

Hearing aids and tinnitus therapy: a 25-year experience

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Abstract

Objectives: (1) To assess the subjective tinnitus perception of patients with audiological proven hearing loss presenting to a tinnitus clinic, both before and after hearing aid provision; (2) to investigate subjective tinnitus perception in patients with unilateral and bilateral hearing loss; and (3) to assess the impact on tinnitus perception, if any, of a digital hearing aid programme in patients provided with hearing aids.

Design: Prospective data collection for patients attending a tinnitus clinic over a 25-year period (1980–2004).

Setting: University teaching hospital otolaryngology department.

Participants: A total of 2153 consecutive patients attending a consultant-delivered specialist tinnitus clinic.

Main outcomes measures: A visual analogue scale was used to assess the degree of tinnitus perception improvement, if any, comparing before versus after unilateral or bilateral aiding (in those with audiometrically proven hearing loss). A further assessment compared the effect of digital hearing aid programme introduction on symptomatic tinnitus perception in patients provided with unilateral or bilateral aids.

Results: A total of 1440 patients were given hearing aids (826 unilateral and 614 bilateral). There was little difference in tinnitus perception, comparing overall aiding results in unilaterally or bilaterally aided patients. Overall, 554 (67 per cent) of unilaterally aided patients and 424 (69 per cent) of bilaterally aided patients reported some improvement in their tinnitus perception following aiding. There was a statistically significant improvement in tinnitus perception, comparing analogue aids with digital hearing aids, following introduction of a digital hearing aid programme in 2000, in both unilaterally ($p < 0.001$) and bilaterally ($p < 0.001$) aided patients.

Conclusions: Provision of hearing aids in patients with audiometrically demonstrable hearing loss can play a very important part in tinnitus control. The additional improvement in tinnitus control observed following introduction of programmable digital aids had a summative effect in the management of these patients.

Key words: Tinnitus; Hearing Loss; Hearing Aids; Patient; Digital

Introduction

Tinnitus is the perception of sound that cannot be heard outside the body. This phenomenon affects many people. Studies have suggested that between 0.5 and 2 per cent of UK adults suffer tinnitus severe enough to have a significant adverse effect on their lifestyle and quality of life.^{1,2} It has been estimated that about 200 000 people in the UK have tinnitus of a severity that prevents them from working or functioning socially.³ In 1953, Heller and Bergman⁴ suggested that, in a normally hearing population, 94 per cent would perceive tinnitus if confined to a sound-proof room for five minutes.⁴

We studied the work of the senior author's tinnitus clinic, and here present the results of hearing aiding

on the tinnitus perception of patients who also had audiometrically proven hearing loss.

Methods

The tinnitus clinic was commenced by the senior author in 1980. Since that time, contemporaneous data have been collected prospectively on all patients seen within the clinic. These patients were either direct referrals from their general practitioner to the tinnitus clinic, or were seen at the request of a consultant colleague. The tinnitus clinic was organised as a multidisciplinary clinic with the help of the audiology department. Tinnitus therapy was available, provided by the senior departmental

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TABLE I
TINNITUS CLINIC, ATTENDANCE AND MAIN COMPLAINT

Years	Total number of patients seen	Male	Female	Unilateral tinnitus symptom	Bilateral tinnitus symptom
1980–1984	415	246	169	240	175
1985–1989	460	290	170	251	209
1990–1994	440	204	236	215	225
1995–1999	458	304	154	217	241
2000–2004	380	198	182	198	182
Total	2153	1242	911	1121	1032

audiologist. The senior author was the only member of medical staff in the clinic, and thus all patients were assessed by the same clinician.

The purpose of this study was to ascertain the effect on subjective tinnitus perception in patients receiving unilateral or bilateral hearing aids (provided to improve the symptomatic complaint of hearing loss, confirmed audiometrically), using prospectively acquired data. The study also evaluated tinnitus perception both before and after introduction of a digital hearing aid programme in 2000. Analysis took account of unilateral versus bilateral aiding, and of patient's subjective symptomatic improvement (assessed using a visual analogue scale). Patients' subjective tinnitus scores were compared before and after hearing aid provision. Furthermore, patients were categorised into those with a greater than 50 per cent improvement, those with a less than 50 per cent improvement and those whose tinnitus was subjectively unaffected by hearing aid use. Following hearing aid provision, tinnitus was re-evaluated once aid fitting was satisfactory and patients were making optimal use of their aid.

