Long-term Effects of Conservative Management of Vestibular Schwannoma on Dizziness, Balance, and Caloric Function

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No sponsorships or competing interests have been disclosed for this article.

Abstract

Objectives. To study the development of dizziness, caloric function, and postural sway during long-term observation of untreated vestibular schwannoma patients.

Study Design. Retrospective review of a prospectively maintained longitudinal cohort.

Setting. Tertiary referral hospital.

Subjects and Methods. Patients with vestibular schwannoma undergoing wait-and-scan management were included—specifically, those who did not require treatment during a minimum radiologic follow-up of 1 year. Baseline data and follow-up included magnetic resonance imaging, posturography, bithermal caloric tests, and a dizziness questionnaire. Main outcomes were prevalence of moderate to severe dizziness, canal paresis, and postural instability at baseline and follow-up, as compared with McNemar’s test.

Results. Out of 433 consecutive patients with vestibular schwannoma, 114 did not require treatment during follow-up and were included. Median radiologic follow-up was 10.2 years (interquartile range, 4.5 years). Age ranged from 31 to 78 years (mean, 59 years; SD, 10 years; 62% women). Median tumor volume at baseline was 139 mm³ (interquartile range, 314 mm³). This did not change during follow-up (P = .446). Moderate to severe dizziness was present in 27% at baseline and 19% at follow-up (P = .077). Postural unsteadiness was present in 17% at baseline and 21% at follow-up (P = .424). Canal paresis was present in 51% at baseline and 56% at follow-up (P = .664).

Conclusions. There was no significant change in the prevalence of dizziness, postural sway, or canal paresis during conservative management of vestibular schwannoma, while tumor volume remained unchanged. This indicates a favorable prognosis in these patients with regard to vestibular symptoms.
vertigo is the strongest negative predictor of quality of life in patients with vestibular schwannomas. Quality of life is also affected by unsteadiness. These observations were confirmed by others. Andersen et al found that 9% of patients with newly diagnosed vestibular schwannoma reported severe dizziness. We do not fully understand why some patients become dizzy while others do not, but tumor growth, fluctuations in vestibular function, and comorbidities are likely explanations for the vestibular symptoms in a majority of cases.

Usually, vestibular compensation will lead to relief from severe dizziness in most patients, despite damage to the vestibular nerve. Tumor growth is believed to disturb the vestibular compensation.

Given the impact of vestibular symptoms on quality of life, it is necessary to know the progression of vestibular function and symptoms if the tumor is left untreated. With regard to subjective vestibular symptoms, there are limited long-term data. No previous study has, to our knowledge, reported the long-term development of postural control during conservative management.

The aim of this study was to investigate the long-term consequences of conservative vestibular schwannoma management on dizziness, postural instability, and caloric function.

Materials and Methods

Patients, Design, Treatment Algorithm, and Ethics

This is a retrospective study of a subset of 433 patients newly diagnosed with sporadic unilateral vestibular schwannoma who were included into a prospectively maintained database. The 433 patients were included between September 2001 and March 2010 and followed up at regular intervals (6 months and 1, 2, 5, and 10 years). Data on management, tumor size, clinical symptoms, hearing, and vestibular function were recorded. Our management algorithm and methods for estimating tumor volumes from MRI scans were published earlier.

The patients were elected for conservative management, GKR, or microsurgery according to the following algorithm based on tumor size and growth: conservative management (wait and scan) if the tumor was <20 mm; GKR for tumors of 20 to 25 mm or smaller, if there was documented growth on serial MRI; and microsurgery for tumors >25 mm.

For the present study, we identified and included patients who, by August 2018, still underwent conservative management and had both MRI and either caloric tests or clinical data at 2 time points over an interval of at least 1 year.

The database and its use for scientific studies were approved by the Norwegian National Data Inspectorate (NSD 13199), and all patients gave their written informed consent at inclusion.

Data Collection for the Present Study

For the present study, we used data on MRI, posturography, and bithermal caloric tests. A questionnaire was filled in, including visual analog scale (VAS) scores for vertigo symptoms, time course, and characteristics of dizziness.

Static posturography was carried out with a force platform (Cosmogamma, Bologna, Italy) containing 3 pressure transducers. The movement of the center of pressure was measured while the patients were instructed to stand still and maintain their balance for 1 minute—both with eyes open and with eyes shut. For statistical analysis, the path length in millimeters with eyes closed was used. For patients undergoing static posturography at baseline, this method was also used at follow-up.

