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Analysis of speech perception with amplification devices in subjects with ear malformation and unilateral hearing loss

Análise da percepção da fala com uso de dispositivos de amplificação em indivíduos com malformação de orelha e perda auditiva unilateral

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Keywords

Hearing aids
Congenital abnormalities
Bone conduction
Speech perception
Unilateral hearing loss

ABSTRACT

Purpose: To verify the speech perception in subjects with ear malformation and unilateral hearing loss, fitted with two types of amplification as follows: conventional hearing aids and softband (band with vibrator bone). **Method:** The study included fifteen subjects of both sexes who presented congenital malformation of the middle or outer ear, diagnosed with unilateral conductive or mixed hearing loss, moderate to severe hearing loss, age range between 15 to 25 years and, prescription from a specialist doctor for hearing device fitting. We performed the speech perception assessment without amplification after the hearing aid and softband fitting, with the hearing aid linked to the bone vibrator (conventional) and the softband (band with the bone vibrator). The subjects were evaluated using the Hearing in Noise Test (HINT), in silence and in noise. **Results:** Seven subjects with unilateral ear malformation were evaluated, 57.1 % had impairment in the right ear and 42.9 % in the left ear. Regarding the type and the level of hearing loss, 71 % of all subjects included in the sample presented moderate conductive hearing loss. The assessment of speech perception was performed during silence, frontal noise, lateral noise and, during three specifics situations: no amplification, with conventional hearing aid and with the softband. The results with the amplification devices were positive in all evaluated conditions. **Conclusion:** Evaluated subjects presented improvement in speech perception, in silence, frontal noise and lateral noise situations, regardless of the type of amplification; however, the difference was not statistically significant.

Descritores

Auxiliares de audição
Anormalidades congênitas
Condução óssea
Percepção da fala
Perda auditiva unilateral

RESUMO

Objetivo: Verificar a percepção da fala de indivíduos com malformação de orelha e perda auditiva unilateral utilizando dois tipos de amplificação: amplificação sonora individual (AASI) convencional e *softband* (faixa com vibrador ósseo). **Método:** Foram selecionados 15 indivíduos, de ambos os sexos, com malformação congênita de orelha externa e/ou orelha média, diagnóstico de perda auditiva unilateral do tipo condutiva ou mista de grau moderado a severo, idade entre 15 e 25 anos, e encaminhamento para amplificação realizado pelo médico otorrinolaringologista. Após a adaptação com AASI e *softband*, foi realizada avaliação da percepção da fala sem uso da amplificação, com AASI acoplado ao arco e vibrador ósseo (convencional) e com uso do *softband* (faixa com vibrador). Os indivíduos foram avaliados por meio do *Hearing in Noise Test* (HINT) nas condições de silêncio e de ruído. **Resultados:** Foram avaliados sete indivíduos com malformação de orelha unilateral, sendo 57,1% na orelha direita e 42,9% na orelha esquerda. Quanto ao tipo e grau da perda, 71, 4% da amostra possuía perda auditiva condutiva moderada. No teste de percepção de fala na condição de silêncio, ruído frontal e ruído lateral, em três situações: sem amplificação, com o uso do AASI convencional e com o uso do *softband*, os resultados com uso de dispositivos de amplificação apresentaram-se melhores em todas as condições. **Conclusão:** Os indivíduos apresentaram melhora sutil, porém não significativa, na percepção de fala tanto em situações de silêncio, ruído frontal e lateral independentemente do tipo de amplificação.

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INTRODUCTION

Ear malformations are anomalies that occur during the period of embryonic development and can affect the outer, middle and/or inner ear.[1] Commonly, congenital anomalies of the ear affect the external ear and the external acoustic meatus, with unilateral or bilateral alterations. The structures of the inner ear are usually normal in their development since they are originated from different embryonic tissues.[2]

Hearing loss is one of the most common clinical findings in these cases, with type and degree varying according to the location of the malformation.[1] The assessment of auditory function in various spatial conditions is extremely important for choosing an appropriate treatment.[3]

It is possible to observe the negative consequences resulting from unilateral hearing loss, such as difficulties with sound localization due to the shadow effect of the head and speech perception, especially in noisy environments, thus affecting the individual's social interactions.[3-5]

Thus, in cases of unilateral malformation, regular clinical monitoring with ear, nose and throat specialists and audiologists is recommended since the contralateral ear has a higher risk of containing abnormalities compared to the general population.

