The utility of facial nerve amplitude and latency ratios in predicting postoperative facial nerve function after vestibular schwannoma surgery

Mazda K. Turel, Krothapalli Srinivasa Babu, Gautam Singh, Ari G. Chacko

Department of Neurological Sciences, Christian Medical College, Vellore, Tamil Nadu, India

Abstract

Background: Despite advances in vestibular schwannoma (VS) surgery and intraoperative electrophysiological monitoring, immediate and delayed facial nerve outcomes are difficult to accurately predict consistently. **Objective:** To determine the utility of proximal to distal facial nerve amplitude and latency ratios in predicting the long-term postoperative facial nerve function in patients undergoing excision of VS. **Materials and Methods:** One hundred consecutive patients undergoing surgery for VS with intraoperative facial nerve monitoring were included. Clinical, radiological, electrophysiological, and postoperative outcome data were prospectively entered into a database. Other parameters such as brainstem distance, size of the porus acusticus, and facial nerve length were also analyzed. **Results:** Of the 100 patients, 53 were women. The mean age was 42.5 ± 14.1 years (range, 14-71 years) and the average tumor size was 4.1 ± 0.8 cm (range, 2.4-6.5 cm). Total excision was done in 89% of patients. Intraoperatively, the facial nerve was anatomically preserved in 86 patients, but electrophysiological responses were obtained from the root entry zone (REZ) in only 77 patients at the end of surgery, 75% of which had good facial function at long-term follow-up. In nine patients where no responses were obtained but the facial nerve was anatomically intact, 50% had good facial function at long-term follow-up. Proximal and distal amplitude and latency ratios, size or consistency of the tumor, brainstem distance, size of the porus acusticus, and length of the facial nerve were not useful in predicting long-term functional outcome. **Conclusions:** While a positive response to facial nerve stimulation at the end of VS surgery is a good predictor of long-term postoperative function, the absence of responses in an anatomically intact nerve does not preclude good function in the long term. Proximal to-distal amplitude and latency ratios did not correlate with the final facial function.

**Key words:** Brain tumor, electrophysiology, facial nerve monitoring, surgery, vestibular schwannoma

Introduction

Functional preservation of the facial nerve is the primary goal to be achieved during microsurgical resection of vestibular schwannomas (VSs). While anatomic integrity of the nerve can be preserved in a majority of cases, this does not guarantee functional preservation. Although a normal initial facial nerve examination after surgery
generally correlates with good long-term facial function, delayed improvement in patients with immediate postoperative facial weakness represents an important finding that needs to be recognized in order to counsel patients and plan rehabilitation. Intraoperative facial nerve monitoring has been shown to improve outcomes. In this study, we assessed proximal to distal facial nerve amplitude and latency ratios in predicting long-term facial function.

While preservation of the facial nerve is indubitably more difficult during excision of larger VSs, smaller tumors occasionally pose a challenge in this regard indicating that other factors may alter operating conditions. Apart from tumor consistency, we wondered whether a large tumor component in the internal auditory meatus (IAM) or a tumor positioned more anterior in the cerebellopontine angle stretching the facial nerve to a greater degree during its course from the IAM to the root entry zone (REZ) also contributed to difficulty in nerve preservation.

Materials and Methods

One hundred consecutive patients who underwent a retrosigmoid approach and excision of a VS in semi-sitting position with intraoperative electrophysiological monitoring of the facial nerve were included in this study. Clinical and radiological data with electrophysiological recordings and functional outcome at follow-up were prospectively entered into a database. Facial function was assessed by one of the authors (GS), who was not the surgeon in any of the cases, by the House-Brackmann (H-B) grading system. Follow-up facial function was also assessed by GS on direct examination in the out-patient clinic or from photographs mailed by patients. For our analysis, we grouped grades I and II as good outcome and grade ≥III as poor outcome. The mean duration of follow-up was 22 ± 18.2 months (range, 3 months to 6 years).

The size of the tumor was documented by using the largest extrameatal diameter in axial, sagittal, or coronal images on gadolinium-enhanced magnetic resonance imaging (MRI). The brainstem distance was measured as the horizontal distance from the anterior lip of the IAM to the brainstem on the MRI. The size of the IAM was assessed by the distance between its anterior and posterior margins at the porus, since usually it is here where it is at its widest. The consistency of the tumor as being predominantly solid or cystic was documented. Intraoperatively, after complete tumor removal, the facial nerve length was measured by placing a sterile thread along the nerve from the REZ to the porus under high magnification and then using a measuring scale to read the length of the thread.

