Auris Nasus Larynx 47 (2020) 763–768

Contents lists available at ScienceDirect

Auris Nasus Larynx

journal homepage: www.elsevier.com/locate/anl

Retrospective evaluation of secondary effects of hearing aids for tinnitus therapy in patients with hearing loss

Yoshihiro Yokota[a], Akinori Yamashita[b], Shinji Koyama[a], Koichi Kitano[b], Shintaro Otsuka[b], Tadashi Kitahara[b,*]

[a] Department of Otolaryngology, Yamato-Takada Municipal Hospital, Japan
[b] Department of Otolaryngology - Head and Neck Surgery, Nara Medical University Hospital, Japan

ARTICLE INFO

Article history:
Received 26 November 2019
Accepted 17 March 2020
Available online 4 May 2020

Keywords:
Hearing loss
Hearing aid
Bilateral tinnitus
Unilateral tinnitus
Wearing side

ABSTRACT

Objective: Acoustic therapies including hearing aids and tinnitus control instruments are widely used in Japan but without high levels of evidence. The outpatient hearing aid clinic at our institution fits patients with hearing aids and instructs patients on how to use them to control tinnitus if present. In this study, we examined the effects of this approach on tinnitus.

Methods: One hundred and eleven of 138 patients who visited our hearing aid clinic from April 2016 to September 2018 purchased hearing aids after fitting. Sixty-six of these patients (31 men, 35 women; mean age 78.0 ± 8.0 years) had both hearing loss and tinnitus and were enrolled. The tinnitus was bilateral in 41 patients and unilateral in 25 (poor hearing ear, $n = 16$, good hearing ear, $n = 9$). Hearing aids were worn bilaterally by 23 patients and unilaterally by 43 (89 devices). Seventeen of the 23 patients wearing bilateral hearing aids had bilateral tinnitus and 6 had unilateral tinnitus, i.e., in 40 ears, the tinnitus side matched the hearing aid side (40 devices) and in 6 ears did not (6 devices). Twenty-four of 43 patients wearing unilateral hearing aids had bilateral tinnitus, meaning that in 24 ears the tinnitus side matched the hearing aid side (24 devices). In six of the remaining 19 cases with unilateral tinnitus, the hearing aid and tinnitus were on the same side (6 devices) and in 13 were on opposite sides (13 devices). Changes in the Tinnitus Handicap Inventory (THI), visual analog scale (VAS, for tinnitus discomfort, severity, and persistence), and Hospital Anxiety and Depression Scale scores were measured immediately before using a hearing aid and 12 months later.

Results: Significant effects of hearing aids on tinnitus were observed in all subjects (THI, $p = 0.0000030$), VAS (severity, $p = 0.000000066$; discomfort, $p = 0.0000013$). Significant effects were observed with bilateral hearing aids (THI, $p = 0.0012$; VAS for severity, $p = 0.00069$; VAS for discomfort, $p = 0.00052$) and with unilateral hearing aids (THI, $p = 0.00055$; VAS for severity, $p = 0.000034$; VAS for discomfort, $p = 0.00007$). Spearman's rank correlation coefficient showed a significant positive correlation between the THI and VAS scores ($p = 0.0033$). In cases of bilateral tinnitus, significant differences were observed with bilateral hearing aids (THI, $p = 0.011$; VAS for severity, $p = 0.0019$; VAS for discomfort; $p = 0.020$) and with unilateral hearing aids (THI, $p = 0.00069$; VAS for severity, $p = 0.00071$; VAS for discomfort, $p = 0.000093$).

Conclusion: Acoustic therapy using hearing aids was effective for tinnitus. Even when bilateral, a unilateral hearing aid is able to improve tinnitus. When unilateral, the ipsilateral hearing aid is able to improve tinnitus.

https://doi.org/10.1016/j.anl.2020.03.005
0385-8146/

1. Introduction

According to a report by Eggermont et al., about 5%–15% of the general US population is aware of constant tinnitus, with the percentage being higher among the elderly [1]. In particular, individuals who experience discomfort and problems in their daily lives related to tinnitus are thought to make up 1%–3% of the general population, which is a figure that cannot be ignored. In an epidemiological study of tinnitus in Japan by Kojima et al., the prevalence of tinnitus increased with age, reaching 15%–30% in the elderly [2]. Although the number of individuals with tinnitus is increasing in today's stressful environment, treatment of the disorder in clinical practice still consists of perfunctory pharmacotherapy and has shown few signs of advances over time.