The intervention for individuals with this impairment consists of adapting electronic devices, but the possibilities are limited as a result of the alteration or absence of the external acoustic meatus. Among the existing options, we highlight the use of bone conduction amplification devices, the fitting of individual sound amplification devices (hearing aids) and the performance of surgeries.[6] Of these, solutions through definitive surgeries do not occur in the first months of life, and the use of conventional hearing aids is not applied in cases of external acoustic meatus agenesis or stenosis due to the impossibility of airway stimulation.[6]

Regarding amplification devices, the hearing aid aims to reestablish and improve the communicative function of the hearing impaired.[2] However, its adaptation is not always indicated due to the anatomical condition of the individuals in question. Thus, the use of bone conduction amplification devices becomes a valid option for individuals with such anomalies.[2]

The use of bone conduction amplification devices aims to vibrate the cochlear structures without having to pass the acoustic stimulus through the structures of the outer and middle ears. The output transducer is a vibrator called a bone conductor. For a correct transmission, the bone conductor is usually situated on one side in a band which uses elastic tension to press the bone conductor against the head.[2]

The decision on the type of amplification to be used is up to the professional responsible for the case, together with the individual and their family members. The possibility of sound amplification by bone conduction is a practical, non-invasive and accessible option in some public services in Brazil.[2]

Bone conduction electronic devices can be measured electro-acoustically, using equipment that measures vibration.[7] Air conduction amplification devices, on the other hand, use objective measurements to verify the prescribed frequency gain or output. Such measurements are performed with a probe microphone and are accurate to verify the hearing aid in the user's ear.[8]

To verify the effectiveness of the hearing aid and the best performance of the individual without noise, it is necessary to perform some speech perception tests, especially those involving the competitor's noise, allowing to simulate a real listening situation and assist in the evaluation of the difficulties affected by the users of amplification devices.[9] However, these speech perception tests are not yet part of the conventional audiological assessment protocol.

One of the tests available for this type of evaluation is the Hearing In Noise Test (HINT), whose objective is to assess the individual difficulty in speech perception through the repetition of simple sentences, both in silence and in noise.[9]

Speech perception is closely related to socialization and learning. Thus, there is a need for scientific evidence in the intervention of individuals with ear malformations who use hearing aids. Thus, the objective was to verify the speech perception of individuals with ear malformation and unilateral hearing loss using two types of amplification: conventional hearing aid and softband (band with bone vibrator).

METHOD

The present study was carried out after approval by the Research Ethics Committee (Process nº. 226/2012) and the subjects' consent to voluntary participation in the work and data publication, confirmed by signing the Informed Consent Form (ICF) or signature in the Term of Assent by those responsible.

Casuistry

Pre-selections were made for subjects with congenital malformations of the outer ear and/or middle ear with unilateral hearing loss without previous experience with the use of amplification, which were randomly allocated into two distinct groups (conventional amplification-hearing aid coupled to the bow with vibrator bone and softband-band with a bone vibrator), with a total of 15 individuals selected, according to the eligibility criteria:

Inclusion criteria:

- Congenital malformation of the outer ear and/or middle ear;
- Both sexes;
- Diagnosis of unilateral conductive or mixed hearing loss of moderate to severe levels;
- Referral for amplification, performed by the ear, nose and throat specialist.

Exclusion Criteria:

- Cognitive alterations attested through the application of the General Nonverbal Intelligence Test (TIG-NV);
- Do not accept to participate in the research;
- Do not attend the scheduled return for follow-up.

Participants followed the procedures below:

General Non-Verbal Intelligence Test (TIG-NV)

This test was carried out by a psychologist in order to track cognitive changes in possible research participants. TIG-NV allows to identify the types of wrong reasoning and the processing involved in its execution, in addition to the usual classifications of intellectual potential. The test is applicable to individuals from 10 to 79 years old with any level of education, and it consists of 30 questions with six alternatives of which only one is the correct one. There is no time limit to answer the test[10,11].

Amplification

After the subject's medical referral for amplification, the process of fitting the electronic devices was carried out following the parameters indicated in accordance with the anatomical characteristics and individual audiological thresholds.

The following devices were used for amplification: conventional hearing aid, Naída Super Power (Phonak), and softband, Ponto Pro Power (Oticon Medical).

The non-linear prescriptive method NAL-NL1 was used to calculate and adjust the electroacoustic characteristics based on the previously entered hearing thresholds.

The settings and prescriptive methods used were the same for the Softband and hearing aids. Regarding the algorithms, only feedback management was activated with the omnidirectional microphone being maintained.

After programming the hearing aids, the verification procedure was performed with threshold measurements in the free field with and without amplification.

Evaluation of speech perception

The individuals underwent a speech perception assessment without using amplification with hearing aids coupled to the bow and bone vibrator (conventional), and using the softband (band with vibrator).

In order to not have a learning effect in the evaluations, the different conditions were applied with an interval of 15 days, according to a previous suggestion[12] through the HINT adapted to Brazilian Portuguese in the conditions of silence and noise[13].

