

# Vibrant Soundbridge and Bone Conduction Hearing Aid in Patients with Bilateral Malformation of External Ear

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## Abstract

**Introduction** Hearing loss is the most common clinical finding in patients with malformation of the external ear canal. Among the possibilities of treatment, there is the adaptation of hearing aids by bone conduction and the adaptation of implantable hearing aids.

**Objective** To assess speech perception with the use of Vibrant Soundbridge (VBS - MED-EL, Innsbruck, Austria) associated with additional amplification in patients with bilateral craniofacial malformation.

**Method** We evaluated 11 patients with bilateral malformation over 12 years with mixed hearing loss or bilateral conductive. They were using the Softband (Oticon Medical, Sweden) and bone conduction hearing aid in the ear opposite the one with the VSB. We performed the evaluation of speech perception using the Hearing in Noise Test.

**Results** Participants were eight men and three women with a mean of 19.5 years. The signal / noise ratio presented significant results in patients fitted with VSB and bone conduction hearing aid.

**Conclusion** The results of speech perception were significantly better with use of VBS combined with bone conduction hearing aids.

## Keywords

- ▶ abnormalities
- ▶ hearing aid
- ▶ speech perception

## Introduction

The malformation of the external ear canal, a type of atresia, occurs in about one in every 20,000 live births.<sup>1</sup> It is characterized by the absence or deformity of the pavilion, aplasia, or hypoplasia of the external auditory canal, middle ear deformities, and, occasionally, internal ear deformities.<sup>1</sup>

Hearing loss is the most common clinical finding, with type and extent of loss relating to the location of the malformation: external ear, middle ear, and / or inner ear.<sup>2</sup>

The treatment possibilities for this malformation include the adaptation of hearing aids by bone conduction, the

adaptation of the implantable hearing aid, or surgical reconstruction of the ear.<sup>2</sup>

The use of an individual hearing aid (HA) is not possible in cases of agenesis or external auditory canal stenosis because of the impossibility of stimulation by air.<sup>3</sup> In such cases, a bone conduction hearing aid may be an option.

Complaints of headaches from bow pressure and dissatisfaction with the aesthetic visibility of bone conduction hearing aid components are common among teens and tweens. All these factors combined lead to reduced use of the device.<sup>4</sup>

The Vibrant Soundbridge (VBS - MED-EL, Innsbruck, Austria) is a surgically implantable middle ear HA consisting of two components: the implantable internal component and

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an external drive. The outside is fixed to the skin, on the patient's head, with a magnet. The device works with batteries, similar to other hearing aids, and it contains a microphone that picks up sound and transmits it through the skin to the internal receiver.<sup>5</sup>

The advantages of binaural hearing are widely publicized and documented. The ability to use both ears functionally promotes a better understanding of speech in a noisy or reverberant environment. The ability to locate sounds is highly dependent on the ability to perceive sounds simultaneously in both ears.<sup>6</sup> In addition, binaural hearing plays a fundamental role in monitoring and control of numerous alerts and guidance situations in people's daily routine. An interference or impairment of this skill often brings feelings of insecurity in relation to the surrounding environment.<sup>7</sup>

Before the satisfactory results in patients with external ear malformation implanted with VSB system, became interested in studying the use of this device associated with the hearing aid, as an alternative to hearing rehabilitation.

The objective of the research was to evaluate speech perception with the use of VBS associated with another amplification device in patients presenting bilateral craniofacial malformation.

## Method

This is a prospective cohort study, conducted upon approval of the Research Ethics Committee (345/2011).

The population consisted of individuals fitted with surgically implantable middle ear HA (VBS) during 2013.

We selected individuals based on the following inclusion criteria: older than 12 years of age; presenting bilateral malformations of the external ear with or without middle ear malformation; bilateral conductive or mixed hearing loss; and having communication difficulties without the HA.

The exclusion criteria were: individuals with central or retrocochlear auditory disorders; individuals with otologic disorders, such as vertigo and Meniere's disease, tinnitus, hearing fluctuation, or inner ear malformations.