Since 2006, postural balance for new patients was measured with dynamic posturography (EquiTest; NeuroCom, Pleasanton, California) and the sensory organization test protocol. This method involved measuring postural sway under 6 sensory conditions where a combination of movement of platform and the visual surroundings was used to challenge the vestibular component of the balance. The composite score was calculated and used for measuring postural sway. These procedures were described in a previous study.

For static posturography, postural sway was defined as the path length in millimeters with the eyes closed. The composite score was used for dynamic posturography.

Caloric Testing

Slow-phase nystagmus velocities were measured by videonystagmography (GN Otometrics, Pleasanton, California) after 30 seconds of irrigation with cold (30°C) and hot (44°C) water into the external auditory canal. Canal paresis was defined as unilateral weakness >25% calculated with Jongkees’s formula.

Dizziness Symptoms

To quantify dizziness, the patients were asked to answer the question “How troublesome is your dizziness usually?” on a 100-mm VAS. To make interpretation of the VAS scores more intuitive, we used a grading system and cut points developed for pain: a VAS score ranging from 0 to 4 mm, “no dizziness”; 5 to 44 mm, “mild dizziness”; 45 to 74 mm, “moderate dizziness”; and 75 to 100 mm, “severe dizziness.”

The patients were also asked about the time course of their dizziness (attacks, periods, constant or no dizziness) and characteristics of dizziness (spinning, rocking, walking on pillows, and other) during the last 3 months.

Statistical Analysis

Stata/SE 15.1 software (StataCorp, College Station, Texas) was used for statistical analysis. The dependent variables were moderate to severe dizziness defined as VAS >44, canal paresis >25%, and unsteadiness on either of the 2 posturography platforms. Normative values between age groups given by NeuroCom International were used to define cut points for unsteadiness on the dynamic platform. In static posturography, unsteadiness was defined as path length >1600 mm when performed with the eyes closed.
Data at baseline were compared with data from the last clinical control. McNemar’s test for paired data (chi-square and exact P values) and paired t tests were used. P values <.05 were considered significant.

**Results**

Out of 433 patients screened at baseline, 223 were selected for wait-and-scan management. Of these, 114 remained untreated by August 2018 and were included in the study (Figure 1). The mean age was 59 years (range, 31-78 years; SD, 10 years), and 62% of the patients were women. The median radiologic follow-up was 10.2 years (interquartile range [IQR], 4.5 years). Figure 2 shows the proportions of patients with dizziness, unsteadiness, and canal paresis from baseline to follow-up. Table 1 shows changes in the number of patients with dizziness, unsteadiness, and canal paresis from baseline to follow-up.

**Dizziness**

The distribution of VAS score at baseline is shown in Figure 3. Moderate to severe dizziness was reported by 27% (n = 27) at baseline and 19% (n = 19) at follow-up. There was no significant change in the proportion with dizziness from baseline until last follow-up. Median follow-up time for the VAS scores was 3.1 years (IQR, 3.1 years).

**Posturography**

Static posturography was used for 64 patients and dynamic posturography for 40 patients. Seventeen percent (n = 18) were unsteady at baseline and 21% (n = 22) at last follow-up. There was no significant change in the proportion with unsteadiness from baseline until last follow-up, also in analysis of the static and dynamic posturography platforms separately. Median follow-up time was 9.1 years (IQR, 6.6 years).

### Table 1. Change in Number of Patients with Dizziness, Unsteadiness, and Canal Paresis from Baseline to Follow-up.

<table>
<thead>
<tr>
<th>Dizziness* (n = 100)</th>
<th>Follow-up</th>
<th></th>
<th>Unsteadiness (n = 104)</th>
<th>Follow-up</th>
<th></th>
<th>Canal Paresis (n = 72)</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Baseline</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Yes</td>
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<td>Yes</td>
<td>13</td>
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<td>Yes</td>
<td>28</td>
</tr>
<tr>
<td>No</td>
<td>4</td>
<td>69</td>
<td>Yes</td>
<td>9</td>
<td>77</td>
<td>Yes</td>
<td>12</td>
</tr>
</tbody>
</table>

*Moderate to severe dizziness.
Caloric testing was included into the testing protocol from June 2003. Fifty-one percent (n = 37) of the patients had canal paresis at baseline and 56% (n = 40) on the last clinical control. There was no significant change in the proportion of patients with canal paresis from baseline until last follow-up. Median follow-up time was 9.1 years (IQR, 6.3 years).

