Int. Adv. Otol. 2011; 7:(3) 385-390

ORIGINAL STUDY

Researching Auditory Perception Performances of Children Using Cochlear Implants and Being Trained by an Auditory Verbal Therapy

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Aim: The main goal of this study is to examine the development of auditory perception performances of children who use cochlear implants who receive auditory verbal therapy.

Materials and Methods: This study includes 15 children with prelinguistic hearing loss who received cochlear implants in Hacettepe University Department of ENT who enrolled in auditory verbal therapy in the Training Unit of Hearing and Speaking Abilities. These hearing impaired children participated in auditory verbal therapy with their mothers and/or fathers for 12 months, and the family was given training programs to apply at home after each therapy session. The auditory perception performances of children were evaluated before implantation and on the 1st, 3rd, 6th and 12th months with the help of IT-MAIS/MAIS (Infant-Toddler/ Meaningful Auditory Integration Scale), LIP (Listening Process Profile), Ling's Five Sound Test and MTP (Monosyllable, Prochee and Polysyllable Test).

Results: The auditory perception performances of children joining auditory verbal therapy programs increased at a rapid pace after implantation, especially in the 1st and 3rd months ($p<0.01$), and reached the maximum level in the 12th month.

Conclusion: The auditory perception performances of children develop rapidly with a combination of early cochlear implantation and regular auditory verbal therapy. As a result, children should be included in auditory verbal therapy after cochlear implantation with the aim of supporting their hearing, expressive speech and language development.

Submitted : 27 January 2011 *Revised: 20 June 2011* *Accepted : 15 June 2011*

Introduction

Cochlear implants are electronic devices which are engineered to provide children and adults who have bilateral severe to profound sensorineural hearing loss who do not adequately benefit from the use of hearing instruments. Cochlear implants offer the possibility of better perception of sounds and better understanding of speech, and are developed with the aim of stimulating existing neural elements in the auditory pathway [1, 2].

When patients are selected for cochlear implantation, they are evaluated according to medical, audiological, language development, psychological and radiological qualities. Appropriate identification of implant candidates can result in considerable progress in their hearing and speaking abilities after cochlear implantation when compared with the situation before implantation. Studies conducted show us that auditory perception and expressive speech development of the children using cochlear implant can be better than the children using hearing instrument [3,4]. Spencer and Oleson [5] found that early access to unilateral cochlear implant input enables children to build better phonological processing skills. The early speech recognition and speech production skills gained from early CI input have been shown to predict children's reading skills. Hay-McCutcheon et al. [6] found that both the receptive and the expressive language ages in children with unilateral CI increased as the children with cochlear implants aged. However, the gap

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between the average performance for normal-hearing children and the overall mean performance in children with CI increased with chronological age. Recent reports indicate that unilateral cochlear implantation in prelingually deaf children within the first year of life may result in speech and language skills comparable to those of children with normal hearing [7-11].

Auditory-verbal therapy (AVT) is an early intervention education option that facilitates optimal acquisition of spoken language through listening by young children with hearing loss. It promotes early diagnosis, one-on-one therapy, and state-of-the-art audiologic management and technology. Parents and caregivers actively participate in therapy. Through guidance, coaching, and demonstration, parents become the primary facilitators of their child's spoken language development. Ultimately, parents and caregivers gain confidence that their child can have access to a full range of academic, social, and occupational choices throughout life [12].

Patients and their families must be trained properly by the experts in auditory verbal therapy after implantation. The abilities such as patients' adaptation to cochlear implants, learning listening to new sound stimuli, making sense of these stimuli and transferring all these to their speaking development are enabled with the trainings.

Materials and Methods

This study includes 15 children who ranged in age from 12-56 months with prelinguistic hearing loss who received cochlear implantation in Hacettepe University Department of ENT and who were trained by the auditory verbal approach in the Training Unit of Hearing and Speaking Abilities. These severe to profoundly hearing impaired children participated in auditory verbal therapy with their mothers and/or fathers for 12 months, and the family was given training programs to apply at home after each session. The auditory perception of children were evaluated before implantation and on the 1st, 3rd, 6th and 12th months with the help of IT-MAIS/MAIS (Infant-Toddler/Meaningful Auditory Integration Scale), LIP (Listening Process Profile), Ling's Five Sound Test and MTP (Monosyllable, Prochee and Polysyllable Test).

1. IT-MAIS & MAIS (Infant-Toddler/ Meaningful Auditory Integration Scale)

IT-MAIS (Zimmerman et al., 2000) [13] is a modification of the Meaningful Auditory Integration Scale (MAIS) (Robbins et al., 1991) [14]. It is a structuredinterview schedule designed to assess the child's spontaneous responses to sound in his/her everyday environment.

The assessment is based upon information provided by the child's parent(s) in response to 10 probes. These 10 probes assess three main areas: 1) vocalization behavior, 2) alerting to sounds; and 3) deriving meaning from sound. IT-MAIS is designed for infants and toddlers[13].

