

Masking Treatment and its Effect on Tinnitus Parameters

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Abstract

Objective: Tinnitus is described as the perception of sound without any external acoustic stimulation. Any pathology of auditory pathways or any system of the human body may result with tinnitus. The pathophysiology of tinnitus accompanying the disorders of auditory system is not fully understood and there is not any particular effective treatment method has been specified. Tinnitus masking therapy has been reported as an effective treatment modality in the treatment of tinnitus. In this study, the results of tinnitus masking treatment on the parameters were evaluated prospectively. **Patients and methods:** Patients with normal physical examination was enrolled in the study. Blood tests (complete blood count, biochemical analysis of lipid profile, and thyroid hormones), pure tone audiometry, tympanometric measurement of the middle ear pressure and stapedial reflexes were performed, Sixty six patients with normal results of blood tests and normal hearing thresholds with type A tympanogram were included. Tinnitus sufferers questionnaires (socio-demographics, clinical information, Tinnitus Handicap Inventory (THI), Beck Depression Inventory (BDI) was filled, audiological tests were performed, tinnitus parameters (frequency, intensity, minimal masking levels, residual inhibition) were measured. After four weeks of the treatment the questionnaires were repeated. **Results:** Masking treatment for tinnitus patients resulted with significant decrease in Tinnitus Handicap Inventory and VAS scores. After four weeks of the masking treatment the questionnaire was repeated. Twenty patients did not respond to treatment. **Conclusion:** Masking therapy is one of the most effective methods of treatment for tinnitus patients. Masking therapy, that is not invasive and cost-effective has an important place in the treatment of tinnitus. Especially in a short time provides a significant reduction in tinnitus parameters.

Keywords: tinnitus, masking therapy.

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INTRODUCTION

Tinnitus is the perception of an abnormal sound in one's ears or head without any auditory stimulus¹. It derives from the Latin word *tinnire*, which means "ring or bell"². Tyler³ defines tinnitus as a sound heard in the ears in the absence of an external stimulus. In another publication, tinnitus is defined as the perception of sounds generated involuntarily in the body⁴.

The mechanism of tinnitus generation is not exactly known. There have been numerous theories put forward concerning tinnitus. Tinnitus is known to accompany almost all disorders developing in the auditory system⁵. The auditory system has a complex structure consisting of the organ of Corti, afferent and efferent pathways, cortical auditory center, and connections enabling their integration. Pathologies, which develop in any point of these connections, lead to an increase in auditory perception through unknown mechanisms⁶.

There is no certain method or pharmacological agent for the treatment of tinnitus, which is due to the uncertainty in the etiology of tinnitus⁷. Tinnitus, which affects 17% of the general population, is the primary complaint experienced by 60% of patients in the field of audiology⁸. This rate increases up to 33% in the geriatric population. Since tinnitus is an old-age symptom, its incidence rate increases with increasing age⁹⁻¹¹. Patients with tinnitus generally live with this problem for a long time. Therefore, patients request to receive explanatory information regarding the quality and intensity of symptoms. In recent years, scales evaluating how patients psychosomatically perceive tinnitus have come into prominence. Attempts to diagnose tinnitus have directed researchers studying this subject to psychoacoustic tests such as tinnitus frequency, severity, minimum masking level and residual inhibition, and numerous questionnaires organized to examine psychosomatic perception related to the ringing sound and how the ringing sound is perceived by patients^{12,13}. The use of questionnaires has provided information concerning the severity of tinnitus and has given opportunity for clinicians to make pretreatment and posttreatment comparisons and complete evaluation. Clinicians also record the tinnitus symptoms, treatment methods, and results of patient satisfaction using the tinnitus assessment questionnaire^{13,14}. The audiological evaluation of tinnitus includes cochleovestibular evaluations. These evaluations involve the determination of certain characteristics such as pitch matching; loudness matching; masking quality (minimum masking level and residual inhibition), which are the parameters for tinnitus as well as history taking; and appropriate audiometric tests^{15,16}. The evaluation of tinnitus is interpreted medically and audiotologically and is used in making individual planning for tinnitus treatment¹⁶. Tinnitus is more disturbing particularly during bedtime at night and in the quiet environment. A sound, a ticking clock, or a radio that can compete with tinnitus will reduce the discomfort. Some doctors advise listening

to FM channels with low volume. Many patients indicated that they benefitted from listening to the sounds made by a radio, not tuned between two stations, with low volume. Such a static sound could be very soothing. This sound is known as white noise. Some patients also use electronic devices that produce soothing sounds or are made to listen to such sounds with tape recorders¹⁷. Tinnitus masking therapy refers to the application of an external sound that affects the tinnitus. Patients often find this sound more acceptable than their own tinnitus. In this method of treatment, the aim is to detect a suitable masking level for tinnitus. It has an important place in the treatment of tinnitus due to its noninvasive and economical formation¹⁸. The aim of this study was to obtain results related to the success of the masking method based on tinnitus parameters by applying this as an alternative treatment on patients with tinnitus who had complaints of ringing and did not recover even though they received the medical treatment at many centers.