### Selection of Hearing Aids

The patients used Softband Ponto (Oticon) by bone conduction and the Naída I SP (Phonak) hearing aid, set in the opposite ear to the VSB.

We used the nonlinear prescriptive method NAL-NL1 to calculate and set electroacoustic characteristics based on the tone thresholds entered previously.

The adjustments and prescriptive methods used were similar for VBS, Softband, and bone conduction HAs. Algorithms were triggered only by managing feedback, by holding an omnidirectional microphone.

After programming the HA, we performed the verification procedure with thresholds of measures in the free field with and without amplification. The minimum intensity was 30 dB SPL as the minimum value allowed, in accordance with the calibration of equipment.

The participants performed the speech perception test three months after activation of the VSB.

### Speech Perception Test

The speech perception test was conducted in two distinct situations through HINT (Hearing In Noise Test), adapted to Brazilian Portuguese<sup>8</sup>:

1. Speak in quiet (Silence): the signal away from the front of the individual in a noise-free test condition (0° azimuth).
2. Speak with frontal noise (Noise Front): the signal and noise are placed directly in front of the individual in a sound condition at 0° azimuth.

For each condition, we displayed a list of 20 sentences, randomly selected by the HINT PRO software itself. Participants received as guidelines the oral instructions contained in the HINT manual.

The evaluator considered the sentence correct when the participant properly repeated all essential words. In this case, the evaluator pressed the "yes" button on the software screen. If the evaluator selected "yes" after the first performance, the program presented the second sentence at an intensity 4 dB below that of the first sentence.

To evaluate the silence, we initially set the level of speech at 45 dBA. This level varied according to participants' answers. If the participant did not correctly repeat the sentence, the intensity level progressively increased by 4 dB steps until the participant could correctly repeat the sentence.

The score for the silence test is expressed in dBA and represents the recognition threshold for 50% of the sentences.

As for the evaluation in noise, we kept this level fixed at 65 dBA. The level of presentation of the sentences varied in the same manner described for the mute condition. The score in dB is the signal-to-noise threshold after going through a list of 20 sentences. Thus, the lower the signal-to-noise ratio, the better the participant's speech perception in this condition.

The HINT was performed in four different situations:

1. Without Vibrant Soundbridge and with Softband: the Softband functions as a conventional bone conductor, adjustable by means of an elastic band, adapting to any head size.
2. With Vibrant Soundbridge and Softband.
3. Without Vibrant Soundbridge, with bone conduction HA: the HA functions as a headband with a bone vibrator.
4. With Vibrant Soundbridge and bone conduction hearing aid.

### Statistical Analysis

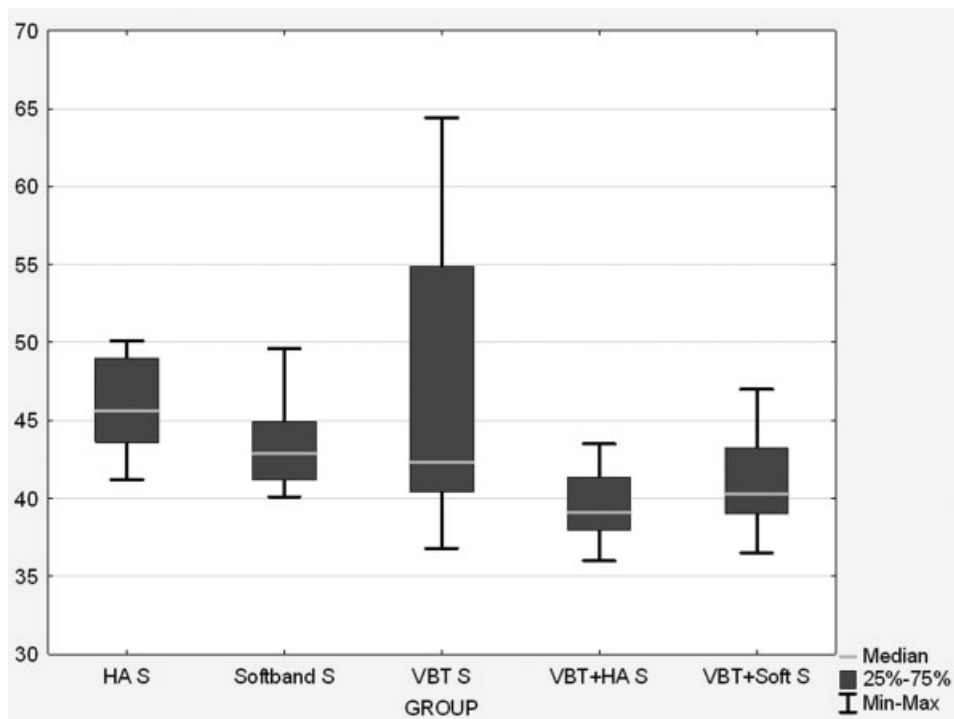
We analyzed the results of the speech perception evaluation in silence using the nonparametric Friedman.