Multimodal therapy for tinnitus has consisted of (1) explanations of tinnitus and the patient's status, (2) pharmacotherapy, (3) acoustic therapy, and (4) psychotherapy. However, the American Tinnitus Association published clinical guidelines for tinnitus in 2014 [3], and based on these guidelines, the Japan Audiological Society published its own guidelines in 2019 [4]. These guidelines summarize the previous literature on tinnitus therapies and provide strict assessments of the recommendation levels for each treatment. Unfortunately, only acoustic therapy and cognitive therapy were strongly recommended for the treatment of tinnitus.

Before 1980, acoustic therapy had been performed as "masking therapy" by Vernon and Schleuning [5] but had not been widely used. In the late 1980s, cognitive therapy was added to acoustic therapy based on Jastreboff's neurophysiological model of tinnitus. Known as tinnitus retraining therapy, this strategy became popular, particularly in the US [6]. This is a method of treating tinnitus that seeks to reduce discomfort by adapting the patient to tinnitus and sound stimulation from a sound generator attached to the ear. A survey using a questionnaire on how much tinnitus disturbed daily life found that this treatment achieved improvement rates of 69%–96% [7]. However, this therapy requires considerable time and effort on the part of both patient and doctor.

Recently, there have been many reports on acoustic therapies using environmental sounds, especially hearing aids [8,9]. Including both a hearing aid for hearing loss and a treatment for tinnitus, such therapies are realistic to recommend to patients with tinnitus and easy for them to understand. Patients at our hospital's outpatient hearing aid clinic are fitted with hearing aids, and if they also have tinnitus, are instructed on the use of the devices to control tinnitus. The aim of this study was to examine the therapeutic effects of this approach on tinnitus.

* Corresponding author.
E-mail address: tkitahara@naramed-u.ac.jp (T. Kitahara).

2. Materials and methods

2.1. Fitting

The Department of Otolaryngology at Yamato-Takada Municipal Hospital includes an outpatient hearing aid clinic for hearing-impaired patients. The chief complaint of all these patients is hearing disturbance, regardless of tinnitus. Over 2 or 3 months, patients are fitted with a device so that they can hear half the sound pressure of their hearing ability. The hearing aid prescription details are automatically formulated with the digital non-linear amplification.

If the device is a good fit, the patient can purchase the device. Patients with extreme left/right differences are recommended to use a hearing aid in the ear with good hearing and those with similar hearing loss on both sides are recommended to use hearing aids on both sides.

2.2. Materials

Our outpatient hearing aid clinic examined 138 patients with the chief complaint of hearing difficulty over the 30 months from April 2016 to September 2018. Devices were purchased by 111 patients (80.4%), 27 (19.6%) of whom returned the device. Sixty-six (59.5%) of the patients who purchased a device had tinnitus and 45 (40.5%) did not. We examined the 66 patients who both purchased hearing aids and had tinnitus. The study group included 31 men and 35 women of mean age 78.0 ± 8.0 (52–97) years. The hearing aids were worn on a total of 89 ears (21 on the right, 22 on the left, and 23 on both sides). The mean hearing ability of the ears wearing hearing aids was 55.6 ± 12.2 (36.3–101.3) dB by quartation.

The tinnitus was bilateral in 41 patients and unilateral in 25 (poor hearing ear in 16 patients, good hearing ear in 9 patients). Hearing aids were worn bilaterally by 23 patients and unilaterally by 43 patients for a total of 89 ears (89 devices). Seventeen of the 23 patients wearing bilateral hearing aids had bilateral tinnitus and 6 had unilateral tinnitus; i.e., in 40 ears, the tinnitus side matched the hearing aid side (40 devices) and in 6 ears they did not match (6 devices). Twenty-four of the 43 patients wearing unilateral hearing aids had bilateral tinnitus, meaning that in 24 ears the tinnitus side matched the hearing aid side (24 devices). Of the remaining 19 cases with unilateral tinnitus, in 6 ears the hearing aid and tinnitus were on the same side (6 devices) and in 13 ears the hearing aid and tinnitus were on opposite sides (13 devices).

2.3. Methods

In the present study, we treated patients with the chief complaint of hearing disturbance, not tinnitus. They were advised that they had better wear hearing aids as long as possible. They were not received any counseling or cognitive therapy at any time during follow-ups.