Data are reported in a format which allows direct-comparison of patients' subjective improvement.

Participants

All patients were seen and assessed by the senior author. Patients underwent blood pressure measurement plus blood tests for urea and electrolytes, thyroid function, full blood count and erythrocyte sedimentation rate. All general practitioner referrals to the tinnitus clinic were screened by the senior author; if the primary complaint was of tinnitus, a tinnitus clinic appointment was made. Referrals were also accepted at a tertiary level from other colleagues.

Following such referral, if audiometry suggested a sensorineural hearing loss, then the patient was offered a hearing aid. Aiding was unilateral or bilateral, depending on the degree of audiological deficit. Due to the long study duration and the consequent evolution in hearing aid technology and audiological criteria, it is beyond the scope of this paper to detail all the specific audiological and aiding criteria used at different stages throughout the 25-year project. Patients were aided audiologically, either unilaterally or bilaterally, if they met the aiding criteria current at the time of tinnitus clinic presentation. During follow up, these patients were asked if their tinnitus had changed following aiding. All patients

requiring a hearing aid up to and including 1999 were offered analogue aiding. In 2000, University Hospital Birmingham was included in the first phase of a digital hearing aid programme. Thereafter, all patients were offered programmable digital aids.

The results presented in this report pertain only to patients provided with hearing aids for hearing loss, and do not include results for masking or tone-matching.

Results

A total of 2153 patients was seen between 1980 and 2004. Table I shows the number of patients seen in each five-year block, and whether their main complaint was unilateral or bilateral tinnitus. The number of patients seen was fairly consistent, at between 380 and 460 per five-year period. It can be seen that, in all the five-year blocks except for 1990–1994, more men than women were referred to the tinnitus clinic.

A total of 1440 patients with audiometrically proven hearing loss were provided with hearing aids. Tables II and III show details for these patients, according to presenting complaint (bilateral or unilateral tinnitus). Of the 1121 patient presenting with unilateral tinnitus, 826 (74 per cent) were supplied with a hearing aid. Of the 1032 patients presenting with bilateral tinnitus, 614 (59 per cent) were provided with a hearing aid.

Table IV details the subjective improvement in tinnitus perception in patients provided with a unilateral aid for hearing loss. The improvement was based on the results of subjective tinnitus assessments (using a visual analogue scale) conducted before and after hearing aid fitting. These two results were compared to give a percentage improvement in tinnitus

TABLE II
UNILATERAL TINNITUS PATIENTS PROVIDED WITH UNILATERAL HEARING AIDS*

Year	UT pts (n)	UA pts (n)
1980–84	240	182
1985–89	251	204
1990–94	215	161
1995–99	217	175
2000–04	198	104
Total	1121	826

*For audiometrically proven hearing loss. UT = unilateral tinnitus; pts = patients; UA = unilaterally aided

TABLE III

BILATERAL TINNITUS PATIENTS PROVIDED WITH BILATERAL HEARING AIDS*

Year	BT pts (<i>n</i>)	BA pts (<i>n</i>)
1980–84	175	103
1985–89	209	97
1990–94	225	117
1995–99	241	137
2000–04	182	160
Total	1032	614

*For audiometrically proven hearing loss. BT = bilateral tinnitus; pts = patients; BA = bilaterally aided

perception. Patients' improvement in tinnitus perception was categorised as: greater than 50 per cent; less than 50 per cent; and none (i.e. no effect).

The results were further analysed to ascertain if any further improvement in tinnitus symptoms occurred in those patients who were digitally aided (i.e. 2000–2004), compared with those receiving analogue aids (i.e. 1980–1999). Analysis was undertaken using the Kendall Tau-B test, a statistical test used for ordinal statistics. The Kendall Tau-B result produced a correlation coefficient of -0.159 with $p < 0.001$. These results indicate that the degree of improvement in tinnitus perception was significantly greater in 2000–2004 compared with 1980–1999.

Table V reveals the subjective improvement in tinnitus perception in patients receiving bilateral hearing aids for hearing loss. Analysis was based upon subjective improvement in tinnitus perception, comparing before and after hearing aid provision, as described above. Improvement in tinnitus perception was compared for those receiving digital aids (2000–2004) versus analogue aids (1980–1999). Analysis of results, using the Kendall Tau-B test, revealed a correlation coefficient of -0.422 with $p < 0.001$. These results indicate that the degree of improvement in tinnitus perception was significantly greater in 2000–2004 compared with 1980–1999.