**Tumor Volume**

In total, 114 patients had radiologic follow-up with at least 2 MRI scans with measurements of tumor volume. Median tumor volume was 139 mm³ (IQR, 314 mm³) at baseline and 139 mm³ (IQR, 288 mm³) at last follow-up. Median follow-up time was 10.2 years (IQR, 4.5 years). Mean tumor volume did not change significantly during follow-up ($P = .446$, paired $t$ test).

The time course and characteristics of dizziness are shown in **Tables 2 and 3**. Only 7% reported constant dizziness at baseline and 9% after a median follow-up of 3.5 years.

**Discussion**

This study found no significant changes in dizziness symptoms, postural balance, or caloric response during long-term conservative management of vestibular schwannoma. To our knowledge, this is the first study to investigate long-term development of objective balance and caloric function in patients with untreated vestibular schwannoma.

The findings indicate a good prognosis in this patient group. In a normal population, the proportion of subjects experiencing dizziness and imbalance tends to increase over time due to aging and age-related diseases. Du Pasquier et al estimated postural stability impairment due to aging, and Saman et al measured postural stability in patients with untreated vestibular schwannoma using functional gait assessment scores and found a correlation between age $\geq 60$ years and decreased postural stability. Breivik et al did not find a significant change in VAS score from baseline to last follow-up but a significant decrease in number of patients with vertigo. Godefroy et al observed 41 patients with vestibular schwannoma with a mean follow-up of 47 months. Some of the patients who reported vertigo or unsteadiness were better at follow-up, and some were worse. No trends were reported.

We found that the function of the vestibular nerve as measured by caloric asymmetry did not seem to deteriorate over time as long as there was no tumor growth. This is in contrast to what was found when long-term hearing outcomes were evaluated in patients with untreated vestibular schwannoma. Several studies have investigated hearing outcome in treated and untreated vestibular schwannomas and found that hearing deteriorates even if the tumor is not treated, but there is a lack of studies investigating changes in vestibular nerve function during conservative management and how it affects symptoms such as vertigo and imbalance.

In our study, postural unsteadiness was present in 17% at baseline and 21% at last follow-up. This is less than that reported by others. Collins et al found that 49% of patients with vestibular schwannoma had abnormal path lengths with eyes closed prior to surgery. Matthies and Samii tested balance with eyes closed and found abnormal results to be most common in patients with tumors compromising the brain stem but almost equally (41%) in purely intrameatal tumors. Gerosa et al found that 62% of patients had abnormal results on computerized static stabilometry before GKR. Indications for surgery might include larger tumors, growing tumors, or more symptoms, including dizziness and postural imbalance. In addition, preoperative patients may have increased postural sway due to nervousness. In a previous study, we found that sway on the dynamic platform was associated with tumor size as well as subjective dizziness. In our study, patients had predominantly small tumors without tumor growth. Different prevalence of abnormal postural sway might also result from different choices of normative values. For static posturography, we used normative values from a previously published study with the same platform to measure the balance of healthy controls with a mean age of 52 years, slightly younger than that in the present study. For dynamic posturography, we used normative values integrated in the software supplied by the producer.

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**Table 2. Time Course of Dizziness at Baseline and Follow-up in 98 Patients with Vestibular Schwannoma.**

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Attacks</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Periods</td>
<td>33</td>
<td>34</td>
</tr>
<tr>
<td>Constant</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>No dizziness</td>
<td>43</td>
<td>44</td>
</tr>
</tbody>
</table>

*aReported dizziness last 3 months.  
*bMean, 3.5 years.