A questionnaire that included the following items was given to patients who visited our outpatient hearing aid clinic

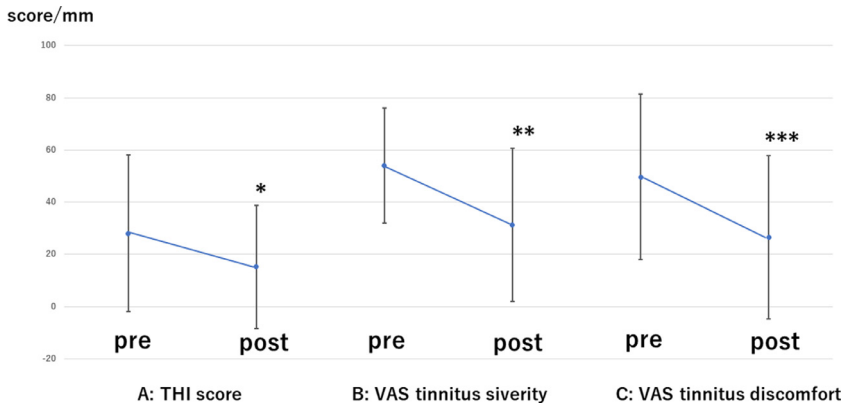

Fig. 1. Marked effects on tinnitus observed using hearing aids. For the patients overall ($n = 66$), significant improvements after wearing hearing aids were observed for (A) the THI score (from 28.00±30.04 to 15.21±23.64; $^{*}p = 0.0000030$, Wilcoxon test), (B) the VAS score for tinnitus severity (from 54.08±22.15 to 31.36±29.36; $^{**}p = 0.000000066$), and (C) the VAS score for tinnitus discomfort (from 49.70±31.77 to 26.55±31.37; $^{***}p = 0.0000013$). THI, Tinnitus Handicap Inventory; VAS, Visual Analog Scale.

immediately before being fitted with hearing aids and 12 months later to determine whether they experienced tinnitus and whether being fitted with hearing aids improved their tinnitus: ears fitted with hearing aids and sides affected by tinnitus; 25 items of the Tinnitus Handicap Inventory (THI); visual analog scale (VAS) scores for tinnitus severity and discomfort; and 14 items of the Hospital Anxiety and Depression Scale (HADS).

2.4. Statistical analysis

The above items were compared immediately before being fitted with hearing aids and 12 months later. The paired *t*-test was used for items that were distributed normally and the Wilcoxon signed-rank test was used as a non-parametric test for items that were not distributed normally. Correlations between the THI and VAS scores for tinnitus severity and discomfort were examined before and after fitting the hearing aid. The before-after change was evaluated using Spearman's rank correlation coefficient.

3. Results

For the 66 patients overall, wearing hearing aids achieved significant improvements in the THI score (from 28.00±30.04 to 15.21±23.64; $p = 0.0000030$, Wilcoxon), VAS score for tinnitus severity (from 54.08±22.15 to 31.36±29.36; $p = 0.000000066$), and VAS score for tinnitus discomfort (from 49.70±31.77 to 26.55±31.37; $p = 0.0000013$, Fig. 1A–1C). Marked effects were observed with both bilateral and unilateral hearing aids. For bilateral hearing aids ($n = 23$), the THI score improved from 29.30±32.79 to 15.65±24.89 ($p = 0.0012$), the VAS score for tinnitus severity from 55.22±20.50 to 31.22±27.82 ($p = 0.00069$), and the VAS score for tinnitus discomfort from 57.87±30.85 to 29.00±34.76 ($p = 0.00052$). For unilateral hearing aids ($n = 43$), the THI score improved from 27.30±28.43 to 14.98±22.94 ($p = 0.00055$) the VAS score for severity from 53.47±22.96 to 31.44±30.15 ($p = 0.000034$), and the VAS score for discomfort from 45.33±31.39 to 25.23±29.32 ($p = 0.00007$).

