

*Processamento auditivo na perda auditiva unilateral: relato  
de caso*

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**Descritores**

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**ABSTRACT**

Unilateral hearing loss represents great risk to academic backwardness, communication, social development, and also to auditory processing. Thus, the aim of this study was to evaluate the auditory abilities of localization, closing, figure-ground, temporal resolution, and simple temporal ordering in a male 17-year-old individual diagnosed with profound unilateral sensorineural hearing loss of idiopathic etiology, without other alterations. The evaluation process consisted on the application of a checklist, and the conduction of conventional clinical audiological evaluation (pure-tone audiometry, logaudiometry, and tympanometry), and of monotic (ipsilateral SSI, Filtered speech test) and diotic (Sound localization, Auditory memory for verbal and non-verbal sounds, AFT-R) auditory processing test. Results showed alteration only in the sound localization test. No complaints were reported regarding the abilities of sound localization, attention, discrimination, and comprehension. In this case study, the profound unilateral sensorineural hearing loss did not seem to restrict the development of the auditory processing abilities evaluated, except for the localization of the sound source.

**RESUMO**

A perda auditiva unilateral representa grande risco para o atraso acadêmico, a comunicação, o desenvolvimento social e também para o processamento auditivo. Assim, o objetivo deste estudo foi avaliar as habilidades auditivas de localização, fechamento, figura-fundo, resolução temporal e ordenação temporal simples de um sujeito do gênero masculino, 17 anos de idade, com diagnóstico de perda auditiva sensorineural unilateral de grau profundo, de causa idiopática, sem outros comprometimentos. O processo de avaliação constituiu da aplicação de um questionário, da realização da avaliação audiológica clínica convencional (audiometria tonal, logaudiometria e imitancimetria) e de testes de processamento auditivo monóticos (SSI ipsilateral, Teste de fala filtrada) e dióticos (Localização sonora, Memória auditiva para sons verbais, Memória auditiva para sons não verbais, AFT-R). Apenas o teste de Localização sonora apresentou resultados alterados. Não foram relatadas queixas relacionadas à habilidade de localização sonora, atenção, discriminação e compreensão auditiva. No caso em estudo, a perda auditiva sensorineural unilateral de grau profundo não pareceu restringir o desenvolvimento das habilidades do processamento auditivo avaliadas, exceto no que se refere à localização da fonte sonora.

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## INTRODUCTION

Researchers have demonstrated the advantages of binaural hearing in comparison to monaural hearing, with regards to sound localization, summation phenomenon, elimination of the head shadow effect, improvement of speech recognition in noise, and less effort in listening<sup>(1,2)</sup>. Thus, unilateral hearing loss has been the subject of several studies, as it represents great risk for academic delay, communication, social development, and auditory processing<sup>(3-5)</sup>.

The evaluation of auditory processing by standardized procedures has contributed to the identification and intervention of the deficits observed. Auditory processing tests, such as the Pediatric Speech Intelligibility and the Gaps-in-Noise test, were used in a study<sup>(4)</sup> to evaluate, respectively, the auditory abilities of figure-ground and time resolution, in 19 subjects (mean age 12 years). Most of them had profound unilateral hearing loss with beginning at preschool age or with unknown etiology. The results were compared to a control group matched by gender, age, and education. The author found poorer results in the group with unilateral hearing loss.

In a study<sup>(5)</sup> conducted with 26 subjects (13 with unilateral hearing loss and 13 with normal hearing) using tests of auditory processing (sound localization in five directions, speech-in-noise test, sequential memory for verbal and for nonverbal sounds, and Random Gap Detection Test – RGDT), the researcher concluded that the temporal resolution ability did not distinguish between subjects with and without hearing loss. Subjects with unilateral hearing loss had poorer performances on tasks of sound localization and auditory closure.

Considering the effects of unilateral hearing loss, it is important to determine the existence of hearing impairments, since this information may guide treatment strategies. Hence, it appeared necessary to identify deficits in the auditory abilities of subjects with unilateral hearing loss.

Therefore, this study had the aim to assess localization, closure, figure-ground resolution, and temporal ordering abilities of a subject with profound unilateral sensorineural hearing loss.

## CLINICAL CASE PRESENTATION

The study was approved by the Ethics Committee of Faculdade de Odontologia de Bauru, Universidade de São Paulo, under protocol number 023/2003. The people who were legally responsible for the subject signed the consent forms, agreeing with the research and the dissemination of its results, according Resolution 196/96 of the CONEP.

The subject DRC (male, 17 years old) came to the clinic complaining of difficulty in listening to speech on one side. First, a questionnaire was applied to learn the hearing history of the patient. Then, a battery of audiological tests was applied: conventional audiological evaluation (pure tone audiometry, speech audiometry and tympanometry) and behavioral tests of auditory processing (monotic and dihotic).