**Table 3. Dizziness Characteristic at Baseline and Follow-up in 91 Patients with Vestibular Schwannoma.**

<table>
<thead>
<tr>
<th>Type of Dizziness</th>
<th>Baseline</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Spinning</td>
<td>20</td>
<td>22</td>
</tr>
<tr>
<td>Rocking</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td>Walking on pillows</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>No dizziness</td>
<td>43</td>
<td>47</td>
</tr>
</tbody>
</table>

*aReported dizziness last 3 months.  
*bMean, 3.4 years.
In this study, canal paresis was present in 51% of cases at baseline and 56% at follow-up. Humphriss et al reported that 63% of their cases had unilateral canal paresis, and in a group of patients selected for operation, 86% had canal paresis defined as unilateral weakness >20%.31

**Strengths and Limitations**

To our knowledge, caloric function and posturography have not been measured in a long-term follow-up study of untreated vestibular schwannoma patients before, and longitudinal data on subjective vertigo are limited. The observation period in this study was relatively long, with 10-year median radiologic follow-up.

A limitation is the use of 2 methods of posturography since they measure balance in different ways. However, for each patient, the same method was used at baseline and follow-up. This means that a change in measured postural sway would never be due to a change of method. Nevertheless, we did perform a separate analysis of the 2 platforms and found no change in postural sway during follow-up in either of them. Since the focus of this study was change during follow-up, we believe that the use of 2 platforms was of no consequence to the conclusions. The VAS is not a validated method for quantifying dizziness, and the Dizziness Handicap Inventory might have been used to advantage. However, the distribution of VAS scores and the Dizziness Handicap Inventory might have been used to advantage. Nevertheless, we did perform a separate analysis of the 2 platforms and found no change in postural sway during follow-up in either of them. Since the focus of this study was change during follow-up, we believe that the use of 2 platforms was of no consequence to the conclusions. The VAS is not a validated method for quantifying dizziness, and the Dizziness Handicap Inventory might have been used to advantage. However, the distribution of VAS scores (Figure 3) in our study is quite similar to the distribution of Dizziness Handicap Inventory scores in the study from Humphriss et al32 and Lloyd et al,3 indicating that the proportion of patients with moderate to severe symptoms might be comparable.

In this study, only the caloric test was used as an indicator of vestibular nerve function, because this was the only method available to us at the time of inclusion. Adding other tests, such as vestibular evoked myogenic potentials and video head impulse tests, could result in a higher detection of patients with impaired function of the vestibular nerve, particularly the inferior ramus. However, a change in function would normally have been detected since the same method was used throughout the follow-up period. Moreover, the caloric test has proven to be quite sensitive, since in a previous study,14 93% of patients with tumors >20 mm were found to have canal paresis >25%.

The most likely explanation for the findings in this study is that central compensation leads to a slight decrease in dizziness over time in patients with newly diagnosed vestibular schwannomas and that this, to some degree, counteracts the effects of aging. Prerequisites for effective central compensation may be a nongrowing tumor and stable peripheral vestibular function.

The clinical significance of this finding is that patients may be reassured that the prognosis is relatively favorable with regard to vestibular symptoms during wait-and-scan management of a nongrowing tumor. Symptoms are likely to remain stable or even decrease slightly over time. Vestibular rehabilitation33 may be indicated to promote central compensation and improve physical function as well as quality of life in patients with significant residual symptoms.

**Summary**

This study found no significant change in the prevalence of moderate to severe dizziness, postural instability, or canal paresis during long-term follow-up of conservatively managed cases of vestibular schwannoma.

**Author Contributions**

Kathrin Skorpa Nilsen, substantial contribution to conception and design of the study; analysis and interpretation of the data; drafting and revising the manuscript for important intellectual content; final approval of the version to be published; agreement to be accountable for all aspects of the work; Morten Lund-Johansen, substantial contribution to conception and design of the study, analysis and interpretation of the data; drafting and revising the manuscript for important intellectual content; final approval of the version to be published; agreement to be accountable for all aspects of the work; Stein Helge Glad Nordahl, substantial contribution to conception and design of the study, analysis and interpretation of the data; drafting and revising the manuscript for important intellectual content; final approval of the version to be published; agreement to be accountable for all aspects of the work; Monica Finnkirk, substantial contribution to conception and design of the study, analysis and interpretation of the data; drafting and revising the manuscript for important intellectual content; final approval of the version to be published; agreement to be accountable for all aspects of the work; Frederik Kragerud Goplen, substantial contribution to conception and design of the study, analysis and interpretation of the data; drafting and revising the manuscript for important intellectual content; final approval of the version to be published; agreement to be accountable for all aspects of the work.

**Disclosures**

**Competing interests:** None.

**Sponsorships:** None.

**Funding source:** None.

**References**