Discussion

In the senior author's tinnitus clinic, during the patient's initial appointment some time was given to explaining the role of tinnitus and hearing loss. It was emphasised that tinnitus does not cause hearing loss, and that, even if the perception of

tinnitus disappeared, hearing loss would still be present and require support. In agreement with Folmer and Carroll,⁵ we found that the use of hearing aids enabled patients to habituate to their tinnitus – i.e. patients paid less notice to their tinnitus when external auditory stimuli were restored. Satisfactory management of the interplay between tinnitus and subjective hearing loss often requires lengthy clinical appointments involving the clinician and tinnitus therapist. It is important that patients fully comprehend their problem, in terms of the current model of tinnitus perception and the complex interplay of the limbic, autonomic and auditory systems in the perception of tinnitus. The neurophysiological model of tinnitus described by Jastreboff *et al.*⁶ can help patients understand the factors and relationships which may precipitate and worsen (or improve) their tinnitus perception.

We are still unsure why the majority of patients who admit to prolonged, spontaneous tinnitus do not seek medical attention. The purely subjective nature of the complaint is one of the difficulties in managing tinnitus patients. Some require only explanation and reassurance that the condition has no life-threatening sequelae; however, others find the condition intrusive and difficult to cope with, and it is vital that opportunities for helping these latter patients are not lost. Along with effects on hearing and emotional state, sleep deprivation is one of the primary complaints of the tinnitus patient.⁷ The emotional and psychological wellbeing of the tinnitus patient may be affected by stress. Sahley and Nodar hypothesise that the heightened awareness of tinnitus during times of stress may be related to a biochemical change mediated by neurotransmitters.⁸ Therefore, the importance of optimising such patients' psychological wellbeing should not be underestimated. Referral for psychological support may be required. In many patients, the tinnitus may well represent the apparent medicalisation of an emotional problem.

Hearing loss and tinnitus perception are often linked, and many studies have investigated the incidence of hearing loss in patients complaining of tinnitus. A 1989 Great Britain study of hearing collected much information, including audiological data.⁹ These data demonstrated that the best predictor of persistent, spontaneous tinnitus was high frequency hearing impairment at 4, 6 and 8 kHz. This finding was

TABLE IV

SUBJECTIVE IMPROVEMENT IN TINNITUS PERCEPTION FOLLOWING UNILATERAL AIDING

Year	UA pts (<i>n</i>)	Tinnitus improvement		
		>50%	<50%	None
1980–84	182	81	43	58
1985–89	204	78	59	67
1990–94	161	55	41	65
1995–99	175	68	44	63
Subtotal 1980–99	722	282 (39%)	187 (26%)	253 (35%)
2000–04	104	68 (65%)	17 (17%)	19 (18%)
Total	826	350	204	272

UA = unilaterally aided patients

TABLE V
SUBJECTIVE IMPROVEMENT IN TINNITUS PERCEPTION FOLLOWING BILATERAL AIDING

Years	BA pts (n)	Tinnitus improvement		
		>50%	<50%	None
1980–1984	103	32	25	46
1985–1989	97	28	27	42
1990–1994	117	34	36	47
1995–1999	137	41	48	48
Subtotal 1980–99	454	135 (30%)	136 (30%)	183 (40%)
2000–2004	160	127 (80%)	26 (16%)	7 (4%)
Total	614	262	162	190

BA pts = bilaterally aided patients

supported by other studies from around the world. The Beaver Dam study in the US and the Blue Mountain hearing study in Australia both investigated patients initially identified through an ophthalmological study.^{10,11} These studies surveyed 3753 and 2015 adults, respectively, regarding otological complaints and noise exposure. The Beaver Dam study investigated many risk factors for tinnitus (at the outset of the study and subsequently at five years), including otological condition, lifestyle and self-reported health conditions. After multiple logistical regression analysis, the authors concluded that hearing loss was the single greatest risk factor for the prevalence of tinnitus. The Blue Mountain study analysed audiometric data in participants who reported tinnitus and compared the results to data from a group with no complaints of tinnitus. Analysis revealed an association between tinnitus and hearing loss. This was most pronounced at the higher frequencies and there was a stronger association in those under 65 years old, although the association was significant in all age groups.

