MCF for resection of VS. A better understanding of the long-term outcomes and the durability of hearing preservation after surgery allows proper counseling of these patients when choosing a treatment plan. We report hearing preservation of individuals at 5 years following surgical resection of their VS.

Materials and Methods

We performed a case series with chart review of 57 patients who underwent MCF for removal of acoustic tumors from February 1998 to December 2009 at our institution, a tertiary care academic medical center. Institutional review board (IRB) approval from the University of Utah (IRB tertiary care academic medical center. Institutional review February 1998 to December 2009 at our institution, a ter-

Figure 1. Study flow diagram showing how many patients were evaluated at each stage of the study.

Table 1

<table>
<thead>
<tr>
<th>Pure Tone Average (dB)</th>
<th>Word Recognition Score (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 - 89</td>
<td>90</td>
</tr>
<tr>
<td>89 - 79</td>
<td>90</td>
</tr>
<tr>
<td>79 - 69</td>
<td>90</td>
</tr>
<tr>
<td>69 - 59</td>
<td>90</td>
</tr>
<tr>
<td>59 - 49</td>
<td>90</td>
</tr>
<tr>
<td>49 - 39</td>
<td>90</td>
</tr>
<tr>
<td>39 - 29</td>
<td>90</td>
</tr>
<tr>
<td>29 - 19</td>
<td>90</td>
</tr>
<tr>
<td>19 - 9</td>
<td>90</td>
</tr>
<tr>
<td>&gt;90</td>
<td>90</td>
</tr>
</tbody>
</table>

Figure 2. Immediate postoperative hearing results following middle cranial fossa removal of acoustic neuroma with word recognition score and pure-tone average displayed.

Results

Between 1998 and 2009, 57 patients underwent 60 MCF surgeries for removal of acoustic tumors (Figure 1). Preoperative serviceable hearing (AAO-HNS class A or B) was present in 49 of 57 subjects (86%), with an average PTA of 23 dB (range, 1-50 dB) and an average WRS of 97% (range, 76%-100%). Preoperative House-Brackmann (HB) 1/6 facial nerve function was present in all 58 subjects. Immediate postoperative serviceable hearing was maintained in 27 of 49 (55%) subjects, with an average PTA and WRS of 31 dB (range, 5-50 dB) and 96% (range, 70%-100%), respectively. Five-year follow-up was obtained for 16 of the 27 subjects with preserved postoperative hearing. For patients who had immediate postoperative serviceable hearing and who later had 5-year follow-up, the average PTA and WRS after surgery were 33 dB (range, 5-50) and 95% (range, 70%-100%), respectively. The hearing characteristics of this group are shown in Figure 2. Of the patients who did not have 5-year follow-up, 1 died of unrelated causes (breast cancer), and the remainder were lost to follow-up. The demographics of this group with 5-year follow-up are shown in Table 1. Among those for whom 5-year follow-up data were available, 12 of the 16 subjects (75%) maintained serviceable hearing with an average PTA and WRS of 35 dB (range, 4-49 dB) and 95%
To account for those patients lost to follow-up, we also calculated a “best”- and “worst”-case scenario to understand the range of hearing preservation if all or none of those patients who were lost to follow-up maintained serviceable hearing. The maximum and minimum rate of serviceable hearing preservation at 5-year follow-up for patients with postoperative serviceable hearing would vary between 85% and 44% if all 11 patients lost to follow-up either maintained or lost serviceable hearing, respectively. Combining the 5-year hearing preservation rate with the initial postoperative hearing preservation rate of 55%, the maximum and minimum overall rate of serviceable hearing preservation in patients undergoing middle fossa resection of acoustic neuromas would be 46% and 24%, respectively.

Of the 16 subjects who did maintain class A or B hearing, the mean change in PTA and WRS was 5 dB (range, –10 to 19 dB) and 4% (range, –26% to 16%), respectively. Of the 4 subjects who did not maintain class A or B hearing, the mean change in PTA and WRS was 16 dB (range, 4.5-23 dB) and 16% (range, 0%-40%), respectively. Significant deterioration of hearing developed in 5 patients (31%), with a mean change of PTA of 20 dB (range, 16-23 dB) and a mean change of WRS of 15% (range, 0%-4%).

