The role of tinnitus evaluation tests in differentiating functional versus organic tinnitus

- Nili Tal Segal, MD
- Max Puterman, MD
- Mark Shkolnik, BSc
- Alexander Niv, MD
- Daniel Kaplan, MD
- Anat Kochva, BSc
- Mordechai Kraus, MD

Objective

To evaluate the usefulness of tinnitus tests in differentiating patients with functional tinnitus from patients with organic tinnitus.

Design

One hundred ninety-six patients with tinnitus were divided into 2 groups. Forty-three patients, group 1, were not exposed to noise and had sensorineural hearing loss. One hundred fifty-three patients, group 2, were exposed to noise and claimed disability. All the patients underwent 4 tinnitus evaluation tests: pitch
matching, intensity matching, residual inhibition, and tinnitus masking. We compared the results of the tinnitus tests between the 2 groups.

Results

Group 1 patients had a high-frequency, low-intensity tinnitus that tended to be more inhibited by narrow-band noise, was usually consistent with type I Feldman masking curve, and could be effectively masked. Group 2 patients had tinnitus that could not be characterized. The results of the tinnitus tests were significantly different between the groups.

Conclusion

Tinnitus tests may help us differentiate functional tinnitus that is not of cochlear origin from genuine tinnitus.

Tinnitus is defined as the perception of sound in the absence of an acoustic source outside the head. According to the British epidemiological investigation on the prevalence of tinnitus and its perceived severity, 0.5% of the general population regards their tinnitus as a severe disabling problem. Clinically, there is a distinction between subjective and objective tinnitus. Objective tinnitus has also been described as “vibratory” tinnitus, is relatively uncommon, its cause is apparent, and specific treatment can be directed to its cause. Subjective idiopathic tinnitus (SIT) is the most common and can be a component of many diseases. The medical evaluation of SIT comprises the following: a complete clinical history, a general medical examination, general otolaryngology examination, cochleovestibular evaluation, and tinnitus evaluation. Tinnitus evaluation is aimed to identify and quantify the subjective complaint of tinnitus. Several tinnitus evaluation tests have been described as part of the evaluation process including pitch matching, loudness matching, and postmasking effect (the measurement of residual inhibition and minimal masking level represented as Feldmann masking curves). The identification of the tinnitus characteristics in these tinnitus evaluation tests is made in terms of the patient’s response to acoustic sound. The results of the tinnitus evaluation process establish the clinical types of tinnitus and form the basis for specific audiologic recommendations such as instrumentation to control the tinnitus.

The group of patients who suffer from SIT is diverse and includes patients with tinnitus and noise-induced hearing loss as well as patients with various otologic diseases. Patients with functional tinnitus that is not of cochlear origin comprise another significant group. Only the former group of patients is recognized for disability and hence for compensation by the social security.

The purpose of our study was to evaluate the usefulness of the tinnitus tests in ear, nose, and throat practice taking into consideration the heterogeneity of the population of patients with tinnitus and the need to differentiate patients with functional tinnitus from the rest.

Materials and Methods

One hundred ninety-six patients participated in the study during the years 2005 to 2006 after approval of the institutional review board. They were divided into 2 groups: the first group (group 1) comprises 43 patients (12 women and 31 men) aged 45 to 87 years (mean age, 60.7 years) with tinnitus and
sensorineural hearing loss who were not exposed to noise and did not claim any disability because of their hearing loss. Thirty-seven had progressive sensorineural hearing loss, and 6 had sudden hearing loss. The second group (group 2) comprises 153 patients (4 women and 149 men) aged 28 to 68 years (mean age, 53.5 years) with sensorineural hearing loss and tinnitus. These patients were exposed to noise and claimed disability because of noise-induced hearing loss. They were consecutively referred to the Hedim Hearing Institute from the Social Security Committee.

All the patients in the study group underwent 4 tinnitus evaluation tests:

1. Tinnitus pitch matching: the pitch matching is performed by using the 2 alternative forced procedures. Vernon and Fenwick suggested this method as the most reliable for pitch matching. Two tones are presented in an alternating manner. The patient is forced to choose which of the 2 tones more closely matches the pitch of his tinnitus. This continues until pitch matching is made.