In the UK, hearing loss is a huge problem, and its management has historically been given little support. Davis's 1989 UK study highlighted the enormity of the problem.⁹ In a multi-city study of 48 313 participants invited to complete a questionnaire, 10 per cent complained of prolonged, spontaneous tinnitus (i.e. tinnitus persisting for more than a few minutes at a time, and occurring not only after loud sounds). A cohort of respondents who had completed the initial questionnaire were audiologically tested. Sixteen per cent (aged: 17–80 years) had a greater than 25 dBHL impairment bilaterally; and 26 per cent had a greater than 25 dBHL impairment uni- or bilaterally. This high rate of hearing impairment contrasted dramatically with other reported rates at the time. It was felt that this was due to the inclusion of 4 kHz at audiological testing. The UK general household survey of 2002¹² revealed that 19 per cent of men and 13 per cent of women reported hearing difficulties. This difference between the sexes was evident in all age groups, but was most pronounced among the elderly. Fifty-two per cent of men aged 75 years and over reported hearing problems compared with 38 per cent of women.

The current study has demonstrated the use of audiological aiding in the management of tinnitus, in patients with audiometrically proven hearing loss. In this study, there is no doubt that the majority

of patients provided with hearing aids, both uni- and bilateral, experienced an improvement in their subjective perception of tinnitus. Tinnitus and hearing loss are inextricably linked, and the rationale for audiological support of tinnitus patients with hearing loss is compelling. In the current, long term study, a dramatic improvement in subjective tinnitus perception was observed in patients provided with either unilateral or bilateral aiding. Often, this was all that was required to control this group of patients.

The limitations of the current study are recognised. These include the heterogeneous nature of the patient group receiving hearing aids. Over the 25-year study period, aiding technology and expertise have changed. Undoubtedly, the analogue aids fitted during the period 1980–1999 were not uniform in terms of technology or fitting protocols, and we accept this as a weakness of the study. The audiological criteria for aiding have undoubtedly changed over the same period and, again, this led to a heterogeneous group with analogue aids. However, because of the large sample size, it is our belief that the groups are still comparable.

- It has been suggested that 0.5–2 per cent of UK adults suffer tinnitus which is severe and has a significant adverse effect on their lifestyle and quality of life
- It has been estimated that approximately 200 000 UK adults have tinnitus of a severity that prevents them from working or functioning socially
- This study aimed to assess the subjective tinnitus perception of patients presenting to a tinnitus clinic, both before and after hearing aid provision, in those with audiologically proven hearing loss
- Provision of hearing aids in those with demonstrable audiometric loss can play a very important part in tinnitus control. The introduction of programmable digital aids had a summative effect on this improvement in tinnitus control

The role of tinnitus counselling in the clinic played an integral role in the management of the patients. It

is difficult to assess the impact on the study results of the changes and improvements in tinnitus retraining over the 25 years of the study.

Over the 25-year study period, new techniques have been introduced to grade tinnitus severity.¹³ These are based on the tinnitus handicap inventory.^{14,15} This is a subjective questionnaire based on self-reporting by the patient. It has robust test-retest reliability and can be used to assess the patient's ongoing subjective tinnitus perception. The tinnitus handicap inventory and the current guidelines for tinnitus severity grading had not been published when the authors' tinnitus clinic opened; thus they have not been used in the reporting of data for the two groups of aided patients.

In 1967, Klockhoff and Lindblom¹⁶ proposed a grading system for studying Ménière's disease. This included three categories for tinnitus: audible in a quiet environment; audible in ordinary noise but divertible (when performing a task); and constant and not divertible, even when working. This grading was not used, as it was felt to be a less precise measurement than the visual analogue scale.

The current study found that, over the years 1980–1999, approximately 35 per cent of patients complaining of tinnitus experienced no improvement in tinnitus perception following provision of unilateral aiding. This figure dropped significantly in the same cohort of patients, to only 18 per cent, after provision of programmable digital hearing aids in 2000. The results for bilateral aiding are similar. Between 1980 and 1999, 40 per cent of patients experienced no improvement in their tinnitus perception following aiding; however, the incidence of no improvement dropped significantly, to only 4 per cent, after programmable digital hearing aids were introduced.

On first consideration, this dramatic decrease may be surprising. However, the 1989 national hearing survey found that the best predictor of tinnitus development was high tone hearing loss. Programmable digital hearing aids are able to provide selective audiological support for these types of selective losses, without the problem of amplification of low frequencies. We conclude that it is this single factor which has so dramatically improved the tinnitus perception of patients supplied with hearing aids for hearing loss.

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