Monotic tests are those in which different stimuli are presented simultaneously in the same ear (ipsilaterally). The following tests were selected: the SSI (Synthetic Sentence

Identification)<sup>(6)</sup> in Portuguese, a monotic test that assesses the ability to perceive background figures for verbal sounds, and has the aim to provide information regarding the physiological mechanism of auditory verbal sound recognition in relation to a speech/noise ratio of zero, -10, and -15; the Filtered Speech test<sup>(6)</sup>, which presents a list of 25 distorted verbal stimuli and evaluates the ability of auditory closure.

Dihotic tests are tests in which the same stimuli are presented simultaneously to both ears. The following tests were selected: sound localization in five directions (right, left, behind, above, and ahead)<sup>(6)</sup>, sequential memory for verbal and nonverbal sounds<sup>(6)</sup>, and Auditory Fusion Test – Revised (AFT-R)<sup>(7)</sup>, which is a procedure for measuring the ability of temporal processing, determining the duration (in ms) for which the listener can detect a brief interval of silence between two tones.

The sound localization test (SL) assesses the ability and the physiological mechanism of binaural interaction<sup>(8)</sup>. Using a rattle, five positions in relation to the subject's head are surveyed: right, left, above, ahead, and behind. The subject indicates the localization of the sound, and is expected to identify at least four out of the five directions<sup>(6)</sup>.

In the test called the Sequential Memory for Verbal Sounds Test (MVSST), three different sequences of three syllables (PA, TA, and CA) are presented orally to the subject to be repeated, following the exact same sequence. The subject is expected to repeat correctly at least two of the three different sequences presented. The Sequential Memory for Nonverbal Sounds Test (MnVSST) uses four musical instruments (rattle, coconut, agogo, and bell), in three different percussive sequences. The subject is asked to identify the musical instruments in the order presented. He or she is expected to identify at least two sequences of three sounds in four attempts. These tests provide information about the physiological mechanisms of auditory temporal processing, with the aim to assess the hearing ability of temporal ordering<sup>(6,8)</sup>.

The SL, MVSST and MnVSST were shown to the subject prior to their application. All selected tests were performed in a soundproof booth. For monotic tests and the AFT-R, we used a two-channel audiometer coupled to a CD player.

According to data from the questionnaire, the patient reported having difficulties with auditory attention, localization, discrimination, and comprehension, with restrictions in performing some tasks and social interaction activities. No complications were reported regarding otological aspects in either ears. The subject could not specify whether this hearing loss was congenital or acquired, but he reported that it was present since his childhood.

The basic audiological evaluation (Table 1) revealed pure-tone air-conduction thresholds within normal limits in the right ear and abnormal in the left ear, indicating profound sensorineural hearing loss. Data from speech audiometry were consistent with those from pure-tone audiometry. A type A tympanogram was observed in both ears, indicating the absence of middle ear disease. Ipsilateral and contralateral stapedial reflexes were present in the right ear, and absence in the left ear. These data were consistent with profound sensorineural hearing loss in the left ear.

**Table 1.** Pure-tone air-conduction threshold values of the patient

Ear	250 Hz	500 Hz	1 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz
Right (dB)	5	10	10	10	10	15	15	10
Left (dB)	100	100	105	115	↓(120)	↓(120)	↓(110)	↓(105)

**Note:** dB = decibel; Hz = Hertz

The results of the auditory processing evaluation were obtained (Tables 2 and 3).

**Table 2.** Scores of the patient in the auditory processing monotic tests

Monotic tests (Right ear)		Correct answers (%)	Standard values (%)
	S/R=0	80	≥80
SSI (ipsilaterally)	S/R= -10	70	≥70
	S/R= -15	60	≥60
Filtered Speech		92	≥70

**Note:** S/N = speech/noise; SSI = Synthetic Sentence Identification

**Table 3.** Scores of the patient in the auditory processing dichotic tests

Dichotic tests	Correct answers	Standard values
Sound localization	3/5 (60%)*	≥4/5 (80%)
Sequential Memory for Verbal Sounds	3/3 (100%)	≥2/3 (100%)
Sequential Memory for Non-Verbal Sounds	3/3 (100%)	≥2/3 (66.6%)
AFT-R	6.7 ms	≤8ms

**Note:** AFT-R = Auditory Fusion Test – Revised; ms = milliseconds; \* = altered results

## DISCUSSION

Conventional peripheral auditory evaluation provides basic information about the subject's hearing abilities. However, hearing deficits have been documented in subjects who have unilateral hearing loss using behavioral assessment measures of the central auditory function<sup>(4,5)</sup>.