Stimulation and recording were done using an intraoperative machine (Nicolet: Viking IV or Endeavor, Madison, WI, USA). During dissection, near or direct handling of the facial nerve neurotonic activity that provided a continuous auditory feedback from the monitoring loudspeaker gave us warning that damage was imminent and dissection ceased in that area temporarily. For electrical stimulation of the nerve, a monopolar platinum tip stimulator was used with a constant current of 0.10 mA, frequency of 4.7 Hz, and pulse width of 0.5 msec. If responses were not obtained at 0.10 mA, no attempt to increase the current was made. Compound muscle action potential (CMAP) responses were recorded using needle electrodes inserted into the orbicular muscles of the eye, mouth, and in the frontalis muscle for three-channel recording. The facial nerve was stimulated at its REZ and at the porus, at precisely the points between which the nerve length was measured and the absolute value of amplitudes and latencies recorded from the electrodes in the facial muscles.

Statistical analysis

For statistical analysis of the predictive value of different parameters, a multivariate analysis using the logistic regression model was performed. The level of significance was set at \( P < 0.05 \). The accuracy of electrophysiological monitoring parameters in predicting long-term function was evaluated by calculation of sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV).

Results

Of the 100 patients, 53 were women. The mean age (±SD) was 42.5 (±14.1) years (range, 14-71 years). The average size of the tumor was 4.1 ± 0.8 cm (range, 2.4-6.5 cm). Total tumor excision was done in 89% and near-total excision in 11% of patients, as per patient’s request. There were seven patients with neurofibromatosis type 2. Intraoperatively, the facial nerve was anatomically preserved in 86 patients. Electrophysiological responses were obtained from the REZ in 77 patients (Figure 1).

Of the 77 patients in whom the facial nerve was preserved both anatomically and electrophysiologically, size of the tumor was not available in two patients. Of the remaining 75 patients, good facial function was seen in the early postoperative period in 40 patients (53%) and poor function was seen in 35 patients (47%). The facial nerve outcome in relation to tumor size is described in Table 1.

Of the 77 patients in whom the nerve was preserved anatomically and electrophysiologically, 59 (76.6%) had long-term follow-up ranging from 3 months to 6 years. These 59 patients were analyzed separately (44 (75%)}
of these had good function and 15 patients (25%) had a poor facial function] [Table 2].

If the immediate function was grade I–II, this had 68.18% sensitivity, 100% specificity, 100% PPV, and 51.7% NPV in predicting long-term facial function. If the immediate function was grade III–VI, then the patient had a 49.3% chance of good long-term facial function. Only one patient with H-B grade V in the immediate postoperative period had good long-term facial function; all the others with good long-term function had H-B grade III/IV at discharge from the hospital [Table 3].

Although the facial nerve was anatomically preserved in 86 patients, electrophysiological responses were absent in 9 of these patients. We had a total long-term follow-up in 67 patients (78%) [59 among electrophysiological response group and 8 among the electrophysiologically silent but anatomically preserved facial nerve group]. The presence of electrophysiological response at the REZ had 91.66% sensitivity, 21.05% specificity, 74.57% PPV, and 50% NPV in predicting long-term facial function [Table 4].

The mean CMAP amplitude after proximal stimulation at the REZ was 108.3 ± 89.4 mV for patients with good postoperative function. These values decreased with increasing facial nerve damage (99.1 ± 91.7 mV in those patients with poor late postoperative facial function).