There were 31 patients from the original MCF cohort with a 5-year follow-up for facial nerve function. This includes 4 patients who did not have serviceable hearing preoperatively and whose hearing results were not included in the study, 11 patients who did not maintain immediate postoperative serviceable hearing, and the 16 patients who maintained immediate postoperative serviceable hearing and also had a 5-year follow-up. Regarding facial nerve function, of the 31 subjects with a 5-year follow-up, 28 (90%) exhibited HB grade 1, 1 (3%) exhibited HB grade 2, and 2 (7%) exhibited HB grade 3 function.

Of the 31 patients with 5-year follow-up, 3 ears (10%) showed tumor recurrence on MRI and received further treatment. The patient with the most dramatic decrease in 5-year hearing outcome was a patient with tumor recurrence.

Discussion

Many physicians continue to debate the optimum treatment for patients with intracanalicular VS and serviceable

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age, y</th>
<th>Tumor Side</th>
<th>PTA, dB</th>
<th>WRS, %</th>
<th>AAO-HNS Class</th>
<th>PTA, dB</th>
<th>WRS, %</th>
<th>AAO-HNS Class</th>
<th>PTA, dB</th>
<th>WRS, %</th>
<th>AAO-HNS Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>90</td>
<td>R</td>
<td>31</td>
<td>100</td>
<td>B</td>
<td>34</td>
<td>100</td>
<td>B</td>
<td>44</td>
<td>84</td>
<td>B</td>
</tr>
<tr>
<td>2</td>
<td>38</td>
<td>R</td>
<td>39</td>
<td>100</td>
<td>B</td>
<td>40</td>
<td>100</td>
<td>B</td>
<td>46</td>
<td>100</td>
<td>B</td>
</tr>
<tr>
<td>3</td>
<td>46</td>
<td>L</td>
<td>46</td>
<td>96</td>
<td>B</td>
<td>50</td>
<td>96</td>
<td>B</td>
<td>66</td>
<td>56</td>
<td>C</td>
</tr>
<tr>
<td>4</td>
<td>52</td>
<td>R</td>
<td>23</td>
<td>100</td>
<td>A</td>
<td>29</td>
<td>100</td>
<td>A</td>
<td>40</td>
<td>94</td>
<td>B</td>
</tr>
<tr>
<td>5</td>
<td>34</td>
<td>R</td>
<td>23</td>
<td>100</td>
<td>A</td>
<td>30</td>
<td>100</td>
<td>A</td>
<td>49</td>
<td>100</td>
<td>B</td>
</tr>
<tr>
<td>6</td>
<td>62</td>
<td>L</td>
<td>35</td>
<td>100</td>
<td>B</td>
<td>41</td>
<td>100</td>
<td>B</td>
<td>46</td>
<td>87</td>
<td>B</td>
</tr>
<tr>
<td>7</td>
<td>42</td>
<td>R</td>
<td>9</td>
<td>100</td>
<td>A</td>
<td>5</td>
<td>100</td>
<td>A</td>
<td>10</td>
<td>100</td>
<td>A</td>
</tr>
<tr>
<td>8</td>
<td>69</td>
<td>L</td>
<td>6</td>
<td>100</td>
<td>A</td>
<td>49</td>
<td>72</td>
<td>B</td>
<td>44</td>
<td>86</td>
<td>B</td>
</tr>
<tr>
<td>9</td>
<td>50</td>
<td>L</td>
<td>5</td>
<td>100</td>
<td>A</td>
<td>33</td>
<td>100</td>
<td>B</td>
<td>55</td>
<td>100</td>
<td>C</td>
</tr>
<tr>
<td>10</td>
<td>54</td>
<td>R</td>
<td>48</td>
<td>100</td>
<td>B</td>
<td>48</td>
<td>96</td>
<td>B</td>
<td>52.5</td>
<td>92</td>
<td>C</td>
</tr>
<tr>
<td>11</td>
<td>38</td>
<td>R</td>
<td>30</td>
<td>100</td>
<td>B</td>
<td>43</td>
<td>92</td>
<td>B</td>
<td>49</td>
<td>100</td>
<td>B</td>
</tr>
<tr>
<td>12</td>
<td>54</td>
<td>L</td>
<td>23</td>
<td>100</td>
<td>A</td>
<td>41</td>
<td>100</td>
<td>B</td>
<td>64</td>
<td>80</td>
<td>C</td>
</tr>
<tr>
<td>13</td>
<td>44</td>
<td>L</td>
<td>18</td>
<td>100</td>
<td>A</td>
<td>14</td>
<td>100</td>
<td>A</td>
<td>4</td>
<td>100</td>
<td>A</td>
</tr>
<tr>
<td>14</td>
<td>41</td>
<td>R</td>
<td>9</td>
<td>100</td>
<td>A</td>
<td>28</td>
<td>100</td>
<td>A</td>
<td>34</td>
<td>92</td>
<td>B</td>
</tr>
<tr>
<td>15</td>
<td>54</td>
<td>L</td>
<td>24</td>
<td>96</td>
<td>A</td>
<td>38</td>
<td>70</td>
<td>B</td>
<td>46</td>
<td>96</td>
<td>B</td>
</tr>
<tr>
<td>16</td>
<td>27</td>
<td>R</td>
<td>10</td>
<td>100</td>
<td>A</td>
<td>6</td>
<td>100</td>
<td>A</td>
<td>6</td>
<td>100</td>
<td>A</td>
</tr>
</tbody>
</table>