We analyzed the evaluation of individuals in the noise situation with the ANOVA test.

We considered the significance level of  $p < 0.001$  for the statistical procedure results in silence and  $p < 0.050$  for the results in noise.

## Results

The study group involved 11 individuals of both sexes (8 men and 3 women) with a mean of 19.5 years, with bilateral malformation of ears and severe mixed bilateral hearing loss.



**Fig. 1** Speech perception responses of individuals in silence situation. Abbreviations: HA hearing aid; VBT, Vibrant Sound Bridge.

The HINT results in the quiet situation are in ►Fig. 1.

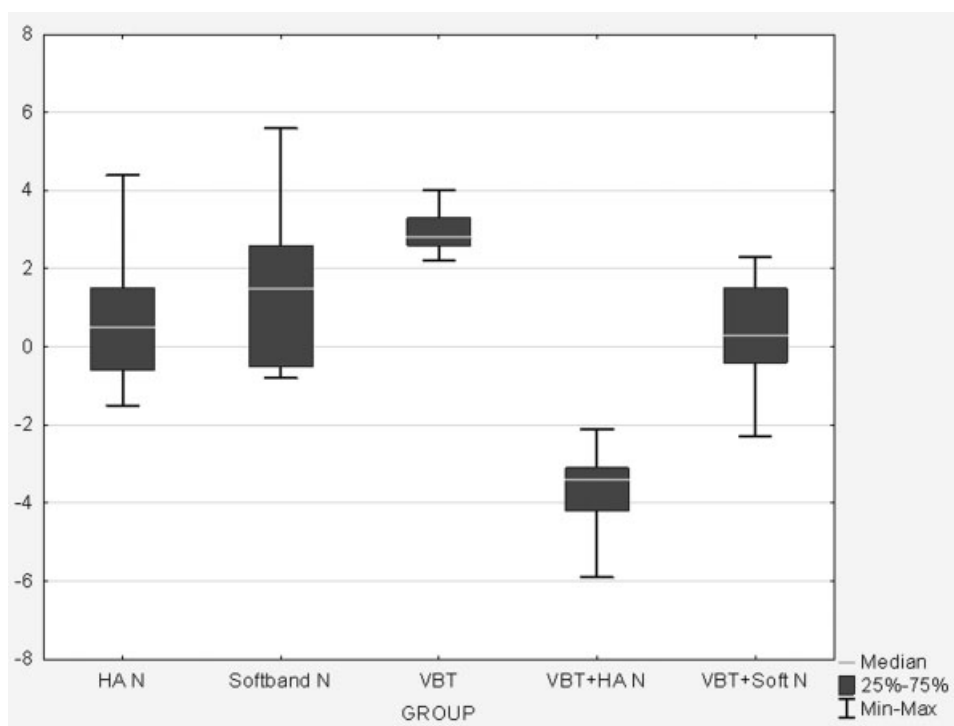
The responses obtained in the noise situation are in ►Fig. 2.