2. Tinnitus intensity matching: we used an ascending method, which means that the audiologist varies the intensity of a test tone at or near the frequency of the tinnitus. The patient was asked to identify the intensity that most closely matches the intensity of his tinnitus.

3. Residual inhibition of tinnitus: residual inhibition was defined as the temporary suppression and/or disappearance of tinnitus after a period of masking. Positive residual inhibition of tinnitus means the ability of a narrow band tone delivered for 1 minute to eliminate the patient’s own tinnitus. Partial inhibition means that after the 1-minute stimulus presentation, the individual reports that the tinnitus loudness level is less than what was before the measurement of the residual inhibition. Negative inhibition was defined as tinnitus that does not change in loudness after the 1-minute stimulus presentation of narrow-band tone.

4. Tinnitus masking curves: masking is the override of perception of 1 acoustic signal by another. Feldmann, at the First International Tinnitus Seminar, identified 5 major different types of masking curves for tinnitus. The 5 major different types of masking curves identified by Feldmann are as follows:

1. Type I: convergence. The threshold curve and masking curve converge from low to high frequency. They meet at the frequency corresponding to the pitch of the tinnitus and coincide for the higher frequencies. This type of masking curve is found most frequently in patients with tinnitus that is cochlear in location, and these patients are the best candidates for acoustic or electrical masking.

2. Type II: divergence. The threshold curve and masking curve diverge from low to high frequencies.
Type III: congruence. Almost any noise that is just above threshold will mask out the tinnitus. The threshold and masking curves practically coincide within an intensity range of 10 dB maximally.

Type IV: distance. To mask the tinnitus, each sound must have an intensity well above its subjective threshold, 20 dB or greater.

Type V: persistence. The tinnitus can not be masked by any stimulus presented.

The Feldmann masking curves are considered a key element in tinnitus evaluation.

Statistical Analysis

A comparison between the study groups was performed for each of the tinnitus evaluation tests. A 1-way analysis of variance (ANOVA) test and \( \chi^2 \) were used for the tinnitus pitch, tinnitus intensity, and residual inhibition tests. Pearson correlation analysis and Tyke Kramer comparisons contrast test were used to compare the distribution of masking curves between the 2 groups.

Results

The 2 study groups did not differ significantly in age. In group 2 (noise exposure), there were significantly more men \((\chi^2 \text{ test, } P = 0.049)\). The average speech reception threshold in group 1 was 47 dB and 44 dB in group 2 \((P = 0.2594)\). The average discrimination in group 1 was 95% and 97% in group 2 \((P = 0.7383)\). For each frequency tested, the differences in hearing threshold levels were insignificant between the 2 groups (1-way ANOVA test, \( P = 0.82 \)).

The distribution of patients according to tinnitus pitch matching is shown in Figure 1. For any frequency tested, the distribution difference between the groups was statistically significant (1-way ANOVA test, \( P < 0.005 \)). In group 1, 35 patients (81.4%) had their tinnitus pitch matching at 4 kHz and above. In group 2, only 60 patients (39.2%) had their tinnitus pitch matching at 4 kHz and above.

The distribution of patients according to tinnitus intensity matching is shown in Figure 2. The average tinnitus intensity in group 1 was 4.04 dB, and in group 2 it was 18.2 dB. This difference was statistically significant (1-way ANOVA test, \( P < 0.005 \)).
The distribution of patients according to their tinnitus inhibition capacity is shown in Figure 3. In group 1, 38 patients (72%) had tinnitus that was completely inhibited by masking noise (positive residual inhibition). In group 2, only 50 patients (33%) had positive residual inhibition. The difference between the groups of patients in the capacity of their tinnitus to be inhibited by masking noise was statistically significant ($\chi^2$ test, $P = 0.0289$).

The distribution of patients according to their types of masking curves is shown in Figure 4. In group 1, all the patients had types I to IV masking curves. None of them had type V masking curve, the one that indicates tinnitus that cannot be masked. Thirty-eight patients (72%) had type I masking curve, which means they are the best candidates for masking instruments. In group 2, 3 patients (2%) had type V and 34 (22%) patients had type I masking curves. The Tyke-Kramer test with 1-way ANOVA showed that there is a significant difference in the distribution of the masking curves between the 2 groups ($P = 0.0386$).