---

**Table 1: Early facial nerve functions at discharge in 75 patients according to tumor size**

<table>
<thead>
<tr>
<th>Size of tumor (cm)</th>
<th>House-Brackmann (early postoperative period) (%)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grade I</td>
<td>Grade II</td>
</tr>
<tr>
<td>&lt;3</td>
<td>2 (29)</td>
<td>4 (57)</td>
</tr>
<tr>
<td>3-3.9</td>
<td>5 (22)</td>
<td>10 (44)</td>
</tr>
<tr>
<td>≥4</td>
<td>1 (2)</td>
<td>18 (41)</td>
</tr>
<tr>
<td>Total</td>
<td>8 (10)</td>
<td>32 (43)</td>
</tr>
</tbody>
</table>

**Table 2: Long-term facial nerve functions in 59 patients according to tumor size**

<table>
<thead>
<tr>
<th>Size of tumor (cm)</th>
<th>House-Brackmann (long-term follow-up) (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grade I</td>
<td>Grade II</td>
</tr>
<tr>
<td>&lt;3</td>
<td>5 (83)</td>
<td>1 (17)</td>
</tr>
<tr>
<td>3-3.9</td>
<td>9 (50)</td>
<td>5 (28)</td>
</tr>
<tr>
<td>≥4</td>
<td>9 (26)</td>
<td>15 (43)</td>
</tr>
<tr>
<td>Total</td>
<td>23 (40)</td>
<td>21 (35)</td>
</tr>
</tbody>
</table>

**Table 3: Final facial nerve outcome as it relates to immediate postoperative facial nerve function in 59 patients**

<table>
<thead>
<tr>
<th>House-Brackmann grade</th>
<th>Facial grade at follow-up</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I–II</td>
<td></td>
</tr>
<tr>
<td>Immediate postoperative facial grade I–II</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Immediate postoperative facial grade III–VI</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>Total</td>
<td>44</td>
<td>15</td>
</tr>
</tbody>
</table>
However, the logistic regression analysis showed no significant correlation ($P = 0.33$). The mean proximal to distal amplitude ratio in patients with good late facial nerve outcome was $0.9 \pm 0.6$ and in those with poor function, it was $0.8 \pm 0.2$ and the difference was not statistically significant ($P = 0.65$).

The mean value of CMAP latency after proximal stimulation at the REZ was $9.1 \pm 2.6$ msec for patients with good postoperative function and $9.5 \pm 1.8$ msec in patients with poor postoperative function. Statistical analysis showed no significant correlation with the facial nerve outcome ($P = 0.77$). Proximal to distal latency ratio showed no significant correlation with the outcome ($P = 0.71$).

In patients with good long-term facial nerve function, the mean tumor size was $3.8 \text{ cm}$ and the facial nerve length was $2.9 \text{ cm}$, whereas in patients with poor function, the mean tumor size was $4.5 \text{ cm}$ and the facial nerve length was $3.1 \text{ cm}$. Statistically there was no significant correlation between the size of the tumor ($P = 0.82$), consistency of the tumor ($P = 0.51$), brainstem distance ($P = 0.13$), size of the porus acusticus ($P = 0.22$), and facial nerve length ($P = 0.64$), and the long-term functional outcome in whom the facial nerve was anatomically preserved [Table 5].

We suspect that tumor size did not have a statistically significant impact on facial nerve function since the majority of our tumors were large (only nine patients with tumors <3 cm) and also probably because our sample size was limited. In the 14 patients where the facial nerve was not preserved anatomically, the average tumor size was $4.2 \text{ cm}$, mean brainstem distance was $2.5 \text{ cm}$, and porus size was $0.8 \text{ mm}$ (these parameters were not significantly different from tumors in which the facial nerve was anatomically preserved) [Table 5].

### Table 4: Impact of electrophysiological response on long-term facial nerve function

<table>
<thead>
<tr>
<th>Electrophysiological response</th>
<th>House-Brackmann grade (long-term outcome)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Good HBG I/II Poor HBG III/IV/V/VI</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>44</td>
<td>15</td>
</tr>
<tr>
<td>No</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>48</td>
<td>19</td>
</tr>
</tbody>
</table>

HBG - House-Brackmann grade

### Table 5: Impact of tumor size, brainstem distance, porus size, facial nerve length, and tumor consistency on long-term facial nerve function in 59 patients