MAIS is a parent report consisting of 10 questions which evaluates how a child bonds to the listening device, alerts to sounds and assembles sounds meaningfully with a hearing instrument or implant before and after implantation [14]. 10 questions which can further be divided into 3 subsections: Questions 1 and 2 are on the child's confidence in using the device, questions 3 to 6 are on awareness to sounds and questions 7 to 10 are on the child's understanding of sounds. The MAIS is designed for children ages 3 years and older[14]. Using information provided by the parent, the examiner scores each question based on the frequency of occurrence of a target behavior. Scores for each question range from 0 ("never demonstrates the behavior") to 4 ("always demonstrates the behavior"). The highest possible score on the IT-MAIS and MAIS is 40 (10 questions x maximum score of 4) [13, 14]. Each child's scores at each test interval were converted to a percentage correct score (total score/40 x 100).

2. LIP (Listening Process Profile)

Archbold developed it in 1994 [15] with the aim of evaluating perception of peripheral sounds and speech sounds before and after implantation of children with cochlear implant and their developing listening abilities. It is a significant test which shows development of listening abilities of the children in early childhood and abilities for perceiving suprasegmental and segmental features of the sound, in the terms of applicability to young children with hearing loss. In the Listening Process Profile; two-choice picture series, a form consisting gradual twenty

one applications which evaluate listening abilities and a surround sound form are used. The surround sound form is for determining abilities of notifying and identifying peripheral sounds. These abilities are graded by direct observations (by the experts) or indirect observations (by the family). Children's only auditory responses to sound and ability of sound identification are evaluated by being processed to surround sound form like N (never), S (sometimes) and A (always) [15].

3. Ling's Five Sound Test

It is developed by Ling [16] and it uses the sounds /a/, /u/, /i/, /s/ and /ş/. These sounds are felt to represent the low, high and middle frequency parts of speech. The child's auditory ability to alert to and differentiate these sounds is evaluated using an open-ended format [16].

4. MTP (Monosyllable, Prochee and Polysyllable Test)

MTP is developed by Erber& Alencewicz [17], and it evaluates the abilities of children aged two or over to identify monosyllablic, two-syllable and three-syllable words. The test is graded in difficulty from easy to hard (MTP–3, MTP–6, MTP–12), and it is a close-ended test [17].

The statistical data used in the study were evaluated by using the computer program SPSS (Statistical Package for Social Sciences) Version 15.0 for Windows, 2006. The data were analysed by using descriptive statistics, percentages, frequencies, and Mann Whitney U Test.

Results

Information related to medical and audiological characteristics of the 15 children using cochlear implants in this study is given in the Table 1. According to this table, 60% (N=9) of the children are boys and 40% (N=6) are girls. Average chronological age of the children was approximately 44 months (range 12-56 months) and hearing loss diagnosis age was approximately 14 months. Hearing age (age at which the child first received amplification) was approximately 18 months; cochlear implant age was 26 months, and auditory verbal therapy age was approximately 15 months. Percentages of average IT-MAIS/MAIS, LIP and MTP test scores of the children participating in the study are given in the Figure 1. These tests were conducted before cochlear implantation, and in the 1st, 3rd, 6th, 12th months following implantation, while the subjects and families were enrolled in auditory verbal therapy.

Table 1. Information related to medical and audiological characters of children using cochlear implants

Features	Children with cochlear implanted
Number	N=15
Gender	9 boys (%60), 6 girls (%40)
Choronologic age (month)	44 months (R: 12-56 months SD: 5,2)
Diagnosis age of hearing loss (month)	14 months(R: 6–32, SD: 5,4)
Mean preimplant pure-tone average (implant ear non-implant ear)	110 dB HL
	105 dB HL
Hearing age(month)	18 months (R: 15–24, SD: 4,8)
Age of cochlear implant (month)	26 months (R: 18–38), SD: 4,3)
Age of auditory-verbal therapy	15 months(R: 12–20), SD: 3,7)

