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Original Article

Comparing Speech Intelligibility in 3 to 5 Years Old Children with Cochlear Implants and Normal Children

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ABSTRACT

Background and Objective: One of the positive outcomes of cochlear implantation is achieving intelligible speech. Therefore, the measurement of speech intelligibility is a standard criterion for assessing the effectiveness of cochlear implants (CIs). The goal of this study was to compare speech intelligibility in 3 to 5 cochlear-implanted children with their age-matched normal children at three levels of correctness of consonants, vowels and words.

Methods: In this cross-sectional study, 40 children (20 children with cochlear implant, and 20 normal children– matched for age as a control group) were recruited. Speech intelligibility was assessed at three levels of correctness of consonants, vowels and words using the Persian speech intelligibility test.

Results: Findings showed significant difference between speech intelligibility in children with CIs and normal children in levels of consonant, vowel and word correctness (P=0.000)

Conclusion: Speech intelligibility at three levels of correctness of consonants, vowels and words in 3 to 5 year old children with CIs were lower than normal children.

Keywords: Speech intelligibility, Cochlear implant, Consonant, Vowel, Word

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Introduction

Speech intelligibility is an appropriate measurement of understandability of verbal message of speaker. speech intelligibility is a relative measure of the degree to which a speaker's speech signal is understood, the relativity depending at a minimum on the identities of speaker and listener, what is spoken and where it is spoken (Weismer, 2008). Various factors can affect speech intelligibility. Some of these factors are level of establishing communication (single word or continuous speech), familiarity of the listener with pattern speech of speaker, communication cues for the listener

(familiar text or unfamiliar text) and the listener's skill. Therefore in assessing speech intelligibility we should use a quantitative method (Kent et al., 1993; McGarr et al., 1983). Hearing loss is one of the disorders that affects speech intelligibility in children with some problems in perceiving speech sounds even if using hearing aid (Chin et al., 2012; Cosetti, 2012). Children with hearing loss may not be able to distinguish different phonemes from each other, and speech production may be disordered due to deprivation of receiving correct auditory stimulator and having problem in stimulus feedback (Hadgins et al., 1942; Angelocci et al., 1964). Correct production of consonants is one of the most important factors that affect speech intelligibility in children with hearing loss (Smith, 1975). Vowels form a significant percentage of speech and are involved in speech intelligibility, having segmental and supra-segmental features. Percentage of correct vowels is very important in determining the speech intelligibility (Monsen and Shaughnessy, 1978).

In speech of children with hearing loss various errors can be seen. Such a disability in articulation of vowels and consonants can affect speech intelligibility (Cowie and Douglas, 1992). Calculating percentage of correct consonants is a potential index of speech intelligibility (Shriberg et al., 1982).

In recent years, neonatal screening for hearing and improvement in cochlear implantation have created hope for children with hearing loss (Chin et al., 2003). Children with cochlear implantation achieve access to speech signals in children with severe to profound sensorineural hearing impairment that using of hearing aids has not helped (Nikolopoulos et al., 1999).

One of the consequences of cochlear implantation is achieving intelligible speech. Therefore the measurement of speech intelligibility is a standard criterion for assessing the effectiveness of cochlear implantation (Osberger et al., 2000).

Kirk and Hill -Brown showed that after one year, cochlear-implanted children in their study, made significant progress in articulation of vowels and consonants (Kirk and Hill-Brown, 1985). Flipsen showed that the correctness of segmental features is one of the most effective factors in speech intelligibility of children with CIs (Flipsen, 2008). In the last studies in Iran, speech intelligibility was more measured at the levels of sentences and connected speech (Darouei, 2014; Poursoroush et al., 2015). The goal of this study was to compare speech intelligibility of children with CIs and normal-hearing children at the levels of correct vowels, consonants and words by using Persian speech intelligibility test (Heydari et al., 2011). By this evaluation, different indices of speech intelligibility in speech of children with and without CIs can be examined, and compared with normal hearing children.