Discussion

Audiologists, otologists, and psychoacousticians all are attempting to find standardized methods to reliably quantify tinnitus. Shulman and Goldstein\cite{goldstein} recommended the use of pitch and loudness matching, Feldmann masking curve procedure, and measuring residual inhibition as standard procedures for
tinnitus evaluation. The results of the tinnitus evaluation are interpreted by a medical-audiologic team and are applied in formulating an individual plan for tinnitus treatment. Among the treatment options are medical methods like drugs, instrumentation, and surgical therapy.\textsuperscript{7,8,9} Nevertheless, the heterogeneity of the group of patients with tinnitus should also be taken into consideration in interpreting the tinnitus evaluation tests.

Disability refers to a reduction in the ability of an individual to perform a specific task and to remain employed at full wages. In litigation cases dealing with disability caused by tinnitus, 4 questions are posed and answered: Is the tinnitus real? Is the tinnitus severe? Is the tinnitus permanent? and What is the cause of tinnitus?\textsuperscript{2,3} Only the first question has a measure, which is the tinnitus sound characterization. Every ear, nose, and throat specialist involved in determining disability is aware of the difficulty in "proving the existence of a person’s tinnitus." With no objective, calibrated, well-established tool that can diagnose and quantify tinnitus, we wanted to examine the usefulness of tinnitus tests in differentiating functional tinnitus from “true” organic tinnitus that originates from the auditory pathway. This tinnitus characterization can help us in some manner, cautiously, to prove its existence and obviously in treatment planning.

We examined the results of 4 tinnitus tests performed on 2 populations of patients: group 1 was patients with tinnitus without noise exposure who had no motivation to bias the tests or to exaggerate their symptom. Group 2 was patients with tinnitus and noise exposure that claimed for disability. These patients might not perform the tinnitus evaluation tests as meticulously as the former group, but some of them obviously have disabling tinnitus. The results showed that the 4 evaluation tests can help us characterize the tinnitus in patients with sensorineural hearing loss. It is usually a high-frequency, low-intensity tinnitus; tends to be more inhibited by narrow band noise; and is usually consistent with type I Feldmann masking curve, which is typical to cochlear tinnitus, and it can be effectively masked. On the other hand, the results of the 4 tinnitus evaluation tests were much more diverse and inconsistent without any identifiable patterns in the group of patients that claimed disability because of noise-induced hearing loss and tinnitus.

We concluded that the 4 tinnitus tests are important and helpful tools in the evaluation of patients with genuine tinnitus. These patients are characterized by a particular tinnitus pattern. Although tinnitus tests are subjective tools they can help us, along with other anamnestic and clinical parameters to confirm the existence of cochlear tinnitus or to suspect, but still not to prove, the existence of malingerings.

Author Contributions

Nili Tal Segal, study design, data collection, writer; Moshe Puterman, Mark Shkolnik, Alexander Niv, Daniel Kaplan, and Anat Kochva; study design; Mordechai Kraus, study design, data collection, writer.

Financial Disclosure

Mark Shkolnik and Anat Kochva are employees of Hedim Hearing Institute.
References

1.
- 1
  - R.R.A. Coles, A.C. David, M.P. Haggard
  - Epidemiology of tinnitus. CIBA Foundation Symposium 85
  - [SD-008]

2.
- 2
  - A. Shulman
  - Subjective idiopathic tinnitus: a review
  - [SD-008]

3.
- 3
  - A. Shulman, B. Goldstein
  - Tinnitus suppression—hearing preliminary results
  - [SD-008]

4.
- 4
  - J. Vernon, J. Fenwick
  - Tinnitus "loudness as indicated by masking levels with environmental sounds."
  - [SD-008]

5.
- 5
  - H. Feldmann
  - Homolateral and contralateral masking of tinnitus
  - J Laryngol Otol Suppl, 4 (1981), pp. 60–70
  - [SD-008]

6.
- 6
  - A. Shulman, B. Goldstein
  - Tinnitus masking: a longitudinal study
7. J.J. Shea
   - Medical treatment of tinnitus

8. A.J. Schleuning, R.M. Johnson
   - Use of masking for tinnitus

9. A. Shulman
   - External electrical tinnitus suppression: a review
     - Am J Otol, 8 (1987), pp. 479–484

    - Tinnitus diagnosis/treatment