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Guidelines for the evaluation of hearing aid fitting (2010)

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ABSTRACT

Objective: The methods to evaluate the efficacy of the adjusted hearing aid for a hearing-impaired person are fitting tests. The tests include those presently carried out for evaluating hearing aid fitting, and the methods of testing and evaluation have been published as "Guidelines for the evaluation of hearing aid fitting (2010)" by the Japan Audiological Society.
Methods: Guidelines for the following 8 test methods are presented. (1) Measurements of speech performance-intensity functions and speech recognition scores; (2) Assessment of hearing aid fitting from the aspect of tolerance of environmental noise; (3) Measurement of real-ear insertion gain (measurement of sound pressure levels at the eardrum); (4) Measurement of the hearing threshold level and the uncomfortable loudness level (UCL) in sound pressure level (SPL) with an inserted earphone; (5) Aided threshold test in a sound field (functional gain measurement); (6) Prediction of insertion gain and aided threshold from hearing aid characteristics and the pure tone audiogram; (7) Measurement of speech recognition in noise; (8) Assessment of hearing aid fitting using questionnaires. In the above tests, (1) and (2) are mandatory tests, and (3) to (8) are informative tests.
Results: By performing test combinations properly selected from the above 8 tests, the benefits of a hearing aid could be determined.
Conclusion: The above test methods were useful and valuable in determining the efficacy of the adjusted hearing aid for a hearing-impaired person during clinical practice.

1. Introduction

There are various selection of hearing aids and hearing-aid adjustments. The method to evaluate the efficacy of the adjusted hearing aid for a hearing-impaired person is the

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fitting test. The Japan Audiological Society has selected test methods whose usefulness and value were determined during clinical practice. The tests include those presently carried out for evaluating hearing aid fitting, and the methods of testing and evaluation have been published as ''Guidelines for the evaluation of hearing aid fitting (2010)''. The aim of these tests is for minimum better fitting of hearing aids.

In these guidelines, test items are selected among those fulfilling the following conditions: test items with (1) obvious decision criteria; (2) the possibility to perform necessary and sufficient evaluation; (3) determined test standards; (4) a reasonable test time; and (5) tests designed for adults.

In this document, guidelines for the following 8 test methods are presented.

(1) Measurements of speech performance-intensity functions and speech recognition scores.
(2) Assessment of hearing aid fitting from the aspect of tolerance of environmental noise.
(3) Measurement of real-ear insertion gain (measurement of sound pressure levels at the eardrum).
(4) Measurement of the hearing threshold level and the uncomfortable loudness level (UCL) in sound pressure level (SPL) with an inserted earphone.
(5) Aided threshold test in a sound field (functional gain measurement).
(6) Prediction of insertion gain and aided threshold from hearing aid characteristics and the pure tone audiogram.
(7) Measurement of speech recognition in noise.
(8) Assessment of hearing aid fitting using questionnaires.

By performing test combinations properly selected from the above 8 tests, the benefits of a hearing aid can be determined. In the above tests, (1) and (2) are mandatory tests, and (3) to (8) are informative tests. (1) and (2) are mandatory because the primary purpose of hearing aid fitting is to improve speech understanding and the major cause of rejection to wear a hearing aid is intolerance to noise.

2. General considerations for sound field measurement

2.1. Test room

Assuming that hearing aid fitting tests in a sound field are performed in general otolaryngology clinics, the following conditions should be considered:

(1) The ambient noise level should not influence the test result.
(2) Reverberation of a test sound should not influence the measurement.
(3) There should be no mental pressure influencing the decision of the test subject.

Specifically, it is desirable that the ambient noise level (L_A) of the test room should not exceed 50 dB. The test room should be treated to lower reverberation. An area of about 2 m × 3 m should be prepared as testing space.

2.2. Calibration in sound field audiometry

2.2.1. Calibration in sound pressure level

In sound field measurement, a test sound is presented from a loudspeaker which is connected to the output of an audiometer. In this situation, when the sound pressure level (SPL) of the test sound at the head position of a test subject (field SPL) is measured for a dial setting in dB hearing level of an audiometer (dial HL), the difference D_{SPL} = (field SPL − dial HL) is the nominal reference level. Field SPL for any dial HL setting of the audiometer can be calculated by adding D_{SPL} to dial HL.

2.2.2. Conversion to hearing level

Hearing level (HL) of the test sound at the head position of a test subject (field HL) is calculated as:

$$\text{field HL} = \text{field SPL} - \text{RTSPL} = \text{dial HL} + D_{SPL} - \text{RTSPL},$$

where RTSPL is reference threshold sound pressure level in a sound field. So, when we define $D_{HL} = D_{SPL} - \text{RTSPL}$, field HL for any dial HL setting of the audiometer can be calculated by adding D_{HL} to dial HL.

(1) *Threshold test*. Values of RTSPL for pure tones under free field and binaural listening conditions are specified as in Table 1 [1]. Although free field cannot be available in clinical settings and band noise or a warble tone instead of a pure tone is often used as a test sound, values in Table 1 are used leniently. When the hearing aid is used monaurally, the 'RTSPL under monaural listening' condition may be used. ANSI (American National Standard Institute) [2] adopted monaural RTSPL which is 2 dB higher than that in Table 1 for every frequency.
(2) *Speech recognition test*. In Japan, RTSPL in speech audiometry is defined as the speech recognition threshold in SPL of 1-digit numerals in the 67-S word lists. This value is reported as 10 dB SPL in a sound field [3].

2.3. Sound attenuation and masking of the non-test ear

If one ear is tested in a sound field and there is a possibility that the test sound is heard in the non-test ear, it is necessary to physically attenuate the test sound delivered to the non-test ear by using an earplug or ear-mold impression. Ear-mold impression can attenuate the test sound by about 25 dB. A commercially available earplug also can be expected to have comparable attenuation when it fits the ear canal. But if it does not, the attenuation effect decreases especially in the low

Table 1
Reference threshold sound pressure levels for pure tones of each frequency under free field and binaural listening conditions (from ISO 389-7: 2005 [1]).

Frequency (Hz)	250	500	1000	2000	3000	4000	6000
Sound pressure level (dB)	11.4	4.4	2.4	−1.3	−5.8	−5.4	4.3

In a monaural listening condition, 2 dB should be added to the above values (from ANSI S3.6: 2004 [2]).

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