Materials and Methods

Participants

Forty monolingual Persian-speaking children aged 3-5 years old participated in this study. They had no history of neurological problems, seizures, physical damage or any other disorders. The children were divided into two groups. The first group included 20 children with CIs with the age ranging from 36 to 62 months (mean age=53 months, standard deviation=7.95). The second group consisted of 20 normal-hearing children who were age-matched with cochlear-implanted children (mean age= 53 months, standard deviation= 8.17).

Children with CIs randomly selected from Baqiyatallah hospital, and normal-hearing children recruited from kindergartens managed under the supervision of the Welfare Organization in Tehran, Iran. All children were monolingual Persian speakers. Children with CIs at least reached two-word sentences level and number of their expression vocabulary were at least 100 words. All of these children had congenital sensorineural hearing loss before cochlear implant surgery and the post implantation period were at least one year at the time of testing. All normal hearing children were in the normal range according to the ASQ questionnaire which was completed by their parents. These children had no motor and structural abnormalities in oral-motor development, based on the clinical assessment. The normal hearing children had no hearing problems according to parental report and medical records.

Table 1. The mean and SD of chronological age and age of Implantation

Groups	Chronological age (month)		Age of Implantation (month)	
	Mean	Standard Deviation	Mean	Standard Deviation
Cochlear implanted children	53	7.9	29.2	8.01
Normal children	53	8.1	---------	----------

Table 2. Differences in levels of speech intelligibility in two groups

Measures	Group	Mean	StandardDeviation	P-value
PCW	Children with CIs	57.75	16.73	0.000
	Normal children	96.1	3.41	
PCV	Children with CIs	65.75	17.23	0.000
	Normal children	97.89	2.23	
PCC	Children with CIs	59.30	17.31	0.000
	Normal children	96.55	2.39	

Data Collection

The test was conducted individually for each child in a quiet room. After communication with children, they were asked to name the pictures. Every single picture of speech intelligibility test WERE SHOWNwith intervals of 3 seconds. The children's speech production were recorded by digital voice recorder (Kingstone DVD-902) that was placed at a distance approximately 40 cm from the speaker. The collected data was stored on CD, and used for listening.

Speech Stimuli

Test of speech intelligibility measurement: This test has 47 images made by Heydari, et al. and was designed for Persian children aged 3 to 5 years old. There are all phonemes in this test. The total number of consonants in all position of words is 154, and total number of vowels is 96. Content validity index of selected words in this test was obtained 75% which is good (Heydari et al., 2011).

Listeners

Twenty normal-hearing listeners (20-30 y, mean=25y) participated in this study. All participants were native speakers of Persian language. The listeners were divided into two groups. The first group included 10 people at least with diploma education, who received training for writing down the words. This group did not have any experience with cochlear-implanted children. The second group included 10 speech therapists at least with bachelor degree, who were familiar with transcription. They were given 4 audio samples randomly. Therefore, only one listener listened to the voices of each of the children. We counted the total number of correct words written down by inexperienced listeners, and then we calculated percent of correct words (PCW) by the following formula:

$$\frac{\text{Total number of correct words}}{\text{Total number of words x 100}} = \text{PCW}$$

In order to calculate percent of correct vowels (PCV) and percent of correct consonants (PCC) we counted total number of correct vowels and consonants, which transcribed by speech therapists and then we calculated PCV, PCC by the following formulas:

$$\frac{\text{Total number of correct words}}{\text{Total number of words x 100}} = \text{PCW}$$

$$\frac{\text{Total number of correct vowels}}{\text{Total number of vowels x 100}} = \text{PCV}$$

Reliability

All records were transcribed and all measures were calculated for two times. To examine inter-rater reliability, 30% of language samples (12 children) were randomly selected and re-transcribed by a second transcriber (one unfamiliar and one speech therapist). The point-to-point agreement indicated 92% for PCV, PCC and PCW.

Analysis

Statistical analysis was conducted using SPSS 24 SPSS Inc., Chicago, Illinois, USA). The mean and standard deviation for age, PCV, PCC, PCW were calculated for every participant. A Kolmogorov-Smirnov test at P>0.05 was conducted, which indicated that the data were non-normally distributed. Mann-Whitney U test was used to detect mean differences in the PCV, PCC and PCW in children with CIs and normal children.

Results

In this study two groups of Persian-speaking children participated. Table 1 shows descriptive statistics including mean and SD of chronological age and age at the cochlear implantation.

