Change in Hearing and Tinnitus in Conservatively Managed Vestibular Schwannomas

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ABSTRACT

Objective: The aim of this study was to evaluate the change of hearing and tinnitus in a group of conservatively managed unilateral vestibular schwannomas (VS). **Design:** Retrospective case series review. **Setting:** Tertiary referral otoneurological and skull base surgery department. **Participants:** Seventy patients affected by unilateral VS with at least two audiograms available were retrospectively evaluated. **Main outcome measures:** Changes in pure tone average (PTA), speech discrimination score (SDS), and tinnitus were analyzed. **Results:** At diagnosis 16 patients (22.9%) had a PTA of 0 to 30 dB and 38 (54.4%) a PTA of 0 to 50 dB. At the end of the follow-up period, 9 patients (12.9%) had a PTA of 0 to 30 dB and 27 (38.7%) had a PTA of 0 to 50 dB, representing a hearing preservation rate of 56% and 70%, respectively. Of patients with both tonal and speech audiometry, 71.4% with class A hearing (PTA < 30 dB/SDS > 70%) maintained their initial hearing and 60% with class A or B hearing (PTA < 50 dB/SDS > 50%) maintained this useful hearing. Forty-two patients (60%) did not show a significant growth in their tumor over the period of observation. In this group of patients the mean PTA after a mean follow-up time of 40 months decreased from 44 dB HL to 50.8 dB HL, with a yearly rate of 2.47 dB HL. The chance of maintaining a PTA of 0 to 30 dB in this group of patients was 57.1% and a PTA of 0 to 50 dB was 81.4%. **Conclusions:** In this group of patients affected by VS and managed conservatively with a mean follow-up of 33.3 months, the risk of losing eligibility for hearing preservation surgery was lower than 30%.

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Conservative management represents a treatment option for patients affected by vestibular schwannomas (VS). Recent reports of large series¹⁻⁴ have shown that a watch, wait, and rescan (W&W) policy is a reasonable choice in selected cases instead of microsurgical removal or radiation therapy. While the natural history of VS, the risk of tumor growth, and failure of conservative management have been widely discussed, few studies^{1,4-8} have reported the change in hearing and therefore the risk of hearing loss in conservatively managed VS. Authors have shown that hearing deteriorates over time in conservatively managed VS independent of tumor growth, and that even in nongrowing tumors there is a significant risk of hearing loss.^{5,6,8}

Many patients with VS experience tinnitus. While the majority of patients with unilateral VS undergoing microsurgical resection report tinnitus,⁹ in the Cambridge series tinnitus was the principal presenting symptom in only 11% (56 of 473).⁹ Similar results were reported in VS patients managed conservatively.^{1,3} To our knowledge no data have been published on the change in tinnitus in these patients nor on the relationship between the presence of tinnitus and the fate of their hearing.

The aim of this study was (1) to evaluate the change of hearing in a group of conservatively managed unilateral VS and (2) to determine the incidence and change of tinnitus over time and its relation to the fate of the hearing in these patients.

MATERIALS AND METHODS

Between March 1988 and December 2000, 129 patients with unilateral sporadic VS referred to

the Department of Otoneurological and Skull Base Surgery of the Addenbrooke's Hospital, Cambridge, UK, were placed on a W&W policy. The clinical records of all these patients were retrospectively reviewed and all relevant data were recorded in a computer database. Patients affected by unilateral VS and with at least two hearing tests during the follow-up period were included. The American Academy of Otolaryngology Head and Neck Surgery (AAO) guidelines for the evaluation of hearing were followed.¹⁰ The pure-tone average (PTA) was calculated as the mean of 0.5-, 1-, 2-, and 3-kHz thresholds. The 3-kHz threshold was obtained from the average of 2 and 4 kHz. Speech audiometry was performed in quiet using Boothroyd word lists,¹¹ scoring by phonemes correctly repeated at several suprathreshold intensities.

The presence of tinnitus was evaluated at the first clinic attendance and on follow-up visits. The temporal characteristics of tinnitus as well as its pitch and severity were evaluated. Tinnitus severity was scored as mild, moderate, or severe. Mild tinnitus is not perceived in the presence of background noise, moderate tinnitus is perceived above the ambient background noise, and severe tinnitus is perceived above the ambient background noise and interfered with sleep. On follow-up visits the tinnitus status of the patient was reassessed.

All patients were followed up with annual gadolinium-enhanced MRI scan at the Addenbrooke's Hospital MRI unit. Maximum tumor size was measured by an experienced neuroradiologist axially along the internal auditory canal (IAC) and parallel to the posterior surface of the temporal bone; the maximum diameter craniocaudally was also measured. Significant tumor growth was defined as a diameter change greater than 2 mm along the same axis on interval MRI.³

Statistical Analysis

Parametric and nonparametric statistics were used as appropriate. Statistical significance was set for $p < 0.05$.

