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DEVELOPMENT OF HEARING PERCEPTION IN SUBJECTS WITH COCHLEAR IMPLANT

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Abstract

Development of speech is a highly integrative process which has to incorporate harmonic functioning of many aspects such as anatomical, physiological, auditory, mental, emotional and social. Anatomical-physiological bases of hearing have been well studied. Cochlear implant is recommended in subjects who do not have any significant increase of the sound through the individual hearing amplifiers or have small benefit and also in subjects whose impairment is over 90dBto 500, 1000, 2000 and 4000 Hz.

The aim of this study was to estimate the development of hearing perception in subjects with prelingual hearing impairment who used cochlear implant with regards to perception and identification of sounds from external environment.

The results of the Test for development of hearing perception showed progression during the follow-up period at 6, 12 and 24 months. It was concluded that the longer the cochlear implant was used, the better results were achieved.

***Keywords*:** impaired hearing, cochlear implant, hearing perception, speech development

Introduction

The beginning of hearing perception means beginning of individual processing of speech sound stimulation which the organism accepts and processes by its own functional structures [1].

What is the influence of the hearing over our life speaks the fact that speech hearing takes 45% of each individual's time, speaking 30%, reading 16% while writing takes 9% of the time [2]. Many studies have been made to analyze the connection between hearing and the speech [3-6].

The revolutionary change of cochlear implant technology made in 1990 had influence on the clinical approach to cochlear implantation as well. The improvement of implants, particularly of the strategy for speech encoding enabled much bigger range in the choice of candidates for cochlear implantation [7-13]. Development of cochlear implants began with the investigations led by Djourno and Euries. In 1982 the first implant system was used clinically for the first time [14-19].

More than thirty different cochlear implants have been developed in the last fifteen years.
All hearing implants are distinguished by the design of the parts they are made of and the way they are created. The revolutionary change in cochlear implant technology happened in 1990 resulting in new clinical approach to cochlear implantation. Cochlear implantation has become a standard procedure for rehabilitation of subjects with impaired hearing.

The modern technology has enabled reduction in their size. The latest models from the last generation of implants are very small sized compared to the previous ones. Efforts are put on further development and improvement of the design and the site of implantation of electrodes in order to secure as closer contact of electrodes with the inner wall of scala tympani as possible by which the threshold of stimulation is decreased and the dynamic range and selectivity for the appropriate stimulus are increased [20-21].

Materials and methods

The investigation was realized at the Hearing, Speech and Voice Rehabilitation Center in Skopje and at the University Clinic for Ear, Nose and Throat in Skopje. The subjects were monitored in the period of at least 6, 12 and 24 months. The age of the subjects ranged from 6 to 32 years, and the mean age was 13±6.2 years.

The mean age at which cochlear implantation was performed was 100.4±75.1 months. The youngest age at which cochlear implantation was performed was 10 months while the oldest was 327 months.

Test for development ofhearing perception was used inthis study for estimation of recognition and identification ability of environmental sounds. (For the estimation 3-grade scale was used: 0 - never, 1-sometimes, 2 - always). The test was conducted in subjects with cochlear implant before and after placing

the hearing amplifier and after the cochlear implant was inserted in order to see the development of the hearing perception. The following statistical methodologies were used:

- Numerical data were presented with central tendency measures (average/ratio) and variability measures (standard deviation);
- Attributive data were presented with absolute and relative frequency;
- For determining the significance of the differences in the analyzed tests among the subjects before and after the hearing amplifier was placed and after the cochlear implant was inserted as well as in subjects with inserted cochlear implant after 6, 12, 24 months of the implantation, non-parametric tests were used for two or more than two dependent parameters (McNemar'stestand Cochran's Qtest);

The values ofp <0.05 were considered statistically significant.

Results

This study presents the results obtained by statistical analysis of data from 31 subjects with prelingual sensorineural hearing disorder with inserted cochlear implant.

Table 1. This table shows the results of the test for development of hearing perception in three groups of subjects in relation to recognition of environmental sounds. The sound of ambulance or police siren was recognized by all subjects with cochlear implant, by not any subject without hearing amplifier and 25 (80.7%) with hearing amplifier. The sound of plane was recognized by half of the subjects without hearing amplifier, 30 subjects with hearing amplifier and with cochlear implant. The sound of footsteps was not recognized by any of the subjects without or with hearing amplifier, while in 7 subjects with cochlear implant the test was positive. The bird song was not recognized by none of the subjects without or with hearing amplifier while it was recognized by 15 subjects with cochlear implant.