<table>
<thead>
<tr>
<th>House-Brackmann grade</th>
<th>Tumor size ($P = 0.82$) (cm) (%)</th>
<th>Brainstem distance ($P = 0.13$) (cm)</th>
<th>Porus size ($P = 0.22$) (cm)</th>
<th>Facial nerve length* ($P = 0.64$) (cm)</th>
<th>Tumor consistency ($P = 0.51$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small ($\leq 1$) Medium ($2 &gt; 1 &lt; 3$) Giant ($\geq 3$)</td>
<td>$\leq 2 &gt; 2$</td>
<td>$\leq 1 &gt; 1$</td>
<td>$\leq 2 &gt; 2$</td>
<td>Solid Cystic</td>
</tr>
<tr>
<td>Good I/II</td>
<td>6 (100) 14 (78) 24 (69)</td>
<td>10 10 10</td>
<td>18 18 18</td>
<td>2 2 2</td>
<td>40 4</td>
</tr>
<tr>
<td>Poor III/IV/V/VI</td>
<td>0 4 (22) 11 (31)</td>
<td>3 3 3</td>
<td>5 5 5</td>
<td>1 1 1</td>
<td>14 1</td>
</tr>
<tr>
<td>Total</td>
<td>6 18 35</td>
<td>13 13 13</td>
<td>23 23 23</td>
<td>3 3 3</td>
<td>54 5</td>
</tr>
</tbody>
</table>

*Data for facial nerve length available only in 53 patients

### Discussion

Mere anatomical preservation of the facial nerve during surgery does not ensure normal or even satisfactory function. Across various reports, the facial nerve functional preservation rate was $80-100\%$ in tumors <2 cm and $56-100\%$ in tumor size between 2 and 4 cm. For those with tumor size >4 cm, the functional preservation rate varied from 20 to $94\%$.

Our facial nerve preservation rates are similar. The immediate auditory feedback offered by the use of intraoperative monitoring greatly enhances the surgeon’s ability to modify the dissection for maximal preservation of function.[1] Continuous free running electromyograms (EMGs) are recorded from the facial muscles, and the auditory loudspeaker monitoring it is linked to alerts the surgeon during dissection, indicating possible harm to the nerve.

Immediate postoperative facial nerve function seems to be the best indicator of long-term function (only $25\%$ of those with poor immediate postoperative function had a good long-term facial outcome).[2] Our findings were similar. However, most significantly, $48\%$ of our patients with poor early postoperative facial function had good long-term outcome, a phenomenon noted by others too.[2] This might give credence to delaying any kind of facial re-animation to at least a year after surgery.

In 1989, Niparko et al.[14] reported the results of correlating proximal to distal amplitude ratios for the first time. Twenty-four of their 29 patients demonstrated equal ratios with proximal and distal stimulation at the end of surgery, $67\%$ of whom had normal facial function at 1 week (H-B grade I); this number improved to $88\%$ at 1-year follow-up. This was corroborated by other studies that demonstrated proximal to distal amplitude ratios to be the most powerful parameter for intraoperative assessment of postoperative facial nerve function.[15,16]

More recently, Schmitt et al.[17] used supramaximal facial nerve stimulation at the REZ and stylomastoid foramen region of the facial nerve and found that it could predict better outcome in the long term.

Although we found a trend toward higher CMAP amplitudes in those with good immediate postoperative
function, as compared to those with poor outcome, we could not establish any correlation between the proximal to distal amplitude and latency ratios and the initial and long-term functional outcome. We suspect that when proximal to distal ratios were good but the long-term facial function was poor, it is possible that the REZ was damaged with an intact distal nerve. Sometimes this might be difficult to recognize intraoperatively and a good response might be obtained if the nerve is stimulated just distal to the REZ when, in fact, the REZ is damaged.

Statistical conclusions may have been limited by the small sample size of our study. Another drawback is that we used the porus as the distal stimulation site and could have missed nerve injuries between the porus and fundus of the tumor deeper in the internal auditory canal.

While a positive response to facial nerve stimulation at the end of VS surgery is a good predictor of long-term postoperative facial function, the absence of responses in an anatomically intact nerve does not preclude good function. Proximal to distal amplitude and latency ratios did not correlate with the final facial nerve function.

Acknowledgments

The authors would like Benjamin Franklin for assistance in electrophysiological monitoring during surgery of all these patients and Nithya Joseph for the statistical analysis of this paper.

References


How to cite this article: Turel MK, Babu KS, Singh G, Chacko AG. The utility of facial nerve amplitude and latency ratios in predicting postoperative facial nerve function after vestibular schwannoma surgery. Neurol India 2014;62:178-82.

Source of Support: Nil, Conflict of Interest: None declared.