The HINT was performed in an acoustically treated room, taking care of the proper positioning of the participant, the professional and the equipment. In both assessment conditions, two loudspeakers were used when necessary, being positioned at a distance of one meter from the participant at 0° azimuth and at the height of the hearing aid.

The system calibration was performed by placing a reference microphone at the location corresponding to the center of the participant's head and one meter away from the speaker, therefore, for the assessment, the subject was instructed to remain in the same position throughout the test, ensuring that the intensity that was reaching the ear was the same as indicated on the computer screen.

A list of 20 sentences was presented for each condition, and the list was randomly chosen by the HINT PRO software itself. Participants were instructed orally according to the guidelines contained in the HINT manual.

The HINT was performed in a free field and the intensity variability was automatically adjusted, following the standard of the equipment itself. The HINT presents strategy, ascending-descending, and makes it possible to determine the speech perception threshold in which the individual must identify the stimulus presented in the established signal/noise ratio 50% of the time. Thus, the initial intensity of speech was 65 dBHL during the presentation of the first four sentences, with variations in intensity of 4 in 4 dBHL in order to estimate the individual's threshold. From the fifth sentence on, the variation became 2 in 2 dBHL, allowing to determine the threshold with greater accuracy.[9,14]

The sentence was considered correct by the evaluator when all the essential words were repeated properly. In this case, the evaluator pressed the "yes" button on the software screen. If "yes" was selected after the first presentation, the second sentence was presented 4 dB below the intensity of the first sentence. On the other hand, if the sentence was considered to be incorrect, the intensity was increased by 4 dB in the next sentence according to the application protocol of the test.

HINT was performed with and without the use of hearing aids with a fixed noise intensity of 65 dBHL, and was presented in four situations: speech without noise, which means the signal is presented in front of the subject in a test condition without noise (0° azimuth); speech with frontal noise, in which the signal and the noise are placed directly in front of the individual in a noise condition at 0° azimuth; speech with noise on the right, performed only when the subject had hearing loss in the left ear, in which the signal is positioned in front of the subject and the noise is emitted at 90° to the right of the subject (noise condition on the right - noise at 90° azimuth), and speech with noise on the left, performed only when the subject had hearing loss in the right ear, in which the signal is positioned in front of the subject and the noise is emitted at 90° to the left of the subject (noise condition on the left - noise at 90° azimuth).[9,14]

Regardless of how the HINT is applied, the software itself creates, for the situation in the free field or with headphones, the compound noise (RC), which consists of a weighted average of the four situations described above: RC = (2* RF+RD+RE)/4[9,14].

The HINT results are expressed by the Sentence Recognition Threshold (LRS) values in the condition of silence, being compared with the averages obtained in subjects with normal peripheral hearing. In the noise condition, the values are expressed through the S/N ratio. Thus, the negative S/N ratio indicates greater difficulty in the test, that is, the more negative the S/N ratio, the better the individual's performance in situations with competitive noise.[9,14]

The data from the present study were tabulated and analyzed using the Microsoft Office Excel. Anova test was used for the statistical analysis of the study and calculation of quantitative results in an inferential way, adopting a significance level of 5%.

RESULTS

The present study selected 15 individuals who met the inclusion criteria established by the authors, however, eight of them were unable to attend the return proposed by the study, being excluded from the sample. Thus, seven individuals were evaluated, two females and five males, aged between 15 and 25 years, with an average of 20 years.

All individuals had unilateral malformations, 57.1% in the right ear and 42.9% in the left ear. As for the type and degree of loss, 71.4% of the sample had moderate conductive hearing loss with a predominance of these hearing characteristics.

The results obtained in the assessment of speech perception in the conditions of silence and frontal noise, without amplification, using conventional hearing aids and using the softband are shown in Table 1.

Table 1. Results of thresholds mean and S/N ratio from the speech perception test in the silence and frontal noise conditions and in three situations: without amplification, conventional hearing aids and the softband

Condition	n	Silence			Noise		
		Mean (thresholds dBHL)	SD	p	Mean (S/N)	SD	p
Without amplification	7	48.80	11.12	0.324	2.97	0.52	0.192
Conventional hearing aid	7	47.33	03.52		1.10	2.20	
Softband	7	42.67	01.84		2.16	2.26	

Anova Test (p<0.05).
S/N: Signal to noise ratio; dBHL: Decibel hearing level, SD: Standard deviation; p: p value

The analysis of the results in the assessment of speech perception with lateral noise condition without amplification, with the use of conventional hearing aids and with the use of the softband is shown in Table 2.

Table 2. Results of thresholds mean and S/N ratio from the speech perception test in the side noise condition and in three situations: without amplification, conventional hearing aids and the softband

Condition	n	Mean (S/N)	SD	p
Without amplification	7	04.18	03.05	p=0.361
Conventional hearing aid	7	-.31	04.29	
Softband	7	01.68	03.46	

Anova Test (p<0.05)
S/N: Signal to noise ratio; dBHL: Decibel hearing level, SD: Standard deviation; p: p value

DISCUSSION

There is a lack of studies related to ear malformation. Due to the demand for public and private services, there is an extreme need for research to be conducted to guide professionals working in the area of Audiology.