Significant positive correlations were observed between the THI score and VAS score for severity ($r = 0.51$, $p = 0.000044$, Spearman's test) and between the THI score and VAS score for discomfort ($r = 0.74$, $p = 0.0000000024$) before wearing hearing aids (Figure 2A, 2B) and between the THI score and VAS score for severity ($r = 0.79$, $p = 0.00000000047$) and between the THI score and VAS score for discomfort ($r = 0.84$, $p = 0.0000000000028$) after wearing hearing aids (Fig. 3A, 3B). With regard to the changes before and after wearing hearing aids, there was a tendency for a positive correlation between the THI score and VAS score for severity ($p = 0.053$) and a significant positive correlation between the THI score and VAS score for discomfort ($p = 0.000017$).

When considering only patients with bilateral tinnitus ($n = 41$), significant improvements were observed in the THI score (from 30.00±35.67 to 16.35±27.45; $p = 0.011$, Wilcoxon test), VAS score for severity (from 56.47±22.16 to 31.88±27.03; $p = 0.0019$), and VAS score for discomfort (from 59.18±32.23 to 31.88±32.45; $p = 0.020$) when hearing aids were worn bilaterally ($n = 17$) and in the THI score (from 29.83±30.03 to 13.00±22.70; $p = 0.00069$), VAS score for severity (from 52.38±22.13 to 25.08±31.06; $p = 0.00071$), and VAS score for discomfort (from 45.42±31.88 to 19.00±27.13; $p = 0.000093$) when a unilateral hearing aid was worn ($n = 24$). The effects of wearing bilateral or unilateral hearing aids were not significantly different in patients with bilateral tinnitus (Fig. 4A–4C).

In patients with unilateral tinnitus ($n = 25$) who wore a unilateral hearing aid ($n = 19$), the tinnitus tended to improve when the hearing aid was fitted on the same side as the tinnitus ($n = 6$), i.e., the THI improved from 12.33±19.47 to 10.33±20.47 ($p = 0.057$, Wilcoxon test), the VAS score for severity from 50.17±28.11 to 33.17±30.45; $p = 0.0012$, and the VAS score for discomfort from 40.50±33.50 to

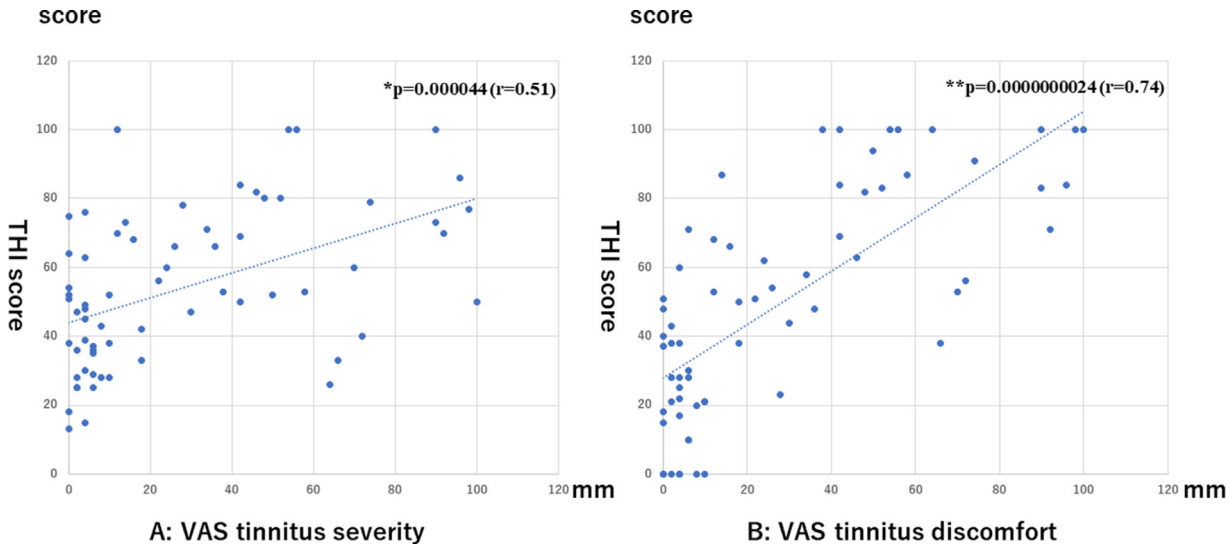

Fig. 2. Correlations between THI score and VAS score for severity and between THI score and VAS score for discomfort before wearing hearing aids. Significant positive correlations were observed between (A) the THI score and VAS score for severity ($r = 0.51$, $^{*}p = 0.000044$, Spearman's test) and (B) the THI and VAS score for discomfort ($r = 0.74$, $^{**}p = 0.0000000024$) before wearing hearing aids ($n = 66$). THI, Tinnitus Handicap Inventory; VAS, Visual Analog Scale.