Abbreviations: AAO-HNS, American Academy of Otolaryngology—Head and Neck Surgery; L, left; PTA, pure-tone average; R, right; WRS, word recognition score.
hearing. Treatment options include observation, stereotactic radiation therapy, and microsurgical resection. Hearing status and the possibility of hearing preservation constitute important elements in the decision-making process. With observation, hearing loss is likely with time. Long-term hearing preservation and control rates with radiosurgery remain to be fully studied.\(^8,9,11\) Carlson et al\(^{24}\) reported rates of serviceable hearing preservation following stereotactic radiation at 1, 3, 5, 7, and 10 years to be 80%, 55%, 48%, 38%, and 23%, respectively. For patients with intracanalicular tumors, microsurgical resection offers a reliable method of achieving cure with high rates of hearing preservation.

Hearing outcomes for this study are presented using the new minimum standard for reporting hearing results approved by the Hearing Committee of the AAO-HNS.\(^{23}\) These scattergrams relate word recognition score to average air conduction pure-tone threshold. Importantly, these new guidelines allow accurate graphical description of diverse patient populations that is visually straightforward to interpret and retains detailed hearing information.

Over the time period studied, 57 patients were treated with the MCF approach. Our immediate postoperative hearing outcomes are comparable with previously published rates, which are between 50% and 70%.\(^{14,15,18,25}\) In our study, 55% of ears with serviceable hearing maintained class A or B hearing at their first postoperative visit. Kutz et al\(^{13}\) reported hearing outcomes after using MCF for the treatment of VS in a series of 46 patients. Eighty-two percent presented with serviceable hearing, which was preserved in 63% of these patients.

In our cohort, among those for whom 5-year follow-up data were available, 75% of ears with class A or B postoperative hearing maintained serviceable hearing at 5-year follow-up. Delayed loss of serviceable hearing occurred in 25% of ears. For the 4 ears that did not maintain class A/B hearing, the average change in PTA and WRS was 16 dB (4.5-23 dB) and 16% (0%-40%), respectively. Furthermore, the patient with the most dramatic change in 5-year hearing had a tumor recurrence. While few studies have evaluated the long-term hearing outcomes of patients who underwent surgical resection of VS, published rates of delayed loss of serviceable hearing vary between 11% and 30%.\(^{16,19}\) Friedman et al\(^{16}\) reported on 23 patients with serviceable hearing after MCF of VS from more than 5 years. Seventy percent maintained serviceable hearing at last follow-up. Furthermore, 2 patients with poor hearing following surgery improved to serviceable hearing throughout the duration of follow-up. Woodson et al\(^{19}\) presented a series of 49 patients treated with MCF with more than 2 years of postoperative audiometric data. Of the 43 patients with postoperative class A or B hearing, delayed loss of serviceable hearing was 31%. It is important to note that these results were corrected for hearing changes in the contralateral ear. We were not able to obtain all of the contralateral ear hearing data, so we did not include this to normalize the hearing loss over time. Normalization of the operated ear to the contralateral ear would potentially make the hearing results even better (assuming that hearing in both ears declines over time), so our results represent a “worst-case scenario” for the hearing.