### Discussion

The adaptation of bilateral amplification devices presupposes the possibility of interaction between the two auditory path-

ways and, thus, provides the individual with binaural hearing loss with a sound of superior quality in terms of clarity, redundancy, binaural summation effect, stereo, and free from head shadow effect.<sup>6</sup> Thus, it seems consistent to suggest that the adaptation of bilateral amplification devices should be privileged whenever there is a contraindication to such.<sup>6,9</sup>

Researchers investigated the simultaneous use of VBS and digital HA in eight adults in the following situations: without



**Fig. 2** Speech perception responses of individuals in noise situation. Abbreviations: HA hearing aid; VBT, Vibrant Sound Bridge.

amplification, unilateral adaptation of VBS, VBS associated with HA with omnidirectional microphone, and HA with omnidirectional microphone unilaterally. The study concluded that the adjustment associated with the amplification devices benefited users in speech perception in silence, with no significant results in the evaluation in the noise condition.<sup>10</sup>

The results from this study show that there was no significant difference between the responses obtained in the silence with individual use of VBS x HA and VBS x Softband. Similar data were found by researchers that evaluated the speech perception of 19 adults who used conventional HA for a period of three months and could not adapt due to chronic irritation, aesthetic, occlusion effect, and insufficient amplification. Participants were surgically fitted with VBS and, after comparing the evaluation of speech perception, stated that there was no difference between the results obtained with HA and VBS.<sup>11</sup>

Another study performed a comparison of speech perception with the use of VBS and open fitting HA with seven adults diagnosed with sensorineural hearing loss at high frequencies. The research found that the VBS gave greater amplification to higher frequencies compared with open fit, however there was no significant difference in relation to speech perception.<sup>12</sup>

In normal hearing individuals, the hearing threshold improved ~3dB, if we go from monaural stimulation to binaural stimulation. This situation is often called binaural redundancy, and may render improved results in terms of speech perception.<sup>13</sup> When an individual tries to understand a vocal stimulus with only one ear, there is a decrease in signal playability. Individuals with bilateral hearing impairment, when bilaterally fit, have better discrimination capacity in noise than in monaural fitting.<sup>14–16</sup>

Some authors<sup>17–19</sup> emphasize that unilateral hearing is insufficient in several aspects related to learning, sound localization, and speech recognition in noise situation. The use of contralateral HA to VBS favored the speech perception in silence and noisy situations. Binaurality can offer benefits in improving the perception of words, greater access to sounds, improved oralization, and sound localization.<sup>18–20</sup>

The results obtained with use of bilateral amplification indicated significant improvement in speech perception in silence and noise situation. In a case study with a six-year-old boy, the VBS was adapted with an interval of two months between surgeries; bilateral adaptation resulted in a 100% score in the speech perception assessment in quiet and in noise.<sup>21</sup>

Experiments indicate that the VBS provides significant results in free field thresholds to search for individuals with bilateral ear malformation with 55.1dB gain for all frequencies studied.<sup>22</sup> Patients with bilateral atresia had a score of 97% correct for two-syllable words in 65dB SPL after binaural adaptation.<sup>23</sup>

It is possible to confirm that bilateral adaptation favors perception of speech, regardless of which amplification device used. Probably, the bilateral implementation of the VBS would be the ideal for the cases evaluated in this study, although this

decision should fall under the ENT physicians responsibility. A team of researchers evaluated quantitatively and qualitatively a group of 15 patients with sensorineural hearing loss, with sequential implant VBS and revealed an improvement in speech perception in silence and noise situation.<sup>24</sup>

Our research shows that the use of HA associated with the VBS provided a significant improvement in speech perception in silence and noise situation (Graphs 1 and 2). However, there is difficulty in the effective use of the bow due to the headaches caused by pressure arc on the mastoid and the negative psychosocial aesthetic impact of visible components of the hearing aid.<sup>25</sup> Thus, bilateral indication for surgery is a viable option for the study population.

Bilateral VSB is a clinical reality, but not all users will have access to this treatment option for audiological, medical and family reasons.

## Conclusion

The results of speech perception were significantly better with use of VBS associated with bone conduction HA.

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