METHODS

Ethical committee approval was obtained on February 24, 2014, for this study. The patients gave their informed consent to participate in this study. The study was conducted on male and female individuals who were older than the age of 16, had tinnitus before the age of 75, had tinnitus for at least 1 year, and applied to the otolaryngology department outpatient clinic. The patients received the masking treatment for at least 1 month, and objective and subjective test results were compared before and after the treatment. All patients included in the study went through a complete otolaryngology examination, and they were evaluated audiotologically in the balance and sound unit. A total of 66 patients including 30 females and 36 males whose pure-tone averages were 30 dB and higher were included in the study. None of the patients had any previous ear operation, ototoxicity, endocrine disease, neuropsychiatric disease, and trauma history. Patients with tinnitus who were below the age of 16, above the age of 75, and/or whose audiological tests or masking treatments were not exactly completed were excluded from the study.

After the patients, who met the inclusion criteria, had the otologic examinations and were informed in detail, their files were regularly kept. Personal Evaluation Form (Medical History Form), which included their demographic, medical, and tinnitus-related characteristics; Visual Analogue Scale (VAS), which is used for the subjective evaluation of tinnitus; and Audiological Evaluation Form, which included the evaluation of tinnitus, were filled out. The individuals were informed about audiological evaluations, and their consents were received.

Afterward, the hearing loss values of individuals were found out through audiological evaluations and tympanometry tests, and data were obtained. It is not predictable which patient can be masked for tinnitus. Masking cannot be obtained in all tinnitus patients. The studies revealed that the difference between the equation

of the loudness and the minimum masking level can be a parameter for accepting the masking noise.

In the following phase, measurement processes of tinnitus were carried out. These processes involved steps of measuring tinnitus frequency, measuring tinnitus severity, determining the minimum masking level, and observing residual inhibition. As a result, patients with full or partial residual inhibition and those with a minimal masking level of under 5 dB were included in the study, while patients with a minimum masking level of over 15 dB and did not have residual inhibition were excluded from the study^{15,16}. Then, the patients were given CDs containing 45-minute narrow-band white noise in MP3 format, and they were asked to listen to this treatment uninterruptedly every day for at least one month. At the end of the treatment, the patients were called once more for the control, and the questionnaires were used again.

Demographic, medical, and tinnitus-related general information of the patients were obtained at the center, where the study was conducted using the personal information form used by the researcher routinely on all patients. Their information related to tinnitus levels was obtained using the Tinnitus Handicap Inventory (THI) applied by the researcher. On the other hand, data related to depression levels were obtained using the Beck Depression Inventory (BDI) applied by the researcher. Audiological tests of the patients were carried out by the audiometrist working at our clinic.

Files of the patients included in the study were regularly kept, and they filled out an in-patient evaluation form and a personal information form. The patient evaluation form (patient's history chart) included the demographic and medical characteristics of the patients. On the other hand, the personal information form included the patients' information such as name/surname, age, weight, height, sex, total years of education, profession, employment status, marital status, number of children, presence of the elderly or infants younger than the age of 2 years they have to provide care for at home, house conditions, total monthly income, place of residence, address, phone number, and presence of tinnitus as well as questionnaire application questions.

Questionnaire Applications

Visual Analogue Scale (VAS)

All forms were filled out by the patients or their relatives, and during this process, individuals were informed in detail. The questions are as follows:

1. Mark the severity of buzzing/ringing in your ears.
2. Mark the frequency and duration of buzzing/ringing in your ears.
3. Specify your discomfort level due to the buzzing/ringing in your ears.
4. Do you experience attention deficit depending on the buzzing/ringing in your ears?

5. Do you experience sleeping problems depending on the buzzing/ringing in your ears?

The purpose of these questions is to reveal how an individual perceives tinnitus severity, frequency, and duration and to what extent they feel discomfort due to tinnitus. The basis of answering VAS questions is to demonstrate the subjective perception level of a patient for each question on a ruler between 0 and 10, and the perception level in all questions increases from 0 to 10.

