Public health

THE ROLE OF AGE ON SPEECH DEVELOPMENT IN SUBJECTS WITH COCHLEAR IMPLANTS

Vesna Lazarovska[1], Mira Jovanovska[1]

[1] *Hearing, Speech and Voice Rehabilitation Center, Skopje, Republic of North Macedonia*

Citation: Lazarovska V, Jovanovska M. The role of age on speech development in subjects with cochlear implants. Arch Pub Health 2021; 13 (2).

doi.org/10.3889/aph.2021.6001

Key words: hearing impairment, cochlear implant, rehabilitation treatment, speech development

***Correspondence:** Vesna Lazarovska, Hearing, Speech and Voice Rehabilitation Center, Skopje. E-mail: vesnalazarovska@gmail.com

Received: 9-Mar-2021; **Revised:** 29-May-2021; **Accepted:** 5-Jun-2021; **Published:** 30-Jun-2021

Competing Interests: The author have declared that no competing interests

Abstract

The cochlear implant has been approved as a method of treating bilateral deep deafness since the 1980s, and since then candidate selection methods have changed several times. Initially, the candidates were only adult patients, and in 1990 the cochlear implant was approved for the first time in children under 2 years of age by the US Food and Drug Administration. In 2000, the same US Administration reduced the limit to one year. The aim of this study was to determine the effect of age at cochlear implantation on speech recognition abilities. Concerning the age groups in which the subjects were assigned to, the best results on the tests were achieved by the group who underwent cochlear implantation at the youngest age. In conclusion, the benefit from cochlear implant in subjects with pre-lingual hearing impairment of the most severe degree has to be stressed and it is much bigger in comparison to individual amplifying hearing aids. If cochlear implant is placed at the youngest age, the results might lead to even 100% of active involvement in the social life of individuals with this kind of impairment.

Јавно здравје

УЛОГАТА НА ВОЗРАСТА ВРЗ РАЗВОЈОТ НА ГОВОРОТ КАЈ СУБЈЕКТИ СО КОХЛЕАРНИ ИМПЛАНТИ

Весна Лазаровска[1], Мира Јовановска[1]

[1] *Завод за рехабилитација на слух, говор и глас, Скопје, Република Северна Македонија*

Цитирање: Лазаровска В, Јовановска М. Улогата на возраста врз развојот на говорот кај субјекти со кохлеарни импланти. Арх Ј Здравје 2021;13(2)

doi.org/10.3889/aph.2021.6001

Клучни зборови: оштетен слух, кохлеарен имплант, рехабилитациски третман, развој на говор

***Кореспонденција:** Весна Лазаровска, Завод за рехабилитација на слух, говор и глас – Скопје, Република Северна Македонија. E-mail: vesnalazarovska@gmail.com

Примено: 9-мар-2021; **Ревидирано:** 29-мај-2021; **Прифатено:** 5-јун-2021; **Објавено:** 30-јун-2021

Конкурентски интереси: Авторот изјавува дека нема конкурентски интереси.

Извадок

Кохлеарниот имплант е одобрен како метод за лекување на билатералната длабока глувост уште од осумдесеттите години, а оттогаш методите на селекција на кандидатите се менувале повеќе пати. Најпрво кандидати биле само возрасни пациенти, а во 1990 година за прв пат се одобрил кохлеарниот имплант и кај деца со најмалку наполнети 2 години живот, од страна на Американската администрација за храна и лекови. Во 2000 година истата Американска администрација го намалила лимитот на една година. Целта на ова истражување беше да се утврди влијанието на возраста при вградувањето на кохлеарниот имплант врз успешноста на говорниот развој. Во однос на возрасната група според која испитаниците беа поделени, најдобри резултати покажа групата кај која имплантацијата беше направена на најмала возраст. Во заклучокот сакаме да потенцираме дека бенефитот од кохлеарниот имплант кај лицата со прелингвално слушно оштетување со најтежок степен е многу поголем во однос на индивидуалните слушни амплификатори. Кога кохлеарниот имплант ќе се вгради во најрана возраст резултатите можат да доведат дури и до 100% активно вклучување на лицето во социјалната средина.