RESULTS

Seventy patients affected by unilateral VS served as subjects. Thirty-four patients were male and 36 female; mean age at diagnosis was 60 years (range, 29 to 81). Mean maximum tumor size at diagnosis was 8.31 mm (2.5 to 23 mm). Mean follow-up was 33.3 months (range, 7 to 111 months).

Hearing

At the outset the mean PTA at diagnosis was 47.26 dB HL (standard deviation [SD], 20.41 dB HL). At the end of the follow-up period the mean PTA was 56.3 dB HL (SD, 21.8 dB HL). The average PTA deterioration rate was 4.4 dB HL/year (SD, 6.4 dB HL). At diagnosis 16 patients (22.9%) had a PTA of 0 to 30 dB and 38 (54.4%) a PTA of 0 to 50 dB. At the end of the follow-up period 9 patients (12.9%) had a PTA of 0 to 30 dB and 27 (38.7%) had a PTA of 0 to 50 dB, leading to a hearing preservation rate, respectively, of 56% and 70%.

Thirty-two subjects had both pure-tone and speech discrimination scores (SDS). Mean SDS at diagnosis was 71.7% (SD, 30.5%); at last follow-up mean SDS was 62.3% (SD, 32.9%). Five of 7 ears (71.4%) with class A (PTA < 30 dB/SDS > 70%)¹⁰ hearing maintained their initial hearing and 9 of 15 ears (60%) with class A or B hearing (PTA < 50 dB/SDS > 50%)¹⁰ maintained this useful hearing.

In the contralateral ear, the mean PTA at diagnosis was 23.21 dB HL (SD, 16.86 dB HL); at the end of the follow-up period the mean PTA was 25.96 dB HL (SD, 17 dB HL). The mean hearing deterioration rate was 1.15 dB HL/year (SD, 2.59

Table 1 Mean Yearly Hearing Deterioration Rate and Standard Deviation in Vestibular Schwannoma and Contralateral Ear

Frequency	VS Ear		Contralateral Ear		P
	Mean	SD	Mean	SD	
0.25 kHz	2.08	6.23	0.43	4.77	0.08
0.5 kHz	3.53	5.29	0.48	4.02	0.002
1 kHz	4.77	8.2	0.89	3.23	< 0.001
2 kHz	5.12	8.36	1.55	3.44	0.003
4 kHz	4.36	7.2	1.87	6.58	0.05
8 kHz	3.6	7.87	1.18	7.28	0.475
PTA	4.44	6.47	1.15	2.6	< 0.001

VS, vestibular schwannoma; SD, standard deviation.

dB HL). Table 1 shows the average hearing deterioration rate (SD) at each frequency in the VS ear and the contralateral ear. Statistical analysis showed that the yearly hearing deterioration rate was higher in the VS ear than in the contralateral ear at frequencies between 0.5 and 4 kHz (Table 1).

Pearson's correlation showed that the PTA yearly change positively correlated with the yearly growth rate (R 0.421; $p < 0.001$). No significant correlation between initial size of the tumor and both growth and PTA yearly change was found ($p > 0.05$). No significant correlation was found ($p > 0.05$) between the initial PTA and both growth and PTA yearly change. In addition, no significant correlation ($p > 0.05$) between the decrease in SDS and the duration of follow-up was evident.

NONGROWTH GROUP

Forty-two patients (60%) showed no growth over the observation period. In this group of patients the mean PTA after a mean follow-up of 39.5 months (range, 12 to 111) decreased from 44 dB HL to 50.8 dB HL with a yearly rate of 2.47 dB HL. At diagnosis, 14/42 patients had a PTA < 30 dB HL and 13/42 between 30 and 50 dB HL; at the end of the follow-up period 8/42 and 14/42 patients had a PTA < 30 dB HL and between 30 and 50 dB HL, respectively. The chance of maintaining a PTA of 0 to 30 dB in this group of patients was 57.1% and a PTA of 0 to 50 dB was 81.4%. Statistical analysis

revealed that growing VS showed a higher yearly deterioration of PTA than nongrowing VS ($p=0.031$). The comparison of each single frequency showed a higher rate in growing tumors than nongrowing VS only at 2 kHz ($p=0.019$).

Hearing deterioration rate in both growing and nongrowing VS was significantly higher than in the contralateral ear at 0.5, 1, 2, and 4 kHz ($p < 0.001$) (Fig. 1).

TREATMENT GROUP

Twenty-seven patients (39%) required treatment because of an increase of tumor size, increase in symptoms, or patient choice. In this group of patients, mean PTA decreased from 52.8 dB HL to 65.4 dB HL with a yearly rate of 7.4 dB HL. At diagnosis, 2/27 patients had a PTA < 30 dB HL and 10/27 between 30 and 50 dB HL; at the time of surgery, after a mean follow-up of 23.4 months (range, 7 to 84 months), 1/27 and 4/27 patients had a PTA < 30 dB HL and between 30 and 50 dB HL, respectively. The chance of maintaining a PTA

of 0 to 30 dB in this group of patients was 50% and a PTA of 0 to 50 dB was 41.6%. At the time of surgery, 1 of 2 ears (50%) with class A hearing and 4 of 8 ears (50%) with class A or B hearing maintained this useful hearing.