When physicians counsel patients on the risk of long-term hearing preservation, it is important to combine the odds of initial hearing preservation with the odds of long-term hearing preservation. In our cohort, initial serviceable hearing preservation was 55%, and among those with a 5-year follow-up, the rate of serviceable hearing preservation was 75%. Thus, the overall long-term hearing preservation in patients with preoperative serviceable hearing was 41%. The combination of initial and long-term hearing odds may be more informative for patients when deciding whether to undergo surgery for the resection of their vestibular schwannoma and risk their current hearing that they may enjoy for a long time with no intervention if their tumor is small and word recognition score is excellent.\(^{26}\) These rates compare favorably with the long-term hearing outcomes for stereotactic radiation.\(^{24}\)

A limitation to this study is that 11 (40%) of the 27 patients with preserved postoperative serviceable hearing were lost to follow-up. Of the patients without a 5-year follow-up, 1 died of unrelated causes (breast cancer), and the remainder were lost to follow-up despite attempts made to contact these patients. Some patients did not have valid contact information, and some chose not to return. This study was conducted at one of the few regional tertiary care referral centers in the intermountain West. As such, our patients come from a large geographical area, and long-term follow-up can be challenging for patients who travel far distances. Since no data exist on these patients lost to follow-up, we cannot make assumptions about this group. Thus, the actual rate of serviceable hearing preservation at 5 years may vary between 85% and 44%, assuming all 11 patients maintained or lost serviceable hearing, respectively. Combining the actual rate of serviceable hearing preservation at 5-year follow-up with the initial postoperative hearing preservation rate of 55% yields an overall 5-year hearing preservation rate in patients with preoperative serviceable hearing that varies between 46% and 24%. To improve this study, more consistent follow-up would be needed.

What is the cause for the deterioration of preserved hearing? Tumor recurrence is an obvious but uncommon cause. Some have proposed that scar tissue in the internal auditory canal may be responsible. In an earlier study, the senior author (C.S.) observed that 56% of patients had deterioration of their preserved hearing with a minimum 3-year follow-up.\(^{18}\) At that time, the internal auditory canal defect was packed with free temporalis muscle, which is felt to be more reactive than the adipose tissue that is currently used. The change to fat packing may be responsible for the decreased incidence of deterioration of preserved hearing (31%) seen in the current study.

In our study, there were 7 patients with class C and 1 patient with class D preoperative hearing who underwent MCF for VS resection. One patient experienced improvement from class C to class B hearing throughout the duration of follow-up. None of
the other 7 patients developed serviceable hearing following surgery. In 1 study, Meyer et al\textsuperscript{14} reported that 6 of 30 patients developed serviceable hearing following surgical resection. Tumor size and location often dictate the choice of surgical approach, but the quality of hearing is an important consideration. Patients with substantial hearing loss preoperatively should not be promised a chance of hearing improvement with MCF.

Overall, preservation in facial nerve function was reliable in patients who underwent MCF. At last follow-up, 93% of patients exhibited good facial nerve function of HB grade 1 or 2, and 7% exhibited facial nerve function of HB grade 3. Our long-term facial nerve function is comparable with previous studies.\textsuperscript{12,13,19} Of 49 subjects, Woodson et al\textsuperscript{19} reported that 46 (96\%) exhibited HB grade 1 and 3 subjects exhibited HB grade 2 with more than 2 years of follow-up. Of the 33 patients with a 5-year follow-up, 4 (12\%) exhibited tumor recurrence on MRI, which is consistent with other studies. Holsinger et al\textsuperscript{12} reported recurrence of tumor in 4 of 47 (9\%) patients who underwent either the MCF approach or the retrosigmoid (RS) approach for resection of vestibular schwannoma.

**Conclusion**

For patients who undergo MCF resection of VS in whom serviceable hearing is preserved after surgery, there is a high rate of long-term hearing preservation. Our results support the existing body of literature that MCF for resection of VS provides durable tumor control with a high rate of hearing preservation and good facial nerve function. Some patients may experience a delayed loss of serviceable hearing. Patients must be counseled of this possibility when choosing a treatment plan.

**Author Contributions**

Tyler S. Quist, data acquisition and analysis, drafting of work and critical revision, final approval; Daniel J. Givens, study design, data acquisition and analysis, drafting of work and critical revision, final approval; Richard K. Gurgel, study design, data analysis, drafting of work and critical revision, final approval; Roukoz Chamoun, data acquisition and analysis, drafting of work and critical revision, final approval; Clough Shelton, study design, drafting of work and critical revision, final approval.

**Disclosures**

Competing interests: None.

Sponsorships: None.

Funding source: None.

**References**