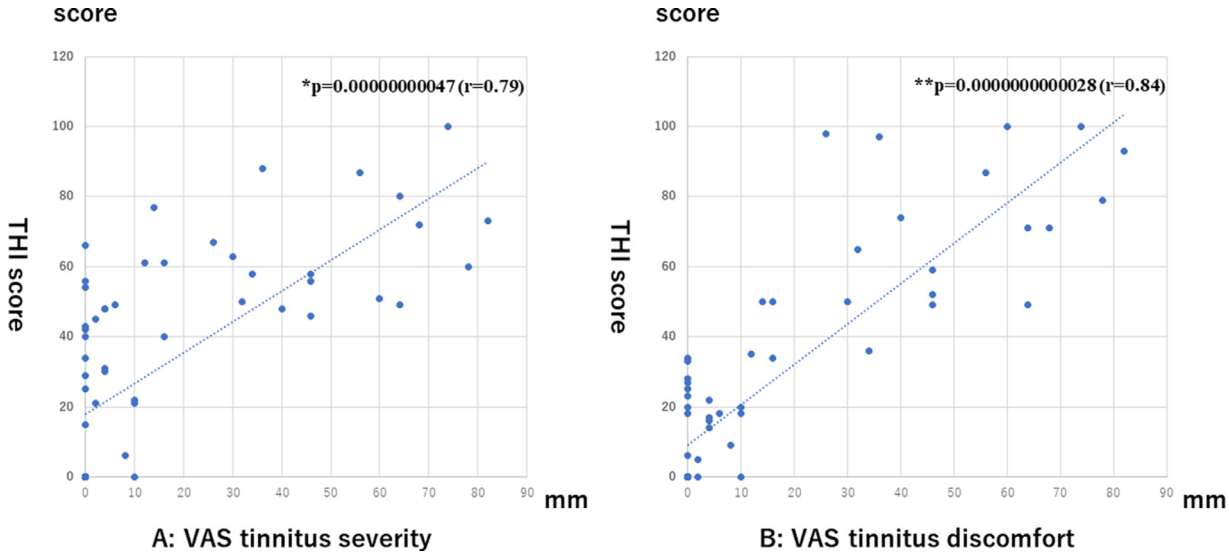

Fig. 3. Correlations between THI score and VAS score for severity and between THI score and VAS score for discomfort after wearing hearing aids. Significant positive correlations were observed between (A) the THI score and the VAS score for severity ($r = 0.79$, $^{*}p = 0.00000000047$, Spearman's test) and (B) the THI score and the VAS score for discomfort ($r = 0.84$, $^{**}p = 0.0000000000028$) after wearing hearing aids ($n = 66$). THI, Tinnitus Handicap Inventory; VAS, Visual Analog Scale.

22.50±31.31 ($p = 0.073$, Fig. 5A–5C). However, no significant improvement was found in patients fitted on the side opposite to the tinnitus ($n = 13$); in this group, the THI score improved from 29.54±26.72 to 20.77±23.34 ($p = 0.11$, paired t-test), the VAS score for severity from 57.00±21.33 to 42.38±24.53 ($p = 0.064$), and the VAS score for discomfort from 47.38±29.17 to 38.00±28.18 ($p = 0.20$, Fig. 6A–6C).

Significant decreases were observed in the HADS score after wearing hearing aids; the anxiety score improved from 5.75±4.16 to 4.77±3.64 ($p = 0.038$, Wilcoxon test) and the depression score from 6.50±4.35 to 4.36±3.71 ($p = 0.000063$).

4. Discussion

Patients who purchased and used hearing aids from our outpatient hearing aid clinic showed significant changes in terms of their THI score, which indicates the degree of difficulty encountered in daily life due to tinnitus, and VAS scores for the severity and discomfort of tinnitus. Good results were obtained regardless of whether patients wore bilateral or unilateral hearing aids and are similar to those of previous studies [8,9] demonstrating that acoustic therapy with hearing aids is effective for tinnitus.