Tinnitus Handicap Inventory (THI)

The Turkish version of THI, which is a questionnaire that has high reliability levels on test repetitions; is not affected by age, gender, and hearing loss; gives open results; is easy to use; and generates psychometrically more explicit measurements, was preferred. Each question in this questionnaire, which consists of a total of 25, has three answer options-Yes, Sometimes, and No-and the scoring of answers is carried out using the scores 4, 2, and 0, respectively. In this manner, results were evaluated with the lowest score of 0 and the highest score of 100.

Beck Depression Inventory (BDI)

BDI involving 21 symptom categories was used to determine the patients' depression levels and symptoms. Items were evaluated with the scores between 0 and 3. The lowest score of the questionnaire is 0, whereas the highest is 63. While scores between 0 and 17 are assessed as "no depression," the scores above 17 are assessed as "depressed."

Audiological evaluation

All audiometric evaluations were conducted in quiet rooms in accordance with Industrial Acoustic Company (IAC) standards. These tests were performed by the researcher using Interacoustic AC-40 clinical audiometers. While Airway hearing thresholds were measured using a TDH-39 speaker within the range of 125-8000 Hz, bone-conduction hearing thresholds were measured using a Radio Ear B 71 vibrator within the range of 500-4000 Hz (according to ANSI 1969 standards)¹⁹. Measurement of tinnitus frequency and tinnitus severity, examination of masking quality, and residual inhibition tests were carried out to form the tinnitus mapping^{20,21}.

Statistical analysis

The data obtained at the end of the study were recorded. The data were arranged as mean \pm standard deviation. The Kolmogorov-Smirnov test was used to control whether or not continuous variables meet normal distribution in data collected before and after 1-month masking treatment. While Mann-Whitney U Test was used to compare two independent groups of numerical variables, Kruskal-Wallis test was used to compare more than two independent groups. The Wilcoxon test was used to compare two dependent groups. Correlations between numeric variables were tested with Spearman's rank correlation coefficient. SPSS for Windows version 22.0 packaged software (SPSS Inc., Chicago, USA) was

used to carry out statistical analysis, and the level of $P < 0.05$ was accepted as statistically significant.

RESULTS

A total of 66 patients with tinnitus were included in this study with 45.5% of the patients (30 patients) female and 54.5% (36 patients), male. The patients were in the age range of 16 and 75 years. While 56% of these patients (37 patients) experienced tinnitus bilaterally, 44% (29 patients) experienced tinnitus unilaterally. When the patients were asked particularly in which ear they felt the tinnitus more, 63.6% (42 patients) stated that they felt tinnitus more in the left ear and 36.4% (24 patients) stated that they felt tinnitus more in the right ear.

Among those who felt tinnitus in the right ear or had bilateral tinnitus and felt tinnitus more in the right ear, 18 patients specified that their tinnitus frequency was 8000 Hz, 3 patients specified 6000 Hz, 2 patients specified 4000 Hz, and 1 patient specified 250 Hz (Figure 1).

Among those who felt tinnitus in the left ear or had bilateral tinnitus and felt tinnitus more in the left ear, 30 patients specified that their tinnitus frequency was 8000 Hz, 1 patient specified 6000 Hz, and 11 patients specified 4000 Hz (Figure 1).

Following the 1-month masking treatment, patients with tinnitus were asked to evaluate the control tinnitus as fully useful, partly useful, and not useful. Twelve patients out of 66 patients described the control tinnitus as fully useful, 28 patients as partly useful, and 26 patients as not useful at all (Figure 2).

When pre-treatment and post treatment VAS scores (tinnitus frequency-duration, discomfort, attention deficit, and sleeping problem) were compared, a significant decrease was observed in all post treatment scores (Table 1).

THI was administered with the patients in the first

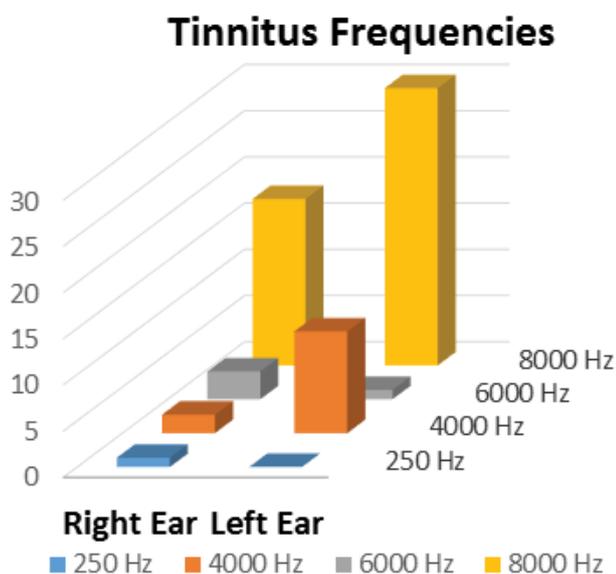


Figure 1. Tinnitus frequencies of patients with tinnitus (Hz).