Table 1. Test for development ofhearing perception

Outside	**Without hearing amplifier**	**With hearing amplifier**	**With cochlear implant/detection**	**P**
Siren (ambulance/police)				
No	31(100%)	6(19.3%)	/	
Yes		25(80.7%)	31(100%)	
Airplane				
No	15(48.4%)	1(3.2%)	1(3.2%)	*0,0005
Yes	16(51.6%)	30(96.8%)	30(96.8%)	**0,0005 ***0,48
Automobile horn				
No	26(83.9%)	6(19.3%)	31(100%)	*0,00002
Yes	5(16.1%)	25(80.7%)	/	
Footsteps				
No	31(100%)	31(100%)	24(77.4%)	
Yes	/	/	7(22.6%)	
Bird song				
No	31(100%)	31(100%)	16(51.6%)	
Yes	/	/	15(48.4%)	
Dogs' barking				
No	27(87.1%)	7(23.3%)	31(100%)	*0,00002
Yes	3(9. 7%)	23(76.7%)	/	

*p-testeddifferences among groups without hearing amplifier/with hearing amplifier

**p-testeddifferences among groups without hearing amplifier/with cochlear implant

***p-testeddifferences among groups with hearing amplifier/with cochlear implant

Table 2. This table illustrates the results of the Test for development of hearing perception obtained from the group of subjects without hearing amplifier, with hearing amplifier and with cochlear implant with respect to the ability for identification of environmental sounds.

The subjects with cochlear implant in comparison with the subjects without and with hearing amplifier had significantly better ability for identification of siren sound, automobile horn, footsteps, bird song and dogs' barking.

The difference in the ability for identification of sound of airplane among subjects with hearing amplifier and with cochlear implant was statistically not significant.

Table 2. Test for development ofhearing perception

Outside	**Without hearing amplifier**	**With hearing amplifier**	**With cochlear implant/identification**	**P**
Siren (ambulance/police)				
No	31(100%)	6(19.3%)	31(100%)	
Yes		25(80.7%)		
Airplane				
No	15(48.4%)	1(3.2%)	4(12.9%)	
Yes	16(51.6%)	30(96.8%)	27(87.1%)	**0,0098***0,37
Automobile horn				
No	26(83.9%)	6(19.3%)	31(100%)	
Yes	5(16.1%)	25(80.7%)	/	
Footsteps				
No	31(100%)	31(100%)	12(38.7)	
Yes	/	/	19(61.3%)	
Bird song				
No	31(100%)	31(100%)	13(41.9%)	
Yes	/	/	18(58.1%)	
Dogs' barking				
No	27(87.1%)	7(23.3%)	31(100%)	
Yes	3(9.7%)	23(76.7%)	/	

**p-tested differences among groups without hearing amplifier/with cochlear implant

***p-testeddifferences among groups with hearing amplifier/with cochlear implant

The results obtained from the Test for the development of hearing perception regarding recognition of human sounds demonstrated that none of the subjects without or with hearing amplifier recognized speaking and yawning while the cochlear implant enabled detection of the speaking sound in 17 subjects and yawning sound in one subject.

A statistically significant difference was registered among the three groups of subjects both in recognition of coughing and smiling sound (Table 3).

Table 3. Test for the development of hearing perception

Human sounds	**Without hearing amplifier**	**With hearing amplifier**	**With cochlear implant/detection**	**P**
Speaking				
No	31(100%)	31(100%)	14(45.2%)	
Yes	/	/	17(54.8%)	
Yawning				
No	31(100%)	31(100%)	30(96.8%)	
Yes	/	/	1(3.2%)	
Coughing				
No	29(93.5%)	12(38.7%)	1(3.2%)	*0,00024
Yes	2(6.5%)	19(61.3%)	30(96.8%)	**0,00000 ***0,0026
Laughing				
No	31(100%)	29(93.5%)	5(16.1%)	***0,00000
Yes	/	2(6.5%)	26(83.9%)	

*p-testeddifferences among groups without hearing amplifier/with hearing amplifier
**p-testeddifferences among groups without hearing amplifier/with cochlear implant
***p-testeddifferences among groups with hearing amplifier/with cochlear implant.

The subjects with cochlear implant identified speaking, yawning and smiling significantly better than those without and with hearing amplifier while the difference was not significant in subjects with hearing amplifier for identification of coughing sound (Table 4).