No significant difference was observed in patients with bilateral tinnitus according to whether they wore bilateral or

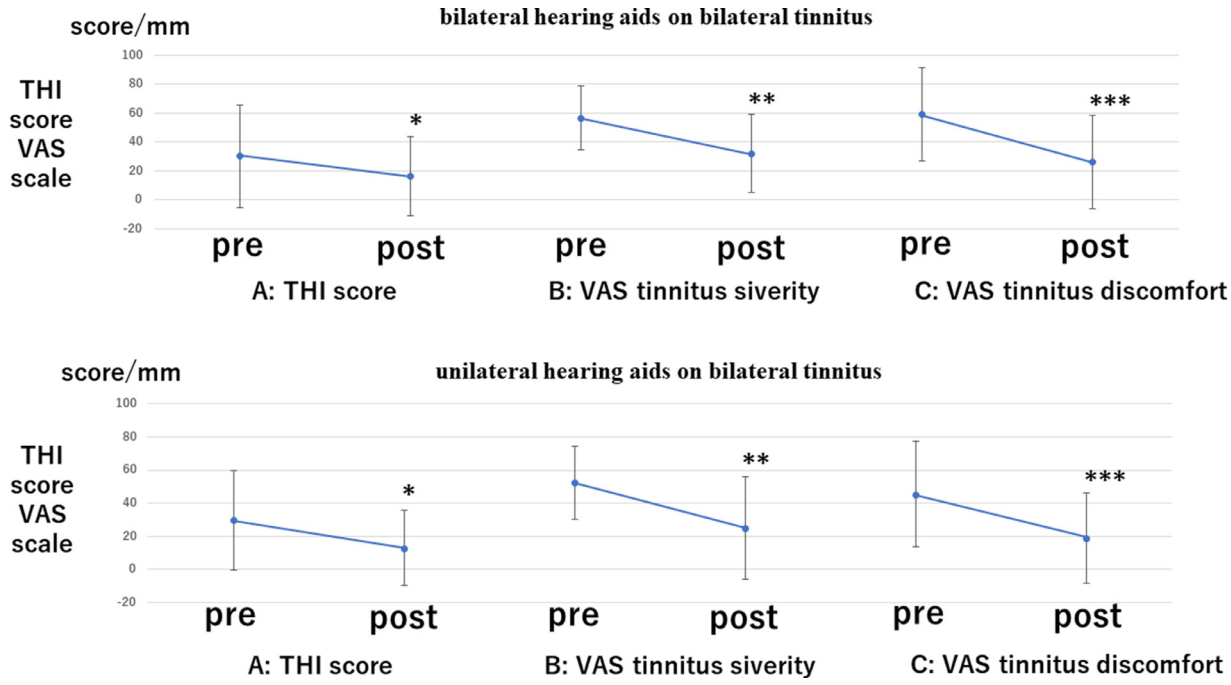

Fig. 4. Effects of bilateral hearing aids and unilateral hearing aids on bilateral tinnitus. When considering only patients with bilateral tinnitus ($n = 41$) significant improvements were observed after wearing bilateral hearing aids ($n = 17$) in (A) the THI score (from 30.00±35.67 to 16.35±27.45; $^{*}p = 0.011$, Wilcoxon test), (B) VAS score for severity (from 56.47±22.16 to 31.88±27.03; $^{**}p = 0.0019$), and (C) VAS score for discomfort (from 59.18±32.23 to 31.88±32.45; $^{***}p = 0.020$). After wearing a unilateral hearing aid ($n = 24$), there were significant improvements in (A) the THI score (from 29.83±30.03 to 13.00±22.70; $^{*}p = 0.00069$), (B) VAS score for severity (from 52.38±22.13 to 25.08±31.06; $^{**}p = 0.00071$), and (C) VAS score for discomfort (45.42±31.88 to 19.00±27.13; $^{***}p = 0.000093$). There were no significant differences in effect between wearing bilateral or unilateral hearing aids in this group. THI, Tinnitus Handicap Inventory; VAS, Visual Analog Scale.