M: Mean (month) SD: Standard Deviation R: Range

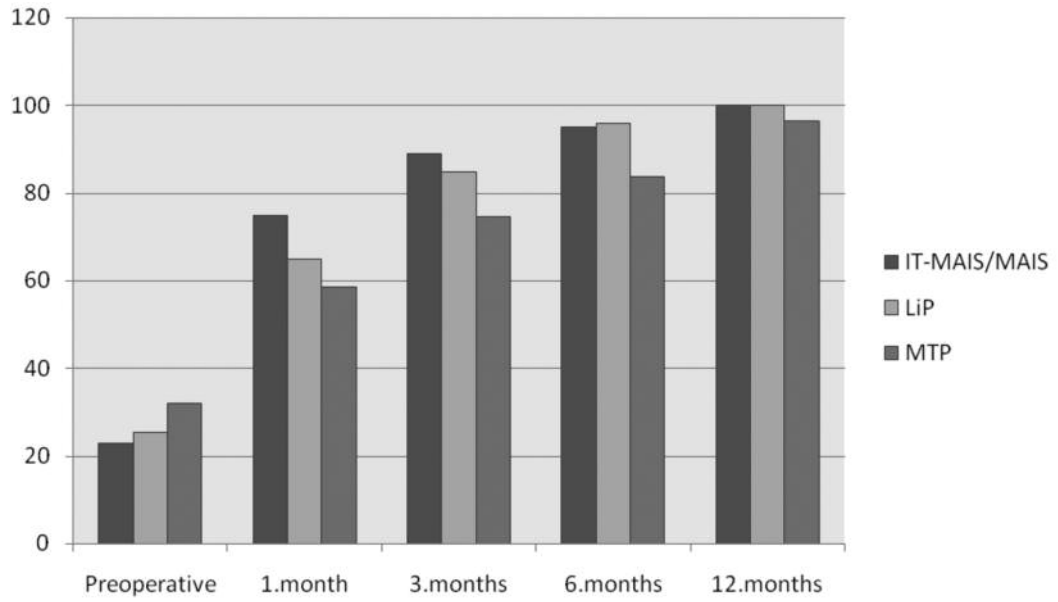

Figure 1. Percentages of average IT-MIAS/MAIS, LIP and MTP test scores of the children using cochlear implants

When we analyze the IT-MAIS/MAIS (bonding to the device, alerting to the sounds and assembling the sounds meaningfully) performance changes of children using cochlear implant before and after implant, we observed that their performance before implant was 23% and this rate went up to 75% in the first month of the implant, to 89% in the third month and to 95% in the sixth month ($p<0.01$).

Main aural ability performances of children such as respond to sound, differentiating the sound and identifying the sound in the period after cochlear implant were increasing gradually and reached 100% at the end of the 12th month. The biggest increase in the LIP test performance was seen between the preoperative period (25,5%) and 1st (65%) month ($p<0,01$), and between the 1st month (65%) and 3rd month (85%) ($p<0,05$).

When the MTP test scores of children using cochlear implants were investigated, it was observed that the most significant performance increase as compared with performance values of identifying monosyllable, two-syllable and three-syllable words in the preoperative period was especially in the 1st (58,5%) and 3rd (74,6 %) months ($p<0,01$).

Upon analyzing performances of alerting to and differentiating between Ling's five sounds of the implanted children we found out that there was a significant increase in the proper identification of sounds /a/, /u/ and /i/ especially in the first and third months ($p<0,01$). Together with this, while children cannot notice the /s/ sound before operation, their average notifying performance increased to 44,3% and their differentiating performance increased 21,6%. In the sixth month of the cochlear implant, notifying /s/ sound reached to 87,8% and differentiating reached to 70,5%, notifying /ş/ sound reached to 90% and differentiating reached to 77,1%. When we look at the Table 2, it is seen that performance of notifying and differentiating Ling's five sounds approximates 100% by the age of 12 months.

Discussion

After cochlear implantation, improvements are observed in auditory perception, visual-motor development and language skills of children. Rapid progress in these fields affects communication, social adaptation, attention and academic abilities in a positive way.

In the literature, it is reported that children who have been been implanted early in life develop more rapidly in both language development and other areas than do children who are implanted at a later age [12, 18,19].

Table 2. Percentages of average detection and discrimination performances between Ling's five sounds of the implanted children

Ling's 5 sounds		Preoperative	1.month	3.months	6.months	12.months
		%	%	%	%	%
/a/	Det.	35.4	75.5	85.3	95.4	100
	Dis.	24.0	46.0	62.5	88.5	100
/u/	Det.	33.5	75.1	85.0	93.6	100
	Dis.	20.7	45.3	60.4	86.9	98.8
/i/	Det.	26.8	73.8	84.5	92.4	100
	Dis.	16.5	36.2	58.3	86.4	97.5
/s/	Det.	---	44.3	66.2	87.8	100
	Dis.	---	12.6	24.0	70.5	96.0
/ş/	Det.	15.5	55.0	68.4	90.0	100
	Dis.	---	18.5	26.8	77.1	96.7

Det: Detection *Dis: Discrimination*

Average age at implantation age of the children in the present study is 26 months while their average auditory verbal therapy age is 15 months. When the literature is analyzed we discover that the age of patient at the time of cochlear implantation is the main factor affecting the language development performance [20,21]. According to Hammes et al (2002) differences in word identification skills and language development of children who use cochlear implant are apparent by 30 months. They reported that children who received a cochlear implant after 30 months have fewer skills and lag in their auditory and verbal skills when compared with children implanted before 30 months of age. Children with cochlear implants can realize improved language development [18]. In addition, listening abilities as assessed with the LIP increase considerably with cochlear implantation and training afterwards [22-24] Sainz et al [25] noted that this improvement happened especially in the 1st month of cochlear implant usage, which is in accordance with our study.

Conclusion

Children with severe to profound hearing loss may reach the same level of hearing-speaking and language development as do children with normal hearing with the help of early identification, proper management using hearing aids and cochlear implantation and following regular auditory verbal therapy.

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