Table 4. Test for the development of hearing perception

Human sounds	**Without hearingamplifier**	**With hearing amplifier**	**With cochlear implant/identification**	**P**
Talking/speaking				
No	31(100%)	31(100%)	9(29%))	
Yes	/	/	22(71%)	
Yawning				
No	31(100%)	31(100%)	26(83.9%)	
Yes	/	/	5(16.1%)	
Coughing				
No	29(93.5%)	12(38.7%)	5(16.1%)	**0,00000 ***0,096
Yes	2(6.5%)	19(61.3%)	26(83.9%)	
Laughing				
No	31(100%)	29(93.5%)	8(25.8%)	***0,00003
Yes	/	2(6.5%)	23(74.2%)	

*p-testeddifferences among groups without hearing amplifier/with hearing amplifier
**p-testeddifferences among groups without hearing amplifier/with cochlear implant
***p-testeddifferences among groups with hearing amplifier/with cochlear implant.

Discussion

Over the last 30 years more than 200,000 people worldwide have been implanted with cochlear implant [22].

Early diagnosis of the hearing impairment is the most significant step in undertaking successful rehabilitation in people with impaired hearing along with decreasing the age at which the cochlear implantation has been made [23].

The evaluation of hearing and speech perception in all subjects in this study was conducted in three phases: without hearing amplifier, with hearing amplifier and with cochlear implant. The Test for the development of hearing perception was made and different sounds were used, such as sounds from musical instruments, environmental sounds, home sounds, sounds of certain objects and differentiation of human sounds.

The results obtained have shown that after cochlear implantation subjects presented a significantly better reaction to all environmental sounds (80.7%) in comparison with the period when subjects did not wear the hearing amplifier (6.5%), but the difference was significant regarding the ability that they had when using the hearing amplifier (54.8%).

Our results are in agreement with those presented in another study [24] where hearing and speech development after cochlear implantation a series of cases was presented.

In our study, none of the subjects without hearing amplifier reacted to the music at home, while 1 subject with hearing amplifier and 12 (38.7%) with cochlear implant identified the music sounds. Ringing of the phone was differentiated by 3 (9.7%) of the subjects with hearing amplifier, a significantly larger number of subjects with hearing amplifier – 32.3% and a highly significantly larger number of subjects with cochlear implant – 77.4%.

In 2007, Lassaletta L. *et al*. [25] conducted a study, which confirmed that even 52% of 65 subjects with cochlear implants expressed pleasant feelings while listening music. Regarding the perception of mobile and fixed telephones, the studies have shown important and beneficial outcome after cochlear implantation, which is consistent with our results [26]. One such study of international character conducted in 10 countries and including 196 subjects has demonstrated that 71% of patients postoperatively could use fixed telephones and 54% mobile telephones [27]. Similar results have been presented in other studies of this type.

Results have shown that cochlear implants improve the ability of speech production to the degree that is not possible to be achieved with the conventional hearing amplifiers. This is to be expected since the hearing device emphasizes the sound stimuli in the low frequency area alone, which is not sufficient for creating an acoustic picture of all sounds and voices and consequently the possibility to develop verbal communication is very small [28].

The benefit of the cochlear implant in comparison with the conventional hearing aids has been confirmed in another study realized in 2001 by Szuchik J. *et al.* [29].

In 1995 [30], a very important multicenter study was conducted in children with cochlear implant by using the test for development of auditory perception.

The study was realized in 35 clinics during the period from 1996 to 2009. A total of 765 children were assessed in different intervals: preoperatively, after the first fitting at 1, 3, 6 and 12 months and annually thereafter, up to a maximum period of 5 years.

The results showed a significant improvement of auditory perceptual skills to all sounds. Significantly better results were obtained after 3, 6 and 12 months. These findings are in concordance with the results obtained in our study.

Conclusion

There was a hearing reaction immediately after activating the implant in all subjects. The results from the first test for development of hearing perception showed progression during the examined period at 6, 12 and 24 months.

The results obtained in relation to recognition and identification of certain words with different complexity showed progress as time went on. The longer the cochlear implant was used, the better results were achieved.

Cochlear implant in prelingual hearing disorder enables enormous increase of hearing threshold and rehabilitation of hearing-speaking treatment leads to development of acoustic picture for all voices.

The hearing and verbal perception in subjects with prelingual hearing impairment was statistically significantly better in comparison to the results obtained in the same subjects when they used hearing amplifiers.

The hearing and verbal perception in subjects with prelingual hearing impairment with cochlear implant improved with the duration of the rehabilitation treatment and it was in proportion with the duration of postoperative rehabilitation, that is, the longer cochlear implant was used, the better results were achieved.

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