Introduction

Early detection of hearing impairment as a prerequisite for timely speech and language treatment in the so-called critical period of speech and language development enables optimal integration of a child in the society. Subjects with severe sensorineural hearing loss greater than 90 dB cannot benefit from the most contemporary conventional hearing aids. In such cases, the unique help is offered by the most modern achievement of microelectronics in the medicine – the cochlear implant, which replaces the function of the inner ear.

The revolutionary changes in the technology of cochlear implant happened in 1990 and consequently it resulted in clinical approach to cochlear implantation. The improvement of implants, especially in the strategy of speech encoding has offered a larger spectrum in the selection of candidates for cochlear implantation[1,6]. Hearing and speech perception in different subjects has shown different results. No matter what the performances and specifics of the implants are, some subjects show more rapid improvement in the skills and some do not.

Research results about speech perception in early implanted children[7,8] showed that speech perception abilities developed significantly rapidly owing to the structure of the central nervous system. The fact that children learn the language spontaneously in the early development, without any didactic instructions, has to be taken into consideration. Moreover, the advanced technical performances of speech processors enable easier and faster rehabilitation[9].

The aim of this study was to determine the influence of age at which subjects received a cochlear implant on the successfulness of speech development.

Material and methods

The study comprised 31 subjects based on the following inclusion criteria:

- Children with auditory status that met the criteria forcochlear implantation by a specialist in otorhinolaryngology – audiology;
- Children with a limited benefit from binaural adequate hearing aids who were undergoing a rehabilitation process for development of hearing and speech perception;
- Children in general health condition and intellectual status determined by a pediatrician – neurologist;
- Opinion of a speech and language therapist regarding the hearing amplifier and the degree of development of hearing and speech perception;
- Parent's readiness and their real expectations;
- Motivation and collaboration of the family.

Each subject or his/her parents gave a consent for participation in the testing.

Test for recognition of monosyllabic words (open-set) was used as a method of the investigation. This method helps in the estimation of the ability of an individual to identify monosyllabic words. There are no adequate pictures for each word. Each word is said only once and the individual is required to repeat the word. The test is performed with no help of lip reading.Subjects are scored taking into account the number of phonemes or words repeated correctly.The evaluation of the results in our study was made at 6, 12 and 24 months.

For the statistical analysis of data, the following statistical methodologies were used: To determine the significance of differences among subjects

prior to and after placement of cochlear amplifier and after cochlear implantation, as well as among subjects with cochlear implant at 6, 12, 24 months following implantation non-parametric tests for two or several dependent variables (McNemar's test and Cochran's Q test) were used.

Non-parametric Spearman Rank Order Correlations was used for determination of the correlation, i.e., association between age of the implanted subjects with cochlear implant and the scores obtained at the test. Differences for p value <0.05 were considered statistically significant.

Results

This study included 31 subjects with the age ranging from 6 to 32 years; the mean age being 13±6.2 years.

The mean age at cochlear implantation was 100.4±75.1 months. The youngest age at implantation was 10 months and the oldest 324 months.

Table 1. Age of subjects (months)/ Age (in months) at cochlear implantation

Parameter	N	mean	SD	Std.Error	Min.	Max.
Age	31	13.0	6.2	1.1	6	32
Age at implantation	31	100.4	75.1	13.1	10	327

The study was conducted by using the Test for recognition of monosyllabic words (open set – understood).

Table 2 illustrates the results obtained from the Test for recognition of monosyllabic words depending on the age of the subjects at cochlear implantation and 6 months after intervention.

The results showed that only 1 child from the youngest age group could not understand any word; there were 2 such subjects in the second age group and 4 in the third age group. The maximum number of understood words (4) in this study period was registered in 1 subject from the first and 1 subject from the second age group, and in none from the third age group.

Table 2. Test for recognition of monosyllabic words (open-set) 6 months after intervention

6 months		Up to 5 years	5.3 - 10 years	> 10 years	Total
No.	0	1	2	4	7
%		11.11%	16.67%	40.00%	
No.	1	1	1	0	2
%		11.11%	8.33%	0.00%	
No.	2	1	5	4	10
%		11.11%	41.67%	40.00%	
No.	3	5	3	2	10
%		55.56%	25.00%	20.00%	
No.	4	1	1	0	2
%		11.11%	8.33%	0.00%	
Total		9	12	10	31

Twelve months after the realized intervention there were no subjects from the youngest age group who could not understand any word; there was 1 subject in the second, and 3 in the third age group.