Tinnitus

At diagnosis, 54 patients (77.1%) reported tinnitus in the VS ear, and in 13 (18.5%) tinnitus was the first presenting symptom. Tinnitus was constant in 35 cases and intermittent in 19 cases. In 77.8% of patients, tinnitus was of a high-frequency pitch, while low- and medium-frequency tinnitus was reported by the remaining 22.2% of patients. Tinnitus was graded as mild in 63.9% of cases, moderate in 25.5% of cases, and severe in 10.6%. In these patients who had tinnitus at diagnosis, the experience was that during the follow-up it was worse in 15.7%, the same in 78.4%, and better in 5.9%. In those patients who had no tinnitus at the diagnosis, none developed tinnitus during follow-up.

Figure 1 Hearing deterioration rate in growing vestibular schwannomas (VS), nongrowing VS, and in the contralateral ear for each frequency and for the pure tone average (PTA) for the frequencies 0.5 to 3 kHz. NS, not significant.

Statistical analysis showed that patients with tinnitus showed a greater PTA deterioration rate than patients with no tinnitus ($p = 0.015$ for intermittent tinnitus and 0.004 for continuous tinnitus). The presence of tinnitus or its worsening was not related to the yearly growth rate of the VS ($p > 0.05$).

DISCUSSION

VS is associated with a deterioration of hearing greater than the "normal" age-related hearing loss. Growing VS were associated with a significantly higher deterioration of PTA than nongrowing VS and a significant positive correlation was found between VS growth rate and PTA change. In the present series, after an average follow-up of 33.3 months, 56% of patients with an initial PTA of 0 to 30 dB and 70% of patients with an initial PTA of 0 to 50 dB maintained their hearing. If speech discrimination scores are also considered, 71.4% of patients with class A hearing and 60% with class A or B¹⁰ hearing maintained this useful hearing. Tschudi and associates¹ reported that after a mean follow-up of 35 months, hearing was maintained in the 67% of VS patients with an initial PTA of 0 to 30 dB and in the 65% of patients with an initial PTA of 0 to 50 dB. In contrast, Charabi and colleagues,⁴ in a series of patients with a longer follow-up, reported that 89% of the patients with class A hearing lost eligibility for hearing preservation surgery. The presence of a VS is associated with a significant long-term risk of hearing loss, especially if the VS is growing. VS ears showed an increase of hearing thresholds (between 0.5 and 4 kHz) higher than the contralateral ear that reflect the progression of presbycusis. The progression of hearing loss was not correlated to the initial VS size or the initial PTA, but growing tumors showed a higher hearing deterioration rate.

Sixty percent of VS did not show significant growth. In this group of patients, after an average follow-up of 39.5 months, 57.1% maintained a 0- to

30-dB PTA and 81.4% a 0- to 50-dB PTA. Similar findings were reported by Warrick et al,⁵ who evaluated the hearing change in a group of nongrowing VS. In their study, 71% and 78% of patients maintained a PTA between 0 to 30 and 0 to 50 dB. Fifty-seven percent of patients with class A hearing and 75% of patients with hearing class A or B maintained their hearing. Rosenberg¹² reported that a change of PTA ≥ 10 dB or SDS $\geq 15\%$ occurred in 50% of nongrowing VS. Other authors have reported that a deterioration of audiological function occurs in the absence of tumor growth^{1,5,6} or even in shrinking tumors.¹³ Although in this series nongrowing VS showed a slower hearing deterioration rate compared with growing tumors, mean PTA deterioration rate was higher than the contralateral ear. Similar results were reported by Graamans et al,⁸ who found that the hearing thresholds corrected for presbycusis correlated with the duration of follow-up. While in growing tumors a direct tumor compression may be responsible for the hearing change, in stable VS other less obvious factors may be responsible. Ischemia induced by the blood-stealing action of the tumor, changes in the vascular supply of the cochlea, biochemical alterations of the inner ear fluids, hair cell degeneration, and dysfunction of the stria vascularis may all play a role in hearing impairment.^{1,14-17}

The finding that the presence of tinnitus is associated with deterioration of hearing thresholds is interesting and has not to our knowledge been reported previously. As with hearing loss, the mechanisms of tinnitus generation in VS are not yet fully understood. It may be considered that the association between tinnitus and hearing deterioration derives from change in the status of the peripheral auditory system caused by tumor growth or other activity (ischemic or biochemical). This is an area worthy of further consideration. In our hands,¹⁸ hearing preservation has proved to be elusive, but even in other surgical series¹⁹⁻²¹ hearing preservation rates rarely reach 50%. In this series of conservatively managed VS, the risk of losing eligibility for hearing preservation surgery was lower than 30%. In addition, 50% of VS requiring treatment

maintained eligibility for hearing preservation procedures (hearing class A or B).

PAPER PRESENTED

The audiometric data herein was reported at the Fourth International Conference on Vestibular Schwannoma and Other CPA Lesions, Cambridge, England, July 2003.

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