Individuals with ear malformations and hearing loss are received at different hearing health services. Clinical practice allows you to have contact with the difficulties presented by the subject, their objections and desires in order to assist in the selection of the best intervention. Thus, it is emphasized that practice based on scientific evidence is fundamental in decision-making and conducting cases.

The sample of the present study showed a predominance of males, with a mean age of 20 years and a higher frequency of unilateral malformation in the right ear, data that corroborate with a previous research.[15]) Regarding the type and level of hearing loss, a higher prevalence of moderate conductive hearing loss was observed. Such results have been observed in a similar way by other studies.[2,16]

The literature describes that difficulties in understanding speech are greater in individuals with hearing loss than in people with normal hearing. Thus, tests that assess speech intelligibility in the presence of competing noise provide relevant information about the communicative contexts that are close to the situations experienced in everyday life[17].

After the individuals were adapted with two different types of amplification devices (conventional hearing aid and softband), the entire sample performed a speech perception test (HINT).

The presence of noisy environments characterizes a challenging situation for speech intelligibility, mainly for individuals who have hearing loss, considering that the number of clues is reduced, leading them to use only the clues available at the moment[17].

The present study found that, after the intervention through the sound amplification, the individuals with ear malformation did not present statistically significant benefits, such as was observed in data already presented by a previous study[2].

The result obtained through the present study with sound amplification (conventional hearing aid and softband), in a situation of silence (Table 1), showed a subtle improvement in speech perception, mainly with the use of the softband, however, no statistical difference was found (p <0.05) between the different conditions. A previous study carried out the analysis of speech perception using amplification devices and found similar results without significant differences in the situation of silence with and without the use of conventional hearing aids[17].

Still regarding the condition of speech in silence, a study that analyzed a sample of 11 individuals, over 12 years of age and with bilateral ear malformation, found no significant differences with the individual use of the Vibrant Sound Bridge × conventional and Vibrant Sound Bridge × Softband[18].

Speech perception in the condition of frontal noise at a fixed intensity of 65 dBHL was assessed according to the same criteria using the HINT test. The data found are described in Table 1 and demonstrate that when the speech perception test was performed using conventional or softband hearing aids, the results were better, even though there is no statistical difference between the different conditions. However, these results showed that, for the three conditions evaluated, the average S/N ratio was positive, which is, the speech signal was presented at a greater intensity than the noise so that the individual could understand the test sentence.[2] Thus, it is important to highlight the possible listening difficulties that individuals may present in noisy environments, contributing to an unfavorable condition for speech intelligibility.[19]

Previous studies in the area, with the objective of evaluating different ways of sound amplification, including the use of conventional hearing aids coupled to a metal rod, a thread and a bone vibrator, also found similar results when analyzing the noise situation.[2,17]

The results obtained in the speech perception test in a situation of lateral noise (Table 2) in which the three conditions are compared (without amplification, conventional hearing aid and softband) indicate that the use of sound amplification can bring benefits to speech intelligibility in this situation, even if it did not present values with a statistically significant difference. However, for conditions without amplification and using a softband, the average S/N ratio was positive. Regarding the use of conventional hearing aids, the average S/N ratio was negative, demonstrating that individuals were able to understand sentences when the noise intensity was louder than the speech signal intensity.

Thus, with the use of conventional hearing aids, individuals performed slightly better, since they were able to understand the sentences when the noise presented was more intense than the speech signal, a situation that describes most environments which patients may come across in the clinical environment. Regarding the speech recognition in noise, previous studies, found results compatible with the data presented in the present study.[18,20-25]

These results, despite showing small benefits with the use of sound amplification, have limitations such as the reduced sample, a fact that may be associated with the prevalence of atresia, which is estimated at 1 in 10,000 births, making it difficult to find subjects affected by the anomaly.[26] However, other studies in this area have also shown a reduced sample[16,26,27].

CONCLUSION

The individuals showed a slight improvement in speech perception in silence with the softband and in situations of frontal and lateral noise with amplification. However, it is not possible to confirm that speech perception in individuals with ear malformation and unilateral hearing loss improved significantly after fitting with both amplifications (conventional hearing aid and softband). Thus, further studies in the area are necessary to find the true relevance of both amplifications studied in individuals with ear malformation and unilateral hearing loss.

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Authors contributions

ILM: analysis and data interpretation, analysis of data, literature revision, article writing; MCF: critical revision of the article and the writing, article submission; MFCGM: conception of the study project, acquirement and interpretation of data.