The maximum number of understood words was 6 and was registered in 1 subject from the first and 1 from the third age group, and in 2 subjects from the second age group (Table 3).

Table 3. Test for recognition of monosyllabic words (open-set) 12 months after intervention

Table 3. Test for recognition of monosyllabic words (open-set) 12 months after intervention

12 months		Up to 5 years	5.3 - 10 years	> 10 years	Total
No.	0	0	1	3	4
%		0.00%	8.33%	30.00%	
No.	2	3	0	0	3
%		33.33%	0.00%	0.00%	
No.	3	0	5	1	6
%		0.00%	41.67%	10.00%	
No.	4	4	1	3	8
%		44.44%	8.33%	30.00%	
No.	5	1	3	2	6
%		11.11%	25.00%	20.00%	
No.	6	1	2	1	4
%		11.11%	16.67%	10.00%	
Total		9	12	10	31

The number of words from the Test for recognition of monosyllabic words that the subjects from all three age groups could understand 24 months after intervention was from 2 to 8. In the group of children with the intervention accomplishedat 5 years of age, 1 (11.1%) child could understand the meaning of 8 monosyllabic words, 3 (25%) children who underwent implantation at the age between 5.3 and 10 years, whereas there were no subjects in the third age group who could understand 8 of the offered 10 monosyllabic words (Table 3).

Table 4. Test for recognition of monosyllabic words (open-set) 24 months after intervention

24 months		Up to 5 years	5.3 - 10 years	> 10 years	Total
No.	0	0	1	2	3
%		0.00%	8.33%	22.22%	
No.	2	0	1	0	1
%		0.00%	8.33%	0.00%	
No.	3	2	0	0	2
%		22.22%	0.00%	0.00%	

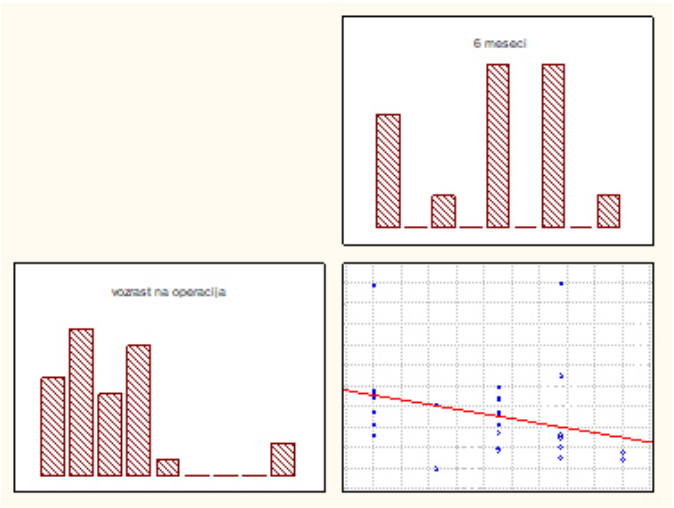
No.	4	0	2	2	4
%		0.00%	16.67%	22.22%	
No.	5	2	1	0	3
%		22.22%	8.33%	0.00%	
No.	6	2	2	1	5
%		22.22%	16.67%	11.11%	
No.	7	2	2	4	8
%		22.22%	16.67%	44.44%	
No.	8	1	3	0	4
%		11.11%	25.00%	0.00%	
Total		9	12	9	30

There was a negative correlation between the age at cochlear implantation and the number of understood monosyllabic words. It meant that a larger number of monosyllabic words could be understood by children in whom the cochlear implantation was finished at the youngest age, and vice versa. The values of the calculated Spearman's coefficient of -0.46 after 6 months, -0.24 after 12 months, and -0.4 after 24 months were statistically significant (Table 4).