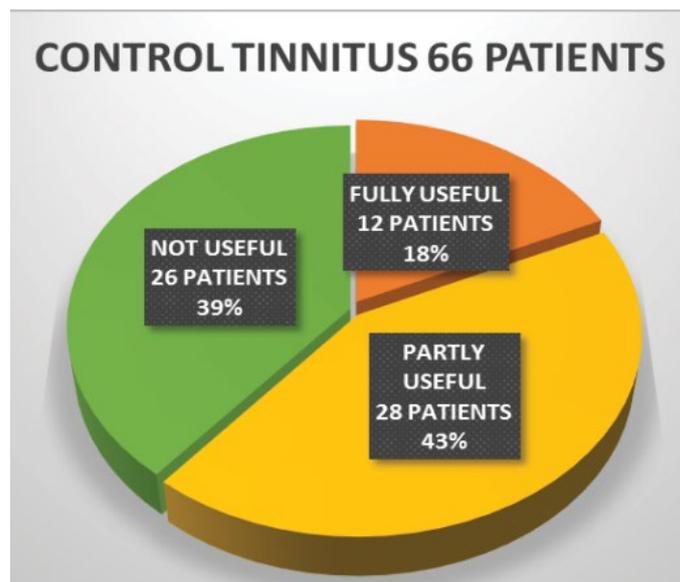


Figure 2. Control ringing results of patients with tinnitus.

Table 1. Comparison of initial and control VAS scores.

| | n=66 | Mean | SD | P value |
|------------------------------|------|------|------|---------|
| Initial (frequency-duration) | | 6.83 | 2.73 | 0.001 |
| Control (frequency-duration) | | 5.34 | 3.34 | |
| Initial (discomfort level) | | 5.42 | 2.26 | 0.001 |
| Control (discomfort level) | | 3.95 | 2.47 | |
| Initial (attention deficit) | | 3.63 | 3.07 | 0.001 |
| Control (attention deficit) | | 2.37 | 2.35 | |
| Initial (sleeping problem) | | 4.27 | 3.68 | 0.001 |
| Control (sleeping problem) | | 3.45 | 3.44 | |

examination and after the 1-month treatment, and the results were compared. The results were named as initial questionnaire results (series 1) of patients with tinnitus and control questionnaire results of the same patients after 1-month masking treatment (series 2), and they were compared with each other (Figure 3).

THI initial results of the patients with tinnitus were weak at 21.2%, average at 27.2%, moderate at 25.8%, severe at 21.2%, and terrible at 4.6%. Following the 1-month masking treatment, THI control results of the same patients were weak at 34.8%, average at 24.2%, moderate at 24.2%, severe at 12.1%, and terrible at 4.6%.

When initial and control THI scores were compared, it was found that mean of total initial THI scores of 66 patients was 38.13 on the moderate level (still able to perform daily activities although the background noise was noticed). The mean of control THI scores was 32.75 on the average level (can easily be masked with the surrounding noise and can be easily forgotten through activities), and a significant correlation was found between the masking treatment and THI score ($P < 0.05$) (Table 2).

When the correlation between pre-treatment and post treatment THI scores and VAS scores of the patients

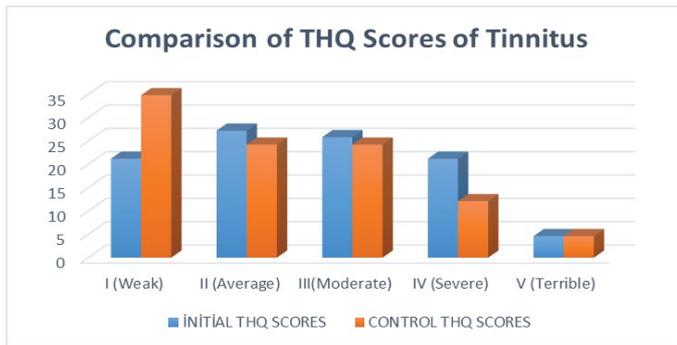


Figure 3. Comparison of THI Scores of patients with tinnitus before and after masking treatment.

