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

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Paper presented in: AAO-HNSF Annual Meeting & OTO Experience; October 7-10, 2018; Atlanta, GA

Keywords:

Vestibular schwannoma / Acoustic neuroma

Long-term prognosis

Posturography / Balance

Vertigo / Dizziness

Caloric test

Untreated / Conservative management/ Observation

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. Vestibular schwannoma patients undergoing wait-and-scan management were included. Baseline data and follow-up with MRI, posturography and bithermal caloric tests. Dizziness questionnaire.

The study included patients who did not require treatment during a minimum radiologic follow-up of 1 year. Main outcomes: prevalence of moderate to severe dizziness, canal paresis and postural instability at baseline and follow-up compared using McNemar's test.

Results. Out of 433 consecutive vestibular schwannoma patients, 114 patients did not require treatment during follow-up and were included. Median radiologic follow-up was 10.2 years (IQR 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 mm^3 (IQR 314 mm^3). This did not change during follow-up (P=0.446).

Moderate to severe dizziness was present in 27% at baseline and in 19% at follow-up (P=0.077). Postural unsteadiness was present in 17% at baseline and 21% at

follow-up (P=0.424). Canal paresis was present in 51% at baseline and 56 % at follow-up (P=0.664).

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 regards to vestibular symptoms.

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Introduction

Conservative management of vestibular schwannomas with regular magnetic resonance imaging (MRI) has become a common management strategy in recent years. Along with the increased availability of MRI, this “wait-and-scan” policy has become feasible due to the fact that about 50 % of small to medium sized tumors do not grow when observed for five years.[1] Other management options are mainly gamma knife radiosurgery (GKR) or microsurgical removal of the tumor. Since vestibular schwannoma is rarely fatal today, the choice between these management modalities is increasingly aimed at preserving the quality of life of the patient.

The most common symptoms in untreated vestibular schwannoma patients are unilateral hearing loss (94-97%), tinnitus (73-83%), unsteadiness (33,5%-63%) and vertigo (20-49%).[2-9] We were the first to demonstrate that vertigo is the strongest negative predictor of quality of life in patients with vestibular schwannomas. Quality of life is also affected by unsteadiness.[10] These observations were confirmed by others.[3,11-13]

Andersen et al[14] found that 9% of newly diagnosed vestibular schwannoma patients 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,[15] 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 regards to subjective vestibular symptoms there is limited long-term data.[12,16-18] 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, 1, 2, 5 and 10 years). Data on management, tumor size, clinical symptoms, hearing and vestibular function were recorded.[10] Our management algorithm and methods for estimating tumor volumes from MRI scans have been published earlier.[19]

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) was chosen if the tumor was less than 20 mm. GKR was chosen for tumors of 20-25 mm, or smaller tumors if there was documented growth on serial MRI. Microsurgery was the treatment of choice for tumors larger than 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 two time points over a time interval of at least one 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 using a force platform (Cosmogamma, Bologna, Italy) containing three 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 with eyes open and same procedure 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 using dynamic posturography (EquiTest, NeuroCom, USA) and the Sensory Organization Test (SOT) protocol. This method involved measuring postural sway under six different sensory conditions where a combination of movement of platform and the visual surroundings were used to challenge the vestibular component of the balance. The composite score was calculated and used for measuring postural sway. These procedures are described in a previous study.[14]

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

Caloric Testing

Slow phase nystagmus velocities were measured by videonystagmography (Hortmann, Germany) 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 greater than 25% calculated using Jongkees' formula.[20]

Dizziness Symptoms

To quantify dizziness, the patients were asked to answer the question "How troublesome is your dizziness usually?" on a 100-mm visual analog scale (VAS). To make interpretation of the VAS scores more intuitive, we used a grading system and cut points developed for pain.[21] A VAS score 0 to 4 mm was ranged as ''no dizziness,'' a score of 5 to 44 mm was ranged as ''mild dizziness,'' a score of 45 to 74 mm was ranged as ''moderate dizziness,'' and a score of 75 to 100 mm was ranged as ''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 three months.

Statistical Analysis

STATA software (StataCorp, USA) was used for statistical analysis. The dependent variables were moderate to severe dizziness defined as VAS> 44, canal paresis greater than 25% and unsteadiness on either of the two posturography platforms. Normative values between age groups given by Neurocom International[22] were used to define cut points for unsteadiness on the dynamic platform. In static posturography unsteadiness was defined as path length more than 1600 mm when performed with eyes closed.[23]

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 less than 0.05 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**). Mean age was 59 years (range 31-78 years; SD 10 years) and 62 % of the patients were female. The median radiologic follow-up was 10.2 years (IQR 4.5 years). **Figure 2** shows proportions of patients with dizziness, unsteadiness and canal paresis from baseline to follow-up. **Table 1** shows changes in 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 at baseline were reported by 27% (N=27), and 19% (N=19) at follow-up. There was no significant change in 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 of the patients and dynamic posturography for 40 patients. 17 % (N=18) of the patients were unsteady at baseline and 21 % (N=22) at last follow-up. There was no significant change in proportion with unsteadiness from baseline until last follow-up, also when analyzing the static and dynamic posturography platforms separately. Median follow-up time was 9.1 years (IQR 6.6 years).