The findings of this case study of a subject diagnosed with profound unilateral sensorineural hearing loss in the left ear and hearing within normal limits in the right ear showed deficit in sound localization. This deficit was verified by his performance on the behavioral auditory processing test, which aims to verify information on this important hearing ability, confirming a previous research<sup>(5)</sup> in which individuals with unilateral hearing loss had impaired performance in tests of sound localization, closing, and communication.

The ability to localize sounds is crucial, not only to determine the source of a sound but also to separate sounds in an environment of multiple sounds<sup>(9)</sup>. A deficit in this ability was expected in this case study, given that the physiological mechanisms of auditory discrimination of sound source direction are dependent on the binaural interaction process, and integrity is required in bilateral hearing. This interaction is dependent on the signals received by both ears and on how auditory information is processed. These interactions help the person in the

localization of sound sources in space and in the identification of figure-ground<sup>(9)</sup>.

Although studies<sup>(9)</sup> have reported that subjects with difficulty in sound localization have alterations in speech comprehension in noisy environments with competition, which requires auditory abilities of closing and figure-ground, such abilities were not altered in this case study. This finding was confirmed by the subject's performance on the filtered speech and the monotic SSI tests, respectively, and demonstrate adequacy in the process of interaction for the mechanism of monotic verbal sound discrimination. This mechanism is of fundamental importance for the comprehension of the auditory information in the presence of competing messages<sup>(10)</sup>.

However, the auditory attention and comprehension complaints corroborate researches<sup>(11)</sup> which have claimed that decreases in speech comprehension in noisy environments increase in the subjects the feelings of confusion and loss of concentration. Restrictions in performing some tasks and social interactions activities were reported by the subject of this study, in agreement with those reported by the researchers<sup>(12)</sup> of a study in which the self-perception of unilateral sensorineural hearing loss in adult non-users of hearing aid devices was evaluated.

Oppositely to another study<sup>(4)</sup> that used the Gaps-in-Noise (GIN) test, the temporal resolution ability was not altered in the present study, as verified by the AFT-R. However, agreement was found with another study<sup>(5)</sup>, in which the RGDT (Random Gap Detection Test) was used. This difference between studies may be due to the different stimuli used in the tests: white noise in the GIN test, and pure-tone in the RGDT and the AFT-R<sup>(13)</sup>. It is noteworthy that three tests are currently available for clinical use (AFT-R, RGDT, and GIN) with the aim to evaluate the auditory temporal resolution ability.

Regarding the auditory ability of temporal ordering, the absence of alterations found in the MVSST and MnVSST indicates that the physiological mechanisms of auditory temporal processing were efficient and not influenced by sound localization deficits and/or by the presence of unilateral hearing loss. However, one study<sup>(8)</sup> revealed a significant correlation between a delay in the ability to localize sounds and alterations in the physiological mechanism of temporal processing due to the difficulty in dealing with temporal cues (difficulty in analyzing acoustic cues in timing and intensity), which, in time, interfered with the ability to sort sounds, verified by testing memory for verbal and nonverbal sounds in sequence.

The findings from this study, which show alterations in only one auditory ability among the five evaluated, do not seem to be explained by the affected side of the hearing loss, because the presence of unilateral hearing loss in the right ear would cause greater impact on auditory perception and processing when compared to hearing loss on the left side<sup>(1)</sup>. Thus, further rese-

arch is needed to elucidate the precise mechanisms responsible for the results obtained in this case of unilateral hearing loss, given that alterations in binaural stimulation result in structural and functional changes in the central auditory system<sup>(14)</sup>.

The literature has emphasized the benefits of electronic devices in cases of subjects diagnosed with hearing loss, as they minimize the problems caused by sensory deprivation. However, in this particular case, due to the profound degree of hearing loss and to the recommendations used in the service<sup>(15)</sup>, the use of an electronic device was not indicated.

## FINAL COMMENTS

In this case study, profound unilateral sensorineural hearing loss did not seem to restrict the development of the auditory processing abilities assessed, except for sound localization. Nevertheless, complaints regarding sound localization, attention, discrimination, and listening comprehension abilities were reported. Considering the impaired hearing ability and the reported complaints, an orientation program and a follow-up auditory evaluation are being conducted, as the use of an electronic device is not indicated due to the degree of hearing loss. It is important to note that this paper refers to the presentation and discussion of only one case of unilateral hearing loss. Therefore, the results and final considerations described here should be understood with some care and should not be generalized. A study with a larger sample should be conducted to confirm these findings, as it is necessary to carry out further investigations using auditory processing tests that assess other abilities, as well as investigate different degrees of a unilateral hearing loss.

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