Table 2. Comparison of pretreatment and posttreatment THI scores.

| | Mean | SD | P value |
|---------------------------------|-------|-------|---------|
| Initial Tinnitus Handicap Score | 38.13 | 22.28 | 0.012 |
| Control Tinnitus Handicap Score | 32.75 | 23.93 | |

was analyzed, a significant correlation was found in both pre-treatment and post treatment periods.

While there was a correlation between the patients' ages and tinnitus parameters, a significant difference was found particularly between Tinnitus Handicap Questionnaires, VAS Frequency-Duration Scores, and Control VAS Discomfort Level Scores. However, no significant difference was found between the other tinnitus parameters and age, and no correlation was obtained.

No significant difference was found between tinnitus and patients' characteristics such as total year of education, profession, employment status, marital status, number of children, liability of giving care to the elderly at home, liability of giving care to infants younger than the age of 2 at home, home conditions, family's total monthly income, and place of residence.

Total scores of THI and Beck Depression Inventory conducted before masking treatment were compared. A positive moderate significant correlation was found between the two questionnaire scores in the patients ($r = 0.433$, $P = 0.001$).

DISCUSSION

Tinnitus is observed in 17% of general population and 33% of the elderly population, with 2% of patients having seriously impaired quality of life^{22,23}. Even though tinnitus is such a common disorder, its pathophysiology is still controversial. Most of the theories suggested to explain tinnitus pathogenesis are based on increased spontaneous activity in nerves. Cochlear hair cells have been suggested to be the cause of tinnitus^{24,25}. In addition, cochlear nerve and central auditory pathways are also reported to be the cause of tinnitus^{26,27}. Although many factors have been suggested in the etiopathogenesis of tinnitus, many cases are idiopathic.

In their study, Meikle and Taylor-Walsh²⁸ determined that 69% of those who applied to otorhinolaryngology

clinics in Sweden were men and 31% were women. Additionally, there are also studies in the literature reporting that male-female rates were equal. Hazell et al.²⁹ reported that 51% of patients with tinnitus were women and 49% were men. In the present study, it was found that 54.5% of the patients (36 patients) were men and 45.5% (30 patients) were women.

Tinnitus is often observed in the age group of 40 and 80 years in the literature and is rarely seen below the age of 20¹⁹. While the average age of the patient group in the present study was 43.6, the youngest patient was 16 years old and the oldest patient was 74 years old. While some studies on tinnitus reported that men and women were affected at equal rate, other studies revealed that tinnitus was more frequent among men (46.6% in women and 53.4% in men)²². In the present study, the majority were men (45.5% in women and 54.5% in men).

In studies on localization of tinnitus, it was reported that 52% of Tyler cases had bilateral tinnitus, 37% had unilateral tinnitus, 10% had tinnitus localized on head, and 1% had tinnitus localized outside of head³. Meikle and Griest reported that 61% of patients with tinnitus stated it as bilateral, 23% as unilateral, 6% described tinnitus localized on head, and 10% described tinnitus on other areas. In the present study, 56% of the patients (37 patients) had bilateral tinnitus and 44% (29 patients) had unilateral tinnitus. In this regard, the mean score obtained in the present study was similar to the mean scores reported in the literature.

Some techniques are used for tinnitus measurement. Among them, tinnitus frequency, tinnitus severity, and masking are the most common ones. Expectation from these techniques is to recreate tinnitus sounds, perform differential diagnoses of different tinnitus classifications, and determine treatment efficiency in advance⁹. These techniques were used in the present study. Reliability of tinnitus frequency varies from patient to patient. Frequency also changes from day to day or in the same day; although tinnitus frequency is stated to be stable, it is very difficult to accurately perform frequency matching in some patients⁸. It was reported in numerous studies that tinnitus frequency generally reached its peak between 3000 Hz and 4000 Hz and mostly remained at 4000 Hz⁹.

It was reported that tinnitus frequencies of 83% of Vernon patients were above 3000 Hz³⁰. In the present study, tinnitus was found to reach its peak especially between 4000 Hz and 8000 Hz, and differently from the general opinion, the majority (72.7%) were found to be at 8000 Hz. No correlation was found between patients' clinics and tinnitus frequencies in the present study.