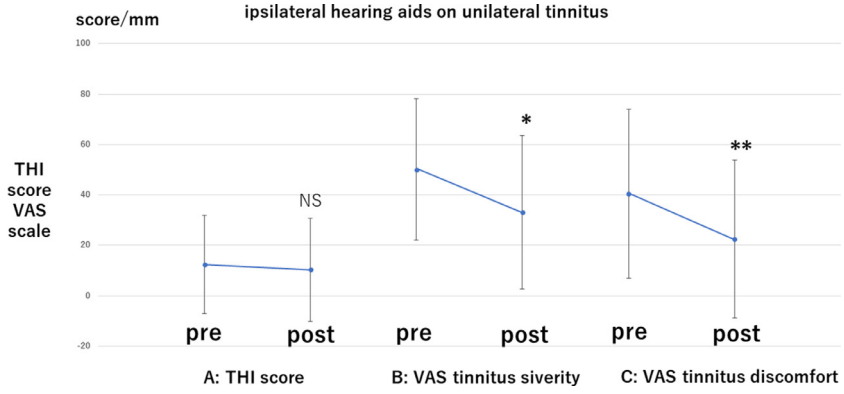

Fig. 5. Effects of ipsilateral hearing aids on unilateral tinnitus. In cases of unilateral tinnitus ($n = 25$), when using a unilateral hearing aid ($n = 19$), the tinnitus tended to improve in patients fitted on the same side as the tinnitus ($n = 6$). (A) The THI score improved from 12.33±19.47 to 10.33±20.47 ($p = 0.057$, Wilcoxon test), (B) the VAS score for severity from 50.17±28.11 to 33.17±30.45 ($^{*}p = 0.0012$), and (C) the VAS score for discomfort from 40.50±33.50 to 22.50±31.31 ($^{**}p = 0.073$). THI, Tinnitus Handicap Inventory; VAS, Visual Analog Scale; NS, not significant.

unilateral hearing aids, with both being effective in treating tinnitus [8,9]. This finding indicates that clinicians do not need to be overly concerned about which side to fit the hearing aid when treating bilateral tinnitus. In contrast, when patients with unilateral tinnitus wore a hearing aid on the side as the tinnitus, the effect of treatment was not significant. This finding highlights the importance of accurate identification of the side with tinnitus and using the hearing aid on that side. Recent reports indicate that bilateral hearing aids can be greatly beneficial depending on the hearing level [10]. In the future, we plan to study more subjects with various levels of hearing.

Our assessments of THI scores and VAS scores for tinnitus severity and discomfort showed significant correlations with each other [11,12]. These observations suggest that simpler VAS assessments could be used instead of the relatively complicated 25-item THI. Furthermore, the HADS value decreased significantly after wearing a hearing aid [8,9], indicating that hearing aids can be expected to improve tinnitus and to have the potential secondary effects of improving anxiety and depression.

This study had some limitations. The first is that, due to the rules governing health insurance and tax deductions for medical expenses in Japan, the study subjects were patients

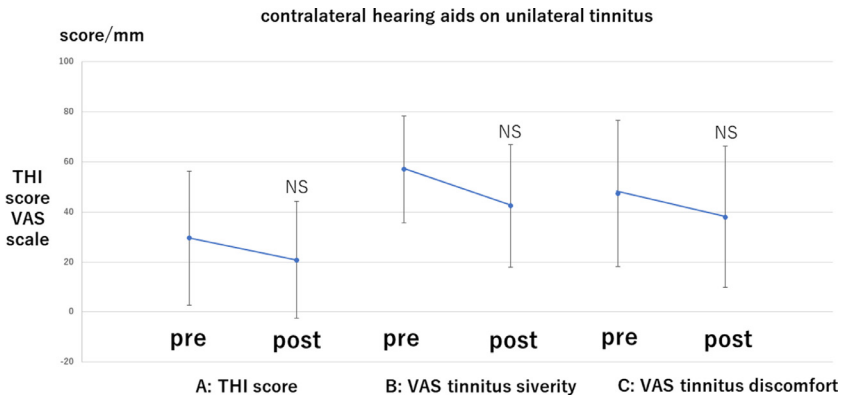

Fig. 6. Effects of contralateral hearing aids on unilateral tinnitus. In patients fitted on the opposite side of the tinnitus ($n = 13$), there was no significant improvement in (A) the THI (29.54±26.72 to 20.77±23.34; $p = 0.11$, paired t-test), (B) the VAS score for severity (57.00±21.33 to 42.38±24.53; $p = 0.064$), or (C) the VAS score for discomfort (47.38±29.17 to 38.00±28.18; $p = 0.20$). THI, Tinnitus Handicap Inventory; VAS, Visual Analog Scale; NS, not significant. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