Caloric Testing

Caloric testing was included into the testing protocol from June 2003. 51 % (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

114 patients had radiologic follow-up with at least 2 MRI scans with measurements of tumor volume. Median tumor volume at baseline was 139 mm^3 (IQR 314 mm^3) and at last follow-up 139 mm^3 (IQR 288mm^3). Median follow-up time was 10.2 years (IQR 4.5 years). Mean tumor volume did not change significantly during follow-up, P=0.446 (paired t-test).

The time course and characteristics of dizziness are shown in **Table 2** and **Table 3**. Only 7 percent reported constant dizziness at baseline, and 9 percent 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 untreated vestibular schwannoma patients.

The findings indicate a good prognosis in this patient group. In a normal population proportion of subjects experiencing dizziness and imbalance tends to increase over time due both to ageing and to age-related diseases.
Du Pasquier et al estimated the postural stability impairment due to aging[24] and Saman measured postural stability in untreated vestibular schwannoma patients using the functional gait assessment (FGA) scores and found a correlation between age over 60 years and decreased postural stability.[25]

Breivik 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.[16]
Godefroy et al[17] observed 41 vestibular schwannoma patients with a mean follow-up of 47 months. Some of the patients that 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 with what is found when evaluating long-term hearing outcomes in untreated vestibular schwannoma patients. Several studies have investigated hearing outcome in treated and untreated vestibular schwannomas,[26] and found that hearing deteriorates even if the tumor is not treated,[16,27-28] but there is a lack of studies investigating changes in vestibular nerve function during conservative management and how it affects symptoms like vertigo and imbalance.

In our study, postural unsteadiness was present in 17 % at baseline and 21 % at last follow-up. This is less than reported by others. Collins et al[29] found that 49% of vestibular schwannoma patients 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.[4]

Gerosa[30] found that 62% of patients had abnormal results on computerized static stabilometry before gamma knife radiosurgery. 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.[14] 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 using the same platform to measure the balance of healthy controls with a mean age of 52 years, which is slightly younger than in the present study. For dynamic posturography, we used normative values integrated in the software supplied by the producer.

Canal paresis was in this study found to be present in 51 % of cases at baseline and in 56 % at follow-up. Humphriss et al reported that 63 % of their cases had unilateral canal paresis,[7] 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 years median radiologic follow-up.

A limitation is the use of two different methods of posturography since they measure balance in different ways. However, for each individual 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 two platforms, and found that there was 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 two different platforms was of no consequence to the conclusions. The VAS is not a validated method for quantifying dizziness, and the dizziness handicap inventory (DHI), might have been used to advantage.

However, the distribution of VAS scores (**Figure 3**) in our study is quite similar to the distribution of DHI scores in the study from Humphriss[32] and Lloyd[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, like 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 larger than 20 mm were found to have a canal paresis greater than 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 non-growing 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 regards to vestibular symptoms during wait-and-scan management of a non-growing tumor. Symptoms are likely to remain stable or even decrease slightly over time. Vestibular rehabilitation[33] 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 vestibular schwannoma patients.

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Table 1. 2 x 2 tables showing change in number of patients with dizziness*(N=100) unsteadiness (N=104) and canal paresis (N=72) from baseline to follow-up

Dizziness*	Yes f	No f	Unsteadiness	Yes f	No f	Canal paresis	Yes f	No f
Yes b	15	12	Yes b	13	5	Yes b	28	9
No b	4	69	No b	9	77	No b	12	23

* Moderate to severe dizziness

b Baseline

f Follow-up

Table 2. Time course of dizziness at baseline and follow-up (mean 3.5 years) in 98 patients with vestibular schwannoma *

	Baseline		Follow-up	
	N	%	N	%
Attacks	15	15	17	17
Periods	33	34	30	31
Constant	7	7	9	9
No dizziness	43	44	42	43

*Reported dizziness last 3 months

Table 3. Dizziness character at baseline and follow-up (mean 3.4 years) in 91 patients with vestibular schwannoma*

	Baseline		Follow-up	
Type of dizziness	N	%	N	%
Spinning	20	22	14	15
Rocking	22	24	23	25
Walking on pillows	5	6	8	9
Other	1	1	5	6
No dizziness	43	47	41	45

*Reported dizziness last 3 months

Fig 1. Flow diagram showing treatment of 433 vestibular schwannoma patients resulting in the inclusion of 114 participants in the present study by august 2018.

