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Original article

EVALUATION OF SPEECH COMPREHENSION USING A TEST OF SIMPLE QUESTION UNDERSTANDING IN COCHLEAR IMPLANT RECIPIENTS

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Abstract

Objectives: The objective of this study was to evaluate speech performance in individuals of different ages with prelingual hearing impairment who use a cochlear implant and to assess the influence of age on the communicative benefit derived from cochlear implantation (CI).

Materials and methods: A retrospective-prospective study was conducted including 31 individuals with prelingual hearing impairment who underwent CI. The age of participants ranged from 6 to 29 years, with a mean age of 13±6.2 years. Individuals were divided into three age groups and were followed for at least 6, 12 and 24 months. The Glendonald Auditory Screening Procedure (GASP), which assesses the ability to understand simple questions, was used.

Results: The performance on the simple question comprehension test was monitored at follow-up intervals of 6, 12 and 24 months. The most favorable outcomes were observed 24 months after cochlear implantation (CI). At 6 months after the intervention, 50% of participants in the youngest age group were unable to comprehend the meaning of any of the simple questions. After 24 months of intervention, CI users were able to understand up to 8 of the 10 administered questions; this maximum performance was attained by 25% of participants in the youngest age group, and by none of the participants in the oldest age group.

Conclusions: The potential for the development of verbal communication skills and speech comprehension is substantially greater when CI is performed at a younger age.

Keywords: cochlear implant, rehabilitation treatment, speech development

Introduction

Early detection of hearing impairment, as a prerequisite for timely rehabilitation treatment during the so-called critical period of speech and language development, enables optimal social integration of the child. Sensorineural hearing loss, which occurs due to damage to the auditory cells in the inner ear, can be treated medically or surgically only in very rare cases. The lack of a sufficient number of auditory cells prevents the conversion of sound energy into electrical energy, thereby sound cannot reach the central nervous system. In fact, these individuals are functionally deaf[1-8]. Unfortunately, for people with severe sensorineural hearing loss greater than 90 dB, even the most modern conventional hearing amplifiers are ineffective. In such cases, the only solution is offered by the most advanced achievements of microelectronics in medicine, the cochlear implant, which serves as a substitute for the nonfunctional inner ear. The objective of this study was to assess speech performance in individuals of different age groups with prelingual hearing impairment who use cochlear

implants and to determine the influence of chronological age on the communicative results associated with cochlear implantation.

Materials and methods

To achieve the set goal, a retrospective-prospective study was conducted involving 31 individuals with prelingual sensorineural hearing loss. All patients who underwent cochlear implantation at our department between September 2022 and December 2024 were considered for inclusion in the study The individuals included in the study had prelingual sensorineural hearing loss, underwent CI and had a follow-up period ranging from 6 months to 24 months. Exclusion criteria were any medical condition requiring medication or surgical treatment, all combined developmental disabilities (mental retardation, developmental dysphasia, autism, and hyperkinetic syndrome); and refusal to provide consent for participation in the study.

The age of the individuals ranged from 6 to 32 years, with a mean age of 13±6.2 years. The subjects were divided into three age groups: the first group included subjects up to five years of age, the second group included subjects aged from 5.3 to 10 years, and the third group included subjects older than 10 years. The mean age at which cochlear implantation was performed was 100.4±75.1 months. The youngest age at which CI was performed was 10 months and the oldest was 327 months.

The research was conducted at the Institute for Hearing, Speech and Voice Rehabilitation in Skopje and at the University Clinic for Ear, Nose and Throat in Skopje. The subjects were followed for at least 6, 12 and 24 months. Each individual gave their consent to participate in the testing, or their parents in the case of minors. The Etic Committee of the Faculty of Medicine in Skopje approved this investigation.

The program for assessing auditory perception and speech development (Evaluation of Auditory Responses to Speech-test battery-EARS) developed by the Austrian company MED-EL was used during the testing. The Glendonald Auditory Screening Procedure (GASP) included the Simple Question Recognition Test, which assesses the ability to recognize simple questions. The person can answer the question and the response is considered correct if the answer demonstrates appropriate recognition. The sentence is presented only once. The test is performed without lip reading, relying exclusively on listening.

For statistical processing of the data obtained during the research, a database was created using the SPSS for Windows statistical program, version 23.0. The following statistical methods were used: series with numerical variables were presented as measures of central tendency (average) and measures of variability (standard deviation); series with categorical variables were presented as absolute and relative frequences. To determine the correlation, that is, the connection between the age of the respondents with a cochlear implant and the test results, the non-parametric Spearman Rank Order Correlation test was used. Values of $p \leq 0.05$ were considered statistically significant.

Results

The distribution shown in Table 1 indicates that 6 months after the intervention, 50% of subjects in the first age group could not understand the meaning of any simple question, while in the other two age groups, this percentage was even higher, around 80%. In the youngest age group, 37.5% of subjects could understand 3 questions, whereas none in the other two groups could.

Table 1. *Simple Question Test - open set (six months after CI)*

Six months after CI	Up to 5 years	5.3 – 10 years	> 10 years	Total
Correct answers: 0	4(50.00%)	9(81.82%)	8(80.00%)	21
Correct answers: 1	1(12.50%)	2(18.18%)	2(20.00%)	5
Correct answers: 3	3(37.50%)	0(0.00%)	0(0.00%)	3
Total per column	8	11	10	29

After 12 months, in the first age group, 12.5% of subjects could understand 6 questions and the same percentage of subjects could understand 7 questions. In the second age group, 9.1% of subjects could understand 6 questions, while in the third age group, the maximum number of the sentences that 20% of subjects could understand was 5 (Table 2).