who visited an outpatient hearing aid clinic with hearing loss as their chief complaint. Therefore, they were not patients who came to hospital to be treated for tinnitus and did not include cases of tinnitus regardless of hearing loss [13]. In this study, we examined the effects that therapy intended to supplement hearing had on tinnitus and cannot exclude the possibility that the study population contained patients with underlying tinnitus-related morbidity [14]. The second is that we cannot exclude a part of cognitive therapy completely in spite of no performance of counseling during follow-ups. In this study, we may say that our tinnitus treatments using hearing aids could be mainly consisted of acoustic therapy. The third is that we checked up subtle changes in THI compared with VAS. We may have focused just on larger changes in THI scores. Anyway, we are planning to examine the effects of acoustic treatment using hearing aids in patients whose chief complaint is tinnitus in the later communication.

5. Conclusion

Acoustic therapy using hearing aids was effective for tinnitus. Even when bilateral, a unilateral hearing aid is able to improve tinnitus. When unilateral, the ipsilateral hearing aid is able to improve tinnitus.

Declaration of Competing Interest

The present study does not include any conflicts of interest.

Acknowledgements

The authors wish to thank Dr. Masashi Choubi, a registered statistician (certificate number 622017) for helpful advice on the statistical analysis and Editage Customer Service (editage.com) for editing a draft of this manuscript.

This study was supported in part by JSPS KAKENHI Grant (17K11340), AMED under Grant Number 18dk0310092h000a, and a Health and Labour Sciences Research Grant for Research on Rare and Intractable Diseases (H29-Nanchito (Nan)-Ippan-031) from the Ministry of Health, Labour and Welfare of Japan.

References

[1] Eggermont JJ, Roberts LE. The neuroscience of tinnitus. Trends Neurosci 2004;27:676–82.
[2] Kojima T, Kanzaki S, Oishi N, Ogawa K. Clinical characteristics of patients with tinnitus evaluated with the tinnitus sample case history questionnaire in Japan: a case series. PLoS One 2017;12:e0180609.
[3] Tunkel DE, Bauer CA, Sun GH, Rosenfeld RM, Chandrasekhar SS, Cunningham ER Jr, et al. Clinical practice guideline: tinnitus. Otolaryngol Head Neck Surg 2014;151(2 Suppl):S1–S40.
[4] Yamasoba T. Clinical practice guidelines for the diagnosis and management of tinnitus 2019. Japan Audiological Society ed.. Kanehara Publisher; 2019.
[5] Vernon J, Schleuning A. Tinnitus: a new management. Laryngoscope 1978;88:413–19.
[6] Jastreboff PJ. Phantom auditory perception (tinnitus): mechanism of generation and perception. Neurosci Res 1990;8:221–54.
[7] McKinney CJ. An evaluation of the TRT method. In: Hazell JWP, editor. Proceedings of the 6th International Tinnitus Seminar. British Society of Audiology; 1999. p. S99–105.
[8] Shekhawat GS, Searchfield GD, Stinear CM. Role of hearing aids in tinnitus intervention: a scoping review. J Am Acad Audiol 2013;24:747–62.
[9] Sereda M, Xia J, Refaie A, Hall DA, Hoare DJ. Sound therapy (using amplification devices and/or sound generators) for tinnitus. Cochrane Database Syst Rev 2018;12:CD013094.
[10] Ricketts TA, Picou EM, Shehorn J, Dittberner AB. Degree of hearing loss affects bilateral hearing aid benefits in ecologically relevant laboratory conditions. J Speech Lang Hear Res 2019;62:3834–50.
[11] Karatas E, Deniz M. The comparison of acoustic and psychic parameters of subjective tinnitus. Eur Arch Otorhinolaryngol 2012;269:441–7.
[12] Nascimento IDP, Almeida AA, Diniz JJ, Martins ML, Freitas TMMWC, Rosa MRDD. Tinnitus evaluation: relationship between pitch matching and loudness, visual analog scale and tinnitus handicap inventory. Braz J Otorhinolaryngol 2019;85:611–16.
[13] Lee K, Makino K, Yamahara K. Evaluation of tinnitus retraining therapy for patients with normal audiograms versus patients with hearing loss. Auris Nasus Larynx 2018;45:215–21.
[14] Brueggemann P, Seydel C, Schaefer C, Szczepek AJ, Amarjargal N, Boecking B, et al. ICD-10 symptom rating questionnaire for assessment of psychological comorbidities in patients with chronic tinnitus. HNO 2019;67:46–50.