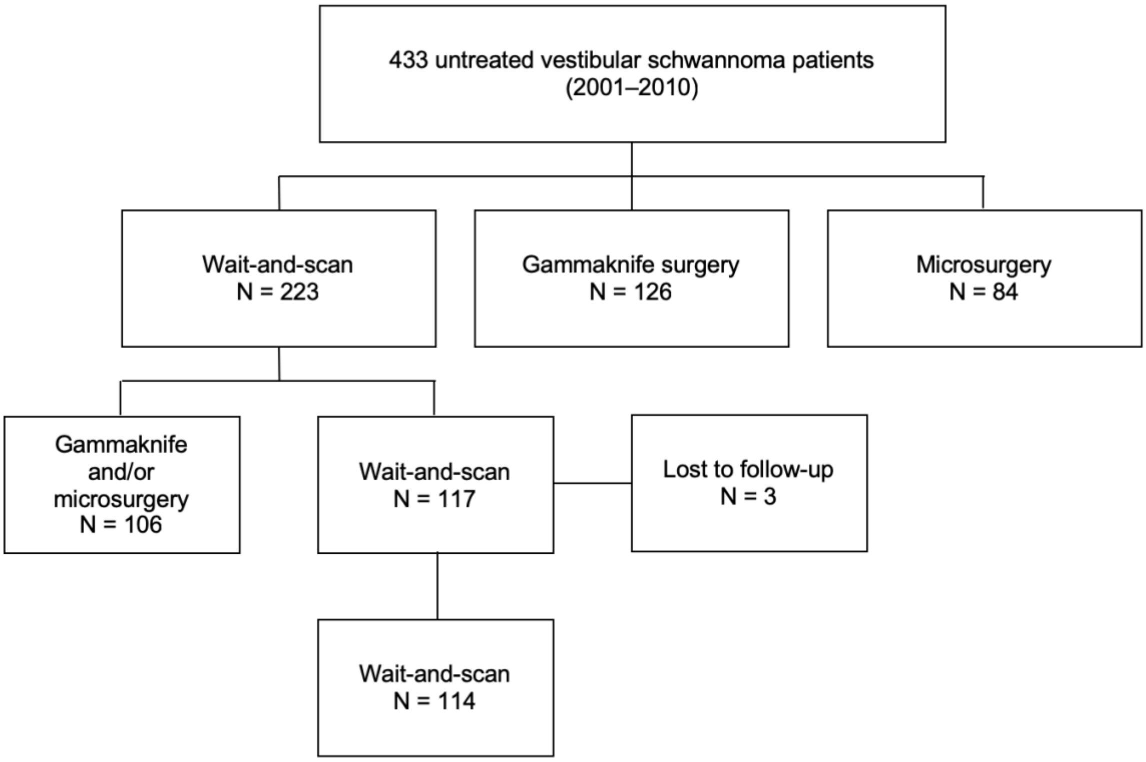

Fig 2. Proportions with moderate to severe dizziness, unsteadiness and canal paresis at baseline and follow-up.

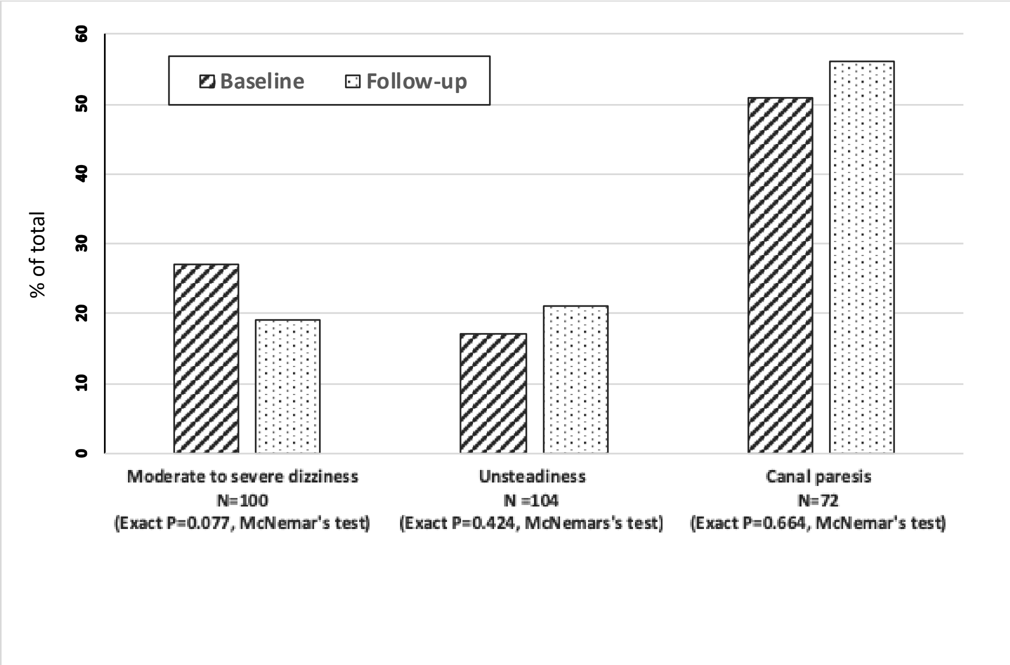

Fig 3. Distribution of VAS-score at baseline in 100 patients with untreated vestibular schwannomas.