Diagnosis studies focus on the psychoacoustics of tinnitus (severity, frequency, and masking). Nevertheless, psychoacoustic character is not helpful in estimating treatment outcomes, and it is insufficient to explain why tinnitus with the same character gives different levels of

discomfort in different people⁴. Therefore, subjective clinic criteria have gained more value in evaluation of tinnitus. In a multicentric double-blind study conducted by Pech A³¹ on 290 patients, statistically significant changes were reported in tinnitus severity, tinnitus frequency, and tinnitus-related discomfort levels of the patients according to the subjective clinic criteria.

Similarly in the present study, significant levels of recovery were recorded in the subjective clinic results of the patients following the minimum 1-month masking treatment. Statistically significant levels of recovery were found in tinnitus severity, tinnitus frequency, tinnitus-related discomfort levels, and tinnitus-related attention deficit according to VAS values.

Recent clinical studies have reported that acoustic tests are not sufficient for diagnosis and follow-up of tinnitus^{32,33}. Therefore, scales evaluating how tinnitus is psychosomatically perceived have come into prominence. It is possible to obtain information on the severity of tinnitus using various questionnaires. The questionnaires give doctors the opportunity for pre-treatment and post treatment evaluations^{14,32,33}. The most reliable and common one of these questionnaires is THI. THI is reported to be a reliable scale with a high level of consistency in the symptom evaluation of patients with tinnitus¹⁴. In the present study, we also used THI and accepted it as a recovery criterion. A statistically significant decrease was found among patients who received masking treatment. The patients were asked the question, "Have you observed any recovery?" and they were asked to respond with the options: "I found it useful," "I found it partially useful," or "I did not find it useful," and a decrease was observed in the THI score of all of 40 patients who reported partial or complete recovery. In the comparison of pre-treatment and post treatment THI scores, a statistically significant difference was obtained.

Even though tinnitus is commonly seen in the community, only 1-3% of patients with tinnitus experience serious discomfort due to tinnitus. Such individuals may experience disorders such as impairment in daily activities, psychological disorders, sleeping problems, and attention deficit. In a previous study, a correlation was suggested between tinnitus and psychological factors³⁴. In the present study, a positive moderate significant correlation was found between the total scores of THI and Beck Depression Inventory administered on our patients for psychological etiology before the masking treatment. It is not exactly known why such additional problems develop in patients with chronic tinnitus. It is not possible to explain the additional problems arising in tinnitus patients only by otologic factors. According to the studies in the literature, the depression incidence rate of patients with tinnitus is about 30%, and tinnitus is observed in 50% of those who receive psychological treatments³⁵. Therefore, studies on tinnitus treatment are not only limited with familiar subjects on auditory system, but also include subjects such as the preparation of rehabilitation and treatment program intended for eliminating social and psychological negative effects caused by tinnitus³⁶.

Although Stouffers and Tyler²² suggested that people with psychological problems had tendency to have tinnitus, they also reported that it has not been sufficiently examined why psychiatric disorders have led to tinnitus. Consequently, a statistically significant difference was found in the efficiency of masking treatment of patients with tinnitus in terms of tinnitus parameters in the present study.

CONCLUSION AND RECOMMENDATIONS

A significant decrease was observed in the measurable parameters of tinnitus after the minimum 1-month masking treatment given to our patients, and 61% of the patients considered the treatment as completely or partially useful. A significant decrease was recorded between pre-treatment and post treatment VAS scores and THI scores of patients with tinnitus after masking treatment. A moderate correlation was also found between the BDI scores of the patients and tinnitus parameters. In the light of these results, masking treatment is one of the most effective treatment methods for the patients with tinnitus for which there is still no common treatment protocol. Masking treatment was performed in the ear with tinnitus if tinnitus was unilateral and in both ears if tinnitus was bilateral. Additionally, masking treatment has been particularly found to be more effective in the patients who recently started suffering from tinnitus (1 year or less), are young, have moderate or lower THI scores, have differences lower than 10 dB between tinnitus threshold and minimal masking level, and were partially affected by tinnitus according to their VAS scores. However, those stating that their tinnitus complaints continue all day and those with high BDI scores (> 17), especially older patients (age of 65 years and over), have not found masking treatment very useful.

The following recommendations can be made in line with the results obtained from this study: it is recommended to administer masking treatment in a quiet environment uninterruptedly for at least 45 minutes a day with earphones or headphones and only in the ear that suffers from tinnitus in patients with unilateral tinnitus. Additionally, it is recommended to conduct studies, which include broader populations, and administer masking treatment for one month or longer terms.

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