Table 4. Correlation – age at surgery/number of understood monosyllabic words

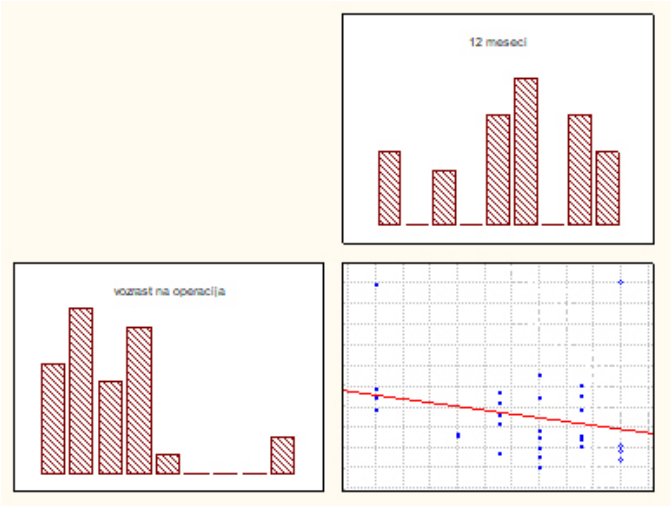
Age at surgery/ Number of understood monosyllabic words	Spearman Rank Order Correlations		
	R	p-level	Sig.N.Sig.
After 6 months	-0.46	p<0.05	Sig.
After 12 months	-0.34	p<0.05	Sig.
After 24 months	-0.4	p<0.05	Sig.

Figure 1. Correlation - age at surgery/number of understood monosyllabic words



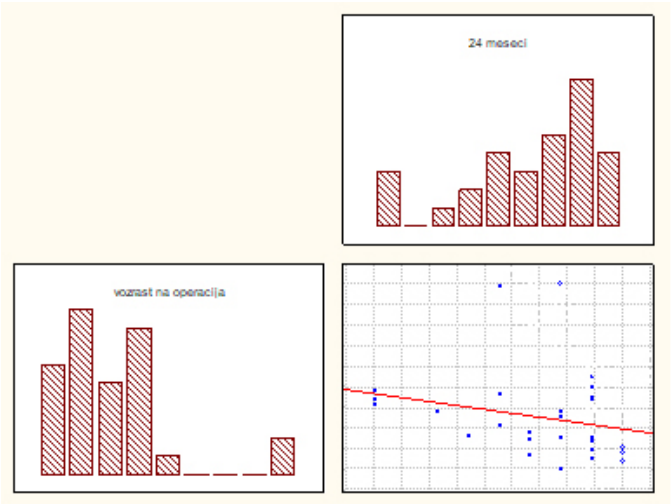
Spearman Rank Order Correlations=-0.46;p<0.05

Figure 2. Correlation - age at surgery/number of understood monosyllabic words



Spearman Rank Order Correlations=-0.3; p<0.05

Figure 3. Correlation - age at surgery/number of understood monosyllabic words



Spearman Rank Order Correlations=-0.4p; <0.05

Discussion

Numerous studies have been conducted worldwide in order to determine the importance of age at cochlear implantation on speech development. May-Mederake B.[10,11] completed two studies including 28 children implanted prior to 2 years of age, who were examined regarding the development of speech, vocabulary and grammar skills. Her findings are consistent with ours and have pointed out to the fact that implantation at a younger age yields better results. Early auditory stimulation enables faster speech and language development.

In the study conducted by Anderson *et al.*[12] and Baumgartner WD.*et al.*[13] similar results were also obtained, confirming that a higher level of speech perception performance can be achieved at earlier ages of implantation.

Allum JH[14]in his study divided the subjects into three age groups: up to 7 years of age, 7-year-olds and older than 7 years. He made the measurement immediately after the implant

activationat 1, 3 and 6 months, and then every 6 months until 24 months following implantation. All children presented with faster rates of progress and higher scores after 6-12 months. Children aged 7 and over showed better results at preoperative tests because of the experience with the hearing amplifiers. After implantation, they had poorer results than the children under 7 years of age. There are many other studies that have examined the importance of age when implantation was made[15].

In the period between 1994 and 2004 different results have been published regarding the discrimination of speech in children with cochlear implant.

Myamotoet *al.* examined 29 children, of whom one half showed good results with the open-set test after implantation.