Table 2 shows the comparison analyses using Mann-Whitney U test. The results showed significant difference for PCV, PCC and PCW between children with CIs and normal children (P=0.000). In children with CIs the mean PCV, PCC and PCW were 65.75, 59.30, and 57.75 respectively. In normal children the mean PCV, PCC and PCW were 97.89, 96.55, and 96.10 respectively.

Discussion

The goal of this study was to compare intelligibility in levels of PCV, PCC and PCW between children with CIs and normal children. Our study showed that percentage of correct vowels, consonants, and words were significantly lower than percentage of normal hearing children. The finding demonstrates that learning of speech production is difficult for children with CIs, and therefore, their speech intelligibility would be in lower level than normal children. These differences can arise from the fact that children with CIs in comparison with normal children have less auditory experiences. Children with CIs didn't receive any auditory input in sensitive period of learning language (Reidy et al., 2017).

This study supports previous studies in this area. For example Huang compared speech intelligibility in children with CIs and normal children and found that speech intelligibility in levels of consonant, vowel and tone are significantly different from normal children (Huang et al., 2005). Ertmer compared intelligibility in three levels of consonant, vowel and word correct by using single word test. He reported that correctness of consonants, vowels and words in normal children is more than the correctness in children with CIs (Ertmer et al., 2011).

Spencer and Olsen showed that children with CIs was delayed in phonetic representation and speech processing skill. They concluded that these skills can affect phonetic accuracy and speech intelligibility (spencer and Olsen, 2008).

Warner et al. reported that accuracy of vowels and consonants in children with CIs were less than the accuracy in normal children (Warner et al., 2010). Chin concluded that children with CIs in comparison with normal children could not reach to the high level of intelligibility in 4 years old (Chin et al., 2003). These findings are very similar to the result of Tye-Murray, who concluded that after 3 years of implantation children still have problems in correctness of consonants, vowels and words (Tye-Murray et al., 1995).

This study also showed that after one to three years of implantation, children are not able to bring production ability and speech intelligibility closer to the normal children.

Conclusion

The findings of this study lead us to conclude that speech intelligibility in levels of consonant, vowel and word correct are lower in 3 to 5 years old children with CIs compared to normal children. Further study is needed to find out whether continuing CI experience can lead children to reach the high level of intelligibility like normal- aged peers.

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Conflict of Interest Statement

Authors declared no conflict of interest.

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مقالهٔ پژوهشی

مقایسهٔ وضوح گفتار در کودکان ۳ تا ۵ ساله برخوردار از کاشت حلزون و کودکان طبیعی

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چکیده

زمینه و هدف: یکی ازمنافع - کاشت حلزون رسیدن به گفتار واضح است. از این رو اندازه گیری وضوح گفتار یک معیار استاندارد برای ارزیابی میزان اثربخشی کاشت حلزون محسوب می‌شود. هدف از مطالعهٔ حاضر مقایسهٔ وضوح گفتار در کودکان ۳ تا ۵ ساله برخوردار از کاشت حلزون با کودکان طبیعی همسان از نظر سن، در سه سطح درستی همخوان، واکه و کلمه است.

روش کار: در این مطالعه مقطعی، ۴۰ کودک (۲۰ کودک برخوردار از کاشت حلزون و ۲۰ کودک طبیعی که از نظر سن همسان شده بودند به عنوان گروه کنترل) انتخاب شدند. وضوح گفتار در سه سطح درستی همخوان، واکه و کلمه با استفاده از آزمون وضوح گفتار فارسی ارزیابی شد.

یافته‌ها: یافته‌ها نشان داد بین وضوح گفتار کودکان برخوردار از کاشت حلزون و کودکان طبیعی در سه سطح درستی همخوان، واکه و کلمه اختلاف معنی‌دار وجود دارد.(P=0/000)

نتیجه‌گیری: وضوح گفتار در کودکان برخوردار از کاشت حلزون در سه سطح درستی همخوان، واکه و کلمه بسیار کمتر از کودکان طبیعی است.

واژه‌های کلیدی: وضوح گفتار، کاشت حلزون، همخوان، واکه، کلمه