Table 2. Simple Question Test - open set (twelve months after CI)

Twelve months after CI	Up to 5 years	5.3 – 10 years	> 10 years	Total
Correct answers: 0	1(12.50%)	4(36.36%)	1(10.00%)	6
Correct answers: 1	0(0.00%)	0(0.00%)	1(10.00%)	1
Correct answers: 2	0(0.00%)	1(9.09%)	4(40.00%)	5
Correct answers: 3	2(25.00%)	3(27.27%)	1(10.00%)	6
Correct answers: 4	3(37.50%)	0(0.00%)	1(10.00%)	4
Correct answers: 5	0(0.00%)	2(18.18%)	2(20.00%)	4
Correct answers: 6	1(12.50%)	1(9.09%)	0(0.00%)	2
Correct answers: 7	1(12.50%)	0(0.00%)	0(0.00%)	1
Total per column	8	11	10	29

After 24 months of intervention, subjects with IC could understand a maximum of 8 of the 10 questions offered, with 25% of subjects in the first age group, 27.3% in the second, while none in the oldest age group achieved this (Table 3).

Table 3. Simple Question Test - open set (twenty-four months after CI)

Twenty-four months after CI	Up to 5 years	5.3 – 10 years	> 10 years	Total
Correct answers: 0	0(0.00%)	1(9.09%)	1(10.00%)	2
Correct answers: 1	2(25.00%)	1(9.09%)	0(0.00%)	3
Correct answers: 2	0(0.00%)	2(18.18%)	0(0.00%)	2
Correct answers: 3	0(0.00%)	1(9.09%)	2(20.00%)	3
Correct answers: 4	1(12.50%)	0(0.00%)	1(10.00%)	2
Correct answers: 5	0(0.00%)	1(9.09%)	1(10.00%)	2
Correct answers: 6	1(12.50%)	2(18.18%)	3(30.00%)	6
Correct answers: 7	2(25.00%)	0(0.00%)	2(20.00%)	4
Correct answers: 8	2(25.00%)	3(27.27%)	0(0.00%)	5
Total per column	8	11	10	29

Subjects who received a cochlear implant at a younger age showed better results on the test to recognize and understand simple questions, which means that they could understand the meaning of a larger number of questions 12 and 24 months after the intervention. These observations are in accordance with the calculated correlations between the age of CI and the number of correct answers. All three calculated correlations (6, 12 and 24 months after CI) were negative, moderate, and statistically significant (Table 4).

Table 4. Correlation-Age of CI / Number of Correct Answers

Age of CI	Spearman rank correlation	P level
6 months after CI	-0.39	<0.05
12 months after CI	-0.4	<0.05
24 months after CI	-0.42	<0.05

Discussion

The level of understanding or comprehension represents the stage at which the association between auditory-verbal input and the underlying cognitive processes is established. At this level, speech stimuli are meaningfully interpreted and an appropriate verbal response can be generated. Mastery of this stage entails the ability to understand and respond to abstract questions.

However, achieving proficiency at the preceding level, that is, understanding specific lexical elements or concepts, does not necessarily imply that individuals with cochlear implants will be able to comprehend entire sentences or utterances containing those elements. Initially, speech stimuli should therefore be presented in simple and brief forms, with a gradual and systematic progression toward more complex linguistic structures.

Numerous studies have been conducted worldwide to determine the importance of age at implantation in speech development. May-Mederake B.[9] conducted two studies in which 28 children implanted before the age of two were examined with respect to speech development, vocabulary, and grammar. The results obtained are consistent with those of our study and indicate that younger the age at implantation is associated with better results. Early auditory stimulation enables faster speech development. Studies conducted by Anderson *et al*.[10] and Baumgartner WD *et al.*[11] obtained similar results, again confirming that speech perception is better at younger ages at implantation. Miyamoto *et al.* examined 29 children, half of whom showed good results on the open-set test after implantation. Ozberger *et al.* showed that postimplantation performance was much better in children implanted before the age of two years compared to those implanted between two and three years of age. Geers *et al.* demonstrated that speech development is considerably better if implantation is performed at the age of three, which is crucial for obtaining information from the environment and developing cognitive and linguistic abilities on which speech development generally depends[12-15].

Auditory and verbal perception in individuals who received a cochlear implant earlier (in this study, before the age of 5) is significantly better than in individuals who received the implant at older ages. The possibilities for oral communication are significantly greater if the child is younger at the time of implantation. In younger individuals, speech development occurs spontaneously, physiologically, with clear articulation, rich vocabulary, and correct grammatical expressions. The results of this study showed that the cochlear implant was also effective in older individuals, but speech development was slower, articulation was unclear, vocabulary was poor and grammar was incorrect. Although these individuals can hear, they inevitably supplement their verbal communication with lip reading and occasional use of gestures.

In conclusion, auditory and verbal perception in individuals who received a cochlear implant earlier (in this study, before the age of 5) is significantly better than in those who received the implant at older ages. In older individuals, speech development is slower, articulation is unclear, vocabulary is poor and grammar is incorrect. The possibilities for oral communication are significantly greater if the child is younger at the time of implantation.

Conflict of interest statement. None declared.

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