Ozbergeret *al.* demonstrated that post-implantation performances were much better in children who were implanted before the age of two compared to children who were implanted at the age between two and three years. Geers *et al.* showed that speech perception performance was much better if implantation was realized by the age of three years, which is crucial for obtaining information from the environment as well as for developing the cognitive and linguistic skills including speech development[16,17].

The variability in speech perception performance among different individuals depends on many factors including age at implantation, way of communication, support from the family, and deafness duration. Myamotoet *al.* consider that 35% of these factors are the reason for the difference in the degree of speech perception.

Conclusion

The results presented in the literature as well as the results obtained in our study have shown that age is one the most important factors for normal and proper speech development. The younger the age, the better results are achieved. Our findings have revealed that cochlear implant is efficient even in older children, but then the development of speech perception is slower; there is unclear articulation, poor vocabulary and irregular grammar usage. Although these children listen, they supplement their verbal communication with lip reading and occasional use of gestures.

References

1. Wilson BS, Finley CC, Lawson DT. Wolford RD. Eddington DK. Rabinowitz WM. Better speech recognition with cochlear implants. Nature 1991; 352:236-238.
2. Skinner MW, Clark GM, Whitfort. Evaluation of new spectral peak coding strategy for the nucleus 22 Channel cochlear implant system. Am J Otol 1994; 15-27.
3. Wilson SJ, Rebscher SH, Kim SJ. Design for a simplified cochlear implant system. IEEE Trans Biomed Eng 2007; 54:973–982.
4. Zeng FG. Trends in cochlear implants. Trends Amplif 2004; 8:1–34.
5. Balkany T. Nucleus freedom north american clinical trial. Otolaryngol Head Neck Surg 2007; 136: 757–762.
6. Koch DB, Osberger MJ, Segel P, Kessler D. HiResolution and conventional sound processing in the HiResolution bionic ear: Using appropriate outcome measures to assess speech recognition ability. Au-

diol Neurootol 2004; 9: 214–223.

7. Robbins A, Kirk KI. Speech perception assessment and performance in pediatric Cochlear implant users. Sem Hear 1996;17:353-369.
8. Eddington DK. Speech recognition in deaf subjects with multichannel intracochlear electrodes. Ann NY Acad Sci 1983;405:241-258.
9. Schneir W, Shiggrin RM. Controled and automatic human information processing: Detection, search, and attention. Psycholog Rev 1977;84:1-66.
10. May-Mederake. Early intervention and assessment of speech and language development in young-children with cochlear implants. IJPORL 2012;76(7): 939-46.
11. May-Mederake B. Determining early speech development in children with cochlear implants usingthe ELFRA-2 parental questionnaire. IJPORL 2012; 76(6): 797-801.
12. Baumgarter WD, Pok SM, Egelierler B, Franz P, Gstotter W, Hamzavi J The role of age in pediatric cochlear implantation. Int J Pedatr Otorhinolaryngol 2002; 62:223-28.
13. Allum JH, Greiinger R, Straubhaar S, Carpenter MG. Auditory perception and speech identification in children with cochlear implants tested with the EARS protocol. Br J Audiol 2000; 34.
14. Robbins AM, Koch DB, Osberger MJ, Zimmerman-Phillips S, Kishon-Rabin L. Effect of age at cochlear implantation on auditory skill development in infants and toddlers. Arch Otolaryngol Head Neck Surg 2004;130, 570-574.
15. Miyamoto RT, Kirk KI, Robbins AM, Todd S, Riley A, Pisoni DB. Speech perception and speech intelligibility in children with multichannel cochlear implants. In: Honjo I, Takahashi H, editors. Cochlear Implant and Related Sciences Update. Advances in Otorhinolaryngology. Basel: Karger; 1997. pp. 198–203.
16. Miyamoto RT, Svirsky MA, Robbins AM. Enhancement of expressive language in prelingually deaf children with cochlear implants. Acta Otolaryngol 997;117:154–157.
17. Osberger MJ, Todd SL, Berry SW, Robbins AM, Miyamoto RT. Effect of age of onset of deafness on children's speech perception abilities with a cochlear implant. Ann Otol Rhinol Laryngol 1991;100:883–888.